6 THERMAL EVALUATION

6.1 Conduct of Review

The staff reviewed the applicant's thermal evaluation, which included Sections 2.2, "Nearby Industrial, Transportation, and Military Facilities;" 2.3, "Meteorology;" 3.1.1, "Materials to be Stored;" 3.1.2.4.4, "Fire Water System;" 3.2.5, "Combined Load Criteria;" 3.3, "Safety Protection System;" 3.4, "Classification of Structures, Systems, and Components;" 4.1.2.3.3, "Fire Water Supply;" 4.2, "Storage Structures;" 4.3, "Auxiliary Systems;" 4.5, "DOE Transfer Cask;" 5.1.1.2, "Loading Operations;" 5.1, "Operation Description;" 5.2, "Spent Fuel Handling Systems;" 5.3, "Other Operating Systems;" 5.4, "Operation Support Systems;" 5.5, "Control Room and Control Areas;" 8.1, "Off-Normal Events;" 8.2, "Accidents;" and 8.3, "Site Characteristics Affecting Safety Analysis;" of the Safety Analysis Report (SAR) (Foster Wheeler Environmental Corporation, 2003a) and Foster Wheeler Environmental Corporation responses to the staff's requests for additional information (Foster Wheeler Environmental Corporation, 2003b,c).

6.1.1 Decay Heat Removal Systems

The staff reviewed the discussion on decay heat removal systems with respect to the following regulatory requirements:

- 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 §72.128(a)(4) requires that spent fuel storage, high-level radioactive waste storage, and reactor-related greater than Class C waste storage and other systems that might contain or handle radioactive materials associated with spent fuel, high-level radioactive waste, or reactor-related greater than Class C waste, must be designed to ensure adequate safety under normal and accident conditions. These systems must be designed with a heat-removal capability having testability and reliability consistent with its importance to safety.

The proposed ISF Facility is comprised of three principal areas: the storage area, transfer area, and cask receipt area (CRA). The Transfer Tunnel facilitates the movement of the spent nuclear fuel (SNF) between these principal areas. The following subsections address the decay heat removal systems associated with these storage and operation areas of the ISF Facility, including the Transfer Tunnel and transfer cask, which will be used to transport the SNF from its current storage facilities to the ISF Facility.

6.1.1.1 Storage Area

The storage vault is a reinforced concrete structure located between the cask receipt and transfer areas as shown in Figure 4.2-9 of the SAR (Foster Wheeler Environmental Corporation, 2003a). The vault structure is separated into two storage vault modules,

designated as Vault 1 and Vault 2. The storage vault modules are enclosed over their top surface by an enclosed, metal-sided structure referred to as the storage area building, which provides a weatherproof enclosure for canister transfer operations using the Canister Handling Machine (CHM). The storage area building is described in Section 4.7.3.1.5 of the SAR. The storage vault system provides storage for 46-cm [18-in] and 61-cm [24-in] diameter ISF canisters placed in storage tubes. The ISF canisters are the primary confinement structures for the SNF from the Peach Bottom Unit 1 reactor; the Shippingport reactor; and Training, Research, and Isotope reactors built by General Atomics (TRIGA) to be stored at the ISF Facility. The tube arrays are configured as shown in Figure 4.2-3 of the SAR. There are 30 61-cm [24-in] diameter storage tubes located in Vault 1. Vault 1 also contains 72 46-cm [18-in] diameter storage tubes. Vault 2 exclusively contains 144 46-cm [18-in] diameter storage tubes. The storage tubes are filled with an inert atmosphere to reduce potential corrosion of the ISF canisters during storage. The foundation slab under the vault modules and both the external and internal dividing walls are made of reinforced concrete nominally 91-cm [3-ft] thick. The reinforced concrete charge face structure (i.e., the ceiling of the storage vault) is 76-cm [2.5-ft] thick.

Cooling-air inlet ducts are formed in the walls of the storage vaults. The inlet ducts have an offset path to prevent direct radiation streaming out from the storage tube assemblies (see Figure 4.2-4 of the SAR). Inlet duct screens and covers prevent debris and wildlife from entering the vault. The inlet duct screen has approximately a 70 percent open area. Cooling air exits the vault through the charge face structure into the storage area building, and is exhausted via louvers placed in the building walls. A radial gap in the annulus between the charge face encast and the storage tube assembly and charge face cover plate (see Figure 4.2-10 of the SAR) permits cooling air to flow up from the vaults into the storage area building (i.e., the top end of the storage tube is laterally centered by four equally spaced pads that are part of the charge face encast tube). The annular gap between the storage and charge face encast tubes is nominally 6.4-mm [0.25-in] wide. The decay heat from the SNF warms the air, thus creating the convection flow to remove decay heat. The heating, ventilation, and air conditioning (HVAC) system is not required to provide cooling or contamination control for the SNF in the storage area (i.e., the storage vault cooling is passive). In addition, the inlet vents in the concrete storage vault walls and exhaust louvers in the storage area building are classified as important to safety (see Section 4.3.1.1 of the SAR).

The ISF canister, which is the primary confinement structure, consists of the canister body assembly and the canister lid assembly. The ISF canister is classified as important to safety. The ISF canister baskets consist of tubes, spacer discs and plates, tie bars, lids and locking plates assembled into the structure to provide location and support for the SNF elements within the ISF canister. There is a specific basket design for each fuel type, as the basket must accommodate the different physical and radiological parameters of the fuel.

The ISF storage tube assembly consists of the storage tube body, storage tube lid and seals, and the internal storage tube plug. 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 the ISF canister storage vessels that are installed within the storage vaults. A support stool that is 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 ISF canisters are loaded into the ISF storage tubes using the CHM. An inert helium atmosphere is established within the ISF storage tube after the

ISF canisters are loaded, in order to provide a dry inert atmosphere around the ISF canister and thereby prevent degradation of the canister during its residence in the storage facility. 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 gas fill process and during storage. The ISF storage tube is protected from tornado missile strike by the charge face structure and the charge face cover plate that is positioned directly above the storage tube. 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 vaults in the lower level of the storage area are radiologically clean, because of the double confinement barrier features of the storage tubes and canisters. These vaults operate at atmospheric pressure and are not occupied. Due to the high radiation levels inside the storage vaults, there are no personnel access features (i.e., doors or access ports) to these areas. Neither supplemental heating nor cooling is provided in the storage vault area. The ISF canisters, storage tubes, charge face, and vault structure have been designed for a minimum temperature of !40 EC [!40 EF] to account for off-normal winter temperatures.

The storage area decay heat removal system was evaluated for the removal of up to 12.9 kW [4.4 × 10^4 BTU/hr] of decay heat distributed between both storage vaults, 6.16 kW [2.1 × 10^4 BTU/hr] in Vault 1 and 6.72 kW [2.29 × 10^4 BTU/hr] in Vault 2. The maximum individual storage tube heat output and vault configurations for this maximum decay heat are presented in Table 4.2-49 of the SAR.

The minimum and maximum normal air temperatures are !32 EC [!26 EF] and 37 EC [98 EF]. The off-normal minimum and maximum temperatures are !40 EC [!40 EF] and 38 EC [101 EF]. Table 4.2-64 of the SAR provides the bounding steady state temperatures for the ISF canisters during storage within the ISF Facility using the bounding storage vault design decay heat loads. Note that the minimum ISF canister temperature corresponding to the minimum off-normal operation environmental temperature provides a lower bound. As a result, the ISF canister temperature corresponding to the minimum normal operation environmental temperature does not need to be considered. In addition, Table 4.2-64 of the SAR also conveys the bounding ISF canister temperatures calculated for the postulated accident condition where 50-percent of the storage vault inlet air ducts are blocked. The maximum normal operation environmental temperature (i.e., 37 EC [98 EF]) was assumed to exist for this postulated accident scenario.

Table 6-1 provides the maximum SNF and storage vault component temperatures for the normal, off-normal, and accident conditions described earlier. Table 6-1 is a compilation of the information presented in Tables 4.2-56, 4.2-58, 4.2-60, and 4.2-62 of the SAR. In addition, the storage vault reinforced concrete temperatures are bounded by the storage tube temperatures delineated in Table 6-1. Unlike the analyses based on 40 watts/ISF canister used to calculate the bounding ISF canister temperatures presented in Table 4.2-64 of the SAR, the temperatures compiled in Table 6-1 were calculated using the applicable maximum allowable per canister heat generation rates: 33 watts/ISF canister for Peach Bottom fuel; 10 watts/ISF canister for Shippingport LWBR fuel; and 36 watts/ISF canister for TRIGA fuel. Therefore, the ISF canister temperatures presented in Table 6-1 are bounded by those presented in Table 4.2-64 of the SAR.

Table 6-1. Maximum SNF and relevant component temperatures during storage [from Tables 4.2-56, 4.2-58, 4.2-60, and 4.2-62 of the SAR (Foster Wheeler Environmental Corporation, 2003a)]

Component	Normal Operation Environmental Temperature (37 EC [98 EF]) EC [EF]	Off Normal Operation Environmental Temperature (38 EC [101 EF]) EC [EF]	50 percent Storage Vault Inlet Duct Blockage Accident Condition (Normal Operation Environmental Temperature) EC [EF]
Peach Bottom Spent Nuclear Fuel			
Storage tube	46.9 [116.4]	48.6 [119.5]	49.1 [120.3]
ISF canister	47.7 [117.9]	49.4 [121.0]	49.9 [121.8]
ISF basket	50.9 [123.6]	52.6 [126.7]	53.1 [127.5]
Fuel element	51.5 [124.7]	53.2 [127.8]	53.7 [128.6]
TRIGA Spent Nuclear Fuel			
Storage tube	48.4 [119.2]	50.2 [122.3]	50.8 [123.4]
ISF canister	50.6 [123.1]	52.3 [126.2]	52.9 [127.3]
ISF basket	56.5 [133.7]	58.2 [136.8]	58.8 [137.9]
Fuel element	56.9 [134.4]	58.6 [137.5]	59.2 [138.6]
Shippingport Reflector Rods			
Storage tube	38.1 [100.6]	39.8 [103.6]	38.4 [101.1]
ISF canister	38.2 [100.8]	39.9 [103.8]	38.5 [101.3]
ISF basket	38.7 [101.7]	40.4 [104.7]	39.0 [102.2]
Fuel element	38.7 [101.7]	40.4 [104.7]	39.0 [102.2]
Shippingport Reflector Modules			
Storage tube	39.2 [102.6]	40.9 [105.7]	39.8 [103.6]
ISF canister	39.4 [102.9]	41.1 [106.0]	39.9 [103.9]
Reflector module	42.5 [108.5]	44.2 [111.6]	43.1 [109.5]

The temperature limits for the SNF and storage area structural materials are reviewed in Section 6.1.2, "Material Temperature Limits," of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the storage area are reviewed in Section 6.1.4, "Analytical Methods, Models, and Calculations;" of this SER. The fire

and explosion hazard assessment for the storage area is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

Canister Handling Machine

The CHM, located in the storage area building, moves individual ISF canisters from the Transfer Tunnel to their storage tube location, and inserts the ISF canisters into the storage tubes. The CHM consists of a single-failure-proof bridge crane with an integral shielded transfer cask. After an ISF canister is lowered into a storage tube and a shield plug is installed, the storage tube is sealed with a cover plate with dual metallic seal rings to provide a redundant, outer confinement barrier during storage.

The storage area building is located in Zone 3 of the HVAC system (see Section 6.1.1.2 of this SER). The HVAC system flow diagram for the storage area is shown in Figure 4.3-2 of the SAR. The storage area building exhaust fans are not required to ensure adequate decay heat removal from the SNF stored in the storage area vaults. The storage area building ventilation includes the sixteen inlet vents in the concrete storage vault walls, the annular gaps between the storage tubes and the charge face encast, and the six fixed louvers in the storage area building walls that permit airflow to support natural convection through the storage vaults. Figures 4.3-8, 4.3-9, and 4.2-4 of the SAR show the fixed inlet and exhaust vents and louvers in the storage vault walls and storage area building. The storage area building is radiologically clean and operates at atmospheric pressure. It is normally occupied during storage vault loading and monitoring operations. The storage area building is heated and ventilated to ensure that the CHM is operated above the minimum operating temperature of 0 EC [32 EF]. Canister handling operations are suspended if the temperature in the storage area building is at or below 0 EC [32 EF] or greater than 40 EC [104 EF]. Electric radiant heaters, wall-mounted exhaust fans and wall-mounted intake dampers maintain design temperatures in the area. The storage area building temperature operating limits are maintained by thermostatically controlling these fans and heaters.

Table 4.2-64 of the SAR is a compilation of the bounding ISF canister temperatures during transfer operations using the CHM for different normal and off-normal conditions. The temperatures documented in Table 4.2-64 of the SAR were obtained using the bounding ISF canister decay heat loads.

The temperature limits for the storage area building and CHM structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the storage area building and CHM are reviewed in Section 6.1.4, “Analytical Methods, Models, and Calculations;” of this SER. The fire and explosion hazard assessment for the storage area building and CHM is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

6.1.1.2 Transfer Area

The transfer area provides the facilities for unloading the SNF from the transfer cask and repackaging it into the ISF canisters. The transfer area includes the fuel packaging area (FPA), canister closure area (CCA), solid waste processing area (SWPA), and the operating gallery. The FPA houses the Fuel Handling Machine (FHM) and is where SNF is removed from the

incoming transfer cask and repackaged into the ISF canisters. The CCA is where the ISF canisters, loaded with SNF, are vacuum dried, helium backfilled, and welded closed. The SWPA is where solid radioactive waste generated in the transfer area is prepared for disposal on the INEEL site. Lastly, the operating gallery is where operators remotely control the various SNF handling operations.

The following discussion provides an overview of the transfer area HVAC system. Subsequent subsections address the specific HVAC system operational requirements for the FPA, CCA, and operating gallery. The HVAC system requirements for the Transfer Tunnel are addressed in Section 6.1.1.4 of this SER.

The ISF Facility design philosophy is such that the HVAC system is not to be relied on to ensure the integrity of the SNF at any time during storage or fuel handling operations. Because the FPA and FHM maintenance area ventilation ductwork and high efficiency particulate air (HEPA) filters form part of the confinement barrier during fuel handling operations, however, these components have been classified as important to safety. Figure 4.3-5 of the SAR schematically depicts the components important to safety and seismic boundaries of the HVAC system that penetrate the confinement barrier of the FPA and FHM maintenance area. The balance of the HVAC system is classified as not important to safety. To ensure that SNF handling operations are not affected, however, the main supply and exhaust fans serving the transfer area have redundant backup fans to allow for periodic maintenance and duty cycling. The effects of loss of filter integrity are minimized through the use of local intermediate filters, pre-filters in the final HEPA housings, and dual HEPA filtration sections in series in the final HEPA housings.

To address the as low as is reasonably achievable (ALARA) design requirement of 10 CFR Part 72, the intent of the HVAC system design is to minimize the spread of contamination by providing filtration, maintaining differential pressures between contamination control zones, and directing air flow from areas of low potential contamination toward areas of higher potential contamination. In addition, the HVAC system is expected to provide sufficient environmental control that will enable structures, systems, and components to operate within normal design temperature parameters in accordance with the ISF Facility technical specifications. The HVAC system is specifically designed to: (i) prevent the accidental release of radiological hazards to the environment, (ii) keep personnel exposure to radiological hazards ALARA, (iii) maintain environmental conditions for habitability and reliable equipment operation, and (iv) provide integrated systems that support safe operation of the facility. The HVAC system is expected to operate continuously throughout the year.

The ISF Facility HVAC system is demarcated into four zones. HVAC system Zone 1 (i.e., areas where highly radioactive materials are processed), which corresponds to the ISF Facility confinement barrier boundary, requires air pressures to be maintained at the maximum negative values with respect to atmosphere so that air flows into this zone. The FPA and FHM maintenance area are in HVAC system Zone 1. Air pressures in HVAC system Zone 2 (i.e., areas surrounding Zone 1 where some potential for radioactive release may exist) are positive with respect to Zone 1 and negative with respect to Zone 3 and ambient pressure. This ensures that air flows from this zone towards the primary confinement barrier. The operating gallery, workshop, CCA, SWPA, solid waste storage area, liquid waste storage tank area, HEPA filter room, Transfer Tunnel, and cask decontamination area fall within HVAC system Zone 2. Occupied areas in the secondary airborne contamination control zone (i.e., HVAC

system Zone 2) are designed for a minimum of four air changes per hour. Room pressure controls are described in Section 4.3.1.2 of the SAR. Zone 3 of the HVAC system (i.e., tertiary areas where there is little potential for radioactive release) consists of those areas where contamination is not expected. As a result, HVAC system Zone 3 areas operate at atmospheric pressure. The storage area building and CRA are designated as HVAC system Zone 3 areas. In addition, the operator's office and the corresponding access corridor; equipment, electrical, HVAC exhaust, and change rooms; and the new canister receipt area of the transfer area were designated HVAC system Zone 3 areas. Note that the operator's office, change room, and corridor will be maintained at a pressure slightly higher than atmospheric pressure. And, finally, HVAC system Zone 4 areas are those ancillary areas where no radioactivity is expected. The offices in the operations area, which is designated as an HVAC system Zone 4 area, are maintained at a pressure slightly higher than atmospheric pressure due to their proximity to the transfer area. Other HVAC system Zone 4 ancillary areas are maintained at atmospheric pressure.

The transfer area HVAC supply and exhaust air flow diagrams, nominal operating differential pressures, and flow quantities are shown in Figure 4.3-3 of the SAR. The transfer area is served by a once-through system consisting of a central make-up air handling unit, final exhaust HEPA filters, and exhaust fans. One-hundred-percent redundant supply and exhaust fans facilitate maintenance and provide backup capability. The Transfer Tunnel, including the cask decontamination zone, also includes stand-alone recirculation air handling units in each of these two areas to augment heating, cooling, and air filtration. These redundant units reduce the size of the central air handling unit and the required exhaust air flow rate. The redundant air handling unit in the decontamination zone receives make-up air from the CRA. Both redundant air handling units are provided with individual HEPA filters and continuous air monitors. Outside supply air entering the air handling unit is filtered before being introduced into the transfer area. In certain areas, backdraft dampers and barometric dampers prevent flow reversal due to accidental room pressurization. Additionally, HEPA filters are installed in the supply air system to the FPA, FHM maintenance area, solid waste storage area, and SWPA to prevent the spread of contamination should a flow reversal occur in these areas. Fire and tornado dampers are provided at ductwork penetrations into the FPA and FHM maintenance area. A fire damper is provided at the ductwork penetration to the CCA. Exhaust air leaving the FPA passes through HEPA filters installed within the FPA before merging with the common exhaust duct. The common exhaust air passes through two stages of HEPA filtration before being discharged to the atmosphere. A variable frequency drive on the exhaust fan increases fan speed to maintain a constant exhaust flow rate as particulate collects on the final HEPA filters. A variable frequency drive on the supply fan modulates fan speed as pressure control dampers open and close.

The HVAC system is designed based on the following criteria: (i) doors, walls, ceilings, and roofs in pressure controlled areas are sealed and well insulated to prevent pressure loss and condensation; and (ii) accurate temperature control is less important than accurate pressure control; therefore, room temperatures may fluctuate when a pressure upset occurs. There are no special humidity requirements, so there are no provisions for humidity control.

The codes and standards listed below provide the principal design and construction requirements for the HVAC system: (i) ASHRAE DG-1 (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.,1993); (ii) ASHRAE Cooling and Heating Load Calculation Manual (American Society of Heating, Refrigerating, and Air-Conditioning

Engineers, Inc., 1992); (iii) ANSI/ASME N509 (American National Standards Institute/ASME International, 1989a); (iv) ANSI/ASME N510 (American National Standards Institute/ASME International, 1989b); (v) ERDA 76-21 (Energy Research and Development Administration, 1976); (vi) Industrial Ventilation—A Manual of Recommended Practice (American Conference of Governmental Industrial Hygienists, 2001); (vii) HVAC Duct Construction Standards—Metal and Flexible (Sheet Metal and Air-Conditioning Contractors' National Association, 1995).

The HVAC system will use either electric resistance or electric radiant heating, chilled water or direct expansion cooling, and direct ventilation with outside air to maintain the required inside design temperatures. An air-cooled chiller and water-to-water heat exchanger (outside the operations area southwest corner) provide chilled water to the HVAC air handling unit heat exchangers. The primary side of the heat exchanger contains a mixture of propylene glycol and water. The secondary side of the heat exchanger contains water. Use of the glycol mixture eliminates the need to drain the chiller and primary piping each winter. Chemicals are added to inhibit corrosion. The primary pump provides constant flow to meet chiller requirements. The secondary pump is equipped with a variable frequency drive and two way coil valves to conserve energy and provide improved part-load performance.

The final transfer area exhaust HEPA filters, as shown in Figure 4.3-4 of the SAR, consist of two banks of multiple, modular air-cleaning units. Each filter bank contains four modular two-stage air-cleaning units, with a total capacity of 674 m^3/min [23,800 cfm]. The design permits one air-cleaning unit to be isolated for filter replacement, and a clean unit to be brought on line without diminishing either the capacity or function of the entire system. HEPA filters are type B, nuclear grade and meet the requirements of ANSI/ASME N509 and ANSI/ASME N510 (American National Standards Institute/ASME International; 1989a,b). Filters are housed in metal enclosures with a series of pressure differential and flow instruments to monitor differential pressure and flow across the individual filter banks.

Intermediate HEPA filters on exhaust ducts serving primary and secondary (i.e., HVAC system Zone 1 and Zone 2) airborne contamination control zones are provided with spare HEPA filters to allow filter changes without shutting the system down. HEPA filters are installed inside the FPA on the inlet to the exhaust ductwork to remove radioactive particulate from the air leaving this area. These filters reduce the number of filter change-outs and the associated dose rate for the final filters in the HEPA filter room. These filters also serve as passive confinement barriers during off-normal and accident conditions.

The exhaust fans are designed for HEPA changes when the particulate loading on the filters reach levels that generate a differential pressure of 10.2 cm [4-in] water. When the differential pressure across a filter reaches this level, the filter will be changed. Exhaust HEPA filters in the FPA will be changed when the dose associated with the filter reaches 2.5 mSv/hr [250 mrem/hr] or 10.2-cm [4-in] water, whichever occurs first. The 2.5 mSv/hr [250 mrem/hr] action level on the filter will ensure that the 5 mSv/hr [500 mrem/hr] limit on the solid waste boxes is not exceeded. Dose rate measurements associated with the internal FPA filters are described in Section 7.3.4 of the SAR. Section 6.4.4 of the SAR provides a detailed discussion regarding the waste characteristics and volumes associated with the filters.

The exhaust stack is nominally 96.5 cm [38 in] in diameter and approximately 24.4 m [80 ft] high. The stack diameter was selected based on fan pressure and discharge velocity requirements. The exhaust height was calculated in accordance with the ASHRAE Handbook

(American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1992). Plume dispersion modeling was performed based on these parameters to ensure that radiation levels at the ISF Facility controlled area boundary are within regulatory limits so that public health and safety is not jeopardized. The exhaust stack features an isokinetic sampler and sample ports. Sample ports are located 90 degrees apart, a minimum of eight stack diameters above the inlet to the stack and a minimum of two stack diameters below the outlet. The exhaust stack is classified as not important to safety. However, it is designed to withstand the effects of a seismic event to ensure that it does not fail and adversely affect structures, systems, and components important to safety in the vicinity. Section 4.1.4 of this SER provides discussion pertaining to the design of the exhaust stack.

The HVAC supply fans are interlocked with the exhaust fans and do not run unless the exhaust fans are running. Moreover, the redundant supply fans are interlocked to prevent simultaneous operation. A similar interlock exists for the redundant exhaust fans. The control system monitors room pressure, initiate alarms, and automatically shuts down the supply fan if a positive pressure is detected in either a primary or secondary contamination control zone.

Additional HEPA filters are provided in other areas to protect supply and exhaust ductwork from contamination and to restrict backflow through the supply ducts should the room ever be pressurized. Filter efficiency test ports are provided on the intermediate filter units.

Supply ductwork serving HVAC system Zones 1 and 2 will be fabricated and installed in accordance with Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA) (1995) high-pressure duct construction standards due to the pressures involved. Ductwork will be galvanized steel with duct liner for thermal insulation. Exhaust ductwork serving HVAC system Zones 1 and 2 will be fabricated and installed in accordance with ERDA 76-21 (Energy Research and Development Administration, 1976), ANSI/ASME N509 (American National Standards Institute/ASME International, 1989a), and SMACNA high pressure duct construction standard. Exhaust ducts are sized to maintain sufficient transport velocities to prevent particulate contaminants from settling out of the air stream.

Ductwork design is based on high (Class 2) contamination levels in the ductwork between the fuel packaging area and the final HEPA filters, moderate (Class 3) contamination levels in other areas, and an operating mode in which the exhaust system is shutdown in case of an accident. Ductwork from the FPA to the final HEPA filters will be welded construction (Level 4) due to potential contamination. Ductwork from the final HEPA filters out through the stack will be welded construction due to the pressures involved. Ductwork in other areas will be nonwelded construction (Level 2) unless welded construction is required due to pressures and routing. This ductwork will be fabricated and installed per the SMACNA high-pressure duct construction standard.

Tornado dampers installed at ductwork penetrations into the FPA automatically close in the event of a tornado. These dampers are designed to prevent the release of contamination due to the pressure differential generated by the presence of a tornado.

The transfer area supply and exhaust fans and battery room HVAC system are connected to the standby motor control center, which can be energized by the standby diesel to ensure ventilation to these areas following a loss of offsite power. The HVAC control system will restart these fans automatically once the motor control center is re-energized by the standby diesel

generator after a power failure to maintain differential room pressures and continue filtration. During a power failure, however, the heating and cooling units will shut down and room temperatures may eventually equalize with the ambient outdoor temperature until offsite power is restored.

The automated HVAC control system used at the ISF Facility is connected to the uninterruptible power supply (UPS) to provide pressure and temperature control during a power failure and to facilitate the orderly restart of the HVAC system once power is restored. The transfer area supply and exhaust fans are fed from the standby motor control center, which is powered by the standby diesel generator during a power failure. During an off-site power failure, these fans will restart automatically and continue to run to maintain differential room pressures.

Room and area design pressures are maintained by keeping the volume of exhaust air constant while varying the volume of supply air. The total volume of supply air is less than the total volume of exhaust air, resulting in negative pressures relative to atmospheric pressure (except for occupied areas such as the Operations Area, which has positive pressures). An automated HVAC control system monitors room pressure, initiates alarms, and automatically shuts down the supply fan if a positive pressure is detected in either a primary or secondary airborne contamination control zone. The make-up and exhaust systems maintain the design pressure differential between rooms. The automated HVAC control system maintains this differential regardless of transient effects caused by changes in atmospheric pressure, wind speed and direction (except tornadoes), doors opening and closing, and routine maintenance procedures.

The HVAC system is not required to mitigate a design basis flood and will be manually shut down if a flood occurs. HVAC equipment on the lower elevations of the ISF Facility could be submerged by floodwaters. The exhaust HEPA filter housings and connecting ductwork on the first floor of the transfer area are designed for airtight operation at pressures in excess of negative 25.4 cm [10 in] water. During a flood event, however, the lower door seals are approximately 78.7 cm [31 in] below the maximum probable flood elevation. Therefore, the exhaust HEPA filters may have water damage. Before restarting the HVAC system after a flood, the interior of the housings will be inspected, cleaned, repaired, and leak tested. The filter elements will be changed and aerosol tested. Portions of the HVAC system that form a confinement barrier are above the maximum probable flood (MPF) 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.

Fuel Packaging Area

The FPA serves as the confinement barrier while SNF is transferred from the U.S. Department of Energy–supplied containers to the ISF canister. The FPA, whose confinement boundary encompasses the FHM maintenance area, is located in Zone 1 of the HVAC system. As a result, air pressures in the FPA and FHM maintenance area are maintained at the maximum negative values with respect to atmosphere so that air flows toward this confinement barrier. The FPA ventilation design criteria (see Section 3.3.2.2 of the SAR) require the suspended airborne radionuclides to be filtered by the HEPA filters within the FPA, the intermediate HEPA filters, and the final HEPA filters.

HEPA filters are installed on the exhaust ducts leaving the FPA. These filters are located inside the FPA and are designed to facilitate replacement using the manipulators. These filters will

act as pre-filters to protect the downstream ductwork from contamination. Isolation dampers are provided to isolate these filters during filter changes. Filter changes will be performed remotely using a manipulator controlled from the operating gallery. The HEPA filters inside the FPA will not require filter efficiency testing since they are only being used as pre-filters. The FPA exhaust duct will be provided with an isokinetic sampler, external to the FPA, to assist in determining the condition and efficiency of the FPA exhaust filters.

Portions of the FPA HVAC system passively ensure that the confinement barriers of the FPA and FHM maintenance area are maintained during off-normal and accident conditions. Figure 4.3-5 of the SAR schematically depicts the systems and components important to safety and seismic boundaries of the HVAC system that penetrate the confinement barrier of the FPA and FHM maintenance area. A "breakaway" joint is provided at the important to safety/not important to safety ductwork interface to protect the important to safety ductwork when subjected to a seismic event. In addition, the tornado pressure boundary for the FPA and FHM maintenance area is the roof, walls, and floor. 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] per Regulatory Guide 1.76 (U.S. Nuclear Regulatory Commission, 1974). The FPA supply tornado damper meets ASME AG–1 gas-tight criteria (ASME International, 1997). The tornado dampers are provided with locking devices to keep them closed after the tornado passes. The locking device is manually disengaged to return the dampers to service. Tornado dampers are installed as close to the primary confinement shield wall as practical and are protected from tornado missiles.

During fuel transfer into and out of the FPA through the cask and canister port, confinement barriers and area pressures are maintained by inflatable seals. An inflatable seal integral to the port engages the casks and canisters before removal of the port plugs. During fuel transfer through the cask and canister ports, the confinement barrier includes the transfer cask and the ISF canister. Benefits of using inflatable seals at these ports during fuel transfer include:

- Continuously maintaining the confinement barrier;
- Eliminating fluctuations in airflow;
- Eliminating fluctuations in area pressures; and
- Contamination control.

Before waste is transferred out of the FPA through the canister waste port or the process waste port, the pressure inside the SWPA is lowered to minimize differential air pressure between the SWPA and the FPA. This will minimize the air flow through the waste port to ensure that the FPA pressure remains at the proper negative pressure relative to other airborne contamination control zones. If there is SNF in the FPA, the waste ports will not be opened unless the following conditions are met:

- Cask port is closed with the cask port plug installed;
- Canister port is closed with the canister port plug installed;
- SNF in the FPA is in a designated storage location; and
- HVAC system is operating.

If the HVAC system becomes inoperable, waste transfer operations are suspended and the waste ports are replaced. Both waste ports must be installed before commencing fuel-handling operations.

The normal indoor temperatures for the FPA are 32.2 EC [90 EF] in the summer and 10.0 EC [50 EF] in the winter (see Section 3.2.5.1.6 of the SAR). In the event of a loss of the HVAC system, the steady-state FPA temperatures are 68.9 EC [156 EF] or 55.0 EC [131 EF] in the summer and !8.3 EC [17 EF] or !32.2 EC [!26 EF] in the winter, depending on whether the lights and motors are on or off (Foster Wheeler Environmental Corporation, 2003a, Table 4.3-2). Note that these steady-state temperatures do not consider diurnal temperature variations and their use was limited to determining the HVAC system design requirements. The normal environmental temperature extremes were used to calculate the FPA temperatures for this loss of HVAC system scenario.

Two scenarios were investigated to assess the thermally induced stresses in the FPA reinforced concrete confinement walls. In both scenarios, the environmental temperatures are modeled using time histories that consider diurnal temperature variations during summer and winter conditions (see Sections 3.2.5.1.6 and 3.2.5.1.10 of the SAR). These scenarios and boundary conditions were determined to be acceptable for establishing the potential creation of thermally induced cracks in the FPA reinforced concrete confinement walls.

Table 4.2-55 of the SAR conveys the maximum SNF and relevant component temperatures within the FPA.

The temperature limits for the FPA structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the FPA are reviewed in Section 6.1.4, “Analytical Methods, Models, and Calculations;” of this SER. The fire and explosion hazard assessment for the FPA is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

Canister Closure Area

The two main sub-assemblies of the ISF canister (i.e., the ISF canister body and lid) are welded together in the CCA, after being loaded with SNF in the FPA. Once the ISF canister closure weld has been completed and tested, the canister is vacuum dried, backfilled with helium, and leak tested.

The canister vacuum dry, helium fill, and leak detection system is required to: (i) vacuum dry the canister and SNF to acceptable levels of dryness, (ii) backfill the ISF canister with helium gas, (iii) facilitate placement of the canister vent plug while maintaining the helium backfill within the canister, and (iv) leak test the canister circumferential closure weld and vent plug seal weld to the required acceptance standards. The canister connection tool provides a leak tight connection between the ISF canister and the vacuum dry and helium fill systems. The canister connection tool is used to remove the canister vent plug for vacuum drying and helium filling and, subsequently, reinserting it while maintaining the required overpressure of the helium backfill in the canister. In addition, two pressure transducers and a thermocouple attached to the canister connection tool measure canister pressure and gas temperature during the drying and helium backfilling operations.

The ISF canisters undergo two cycles of vacuum drying and helium filling. The canister is held in vacuum for a period of at least 2 hr with a pressure rise of less than 1.3 kPa [10 Torr] per hour. To aid the drying and welding processes the canister is heated, as required, to a temperature range of 26.7 to 37.8 EC [80 to 100 EF].

The canister connection tool has a minimum design pressure of less than 133 Pa [1 Torr] absolute and a maximum design gauge pressure of 345 kPa [50 psi]. The canister connection tool and the associated piping system are fabricated from stainless steel and designed to the requirements of ASME B31.1 (ASME International, 2001a). The canister connection tool incorporates a lifting feature so that the CCA crane can lift it on and off the canister. Before each vacuum dry and helium fill operation the canister connection tool is leak tested.

The canister helium fill system connects to the canister connection tool and is designed to provide an inert helium environment to the canister at an atmospheric pressure of 138 kPa ± 6.9 kPa at 32.2 EC ± 5.6 EC [20 psia ± 1 psia at 90 °F ± 10 °F]. The canister helium fill system includes a pressure relief device set to a gauge pressure of 276 kPa [40 psig] to protect the canister from over-pressurization resulting from off-normal events such as failure of cylinder pressure regulators. The helium fill system is designed to withstand a vacuum of less than 133 Pa [1 Torr]. This low design pressure mitigates against the effect of the helium fill system experiencing the vacuum of the vacuum fill system. The canister helium fill system piping is designed to ASME B31.1 (ASME International, 2001a).

Both the canister lid assembly to body assembly closure weld and vent plug seal weld are helium leak tested in accordance with the requirements of the ASME International Boiler and Pressure Vessel Code, Section V, Article 10, Appendix IV (2001b) to verify that no leakage can be detected that exceeds the rate of 1×10^{-4} std cm^3/s [6.1×10^{-6} in^3/s]. The leak testing is performed in accordance with ANSI N14.5 (American National Standards Institute, 1997) using a portable, hand held helium sniffer. The helium sniffer is source-checked before and after leak testing.

Operational safety for the vacuum dry, helium fill and leak check system is provided during normal, off-normal, and accident conditions. Under normal conditions, the storage canister is designed to handle the differential pressure associated with near-absolute vacuum. Therefore, no safety feature is required to limit the vacuum. The vacuum pump draws through a HEPA filter to prevent the spread of contamination.

The vacuum dry and helium fill system has a pressure relief device set to less than design pressure, to protect the canister from failure of helium pressure regulators. The helium backfill system will use helium with a specified purity of at least 99.995 percent to minimize oxidation and degradation of the SNF. Administrative controls prevent operation of the equipment when temperatures in the CCA are below 0 EC [32 EF]. The systems will shut down during an earthquake. The system is not required to maintain fuel integrity or temperature, or prevent release of radioactive material.

The majority of the vacuum, helium fill, and leak detection system is located within the equipment room as shown in Figure 4.7-16 of the SAR. The connection tool and its HEPA filter, which is located between the canister connection tool and the vacuum pump, are located within the CCA. The individual assemblies of the canister vacuum dry, helium fill, and leak detection system and their detailed individual functional requirements have been documented within the SAR.

The CCA is located in Zone 2 of the HVAC system. Therefore, air pressures in this zone are positive with respect to Zone 1 and negative with respect to Zone 3 and ambient pressure. This ensures that air flows from this zone towards the primary confinement barrier. The ventilation design criteria (see Section 3.3.2.2 of the SAR) is such that potential airborne radionuclides within the CCA are filtered by two banks of HEPA filters (i.e., intermediate and final HEPA filter banks). The estimated release of airborne radionuclides to the CCA is based on the air flow through the gap between the inside wall of the ISF canister and the outside diameter of the shield plug. The air flow is a result of the natural convection of the air being heated by the spent fuel decay heat and the canister heater.

The maximum steady state temperatures within the canister trolley cask will occur while the cask is jacked up into the CCA. In this position a 91.4-cm [3-ft] high section of the cask is within the concrete roof of the transfer tunnel. To ensure that the results are conservative, it has been assumed that there is no heat loss from any part of the cask above the level of the transfer tunnel roof. Canister heat that is passed radially into the cask from above the level of the transfer tunnel roof will be conducted down through the cask steel shielding into the transfer tunnel area, before being transferred to the HVAC air environment in the Transfer Tunnel. The natural convection heat transfer that occurs across the air gaps between the inside wall of the canister heater module and the canister, and between the outside wall of the canister heater module and the inside surface of the canister cask, were modeled using surface effect elements. The thermal radiation that occurs across these air gaps was modeled using a radiation matrix utility. Neither the canister lifting cage nor the canister heater module elements were represented explicitly in the model. The natural convection heat transfer and thermal radiation from the outside surface of the canister trolley cask to the ambient transfer tunnel air environment was modeled using surface effect elements. The applied heat transfer coefficient was temperature dependent and based on a laminar natural convection correlation.

Two scenarios were investigated to assess the thermally induced stresses in the CCA reinforced concrete confinement walls. In both scenarios, the environmental temperatures are modeled using time histories that consider diurnal temperature variations during summer and winter conditions (see Sections 3.2.5.1.6 and 3.2.5.1.10 of the SAR). These scenarios and boundary conditions were determined to be acceptable for analyzing the potential creation of thermally induced cracks in the CCA reinforced concrete confinement walls.

The temperature limits for the CCA structural materials are reviewed in Section 6.1.2, "Material Temperature Limits," of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the CCA are reviewed in Section 6.1.4, "Analytical Methods, Models, and Calculations;" of this SER. And, finally, the fire and explosion hazard assessment for the CCA is reviewed in Section 6.1.5, "Fire and Explosion Protection," of this SER.

<u>Solid Waste Processing Area</u>

The SWPA is the collection area for radioactively contaminated solid material such as towels, rags, and spray bottles from the ISF Facility where it is treated and prepared for shipment. The SWPA is outfitted with a sump pit that is used to send wastewater to the liquid waste storage tank.

The SWPA is located within Zone 2 of the HVAC system. Air pressures in this zone are positive with respect to Zone 1 and negative with respect to Zone 3 and ambient pressure. This ensures that air flows from this zone towards the primary confinement barrier. According to Table 4.3-1 of the SAR, the normal operating indoor HVAC design temperatures for the SWPA are between 21.1 EC [70 EF] and 26.7 EC [80 EF]. No off-normal or accident temperature analyses were performed for the SWPA.

The temperature limits for the SWPA structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the SWPA are reviewed in Section 6.1.4, “Analytical Methods, Models, and Calculations;” of this SER. The fire and explosion hazard assessment for the SWPA is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

<u>Operating Gallery</u>

The operating gallery is the centralized operations area for ISF Facility personnel to remotely control SNF handling operations throughout the facility. The operations remotely performed from the operating gallery include, but are not limited to: (i) SNF handling and HVAC maintenance operations within the FPA; (ii) ISF canister closure welding and testing, vacuum drying, helium backfilling, and leak testing within the CCA; and (iii) emplacement of the ISF canisters into the storage tubes using the CHM within the storage area.

The operating gallery is located within Zone 2 of the HVAC system. Air pressures in this zone are positive with respect to Zone 1 and negative with respect to Zone 3 and ambient pressure. This difference in pressure ensures that air flows from this zone toward the primary confinement barrier. According to Table 4.3-1 of the SAR, the normal operating indoor HVAC design temperatures for the operating galley are 21.1 EC [70 EF] for heating and 26.7 EC [80 EF] for cooling.

The temperature limits for the operating gallery structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the operating gallery are reviewed in Section 6.1.4, “Analytical Methods, Models, and Calculations;” of this SER. The fire and explosion hazard assessment for the operating gallery is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

6.1.1.3 Cask Receipt Area

The CRA provides the equipment necessary to transfer incoming SNF transportation casks from truck-mounted transporters to a rail-mounted cask trolley for subsequent movement into other areas of the ISF Facility. The CRA incorporates a single-failure-proof cask receipt crane to lift the transport cask from its transport vehicle and place it on the cask trolley. The cask trolley moves within the enclosed Transfer Tunnel that connects the CRA with the transfer area and storage area.

The CRA is located in Zone 3 of the HVAC system. Contamination is not expected in this area and, as a result, operations are conducted at atmospheric pressure. This area is heated and

ventilated to ensure that the temperature is maintained above 0 EC [32 EF], which is the minimum operating temperature for the cask receipt crane. Unit heaters, wall-mounted exhaust fans, and wall-mounted intake dampers maintain design temperatures inside the area. Cask handling operations are suspended if the temperature in the CRA is at or below 0 EC [32 EF]. The ventilation system also removes diesel fumes from the building when a truck is being loaded or unloaded. This is accomplished with a separate, dedicated fume collection system that captures diesel fumes at the exhaust pipe of the truck and directs these fumes to the outside of the CRA.

For summer off-normal temperature conditions, Table 4.3-2 of the SAR indicates that the CRA temperatures are 65.0 EC [149 EF] and 42.8 EC [109 EF], depending on whether the lights and ancillary equipment motors are on or off. For winter off-normal temperature conditions, Table 4.3-2 of the SAR indicates that the CRA temperatures are 1.7 EC [35 EF] and !32.2 EC [!26 EF], once again, depending on whether the lights and motor are on or off. Recall that the temperatures conveyed in Table 4.3-2 of the SAR were derived assuming a loss of the HVAC system under normal environmental operating temperatures.

The temperature limits for the CRA structural materials are reviewed in Section 6.1.2, "Material Temperature Limits," of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the CRA are reviewed in Section 6.1.4, "Analytical Methods, Models, and Calculations;" of this SER. The fire and explosion hazard assessment for the Cask Receipt Area is reviewed in Section 6.1.5, "Fire and Explosion Protection," of this SER.

6.1.1.4 Transfer Tunnel

Although the Transfer Tunnel is structurally part of the vault structure, it is not considered a functional part of the vault storage system. The Transfer Tunnel provides for movement of the SNF between the three principal ISF Facility operational areas (i.e., the CRA, transfer area, and storage area).

The Transfer Tunnel is located within Zone 2 of the HVAC system. Air pressures in this zone are positive with respect to Zone 1 and negative with respect to Zone 3 and ambient pressure, ensuring air flows from this zone toward the primary confinement barrier. The ventilation design criteria (see Section 3.3.2.2 of the SAR) are is such that potential airborne radionuclides within the Transfer Tunnel and CCA are filtered by intermediate HEPA filters located in these areas and the final HEPA filters. The estimated release of airborne radionuclides to the Transfer Tunnel or CCA is based on the airflow through the gap between the inside wall of the ISF canister and the outside diameter of the shield plug. The airflow is a result of the natural convection of the air being heated by the SNF decay heat and the canister heater, which is used to preheat the ISF canister to facilitate the requisite vacuum drying and helium backfilling operations.

The normal indoor temperatures for the Transfer Tunnel are 32.2 EC [90 EF] in the summer and 10.0 EC [50 EF] in the winter (see Section 3.2.5.1.6 of the SAR). In the event of a loss of the HVAC system, the steady-state Transfer Tunnel temperatures are 72.8 EC [163 EF] or 58.3 EC [137 EF] in the summer and !19.4 EC [!3 EF] or !32.2 EC [!26 EF] in the winter, depending on whether the lights and motors are on or off (Foster Wheeler Environmental Corporation, 2003a,

Table 4.3-2). Note that these steady-state temperatures do not consider diurnal temperature variations and their use was limited to determining the HVAC system design requirements. The normal environmental temperature extremes were used to calculate the Transfer Tunnel temperatures for this loss of HVAC system scenario.

Two scenarios were investigated to assess the thermally induced stresses in the Transfer Tunnel reinforced concrete confinement walls. In both scenarios, the environmental temperatures are modeled using time histories that consider diurnal temperature variations during summer and winter conditions (see Sections 3.2.5.1.6 and 3.2.5.1.10 of the SAR). These scenarios and boundary conditions were determined to be acceptable for analyzing the potential creation of thermally induced cracks in the Transfer Tunnel reinforced concrete confinement walls.

The temperature limits for the Transfer Tunnel structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the Transfer Tunnel are reviewed in Section 6.1.4, “Analytical Methods, Models, and Calculations;” of this SER. The fire and explosion hazard assessment for the Transfer Tunnel is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

6.1.1.5 Transfer Cask

The transfer cask is used to transport the SNF from its current storage location to the ISF Facility. The transfer cask is constructed with a 304 stainless steel cavity liner, chemical lead shielding, a mild steel outer shell, and a 304 stainless steel overlay (Battelle Memorial Institute, 1970).

The normal operation design temperatures for the transfer cask are 54.4 EC [130 EF] {with a 24-hr average direct solar insolation heat flux of 9.46 kW-hr/m^2 [3,000 BTU/ft^2] per day} in the summer and !40.0 EC [!40 EF] in the winter (Battelle Memorial Institute, 1970). These design parameters bound the normal, off-normal, and accident condition environmental temperatures and insolation for the ISF Facility site. In addition, the assumed SNF decay heat was 4.17 kW [14,250 BTU/hr], which adequately bounds the SNF decay heat expected to be transferred to the ISF Facility in the transfer cask for a given shipment. Table 6-2 delineates the maximum transfer cask component temperatures under these bounding environmental and load conditions. It should be noted, however, that the assumed 4.17 kW [14,250 BTU/hr] SNF decay heat rate is significantly higher than the maximum decay heat of the SNF that will be transferred to the ISF Facility. As a result, the winter condition transfer cask temperatures reported in Table 6-2 of this SER are expected to be significantly lower.

The temperature limits for the Transfer Cask structural materials are reviewed in Section 6.1.2, “Material Temperature Limits,” of this SER. The analytical methods, models, and calculations used to assess the decay heat removal capabilities of the transfer cask are reviewed in Section 6.1.4, Analytical Methods, Models, and Calculations, of this SER. The fire and explosion hazard assessment for the transfer cask is reviewed in Section 6.1.5, “Fire and Explosion Protection,” of this SER.

Table 6-2. Maximum transfer cask component temperatures under bounding environmental and load conditions (Battelle Memorial Institute, 1970; Figure 24)

Transfer Cask Component	Approximate Temperature (Summer Conditions) EC [EF]	Approximate Temperature (Winter Conditions) EC [EF]
Spent nuclear fuel can	232 [450]	104 [220]
Basket	191 [375]	90.6 [195]
Basket rim (average)	157 [315]	57.2 [135]
Inner liner	118 [245]	18.3 [65]
Outer shell	116 [240]	15.6 [60]
Overlay shell	93.3 [200]	!3.89 [25]

6.1.2 Material Temperature Limits

The staff reviewed the discussion on material temperature limits with respect to the following regulatory requirements:

- 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 §72.128(a)(4) 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 a heat-removal capability having testability and reliability consistent with its importance to safety.

6.1.2.1 Storage Area

The storage area component temperature limits are summarized in Table 6-3 (see Table 4.2-53 of the SAR). The temperature limits for both normal and short term accident conditions are delineated.

The effects of temperature and operating conditions on the long-term behavior of the fuel cladding are not well documented for the fuels to be stored at the ISF Facility. In addition, some of the fuels to be stored are known to be damaged. As a result, no credit will be taken for the fuel cladding being a confinement barrier. Because of this condition, all fuels will be placed in sealed canisters, consistent with the fuel canning requirements in 10 CFR 72.122(h)(1).

The materials used in the fabrication of the storage tube, ISF canister, and baskets for Peach Bottom and TRIGA SNF and Shippingport reflector contents (modules and rods) are compiled in Tables 6-4 through 6-8 of this SER.

Canister Handling Machine

The CHM component temperature limits are summarized in Table 6-9 of this SER (see Table 4.2-53 of the SAR). The temperature limits for both normal and short term accident conditions are delineated. The CHM and its structural support have been classified as important to safety. The materials used in the fabrication of the CHM and its support are presented in Table 6-10 of this SER.

The CHM will not be operated if the temperature in the storage area building is less than 0 EC [32 EF]. The storage area building temperature would only reach this temperature if there is a failure of the HVAC system. Failure of the storage area HVAC system can also result in ambient temperatures up to 67.8 EC [154 EF]. The CHM shall not be operated at temperatures greater than 40.0 EC [104°F].

Table 6-3. Allowable temperature limits for ISF Facility components (from Table 4.2-53 of the SAR)

Component	Temperature Limits	
	Normal EC [EF]	**Short Term EC [EF]**
Peach Bottom fuel (1, 2, and ART)*	300 [572]	300 [572]
TRIGA (aluminum clad)†	204 [400]	204 [400]
TRIGA (stainless steel clad)‡	427 [800]	427 [800]
Shippingport reflector rods (loose)§	322 [612]	570 [1,058]
Shippingport reflector modules§	322 [612]	570 [1,058]
ISF basket (17-4 Ph)‡	343 [650]	343 [650]
ISF basket (stainless steel)‡	427 [800]	427 [800]
ISF canister‡	427 [800]	427 [800]
Storage tube‡	371 [700]	371 [700]
Concrete[2]	66/93 [150/200]	177 [350]
ISF canister cask shield wall‡	371 [700]	371 [700]

*Limit is based on pyrolytic carbon in an oxygen environment. The limit in a dry inert helium environment is higher.
†Limit is based on Perry's Chemical Engineer's Handbook, 6th Edition.
‡Limit is based on ASME International Boiler and Pressure Vessel code, Section II, Part D, Material Limits.
§Limit is based on NUREG–1567 for zirconium cladding.
[2]Limits are based on ACI 349, Section A.4. Note that under normal operating conditions that the allowable concrete temperature is 66 EC [150 EF] except for local areas, such as around a penetration, which are allowed to have increased temperatures not to exceed 93 EC [200 EF].

Table 6-4. Storage tube component materials (from Section 4.2.3.2.2 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Storage tube body	ASME SA 333	Grade 6	—
Storage tube top forging	ASME SA 350	Grade LF2	—
Storage tube flat closure plate	ASME SA 350	Grade LF2	—
Storage tube lid	ASME SA 516	Grade 55	—
Storage tube lid cap screws	ASME SA 193	Grade B7	—
Storage tube lid cover plate	ASME SA 516	Grade 55	—
Storage tube lid cover plate cap screws	ASME SA 193	Grade B7	—
Metal seal rings	Inconel Alloy 718	—	Silver Plated
Storage tube plug body	ASTM A 333	Grade 6	—
	ASTM A 36	—	—
Storage tube lifting pintle	ASTM A 434	Grade 4340 Class BC	—
Support stool plate sections	ASTM A 572	Grade 42 Type 1	—
Support stool alignment guides	ASTM A 6	—	—
	ASTM A 572	Grade 42 Type 1	—
Support stool anchor bolts	ASTM 193	Grade B7	—

Table 6-5. ISF canister component materials (from Section 4.2.3.2.3 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Canister body	ASME SA 312	Type 316L	—
Upper and lower heads	ASME SA 240	Type 316L	—
Upper and lower impact plates	ASME SA 240 ASME SA 351 CF3M or CF3MN	Type 316L CF3M or CF3MN —	— or — or —
Impact plate retaining ring	ASME SA 240	Type 316L	—
Shield plug retaining ring	ASME SA 240 ASME SA 479	Type 316L Type 316L	— or —
Upper and lower impact limiters	ASME SA 312	Type 316L	—
Upper and lower lifting ring	ASME SA 240	Type 316L	—

Table 6-6. Peach Bottom SNF basket component materials (from Section 4.2.3.2.4 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Lid, locking plate, base plate, and top plate	ASME SA 240	Type 316L	—
Lifting pintle	ASME SA 479	Type 316L	—
Spacer plate, base plate, and top plate	ASME SA 693	Type 630 (17-4 Ph)	—
Tie bar, lid securing pin, and special screw	ASME SA 564	Type 630 (17-4 Ph)	—
Fuel tube	ASME SA 213	Type 316L	—

Table 6-6. Peach Bottom SNF basket component materials (from Section 4.2.3.2.4 of the SAR) (continued)

Item/Component	Material Specification	Type/Grade	Notes
Gadolinium phosphate container tube	ASME SA 213	Type 316L	—
Repository neutron absorber material	Gadolinium Phosphate	—	—

Table 6-7. TRIGA SNF basket component materials (from Section 4.2.3.2.4 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Lid and locking plate	ASME SA 240	Type 316L	—
Lifting pintle	ASME SA 479	Type 316L	—
Spacer plate, base plate, and top plate	ASME SA 693	Type 630 (17-4 Ph)	—
Tie bar, lid securing pin, and special screw	ASME SA 564	Type 630 (17-4 Ph)	—
Lid securing rod	ASME SA 479	Type 316L	—
Fuel tube	ASME SA 213	Type 316L	—
Spacer	ASME SA 312	Type 316L	—
Gadolinium phosphate container tube	ASME SA 213	Type 316L	—
Repository neutron absorber material	Gadolinium Phosphate	—	—

Table 6-8. Shippingport SNF and reflector rod basket component materials (from Section 4.2.3.2.4 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Shippingport Reflector IV Basket			
Extended aluminum guide rails	ASTM SB 211	Alloy 6061 T6	—
Spacer plates	ASME SA 240	Type 316L	—
Machine screws	ASME B 18.6.3 693	Type B8M	—
Load distribution plate	ASME SA 240 ASME SA 312	Type 316L	—
Shippingport V Module Basket			
Guide rails	ASME SA 240	Type 316L	—
End and intermediate plates	ASME SA 240	Type 316L	—
Tie rods	ASME SA 479	Type 316L	—
Tie rod support tubes	ASME SA 213	Type 316L	—
Machine screws	ASME B 18.6.3	Type B8M	—
Load distribution base plate	ASME SA 240 ASME SA 312	Type 316L	—
Shippingport Reflector Rod Basket			
Lid and locking plate	ASME SA 240	Type 316L	—
Lifting pintle	ASME SA 479	Type 316L	—
Tie bar, lid securing pin, and special screw	ASME SA 564	Type 630 (17-4 Ph)	—
Spacer plate, base plate, and top plate	ASME SA 693	Type 630 (17-4 Ph)	—
Fuel tubes	ASME SA 213	Type 316L	—

Table 6-9. Allowable temperature limits for the CHM components (From Table 4.2-53 of the SAR)

Component	Temperature Limits	
	Normal EC [EF]	Short Term EC [EF]
CHM shield wall*	371 [700]	371 [700]
CHM guide tube*	371 [700]	371 [700]
CHM JBROC ‘N’†	100 [212]	100 [212]

*Limit is based on ASME Boiler & Pressure Vessel code, Section II, Part D, Material Limits.
†Limit based on manufacturer’s data.

Table 6-10. CHM and structural support materials (from Table 4.7-5 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Bridge Components			
Bridge girders	ASTM A 36	—	<1.59 cm [< 0.625 in]
Bridge end tie frame			or
Bridge end tie cross beam	ASTM A 516	Grade 70	> 1.59, < 6.35 cm [> 0.625, < 2.50 in]
Trolley frame			
Turret Components			
Turntable	ASTM A 572	Grade 42/50 Type 1	—
			or
	ASTM A 490	Grade 355 EM	—
Turntable bolts	ASTM A 490 M	Type 1	—
			or
	BS 970 817M40 “W”	—	—

Table 6-10. CHM and structural support materials (from Table 4.7-5 of the SAR) (continued)

Item/Component	Material Specification	Type/Grade	Notes
Turret Components			
Turret body	ASTM A 27	Grade U60-30 Class 2	—
			or
	BS3100	Grade A1 Normal	—
Turret body bolts	ASTM A 490 M	Type 1	—
			or
	BS 970 826M40 “W”	—	—
Nose shield body	ASTM A 27	Grade U60-30 Class 2	—
			or
	BS3100	Grade A1 Normal	—
Shield skirt	ASTM A 27	Grade U60-30 Class 2	—
			or
	BS3100	Grade A1 Normal	—
Turret rotate seismic lock pin	ASTM 108	Grade 1040	—
			or
	BS970 080M40N	—	Heat Treat to 279 MPa [40,500 psi] yield strength
Base locking pin	ASTM A 434	Grade 4340 Class BD	
			or
	BS970 817M40 “T”	—	—

Table 6-10. CHM and structural support materials (from Table 4.7-5 of the SAR) (continued)

Item/Component	Material Specification	Type/Grade	Notes
Turret Components			
Enclosure structure	ASTM A 572 BS7191	Grade 50 Type 1 Grade 355 EM	— or —
Hoist drum	ASTM A 333 BS HFS Tube DIN 2448/1629 ST52.0	Grade 10 —	— or —
Wire rope	Bridon Ropes	Grade 1960	1.59 cm [0.625 in] Diameter with a Minimum Breaking Force of 179 kN [40,200 lbs]
Hoist load block	ASTM A 508 BS4670	Class 4a Grade 826M40	— or —
Grapple body	ASTM A 434 BS970 709M40 “T”	Grade 4340 Class BC —	— or —
Grapple head	ASME SA516-60 BS EN 10025 S355J2G3	— —	— or —
Grapple jaws	ASTM A434 BS970 709M40 “T”	Grade 4340 Class BC —	— or —

6.1.2.2 Transfer Area

The material temperature limits for the various transfer area subareas (i.e., FPA, CCA, SWPA, and the operating gallery) are reviewed in the following subsections.

Fuel Packaging Area

See Table 6-3 of this SER for the allowable temperature limits for the ISF Facility structures, systems, and components. The ISF Facility structures, systems, and components applicable to the FPA are those pertaining to the SNF, ISF baskets, ISF canisters, and the reinforced concrete confinement structure.

The FHM and its structural support located in the FPA have been classified as important to safety. The materials used in the fabrication of the FHM and its support are presented in Table 6-11 of this SER. Normal temperature conditions in the FPA are between 10.0 EC [50 EF] and 32.2 EC [90 EF]. The minimum and maximum off-normal temperature inside the FPA is !32.2 EC [!26 EF] and 68.9 EC [156 EF] respectively. The FHM will not be operated when FPA temperatures are below 0 EC [32 EF] or above 68.9 EC [156 EF].

Table 6-11. FHM and structural support materials (from Table 4.7-3 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Structural and Load Carrying Members	ASME SA 36	–	<1.59 cm [< 0.625 in]
	ASME SA 537 or SA 516	Class 1 Grade 70	> 1.59, < 6.35 cm [> 0.625, < 2.50 in]
Bolting	SAE	Grade 5	—
Cables	IWRC 6 × 37	Improved Plow Steel	—
Axles	ASTM A 311	Class B Grade 1144	—
Wheels	ASTM A 331	Grade 4140	—
Hook	ASTM A 331	Grade 4140	—
Rails	ASTM A 108	Grade 1044	—

Canister Closure Area

See Table 6-3 of this SER for the allowable temperature limits for the ISF Facility structures, systems, and components. The ISF Facility structures, systems, and components applicable to the CCA are those pertaining to the SNF, ISF baskets, ISF canisters, and reinforced concrete confinement structure.

Solid Waste Processing Area

See Table 6-3 of this SER for the allowable temperature limits for the ISF Facility structures, systems, and components. The ISF Facility structures, systems, and components applicable to the SWPA are those pertaining to the reinforced concrete confinement structure.

Operating Gallery

The maximum allowable temperature limits for the operating gallery correspond to the applicable component temperature limits delineated in Table 6-3 of this SER.

6.1.2.3 Cask Receipt Area

The cask receipt crane and its structural support located in the CRA have been classified as important to safety. The materials used in the fabrication of the crane and its support are presented in Table 6-12 of this SER.

Normal temperatures in the CRA are controlled by the HVAC system within a range of 4.5EC [40EF] to 40.6EC [105 EF]. The minimum and maximum anticipated off-normal temperatures in the CRA are !32.2EC [!26 EF] and 65.0EC [149 EF], respectively. Load handling operations are terminated, and the cask receipt crane will remain unloaded at temperatures below 0EC [32EF] or above 40.6EC [105 EF].

Table 6-12. Cask receipt crane and structural support materials (from Table 4.7-1 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Structural and load carrying members	ASTM A 36	—	<1.59 cm [< 0.625 in]
	ASTM A 516	Grade 70	> 1.59, < 6.35 cm [> 0.625, < 2.50 in]
Equalizer beam	ASTM A 572	—	—
Equalizer support beam	ASTM A 572	—	—
Main girder	ASTM A 572	—	—
Bolting	ASTM A 325	—	—
Cables	IWRC 6 × 37	Improved Plow Steel	—
Drum	ASTM A 572	Grade 50	—

6.1.2.4 Transfer Tunnel

See Table 6-3 of this SER for the allowable temperature limits for the ISF Facility structures, systems, and components. The ISF Facility structures, systems, and components applicable to the Transfer Tunnel are those pertaining to the cask and canister transfer trolleys, and reinforced concrete.

The transfer cask and ISF canister trolleys used in the Transfer Tunnel have been classified as important to safety. The materials used in the fabrication of these cask trolleys are presented in Table 6-13 of this SER.

The cask trolleys are designed to operate within a temperature range of 0EC [32EF] to 40.6EC [105EF]. The cask trolleys will not be used to transfer SNF if the temperature is outside this range. The minimum and maximum off-normal temperature conditions could occur when the cask trolley is in the CRA or Transfer Tunnel.

Table 6-13. Transfer cask and canister cask trolley materials (from Table 4.7-2 of the SAR)

Item/Component	Material Specification	Type/Grade	Notes
Structural and load carrying members	ASTM A 36	—	<1.59 cm [< 0.625 in]
	ASTM A 516	70	> 1.59, < 6.35 cm [> 0.625, < 2.50 in]
Bolting	ASTM A 325	—	—
	ASTM A 490	—	—
Axles	ASTM A 322	Grade 4140 or Grade 4340	—
Wheels	ASTM A 322	Grade 4140 or Grade 4340	—
Seismic lock pin	ASTM A 322	Grade 4140 or Grade 4340	—
Seismic uplift restraints	ASTM A 572	Grade 50	—

6.1.2.5 Transfer Cask

The transfer cask materials are compiled in Table 6-14 of this SER (Battelle Memorial Institute, 1970).

Table 6-14. Transfer cask component materials

Item/Component	Material Specification	Type/Grade	Notes
Basket	Aluminum	Alloy 6061-T6	—
Inner liner	Stainless steel	Type 304	—
Shielding	Chemical lead	—	—
Outer shell	Mild-steel	—	—
Overlay shell	Stainless steel	Type 304	—

6.1.3 Thermal Loads and Environmental Conditions

The staff reviewed the discussion on thermal loads and environmental conditions with respect to the following regulatory requirements:

- 10 CFR 72.92(a) requires that the natural phenomena that may exist or that can occur in the region of a proposed site must be identified and assessed according to their potential effects on the safe operation of the Independent Spent Fuel Storage Installation (ISFSI). The important natural phenomena that affect the ISFSI design must be identified.

- 10 CFR 72.122(b)(1) requires that the structures, systems, and components important to safety must 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 ISFSI and to withstand postulated accidents. (2)(i) Structures, systems, and components important to safety must 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 their intended design functions. The design bases for these structures, systems, and components must reflect: (A) 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 (B) Appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena. (ii) The ISFSI also should 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, high-level radioactive waste, or reactor-related greater than Class C waste or on to structures, systems, and components important to safety. (3) Capability must be provided for determining the intensity of natural phenomena that may occur for comparison with design bases of structures, systems, and components important to safety.

6.1.3.1 Thermal Loads

The following subsections are a review of the applicable thermal loads for the three principal areas of the ISF Facility (i.e., storage area, transfer area, CRA), the Transfer Tunnel, and the transfer cask.

Storage Area

The Peach Bottom, Shippingport, and TRIGA SNF is to be stored in the ISF Facility storage area. The Peach Bottom and Shippingport fuel types were removed from their respective reactors no later than 1974 and 1983. The TRIGA fuel age varies significantly. According to Section 3.1.1.4, “Decay Heat,” of the SAR, the decay heat output of each of the fuel types to be stored in the proposed facility were approximated using the ORIGEN2 computer program (Croff, 1980). The results of these computations were presented in Figures 3.1-9 through 3.1-13 of the SAR. Assuming an emplacement date of July 2004, the decay heats for the different fuel types to be stored at the proposed Facility are summarized in Table 4.2-52 of the SAR. It was pointed out in the SAR that the TRIGA fuels exhibit the largest variance from the average values presented in Figures 3.1-9 through 3.1-13 of the SAR. That is, the TRIGA SNF elements, or modules, can generate up to 2 W/element of decay heat. The submitted SNF decay heat calculations were independently verified by the staff (Yang, et al., 2003).

For the SNF currently identified for storage at the ISF Facility, the bounding decay heat rate for the ISF canister is 36 W [123 BTU/hr]. Additionally, thermal analyses for the storage vault were performed using a bounding SNF decay heat rate consisting of a mixture of ISF canisters with SNF decay heat loads of 40W [136 BTU/hr] and 120 W [409 BTU/hr].

Canister Handling Machine

The thermal loads applicable to the CHM are the decay heat rates originating from the SNF contained within the ISF canister being transferred for emplacement within its storage tube and the additional heat sources arising from the various CHM motors. The bounding ISF canister SNF decay heat load considered in the thermal analyses of the CHM was 120 W [409 BTU/hr].

Transfer Area

The applicable thermal loads for the principal subareas of the transfer area (i.e., FPA, CCA, SWPA, and operating gallery) were considered. No appreciable thermal loads were identified for the SWPA or the operating gallery.

The thermal loads applicable to the FPA are the decay heat rates originating from the SNF being loaded into the ISF canister, any temporary staging of SNF within the FPA, and the electrical motors and lights required to operate the FHM and other relevant FPA equipment. The thermal loads applicable to the CCA are the decay heat rates originating from the SNF being sealed within the ISF canister, the ISF canister closure weld preheater, the welding torch used for the closure weld, and the electrical motors and lights required to operate additional CCA equipment. The bounding ISF canister decay heat load for the SNF currently identified for storage at the ISF Facility is 36W [123 BTU/hr].

Cask Receipt Area

The thermal loads applicable to the CRA are the decay heat rates originating from the SNF sealed within the transfer cask and the motors and lights required to operate additional CRA equipment, including the cask receipt crane.

Transfer Tunnel

The thermal loads applicable to the Transfer Tunnel are the decay heat originating from the SNF sealed within the transfer and ISF canister casks and the motors and lights required to operate additional Transfer Tunnel equipment, including the transfer and ISF canister cask trolleys.

Transfer Cask

The thermal loads applicable to the transfer cask are the decay heat originating from the SNF sealed within its confines. Table A8.1-1 of Appendix A of the SAR conveys the transfer cask SNF decay heat rates.

6.1.3.2 Environmental Conditions

The meteorological conditions at the proposed ISF Facility site are documented in Section 2.3 of the SAR. The National Oceanic and Atmospheric Administration (NOAA) and its predecessor agencies have been compiling meteorological data for the INEEL site since 1949. A NOAA meteorological observation station and research tower are located near the Central Facilities Area, approximately 3.2 km [2 mi] south of the ISF Facility site. Given the close proximity to the site and the uniformity of the terrain, the data measured at the NOAA meteorological observation station are considered to be applicable to the ISF Facility.

Using the methodology recommended by NUREG–1536, Section 2.0.V.2.b.1, (U.S. Nuclear Regulatory Commission, 1997) the minimum and maximum normal environmental temperatures for the ISF Facility are -32 EC [-26 EF] and 37 EC [98 EF] (Section 3.2.5.1.6 of the SAR). Table 2.3-13 of the SAR conveys the daily temperature extremes for each month of the year for the proposed ISF Facility. In addition, on average, 42 percent of the days in the year contain a freeze and thaw cycle (i.e., the minimum air temperature is less than or equal to 0 EC [32 EF] and the maximum air temperature exceeds 0 EC [32 EF] on the same day). The minimum off-normal site temperature is -40.0 EC [-40 EF] and the maximum is 38.3 EC [101EF] (see Section 3.2.5.1.10, Off-normal and Accident Thermal Loads (T_a), of the SAR).

Table 2.3-6 of the SAR delineates the monthly extreme and average precipitation for the ISF Facility site. The average annual precipitation was determined to be 22.1 cm [8.72 in]. Moreover, the maximum amount of precipitation measured in a 24 hour period to date was 4.2 cm [1.64 in] (from Table 2.3-7 of the SAR).

The monthly extreme and average snowfall amounts for the ISF Facility site are presented in Table 2.3-8 of the SAR. The average annual snowfall was determined to be 70.1 cm [27.6 in]. The maximum amount of snowfall measured in a 24 hour period to date was 21.8 cm [8.6 in].

The monthly average insolation data for the proposed ISF Facility were derived from the National Aeronautics and Space Administration Surface Meteorology and Solar Energy Data Set. In the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-6), the minimum average solar insolation at the site {1.59 kW-hr/m^2 [504 BTU/ft^2] per day} occurs in the month of December, and the maximum {6.82 kW-hr/m^2 [2,160 BTU/ft^2] per day} occurs in the month of July.

The average monthly subsoil temperatures at the INEEL site, based on data accumulated over a 7–yr period for sandy soil and asphalt surfaces over a depth range of 0.61 to 2.13 m [2 to 7 ft], were presented in Figures 2.3-2 and 2.3-3 of the SAR, respectively. These figures illustrate that the average subsoil temperatures under the asphalt are approximately 5.6 EC [10 EF] higher than under the sandy soil near the surface in the summer months. The maximum average subsoil temperature under the asphalt lies somewhere in the range of 26.7 to 29.4 EC [80 to 85 EF]. In the winter months, the average subsoil temperatures under the asphalt exhibit slightly colder temperatures than the sandy soil over a longer period and greater depth. The minimum average subsoil temperatures under the asphalt are somewhere in the range of !3.9 to !1.1EC [25 to 30EF].

To account for the daily and seasonal cycles of the ambient air temperatures, historic temperature records from the INEEL are used to develop the reinforced concrete design temperature time histories for both the summer and winter. These time histories include the actual coldest and warmest consecutive 7-day periods in the 48-yr history of recording temperatures at the INEEL. To bring the concrete close to ambient conditions, a "lead-in" period of several days was included in the time history. To give the concrete sections time to react to the temperature change, a "lag" period of several days was included in the time history. The 13 concurrent-day summer and winter time histories are delineated in Section 3.2.5.1.6 of the SAR.

The staff reviewed the local meteorological data and discussions presented in the Safety Analysis Report and found these acceptable because reliable data sources were used, and the data are appropriately summarized. The applicant adequately presented information regarding temperatures recorded during the onsite measurement program and at other nearby sites, and, therefore, satisfied the requirement of 10 CFR §72.92(a).

6.1.4 Analytical Methods, Models, and Calculations

The staff reviewed the discussion on analytical methods, models, and calculations with respect to the following regulatory requirements:

- 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 §72.128(a) requires that spent fuel storage, high-level radioactive waste storage, and reactor-related greater than Class C waste storage and other systems that

might contain or handle radioactive materials associated with spent fuel, high-level radioactive waste, or reactor-related greater than Class C waste, must 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 waste generated.

6.1.4.1 Storage Area

The decay heat removal characteristics of the storage area were assessed using a combination of numerical solutions for nonlinear closed-form equations and finite element modeling. This methodology was implemented in the following manner. First, the steady state cooling air flow rates for the applicable normal, off-normal, and accident conditions were established. The basis for the governing equations used to accomplish this task is documented in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-10) and the cited proprietary calculation reports. In addition, a sensitivity analysis investigating the effects of varying the flow resistance attributable to the vault inlet ports, the annular flow passages between the storage tubes and charge face structure, and the outlet louvers in the upper storage area building was presented. This sensitivity analysis demonstrated that the convective air flow rates within the storage vault are predominantly controlled by the flow resistance associated with the annular flow passages between the storage tubes and charge face structure.

Second, having established the approximate steady state convection air flow rates through the storage vaults, the applicant assessed the convective heat loss from the individual ISF Facility storage tubes in the finite element models used to approximate the storage tube and ISF canister temperatures under normal, off-normal, and accident conditions. As reported in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-12) and the cited proprietary calculation reports, a two dimensional, axisymmetric finite element model of the storage tube, its base support plate, and the ISF canister was used to approximate the storage tube and ISF canister wall temperatures. The decay heat thermal load originating from the stored SNF and the convective heat loss from the external surface of the storage tube are applied in this two-dimensional model. The basis for the heat transfer coefficients used in these models were provided in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-11).

Third, a detailed three-dimensional finite element model of the ISF canister, its basket and the loaded SNF is used to establish the ISF basket and SNF cladding temperatures. The decay heat thermal load originating from each of the stored SNF elements or modules are explicitly modeled. In addition, the ISF canister wall temperature boundary condition, which was calculated from the two-dimensional, axisymmetric model described earlier, was applied in the model. The decay heat transfer through the helium gas within the ISF canister was modeled as a conduction only process. Heat loss from the ends of the ISF canister was not considered.

The relevant thermal material properties, including thermal conductivities, air density temperature dependencies, and surface emissivities used to approximate the storage tube, ISF canister, ISF basket, and SNF cladding temperatures were provided and referenced.

The methodology used to assess the reinforced concrete storage vault structure temperatures and temperature gradients was provided in the applicant's response to the staff's Request for Additional Information and a supporting calculation report (Foster Wheeler Environmental Corporation, 2003b, question 6-2). To take credit for the large thermal inertia (i.e., large specific heat) of the storage vault reinforced concrete, a transient thermal analysis was performed using ambient temperature time histories for the coldest and warmest 13-day periods derived from 50 years of historical temperature data for the INEEL site as the environmental boundary condition. Note that these temperature time histories envelop the normal, off-normal and accident environmental temperatures for the INEEL site. The response of the storage vault reinforced concrete to these temperature time histories was determined using several finite element models with varying reinforced concrete wall section thicknesses and inside and outside wall surface temperature boundary conditions. The results of these analyses were subsequently used to assess the effect that the forces and moments generated by thermal contraction and expansion and temperature gradients have on the structural integrity of the storage vault reinforced concrete walls. The relevant thermal reinforced concrete material properties, including the thermal conductivity and specific heat, were provided and referenced. Although the staff found that the storage vault reinforced concrete walls could potentially experience some minor spalling, it was determined that such spalling would not affect the structural integrity of the walls. Note that this is most likely to occur on both the interior and exterior surfaces of the reinforced concrete walls of the storage vault that are exposed directly to the external environment. Moreover, the maximum allowable temperature difference between the interior and exterior surfaces of the storage vault reinforced concrete walls was reported to be 21 EC [38 EF] (Foster Wheeler Environmental Corporation, 2003b). It was also reported that the time needed to generate a 21 EC [38 EF] temperature difference through the reinforced concrete storage vault wall is in excess of 270 hours for the postulated 100-percent vent blockage scenario.

In addition to evaluating the potential thermal gradients experienced by the storage vault reinforced concrete, an assessment of the potential thermal gradients experienced by the storage tube and ISF canister was also performed [see the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, questions 6-1 and 6-3)]. This assessment included consideration of uniform and nonuniform spatial distributions of the SNF decay heat.

<u>Canister Handling Machine</u>

The thermal analysis of the CHM was accomplished by modeling the conduction, convection, and radiation heat transfer processes between the CHM wall and the neutron shield as a pseudo pipe.

A thermosyphon air cooling flow travels vertically upwards in the gap between the outer CHM wall and the neutron shielding. This airflow is modeled using inlet temperatures set at 37.8 EC [100 EF] and 67.8 EC [154 EF], the normal and off-normal upper storage area building temperatures. Note that the 67.8 EC [154 EF] inlet temperature corresponds to a loss of the HVAC system and a normal condition environmental temperature of 36.7 EC [98 EF]. The basis

for the upper storage area building temperatures used in the analyses were provided in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-9). The heat transfer coefficient applied to both sides of the annulus is temperature dependent and based on fully developed laminar flow (see the applicant's response to the staff's Request for Additional Information, question 6-11).

The convection that occurs from the outside of the CHM neutron shielding to the ambient air in the storage area building was included in the CHM heat transfer models. Radiation heat loss from the surface of the CHM neutron shielding to the storage area building was also accounted for in the model. The relevant thermal material properties, including thermal conductivities, air density temperature dependencies, and surface emissivities used to approximate the CHM, ISF canister, ISF basket, and SNF cladding temperatures were provided and referenced.

The applicant's response to the staff's Request for Additional Information (question 6-12) summarizes the methodology used to model the CHM heat transfer processes with appropriate citations of the supporting calculation reports.

6.1.4.2 Transfer Area

The following subsections document the staff's review of the analytical methods, models, and calculations used to assess the relevant thermal characteristics of the primary operational and confinement areas of the transfer area (i.e., the FPA, CCA, SWPA, and operating gallery).

Fuel Packaging Area

A summary of the thermal models developed for the FPA is provided in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, questions 6-2 and 6-12). Thermal analyses of the fuel operations and monitoring station, decanning station, fuel bucket operations station, and fuel loading stations within the FPA were performed. Supporting calculation reports were cited. In addition, the reinforced concrete FPA confinement wall temperatures and temperature gradients were assessed in a manner consistent with the methodology used for the storage vault (see Section 6.1.4.1 of this SER).

The normal {32.2 EC [90 EF]} and off-normal {68.9 EC [156 EF]} FPA summer temperatures were determined using the methodology documented in the applicant's response to the staff's Request for Additional Information (question 6-9. Note that the 68.9 EC [156 EF] off-normal temperature corresponds to a loss of the HVAC system and a normal condition environmental temperature of 36.7 EC [98 EF].

The relevant thermal material properties, including thermal conductivities, air density temperature dependencies, and surface emissivities used to approximate the ISF canister, ISF basket, and SNF cladding temperatures within the different operational stations within the FPA were provided and referenced. In addition, the bases for the various heat transfer coefficients used in the FPA heat transfer models were provided in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-11).

Canister Closure Area

A summary of the thermal models developed for the CCA is provided in the applicant's response to the staff's Request for Additional Information (questions 6-2 and 6-12). The relevant thermal analyses performed for the CCA were those conducted for the reinforced concrete CCA confinement walls, ISF canister trolley cask, ISF canister, ISF basket, and SNF. Supporting calculation reports were cited. The reinforced concrete CCA confinement wall temperatures and temperature gradients were assessed in a manner consistent with the methodology used for the storage vault (see Section 6.1.4.1 of this SER).

To assess the ISF canister trolley cask, ISF canister, ISF basket, and SNF temperatures during the ISF canister closure welding process, the relevant ambient temperatures are those of the CCA and Transfer Tunnel [see the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-12)]. The normal and off-normal CCA and Transfer Tunnel temperatures (see Tables 4.3-1 and 4.3-2 of the SAR) were determined using the methodology documented in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-9).

The relevant thermal material properties, including thermal conductivities, air density temperature dependencies, and surface emissivities used to approximate the ISF canister trolley cask, ISF canister, ISF basket, and SNF cladding temperatures during the ISF canister closure welding process within the CCA were provided and referenced. In addition, the bases for the various heat transfer coefficients used in the CCA heat transfer models were provided in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-11).

Solid Waste Processing Area and Operating Gallery

The normal SWPA design temperatures and the normal and off-normal operating gallery design temperatures (see Tables 4.3-1 and 4.3-2 of the SAR) were determined using the methodology documented in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-9).

6.1.4.3 Cask Receipt Area

The normal and off-normal CRA design temperatures (see Tables 4.3-1 and 4.3-2 of the SAR) were determined using the methodology documented in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-9).

6.1.4.4 Transfer Tunnel

The normal and off-normal Transfer Tunnel design temperatures (see Tables 4.3-1 and 4.3-2 of the SAR) were determined using the methodology documented in the applicant's response to the staff's Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-9). In addition, the reinforced concrete Transfer Tunnel confinement wall

temperatures and temperature gradients were assessed in a manner consistent with the methodology used for the storage vault (see Section 6.1.4.1 of this SER).

6.1.4.5 Transfer Cask

The Transfer Cask heat transfer model was used to assess the cask component temperatures when subjected to the following thermal load conditions:

- 54.4 EC [130 EF] ambient temperature with a 24-hr average insolation heat flux of 9.46 kW-hr/m^2 [3,000 BTU/ft^2] per day.

- !40.0 EC [!40 EF] ambient temperature with no insolation heat flux.

- Fire radiant source having a temperature of 802 EC [1,475 EF] for a duration of 30 min. The effective source emissivity of the fire was assumed to be 0.9 and the thermal absorptivity of the exposed cask surface was assumed to be 0.8.

These thermal load conditions bound the normal, off-normal, and accident condition environmental temperatures and insolation for the ISF Facility site. In addition, the assumed SNF decay heat of 4.17 kW [14,250 BTU/hr] bounds the decay heat load of the SNF that will be transferred to the ISF Facility per shipment.

6.1.5 Fire and Explosion Protection

The staff reviewed the discussion on fire and potential onsite and offsite explosions with respect to the following regulatory requirements:

- 10 CFR §72.122(c) requires that the structures, systems, and components important to safety must 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 ISFSI, particularly in locations vital to the control of radioactive materials and to the maintenance of safety control functions. Explosion and fire detection, alarm, and suppression systems shall be designed and provided with sufficient capacity and capability to minimize the adverse effects of fires and explosions on structures, systems, and components important to safety. The design of the ISFSI must include provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

6.1.5.1 Fire

<u>ISF Facility Fire Hazards from Nearby Facilities</u>

According to Section 2.2 of the SAR, the nearest industrial facility to the INEEL is located approximately 68 km [42 mi] away in Idaho Falls, Idaho. The nearest military facility is the Naval Reactor Facilities area, which is located approximately 8 km [5 mi] away from the ISF Facility. The proposed ISF Facility is located adjacent to the Idaho Nuclear Technology and Engineering Center (INTEC).

The INTEC is comprised of the Fluorinal Dissolution Process and Fuel Storage Facility, Remote Analytical Laboratory, Fuel Storage Building (housing 3 storage pools for spent nuclear fuel), Three-Mile Island Unit 2 (TMI-2) ISFSI, High-Level Waste Tank Farm (includes 11 underground stainless steel storage tanks for radioactive liquid waste generated during reprocessing of spent fuel and plant decommissioning work), New Waste Calcining Facility, INTEC-601/602 Processing Corridors (used to chemically separate high enriched uranium from dissolved spent fuel during reprocessing), Central Facilities Area, and Test Reactor Area. No credible fire or explosion hazards have been identified for the ISF Facility as a result of being collocated with the INTEC facilities. In addition, there are no natural gas pipelines, oil or gasoline plants that pose a fire or explosion hazard to the ISF Facility.

The nearest public transportation routes are U.S. Highway 20/26 and the Mackay Branch of the Union Pacific Railroad {6 km [4 mi] and 11 km [7 mi], respectively, south of the ISF Facility site}. No credible fire or explosion hazards have been identified for the ISF Facility as a result of traffic on these transportation routes.

Controlled access routes near the INTEC site and within the vicinity of the ISF Facility are the East Perimeter Road and Mackay Branch railroad spur (which passes within 120 m [394 ft] of the ISF site). The East Perimeter Road lies on the western boundary of the ISF Facility and the Mackay Branch railroad spur passes to the south and east of the ISF Facility. Spent nuclear fuels, radioactive waste, and chemicals are transported along these routes. A review of the potential accident scenarios associated with these hazardous materials can be found in Chapter 15, Accident Analysis, of this SER. No credible fire or explosion hazards have been identified for the ISF Facility as a result of being in the proximity of these hazardous material transportation routes.

The entire INTEC area is kept vegetation free; therefore, there is no fuel for a range fire originating westward from the ISF Facility site. Range fires could approach the proposed site, however, from the east and south. According to Section 2.1.2, "Site Description," of the SAR, the quantity of vegetation east and south of the site is limited and the potential range fires can be addressed by the INEEL fire suppression equipment, if necessary.

The diesel generator area, Guard House, Visitor Center, Administration Center, Storage Warehouse, and switchyard area are located within the general yard area of the ISF Facility site.

The backup diesel generator is located approximately 6.1 m [20 ft] away from the ISF Facility in the switchyard area. The 3, 785 L [1,000 gal] double wall fuel oil tank will be designed to meet NFPA 30 (National Fire Protection Association, Inc., 1996a) requirements. A fire originating from the backup diesel generator fuel tank does not pose a hazard to the ISF Facility. The ISF Facility power supply transformer is also located in the switchyard area, which contains a seismic switch system important to safety. The transformer contains approximately 2,271 L [600 gal] of oil. The distance separating this transformer from the ISF Facility ensures that it is not a fire hazard that could potentially affect the ISF Facility in accordance with Factory Mutual Data Sheet 5-4, *Transformers* (Factory Mutual Insurance Company, 2001).

According to Section 4.1.2.4 of the SAR, limited amounts of chemicals and compressed gas bottles are used for ISF Facility operations and are stored at various locations within the ISF Facility site boundary. There are no wastewater holding ponds or open-air chemical storage

tanks on the ISF Facility site. Several storage facilities and wastewater holding ponds exist, however, outside the ISF Facility site boundary as part of INTEC operations.

The visitor center, guard house, administration center, and storage warehouse will contain various amounts of Class A combustibles. Given that these facilities are located in excess of 15.2 m [50 ft] from the ISF Facility, however, the combustible materials stored at these locations do not pose a fire hazard to the ISF Facility, in accordance with NFPA 80A (National Fire Protection Association, Inc., 1996b).

<u>ISF Facility Fire Protection System</u>

The fire protection system at the proposed ISF Facility utilizes both passive and active components. The passive components of the system includes fire walls and fire doors. The active components consist of (i) fire and smoke monitoring, detection, and alarm systems, (ii) a fire water supply, (iii) fire hydrants, (iv) sprinkler systems, (v) fire standpipes and hose stations, (vi) portable fire extinguishers, (vii) fire dampers, (viii) smoke removal system, and (ix) offsite fire department support.

Passive fire protection includes fire barrier walls, fire doors, and fire barrier penetration seals. The stair enclosures are 1-hr fire rated enclosures for life safety purposes. The remaining fire-rated walls, described in Section 4.3.8.1 of the SAR and in the Fire Hazard Analysis (Utility Engineering, 2003), are 1-hr fire-rated throughout the ISF building. Penetrations in the fire rated walls will be sealed in accordance with NFPA 221 (National Fire Protection Association, Inc., 1997a). Fire doors in the 1-hr fire-rated walls are fire rated in accordance with NFPA 80 (National Fire Protection Association, Inc., 1999a).

The communications and alarm system provides the ISF Facility site with fire detection, alarm capability, and internal and external communications. The fire detection and alarm system detects fires within the facility and provides supervisory warnings, trouble signals, and alarms to the INEEL Central Fire Alarm Station. The fire detection systems will be designed in accordance with NFPA 72 (National Fire Protection Association, 1999b). Section 4.3.8.2.4 of the SAR and the Fire Hazard Analysis (Utility Engineering, 2003) provide a detailed description of the ISF Facility fire detection system.

The ISF site receives fire brigade response from INEEL. A fire alarm status panel assists the fire brigade in locating the fire. The communication system provides the ISF Facility with voice, data, and personnel paging. This system connects to the existing INTEC broadband local area network. The ISF Facility employs discrete control areas for the supervision of activities within those areas. Examples of control areas include the CRA, operating gallery, CCA, and storage area. The design of all control areas incorporates features (accessibility, shielding, lighting, ventilation, communication, etc.) needed to support normal operations and to provide safe control of the facility under off-normal or accident conditions as indicated in Section 3.1.2.4.5 of the SAR.

A detailed description of the ISF Facility fire protection water supply system is provided in Section 4.3.8.2.1 of the SAR and Fire Hazard Analysis (Utility Engineering, 2003). The fire water system is classified not important to safety.

The various fire water system components and their respective design codes are as follows:

- Fire pumps — NFPA 20 (National Fire Protection Association, 1999c);
- Water supply tanks — NFPA 22 (National Fire Protection Association, 1998a);
- Fire hydrants and water mains — NFPA 24 (National Fire Protection Association, 1995) and American Water Works Association specifications;
- Sprinkler systems — NFPA 13 (National Fire Protection Association, 1999d);
- Standpipe and hose stations — NFPA 14 (National Fire Protection Association, 1996c);
- Portable fire extinguishers — NFPA 10 (National Fire Protection Association, 1998b).

Fire dampers in the ventilation ducts that penetrate into the FPA confinement barrier are fire-rated components installed in accordance with NFPA 90A (National Fire Protection Association, 1999e).

Smoke from a fire in the ISF Facility building will be removed by the building's ventilation exhaust fans, except in the Fire Area 1 rooms. The rooms in Fire Area 1 will be isolated by fire dampers, with the ventilation fans tripped, until radiological concerns can be addressed. Fans will be manually operated to exhaust any remaining smoke from the area after the radiological concerns are addressed. Portable exhaust fans may be used by the INEEL fire department, as necessary (Section 4.3.8.2.6 of the SAR).

The 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 will be maintained in accordance with NFPA 25 (National Fire Protection Association, 1998c). See Section 4.3.8.4 of the SAR and the Fire Hazard Analysis (Utility Engineering, 2003) for additional details pertaining to the fire protection system inspection and testing requirements.

For fire hazards evaluation purposes the ISF Facility is divided into three fire areas:

- Fire Area 1: areas where SNF is removed from the transfer cask, processed into the new storage canisters, and prepared for storage.
- Fire Area 2: areas where the SNF is passively stored.
- Fire Area 3: the remaining portions of the ISF building, support structures, and yard area.

With the exception of Fire Area 1 (Transfer Tunnel, FPA, and CCA), Fire Area 2 (storage vaults), and a portion of Fire Area 3 (second floor storage area), the automatic fire suppression system in the ISF building generally uses wet-pipe sprinklers in the climate-controlled portions of the building, and dry-pipe sprinklers in the remaining areas (Section 4.3.8.2.2 of the SAR).

Fire Area 1 contains areas where SNF is packaged for interim storage; because of concerns with potential criticality and spread of contamination, the area does not have automatic water suppression. Fire Area 2 is inaccessible to personnel and does not normally contain

combustible materials or credible ignition sources. A fire zone within Fire Area 3 for the second floor storage area contains equipment used to transport ISF canisters to the storage vaults (Fire Area 2). Because of concerns for potential spread of contamination combined with a low combustible loading, portions of Fire Areas 1, 2, and 3 do not have automatic water suppression systems.

The primary HEPA filters in Fire Area 3 (HEPA filter room) are provided with an internal deluge system in accordance with NFPA 801 (National Fire Protection Association, 1998d).

The ventilation system has smoke detectors and fire dampers to shut off fans and protect wall openings in the event of fire. Ductwork penetrations into the FPA have heat-activated fire dampers with electro-thermal links that close to confine a fire in the FPA and prevent the spread of contamination through the ductwork.

The ISF Facility is designed so that the structures, systems, and components important to safety do not require electrical power to perform their safety functions. Therefore, no unique features are provided to protect the electrical power and control cabling from fire exposure, other than that normally provided by a non-combustible construction type and administrative controls to limit the potential fire loading in important to safety areas of the facility.

Where the performance of a structure, system, or component important to safety function depends upon control instrumentation, e.g., a limit switch, the design employs redundant circuits that are independent and physically separated.

The INEEL fire department provides off site fire response in accordance with the emergency plan. The applicant’s response to the staff’s Request for Additional Information (Foster Wheeler Environmental Corporation, 2003b, question 6-22) describes the projected INEEL fire department response times to the ISF Facility.

Lightning protection for the ISF Facility will be designed and installed in accordance with NFPA 780 (National Fire Protection Association, 1997b).

See Section 4.3.8.5 of the SAR (Foster Wheeler Environmental Corporation, 2003a) for details pertaining to the qualification and training of personnel in fire protection systems and safety procedures.

Overall, the scenarios for a fire in any location inside or outside of the ISF building considering the fire location, intensity, and duration have been analyzed and are discussed in Section 8.2.4.4 of the SAR and in the Fire Hazard Analysis (Utility Engineering, 2003).

Storage Area

The storage vaults are designated as being in Fire Area 2. This fire area boundary isolates the ITS passive SNF storage area from credible fires outside this area. The storage vault structure has a fire resistive construction with a minimum 3-hr fire rating for the structural components. Penetrations into this area are constructed and maintained for a 1-hr fire rating except for the air inlets in the exterior walls and charge face annular gap around each storage tube. This area is a high radiation area that is not accessible once SNF is stored in the storage tubes. The 1-hr fire-rated barrier between this and surrounding areas will provide fire protection from exposure

fire hazards outside this area. A low combustible loading would occur in the storage vaults even if the single largest Class B fluid container inventory from the second floor storage area entered through the annular gaps. No credible ignition source exists in the storage vaults. As a result, neither fire detection nor fire sprinkler systems are provided in the storage vault area. Fire detection systems are installed, however, in the upper storage area building. Fire sprinklers are not installed inside the storage area building to ensure that an inadvertent actuation will not result in water entering the vault through the air vents in the charge face. See Section 4.3.8 of the SAR and the Fire Hazard Analysis (Utility Engineering, 2003) for additional discussion on the fire detection system and fire hazards inside the storage area.

Canister Handling Machine

The CHM is located within the upper storage area building. The upper storage area building has a fire-resistive construction for the first 2.74 m [9 ft] of wall elevation. The remainder of the structure is steel-framed noncombustible construction with no fire-rated barriers except the floor. The structures, systems, and components important to safety in this area include the CHM and SNF canisters during transfer operations to the storage vaults.

The postulated fire loading in the second-floor storage area is associated with CHM operation. Administrative controls on the quantity of materials in this area limit the potential fire loading. The postulated combustibles consist of Class A and B materials that constitute a low combustible loading. One-hour fire-rated barriers will be constructed between the upper storage area building area and the Transfer Tunnel (Fire Area 1) and storage vaults (Fire Area 2). The upper storage area building will have fire detection systems installed, but automatic fire suppression is not provided due to the radiological considerations associated with the storage vaults.

The worst-case postulated fire in this area is from high flashpoint lubricants in various machinery. The CHM structural material heat capacity and seismic structural integrity ensure that this fire loading will not adversely affect the important to safety function of the CHM. The ISF canister will be in the CHM during transport in this area, and therefore will not be exposed directly to a postulated fire.

Section 4.7.3.3.8 of the SAR and the Fire Hazard Analysis (Utility Engineering, 2003) provide detailed information regarding the CHM fire protection design features.

Transfer Area

The following subsections address the fire hazard analyses and fire protection design features of the FPA, CCA, SWPA, and operating gallery within the transfer area. Refer to Section 4.3.8 of the SAR for details on the fire protection system for the transfer area and an evaluation of fire hazards in this area.

Fuel Packaging Area

The FPA is a reinforced concrete structure which has been given a Fire Area 1 designation. The purpose of this fire area boundary is to isolate important to safety fuel handling and processing activities from all credible fires outside this area.

A fire detection system is installed in the FPA, including the FHM maintenance area. The HVAC system ducts serving the FPA are provided with dampers to prevent the spread of fire and smoke from within this area. The dampers receive a close signal from the fire alarm control panel upon actuation of area smoke detectors and also have fusible links.

The structural components of the FPA have a minimum 3-hour fire rating. The doors, shield windows, HVAC penetrations, electrical penetrations, and other non-structural components are constructed and maintained for a 1-hour fire rating or an equivalency evaluation is performed if listed components are not available. The FPA consists of two fire zones, the west end where crane maintenance is performed and the east end where fuel packaging activity is performed.

The postulated fire loads for the FPA and FHM maintenance area are evaluated in the Fire Hazard Analysis (Utility Engineering, 2003). Administrative controls on the quantity of Class A and B combustible materials allowed in these areas limit the potential fire loading. The 1-hr fire-rated barriers, including equivalency evaluated components, between these and surrounding areas will be installed. Automatic fire suppression is not provided due to the radiological considerations of potentially spreading contamination outside this area.

HVAC ductwork that penetrates the confinement barrier of the FPA and FHM maintenance area provides a minimum 1-hr fire barrier to prevent fires outside the confinement barrier from spreading into the FPA or FHM maintenance area.

Smoke detectors in the FPA system exhaust duct and in the FPA and FHM maintenance area will shut down the transfer area supply and exhaust fans and close the electro-thermal link fire dampers in the supply and exhaust ductwork if smoke is detected from a fire inside the confinement barrier or the in-cell HEPA filters. These dampers can also close due to high temperature if the fire event is in an area outside the FPA or FHM maintenance area, to prevent the fire from spreading into the confinement barrier. Low combustibility air filters will be utilized throughout the facility in accordance with UL 586 (Underwriters Laboratories, 1999) and UL 900 (Underwriters Laboratories, 1995). The final HEPA filters will have fire detectors and a deluge suppression system.

Section 4.7.3.3.7 of the SAR and the fire hazard analysis (Utility Engineering, 2003) provide detailed information regarding the FHM fire protection design features.

Canister Closure Area

The CCA is a reinforced concrete structure which has been given a Fire Area 1 designation. The purpose of this fire area boundary is to isolate important to safety fuel handling and processing activities from all credible fires outside this area.

A fire detection system is installed in the CCA, and the HVAC system ducts serving the CCA are provided with dampers to prevent the spread of fire and smoke from within this area. The dampers receive a close signal from the fire alarm control panel upon actuation of area smoke detectors and also have fusible links.

The structural components of the CCA have a minimum 3-hr fire rating. The door, shield window, HVAC penetrations, electrical penetrations, and other non-structural components are

constructed and maintained for a 1-hr fire rating or an equivalency evaluation is performed if listed components are not available. The CCA is a single fire zone in this fire area.

The postulated fire loading in the CCA is associated with electric arc welding of the fuel canister and weld inspection activities. Administrative controls on the quantity of materials in this area and restrictions on the use of flammable storage cabinets limit the potential fire loading. The postulated combustibles consist of Class A and B materials. The 1-hr fire-rated barriers, including equivalency evaluated components, between these and surrounding areas will be installed. Automatic fire suppression is not provided due to the radiological considerations of potentially spreading contamination outside this area.

An assessment for the potential generation of flammable gases within the CCA was performed in Section 4.2.3.3.8 of the SAR. It was concluded that, based on anticipated fuel conditions and the vacuum drying process used to prepare the canisters for storage, flammable hydrogen concentrations (greater than 4 percent) will not occur in the ISF canisters.

Even though flammable gas mixtures are not expected to be produced during the fuel loading and canister closing operations, the canister loading operations have been designed to prevent flammable gas incidents by removal and prevention of gas accumulation, and monitoring for presence of flammable gases. Specifically, the canister loading and closing operations are carried out in areas where there is always forced ventilation that will positively change the air environment around the ISF canister, preventing pockets of flammable gases from collecting in the working areas. Moreover, because ISF canister closure operations cause the greatest risk of igniting flammable gas, as canister welding produces an ignition source, the atmosphere near the canister shield plug will be sampled with a hand-held atmosphere monitor to ensure that flammable gases are not present at a level that could lead to a deflagration before starting the ISF canister welding process.

Additional CCA and ISF canister design features intended to preclude the formation and buildup of flammable gases are described in Section 4.2.3.3.8 of the SAR (Foster Wheeler Environmental Corporation, 2003a).

Solid Waste Processing Area

The SWPA is a single-story, part steel-frame, part concrete structure at grade level on the west side of the Transfer Tunnel (Fire Area 1). The steel structure is non-combustible construction with 1-hr fire rating. The reinforced concrete structure is fire resistive construction with a minimum 3-hr fire rating for the structural components. No structures, systems, or components important to safety are in this zone, but part of the walls and ceiling form part of the boundary for the FPA and Transfer Tunnel. The barriers surrounding the SWPA are 1-hr fire-rated, based on the contents and the potential for radiological releases. The walls and doors between the three fire zones that make up this area are not fire rated.

The postulated fire loading in the SWPA is associated with waste processing equipment and miscellaneous dry combustibles. Administrative controls on the quantity of postulated Class A and B materials that may reside in this area and restrictions on the use of flammable storage cabinets limit the potential fire loading. Both fire detection and automatic fire suppression are provided in the SWPA.

Operating Gallery

The operating gallery is a second-floor, steel-frame structure in a two-story building that is U-shaped around the east end of the FPA (Fire Area 1). The structure has a non-combustible construction with no fire-rated exterior walls. The floor is a 1-hr fire-rated barrier over the electrical room, battery room, HEPA filter room, and HVAC exhaust room; and the walls separating this area from the FPA are rated as described in the Fire Area 1 description.

The postulated fire loading in the operating gallery is associated with operations activity from this area. Administrative controls on the postulated quantity of Class A combustible materials in this area limit the potential fire loading. Both fire detection and automatic fire suppression are provided in this area.

<u>Cask Receipt Area</u>

The CRA is a tall, single-story, steel-frame structure on the south side of the storage area and is attached to the Transfer Tunnel. The structure has a non-combustible construction with no fire rating on the exterior walls. The structures, systems, and components important to safety in this area include the transfer cask, transfer cask trolley, and the cask receipt crane.

The postulated fire loading in the CRA is associated with transferring the transfer cask from the transport vehicle to the transfer cask trolley by way of the cask receipt crane. Administrative controls on the postulated quantity of Class A and B combustible materials in this area limit the potential fire loading (e.g., transport vehicles or other flammable-fueled vehicles will be either excluded from the area or administratively limited in fuel capacity). A 1-hr fire-rated barrier will be constructed between this area and the Transfer Tunnel south wall. Fire detection with an automatic dry pipe fire suppression system is provided in this area.

The transfer cask and its trolley are inherently fire resistant and will not be adversely affected by a postulated diesel fuel or lube oil fire.

The structural supports for the 155-ton cask receipt crane will be protected by 1-hour fire proofing at the floor level up to a height determined by the fire hazard analysis (Utility Engineering, 2003) to ensure that direct flames will not overheat the important to safety structural elements. The postulated diesel fuel spill will drain to the west side of the structure, because of floor slope, and collect in a trench provided to contain these fluids. The postulated fire could temporarily burn around the transfer cask, its trolley, or structural support members for the cask receipt crane, but would quickly pool in the drainage trench. Postulated lube oil spills between the transfer cask trolley rails would run along the rail slots and minimize the size of the spill by confinement to the narrow rail slots. The separation by drainage to the trench or within the rail slots will further minimize the heating affect of this postulated fire. In addition, the volume of the CRA will ensure that significant heating of structures above this floor-based fire will not occur, due to the relatively small size of the postulated worst-case fire.

The cask receipt crane design meets the requirements NFPA 70 (National Fire Protection Association, 1999f) to minimize the likelihood and effect of any fires that might occur from faulty electrical equipment.

Transfer Tunnel

The Transfer Tunnel is a reinforced concrete structure which has been given a Fire Area 1 designation. The purpose of this fire area boundary is to isolate important to safety fuel handling and processing activities from all credible fires outside this area.

A fire detection system is installed in the Transfer Tunnel. An automatic fire suppression system is not provided in this area, however, because of the radiological considerations of potentially spreading contamination by spraying contaminated casks or trolleys operating in the area.

The structural components of the Transfer Tunnel have a minimum 3-hour fire rating. The doors, HVAC penetrations, electrical penetrations, and other non-structural components are constructed and maintained for a 1-hour fire rating. The Transfer Tunnel consists of two fire zones, the south end where decontamination activities occur, and the north end where transfer activity between the storage area, FPA, and CCA occurs.

The postulated fire loads for the Transfer Tunnel are evaluated in the fire hazard analysis (Utility Engineering, 2003). Administrative controls on the quantity of Class A and B combustible materials allowed in the Transfer Tunnel limit the potential fire loading.

The ISF canister and transfer cask trolleys are designed to satisfy the requirements of NFPA 70 (National Fire Protection Association, 1999f) to minimize the likelihood and effect of any fires that might occur from faulty electrical equipment.

Transfer Cask

The transfer cask was evaluated for a postulated fire accident scenario having a duration of 30 minutes and a flame temperature of 788 EC [1,450 EF] (Battelle Memorial Institute, 1970). This evaluation adequately demonstrated that the fuel cladding temperature limit is not exceeded when the transfer cask is subjected to these accident conditions.

6.1.5.2 Explosion

ISF Facility Explosion Hazards from Nearby Facilities

No credible explosion hazards originating from nearby facilities that could potentially affect the ISF Facility were identified.

6.2 Evaluation Findings

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

- Sufficient information was provided by the applicant to demonstrate that the decay heat generated by the spent nuclear fuel to be stored at the ISF Facility will not exceed the heat removal capacities of the ISF Facility storage area, transfer area, CRA, Transfer Tunnel, and transfer cask (including operational equipment) under normal, off-normal,

and accident loading conditions. Therefore, the requirements of 10 CFR §72.122(h)(1) and §72.128(a)(4) have been adequately demonstrated.

- All SNF to be stored at the ISF Facility will be placed in sealed canisters, consistent with the requirements in 10 CFR §72.122(h)(1). In addition, it was adequately demonstrated that SSCs important to safety will be operated and maintained within their minimum and maximum temperature criteria for normal, off-normal, and accident conditions. Therefore, the requirements of 10 CFR §72.128(a)(4) have been adequately demonstrated.

- Reliable data sources have been used to present temperatures and insolation for the INEEL site, including data recorded by the INEEL onsite measurement program. Therefore, the SAR shows that information on temperatures and insolation at the proposed site is acceptable and in compliance with 10 CFR §72.92(a) and §72.122(b)(1).

- The analytical methods, models, and calculations used to establish the thermal characteristics of the ISF Facility and its operational areas were documented in an acceptable manner. Therefore, the requirements of 10 CFR §72.122(h)(1) and 10 CFR §72.128(a)(4) as they pertain to the analytical methods, models, and calculations have been satisfied.

- The SAR and the supporting fire hazards analysis adequately describe the potential fire hazards for the ISF Facility. In addition, adequate justification for excluding potential explosion hazards as a credible accident scenario was provided. Through design of the ISF Facility and administrative procedures, the volume of potential combustible materials will be kept below the design bases of the applicable structures, systems, and components important to safety. In summary, the SAR shows that the fire and explosion hazards at the site are acceptable and in compliance with the requirements of 10 CFR §72.122(c). Based on the assessment of the fire protection measures and the potential fire and explosion hazards at the site, there is reasonable assurance that the ISF Facility will not be exposed to fires or explosions that are beyond the design bases for the ISF Facility.

6.3 References

American Conference of Governmental Industrial Hygienists. *Industrial Ventilation—A Manual of Recommended Practice*. Cincinnati, OH: American Conference of Governmental Industrial Hygienists. 2001.

American National Standards Institute. *Radioactive Materials—Leakage Tests on Packages for Shipment*. ANSI N14.5. Washington, DC: American National Standards Institute. 1997.

American National Standards Institute/ASME International. *Nuclear Power Plant Air-Cleaning Units and Components*. ANSI/ASME N509–1989. New York City, NY: ASME International. 1989a.

American National Standards Institute/ASME International. *Testing of Nuclear Air Treatment Systems*. ANSI/ASME N510–1989. New York City, NY: ASME International. 1989b.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. *Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities*. ASHRAE DG–1. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1993.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. *ASHRAE Handbook: Cooling and Heating Load Calculation Manual*. 2nd ed. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1992.

ASME International. *Power Piping*. ASME B31.1. New York City, NY: ASME International. 2001a.

ASME International. *Boiler and Pressure Vessel Code*. Section V, Article 10, Appendix IV. New York City, NY: ASME International. 2001b.

ASME International. *Code on Nuclear Air and Gas Treatment*. ASME AG–1. New York City, NY: ASME International. 1997.

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

Croff, A.G. *ORIGEN2—A Revised and Updated Version of the Oak Ridge Isotope Generation and Depletion Code*. ORNL–5621. Oak Ridge, TN: Oak Ridge National Laboratory. 1980.

Energy Research and Development Administration. *Nuclear Air Cleaning Handbook: Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Applications*. ERDA 76-21. Oak Ridge, TN: Oak Ridge National Laboratory. 1976.

Factory Mutual Insurance Company. *Transformers*. Loss Prevention Data Sheet 5-4. Norwood, MA: Factory Mutual Research. January 2001.

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–03–0009. Richland, WA: Foster Wheeler Environmental Corporation, Idaho Spent Fuel Facility Project. January 22, 2003b.

Foster Wheeler Environment Corporation. *Response to NRC Second Round Request for Additional Information (Proprietary)*. Idaho Spent Fuel Facility License Application. FW–NRC–ISF–03–0199. Docket No. 72-25. Richland, WA: Foster Wheeler Environment Corporation, Idaho Spent Fuel Facility Project. August 28, 2003c.

National Fire Protection Association. *Fire Doors and Fire Windows*. NFPA 80. Quincy, MA: National Fire Protection Association. 1999a.

National Fire Protection Association. *National Fire Alarm Code*. NFPA 72. Quincy, MA: National Fire Protection Association. 1999b.

National Fire Protection Association. *Standard for the Installation of Stationary Pumps for Fire Protection*. NFPA 20. Quincy, MA: National Fire Protection Association. 1999c.

National Fire Protection Association. *Standard for the Installation of Sprinkler Systems*. NFPA 13. Quincy, MA: National Fire Protection Association. 1999d.

National Fire Protection Association. *Standard for the Installation of Air-Conditioning and Ventilating Systems*. NFPA 90A. Quincy, MA: National Fire Protection Association. 1999e.

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

National Fire Protection Association. *Standard for Water Tanks for Private Fire Protection*. NFPA 22. Quincy, MA: National Fire Protection Association. 1998a.

National Fire Protection Association. *Standard for Portable Fire Extinguishers*. NFPA 10. Quincy, MA: National Fire Protection Association. 1998b.

National Fire Protection Association. *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. NFPA 25. Quincy, MA: National Fire Protection Association. 1998c.

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

National Fire Protection Association. *Standard for Fire Walls and Fire Barrier Walls*. NFPA 221. Quincy, MA: National Fire Protection Association. 1997a.

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

National Fire Protection Association. *Flammable and Combustible Liquids*. NFPA 30. Quincy, MA: National Fire Protection Association. 1996a.

National Fire Protection Association. *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*. NFPA 80A. Quincy, MA: National Fire Protection Association. 1996b.

National Fire Protection Association. *Standard for the Installation of Standpipe, Private Hydrants, and Hose Systems*. NFPA 14. Quincy, MA: National Fire Protection Association. 1996c.

National Fire Protection Association. *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*. NFPA 24. Quincy, MA: National Fire Protection Association. 1995.

Sheet Metal and Air-Conditioning Contractors' National Association. *HVAC Duct Construction Standards—Metal and Flexible*. Chantilly, VA: Sheet Metal and Air-Conditioning Contractors' National Association. 1995.

Underwriters Laboratories. *UL Standard for High-Efficiency Particulate Air Filter Units.* UL 586. Northbrook: IL: Underwriters Laboratories. 1999.

Underwriters Laboratories. *UL Standard for Safety Air Filter Units.* UL 900. Northbrook: IL: Underwriters Laboratories. 1995.

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

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

Utility Engineering. Idaho Spent Fuel Project—Fire Hazards Analysis. ISF–FW–RPT–0113. Rev. 4. Denver, CO: Utility Engineering. 2003.

Yang, L., O. Povetko, and S. Hsiung. *Characteristics of Fuels to be Stored at the Proposed Idaho Spent Fuel Facility Final Report*. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 2003.