9.1.4 Fuel Handling System

The fuel handling system (FHS) provides a safe means for handling and performance monitoring of fuel assemblies and control components from the time of receipt of new fuel assemblies to the storage and removal of spent fuel. This includes installing and removing fuel assemblies in the reactor vessel, transferring irradiated fuel assemblies from the reactor vessel to the spent fuel pool (SFP), storage of irradiated fuel assemblies, and removal of irradiated fuel assemblies through the Spent Fuel Cask Transfer Facility (SFCTF). The system also provides a means of safely receiving, inspecting, storing, and handling new fuel.

The FHS design maintains occupational radiation exposures as low as is reasonably achievable (ALARA) during transportation and handling.

The specific cask design is not part of the FHS or SFCTF. A COL applicant that references the U.S. EPR design certification will perform appropriate tests and analyses, which demonstrate that an identified NRC-approved cask can be safely connected to the SFCTF, and the cask and its adapter meet the criteria specified in Table 9.1.4-1, prior to initial fuel loading into the reactor.

9.1.4.1 Design Bases

The following major components are safety-related and designed to Seismic Category I requirements:

- New and spent fuel storage racks.
- Transfer tube, isolation devices, and expansion joints.
- Cask loading pit penetration assembly.
- Spent fuel cask transfer machine (SFCTM).
- SFCTF fluid and pneumatic systems isolation devices.

The design basis requirements and design criteria are as follows:

The FHS components are located inside the Reactor Building (RB) and Fuel Building (FB) structures, which are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods and external missiles (GDC 2).

The seismic design of the system components meets the guidance of RG 1.29 (Position C1 for safety-related portions and Position C2 for non-safety-related portions).

The FHS components are not shared among nuclear power units (GDC 5).

The design of the FHS includes the safe handling, storage, and removal of fuel under both normal and accident conditions (GDC 61).

The design of the FHS prevents inadvertent criticality (GDC 62). The fuel racks (FR) are designed to store fuel assemblies in an appropriate manner during normal operation and the safe shutdown earthquake (SSE) so that criticality accidents are avoided, and the fuel assemblies are not damaged by overloading or overheating.

The FHS is designed and arranged so that dropped loads do not result in fuel damage that would release radioactivity in excess of 10 CFR 100 guidelines or impair the safe shutdown of the plant.

The fuel transfer tube facility (FTTF) provides containment isolation so that offsite dose limits are not exceeded during a design basis accident (DBA).

The cask loading pit penetration assembly maintains its portion of the cask loading pit fluid boundary to avoid draining the SFP to a level that prevents decay heat removal from the stored fuel.

The safety-related components of the SFCTF are designed to maintain the fluid boundary to preclude the loss of significant inventory in the SFP during cask loading operations, including SSE, and the postulated drop of a fuel assembly from the maximum handling height in the cask loading pit onto a connected cask. Additionally, the safety-related components of the SFCTF are designed to maintain the fluid boundary during and following the beyond design basis large commercial aircraft impact event described in Section 19.2.7.

The SFCTM is designed to prevent tipping or dropping of the fuel cask during cask handling operations in the loading hall, including an SSE and the beyond design basis large commercial aircraft impact event.

The SFCTF is designed to maintain operational doses as low as reasonably achievable (ALARA).

The SFCTF is designed so that the cask loading operation is reversible in case spent fuel needs to be unloaded from the cask to the spent fuel storage racks.

9.1.4.2 System Description

FHS equipment is needed to perform the following functions:

- New fuel handling and storage.
- Refueling.
- Spent fuel storage and activities during plant normal operation.

- SFCTF operations.

This equipment consists of fuel assembly handling devices such as the refueling machine, FTTF, new fuel elevator, spent fuel machine, auxiliary crane, Spent Fuel Cask Transfer Facility, and fuel racks. The areas associated with the fuel handling equipment are the refueling cavity consisting of the reactor cavity, the core internal storage area and the reactor building transfer compartment, and the fuel pool consisting of the transfer pit, the loading pit and the spent fuel storage pool, loading hall, and the new fuel storage area.

Figures showing the overall system arrangement in the RB and FB are provided in Section 3.8. Section 3.8.4.1 describes the FB as a Seismic Category I structure. The loading hall and cask loading pit are integral to the FB concrete structure and are designed as Seismic Category I structures. Section 3.8.4.2 identifies the applicable codes and standards used for the design of Seismic Category I structures other than the RB and Reactor Containment Building. Section 3.8.4.4.1 lists the general design procedures applicable to other Seismic Category I structures. The design of anchors and embedments conforms to the requirements of ACI 349-06. The results of seismic analyses for Seismic Category I structures are given in Section 3.7.

9.1.4.2.1 General Description

The fuel handling equipment can handle a fuel assembly underwater from the time a new fuel assembly is lowered into the underwater fuel storage area until the irradiated fuel assembly is placed in a spent fuel cask for shipment from the site. Underwater transfer of spent fuel assemblies provides radiation shielding and cooling for removal of decay heat. The enriched boric acid concentration in the water is sufficient to preclude criticality.

The reactor cavity, the core internal storage compartment, and the reactor building pool transfer compartment are flooded only for refueling during plant shutdowns. The SFP remains full of water and is always accessible to operating personnel.

New Fuel Handling and Storage

New fuel containers are received in the FB loading bay. Typically, each container carries two fuel assemblies. New fuel containers are raised one at a time through a floor opening to the new fuel examination area located at Elevation +48 feet, 6.75 inches with the use of the auxiliary crane. The new fuel assemblies are removed from the container for individual examination using the auxiliary crane and new fuel handling tool. The new fuel assembly is raised through the floor opening until the fuel assembly lower end clears the fuel pool operating floor level (+64 feet) and is then moved and either lowered in the new fuel dry storage area or in the new fuel elevator basket. This process is repeated for the remaining new fuel containers. The new fuel elevator lowers the fuel assembly into the spent fuel storage pool for underwater storage. Administrative controls prevent movement of a new fuel assembly over the spent fuel racks while it is moved from the new fuel storage rack or new fuel examination area to the new fuel elevator. The auxiliary crane could be used to move fuel in the spent fuel pool. The auxiliary crane is interlocked to ensure the maximum load drop height of a fuel assembly onto the top of the spent fuel rack or the spent fuel pool floor does not exceed the drop height assumed in load drop analyses. The interlock allows for the new fuel to be lowered into the new fuel elevator or into the spent fuel pool near the new fuel elevator. The new fuel assemblies placed in the new fuel dry storage will be moved to underwater storage prior to the refueling outage. From the spent fuel storage racks, the fuel assemblies are transferred under water until loaded into the reactor.

Refueling Procedure

Refueling operations are started after the reactor coolant system (RCS) is borated as specified in the Technical Specifications and cooled down to refueling shutdown conditions.

The refueling operation is divided into five major evolutions: (1) RCS and refueling system preparation, (2) disassembly of the reactor, (3) fuel handling during refueling operations, (4) reassembly of the reactor, and (5) preoperational checks and startups. A general description of a typical refueling operation through these evolutions is provided below.

RCS and Refueling System Preparation

The reactor is shut down, borated, and cooled to refueling conditions. After an initial radiation survey, access to the reactor vessel head is allowed. The coolant level in the reactor vessel is lowered to a point slightly below the vessel flange. The fuel transfer tools and equipment are checked, inspected and tested for operation.

Disassembly of the Reactor

Mechanical and instrumentation connections to the reactor pressure vessel are disconnected to allow removal of the vessel head. The refueling cavity is prepared for flooding by checking the underwater lights, and tools; closing the refueling cavity drain lines; and removing the blind flange from the fuel transfer tube. The accessible portion of the reactor cavity ring is inspected for damage at welds and the area that functions as an expansion joint, including the protective cover (Refer to Figure 9.1.4-12—Permanent RPV Refueling Cavity Ring - General Configuration). With the refueling cavity prepared for flooding, the vessel head is unseated and raised above the vessel flange using the reactor building polar crane (refer to Section 9.1.5 for equipment handling heavy loads). Water from the in-containment refueling water storage tank (IRWST) is directed into the reactor coolant system in order to fill the RB refueling cavity. The vessel head is lifted and placed on the head stand. When the RB refueling cavity water level reaches the specified depth for shielding and the water level in the FB transfer pit is equalized to the refueling cavity level, the fuel transfer tube isolation valve is opened. The refueling machine is positioned over the core and the control rod drive shafts are disconnected. Once the control rod shafts are disconnected, the internals lifting rig is installed. The upper internals are removed from the vessel and stored in the refueling canal in a designated area located away from the fuel load path. The refueling machine is indexed over the core and tested underwater. The core is ready for refueling when all fuel handling prerequisites have been met and the reactor cavity and connected pools have stable water levels and no evidence of abnormal leakage.

Fuel Handling during Refueling Operations

The refueling sequence begins in the RB with the refueling machine. Spent fuel assemblies are removed; and partially irradiated fuel assemblies are relocated in the core per the refueling plan and new fuel assemblies are added to the core. The general fuel handling sequence for a full core off load or a core fuel shuffle are essentially the same, except for the number of fuel assemblies removed from the reactor vessel.

The general fuel handling sequence for refueling involving moving the fuel assembly from the reactor vessel to the SFP is as follows:

1. The refueling machine is automatically or manually positioned over a fuel assembly in the core. Once the refueling machine mast is positioned over the selected fuel assembly; the fuel assembly gripper is lowered and engages the fuel assembly.

2. The refueling machine withdraws the selected fuel assembly from the core and raises it to a predetermined height sufficient to clear the vessel flange and reactor cavity ring cover. The maximum height of the fuel assembly is limited to provide sufficient water covering the fuel assembly. The fuel assembly is then transported to the fuel transfer tube facility area of the reactor building refueling cavity.

3. The fuel transfer system conveyor car is positioned in the fuel transfer tube facility area of the refueling cavity, and the fuel container is in the vertical position.

4. The refueling machine is positioned to line up the fuel assembly over the empty fuel container. The fuel assembly is lowered and placed into the empty fuel container of the conveyor car. The upender pivots the fuel container to the horizontal position and is transported by the conveyor car to the SFP side of the fuel transfer tube facility. The upender then pivots the fuel container to the vertical position.

5. The spent fuel machine is positioned over the fuel assembly then it latches and withdraws the assembly from the fuel container. The spent fuel machine then transports the fuel assembly to a predetermined location in the SFP where it is lowered into the fuel rack location and unlatched.

The general fuel handling sequence for refueling involving moving the fuel assembly from the SFP to the reactor vessel is as follows:

1. A fuel assembly is taken from a specified location in the SFP storage rack and loaded into the empty fuel container of the conveyor car by the spent fuel machine.

2. The upender pivots the fuel container to the horizontal position and the conveyor car moves the fuel assembly through the fuel transfer tube to the fuel transfer tube facility area in the RB. The upender then pivots the fuel container back to the vertical position.

3. The refueling machine is then located over the fuel assembly and withdraws it from the fuel container. The refueling machine then transports the fuel assembly over the core area and inserts it into a specified location in the core.

The foregoing procedures are repeated until the reactor vessel refueling is completed.

Reassembly of the Reactor

After the core mapping is complete, the reactor vessel is reassembled. The SFP is isolated from the refueling cavity and the RB refueling cavity water level is lowered to just below the reactor vessel flange and the vessel head is installed. The mechanical and instrumentation connections are reinstalled.

Pre-operational Checks and Startup

In the final phase, the blind flange on the fuel transfer tube is re-installed and the fuel handling areas inside the RB are cleaned and restored.

Spent Fuel Storage and Activities During Plant Normal Operation

Spent fuel is stored in the fuel storage racks in the spent fuel storage pool. The fuel pool cooling system removes the decay heat from the spent fuel assemblies stored in the pool (refer to Section 9.1.3). After sufficient decay, spent fuel assemblies may be removed from the SFP.

During normal operation, handling activities related to rearrangement and inspection of the spent and new fuel assemblies in the fuel storage pool and in the new fuel dry storage area take place. The spent fuel machine and auxiliary crane are used to relocate fuel and fuel assembly inserts.

Prior to initiating these activities in the SFP, the following checks are made:

- Verification of the SFP readiness, including lighting.

- Verification that the fuel pool cooling and purification system and support systems are available and capable of handling the expected spent fuel heat load.

- Verification of SFP boron concentration to maintain subcriticality of the fuel assemblies.
- Verification of water level in the SFP to keep the radiation levels within acceptable limits when the fuel assemblies are relocated in SFP.
- Verification of the SFP gates integrity to make sure there is no unexpected loss of SFP water level during fuel movement operations.

Other than the handling of fuel and fuel assembly inserts, the inspection and testing of the fuel handling tools and accessible components and equipment are also carried out during the plant normal operation. The calibration of instruments and circuits, and the testing of electrically operated equipment and components, including the checking for proper operation of interlocks, are accomplished.

Spent Fuel Cask Transfer Facility Operation

After sufficient decay, spent fuel assemblies may be removed from the SFP for loading into a spent fuel cask using the SFCTF. The SFCTF includes equipment for receipt and preparation of a spent fuel cask, transfer of the cask within the loading hall, connection of the cask to the loading pit, and removal of the loaded cask from the FB.

The following four workstations perform their respective cask loading and supporting operations:

- Lifting station is where the cask is placed on the SFCTM by the gantry crane (not a part of the SFCTF) outside the FB prior to cask loading, and is removed from the SFCTM by the gantry crane after loading.
- Handling opening station (loading hall) is where empty casks are prepared for fuel loading and loaded casks are prepared for final removal from the FB. Lifting operations are performed by the fuel building auxiliary crane (not a part of the SFCTF) through the handling opening.
- Biological lid handling station (loading hall) is where the biological lid is removed from the empty cask prior to fuel loading, and is placed back on the cask after loading.
- Penetration station (loading hall) is where the cask is connected to the loading pit penetration assembly and spent fuel is loaded using the spent fuel machine. The spent fuel machine and loading pit are not part of the SFCTF.

The SFCTF is designed to be remotely operated during normal operation, with no personnel in the loading hall, from the time the cask is connected to the penetration assembly and to be leak tested (prior to fuel movement) until the biological lid is placed back on the loaded cask. However, operator entry into the loading hall may be required during this phase of operations for the performance of corrective action or manual operation to address abnormal situations such as:

- Failure of moving parts, such as improper functioning of an anti-seismic locking device, failure of docking mechanism leading to incorrect docking, failure of the spent fuel cask transfer machine (SFCTM) travel drive motor or failure of the biological protections to open.
- Loss of power supply.
- Seismic event.

Shielding is provided on the SFCTM, and by the close tolerances between the cask and the loading hall ceiling, so that occupational doses are minimized if an operator is required to enter the loading hall for abnormal conditions. The under-pool loading configuration precludes contamination of the exterior surface of the cask, which minimizes occupational dose during cask loading operations. The anticipated dose rates for operators in the loading hall during cask handling operation are identified in Figure 12.3-33—Fuel Building +0 Ft Elevation Radiation Zones.

A general description of the SFCTF operations is described in this section. Operator training procedures and guidance for handling the SFCTF loads will be developed in accordance with ASME B30.2-2005 (Reference 8). Operator training and procedures are developed by the COL applicant as described in Sections 13.2 and 13.5.

Receipt and Preparations

Preparations for cask loading operation include preparing the gantry crane to interface with the SFCTM and performing regular inspections and checks of the SFCTM.

After arrival of the spent fuel cask on the transport trailer, a visual and radiological inspection of the cask is performed. The cask is lifted using the gantry crane. The SFCTM is towed under the crane, and the cask is placed on the SFCTM. The positioning of the cask is performed with screw jacks and position measurement equipment and the cask is locked in place on the SFCTM.

The design of the SFCTF does not require the cask to be lifted inside the FB, thus precluding concerns about dropping the cask onto stored fuel or safety-related equipment.

The SFCTM is towed into the FB. The SFCTM is automatically centered using a lateral guiding device sliding against guiding rails on the loading hall walls. The SFCTM brakes are secured. The towing equipment is then removed from the loading hall and the loading hall door closed. The SFCTM is then connected to the fluid systems and the electrical power supply. The SFCTM is moved into the handling area opening and the anti-seismic locking devices are engaged.

The cask is prepared for loading in the handling area. The specific preparation steps depend on the cask design. The following process is considered representative. The handling opening above the cask is opened. Leak-tightness and radiation checks are performed, and lids (except the biological lid) are removed by the auxiliary crane. The flange is unbolted. If necessary, cask-specific adaptors for interface with the SFCTF fluid systems are installed and the centering or locking ring is placed on the SFCTM with the auxiliary crane. The cask may be filled with demineralized water at this stage, depending on the cask design, and then the handling opening is closed.

The cask loading pit area is also prepared to begin cask loading operations. The cask loading pit is filled and the leak-tightness of the penetration assembly is confirmed.

Cask Loading Operations

After the cask and loading pit preparations are completed, the anti-seismic locking devices on the SFCTM are unlocked and the SFCTM is moved to the biological lid handling station. The anti-seismic locking devices are re-engaged prior to handling activities. The biological lid handling station gripper is lowered, and the lid is lifted and held in the ceiling recess. The lifting screw is locked to prevent movement. While the SFCTM remains in this location, the penetration assembly lower cover is removed by raising the elevator on the SFCTM until it is against the cover. Operations personnel are required in the area to unbolt the lower cover. The lower cover is removed, stored on the SFCTM, and the elevator is lowered.

After completion of activities at the biological lid handling station, the anti-seismic locking devices are unlocked and the SFCTM is moved to the penetration station. The SFCTM is guided into place with the assistance of video monitoring and proximity detectors. The anti-seismic locking devices are re-engaged. The biological lid is lowered and placed on a support storage location on the SFCTM. Inspections of the biological lid may be performed, if necessary.

The penetration assembly is connected to the cask by engaging the penetration assembly docking flange with the docking device on the SFCTM. The leak-tightness flange of the penetration assembly is centered on the cask via the centering/locking ring. After the cask is docked, adjustments may be made by operations personnel to the cask-SFCTM interface to allow for thermal expansion of the cask while maintaining seismic integrity. The leak-tightness of the seals between the penetration assembly and the cask is checked by a compressed air circuit between the seals.

After docking activities are completed, the penetration assembly vent is opened and the cask and penetration assembly are filled with borated water until the pressure is equalized across the penetration upper cover with the previously filled cask loading pit. The penetration upper cover may then be opened.

To begin loading fuel assemblies, the cask loading pit swivel gate is opened (loading pit slot gate has been removed prior to this step), and fuel assemblies are transferred one at a time by the spent fuel machine from the spent fuel storage racks to the cask. Upon completion of cask loading operations, the loading pit swivel gate is closed.

After the cask has been loaded, the penetration assembly upper cover is closed, pressurized, and locked. Seal leak-tightness is controlled by the compressed air circuit between the seals. The penetration assembly is emptied, rinsed with demineralized water, and dried with compressed air. The cask is disconnected from the penetration assembly by reversing the screws of the docking device until the penetration assembly is at its upper-most position. The biological lid is lifted from its support on the SFCTM prior to travel to the biological lid handling station.

Cask Closing Operations

After the cask has been disconnected from the penetration assembly, the anti-seismic locking devices are unlocked at the penetration station and the SFCTM is moved to the biological lid handling station, where the anti-seismic locking devices are engaged. The biological lid is lowered on the cask with the gripper. After radiological checks, personnel may enter the loading hall to install the penetration bottom cover. The bottom cover is lifted by the SFCTM elevator and bolted in place.

The anti-seismic locking devices are unlocked at the biological lid handling station and the SFCTM is moved to the handling opening station. The anti-seismic locking devices are engaged and cask closure activities are initiated. Specific cask closure activities are dependent on the cask design, so the following steps are representative. The biological lid flange is bolted to the cask and leak-tightness checks are performed. The cask is drained and vacuum-dried. The fluid systems are rinsed. The handling opening is opened and the centering/locking ring is removed with the auxiliary crane. Additional lids are placed on the cask and bolted. Radiological activity checks are performed.

Cask Removal Operations

After the cask closure activities have been completed, the anti-seismic locking devices are unlocked, and the SFCTM is disconnected from the fluid systems and electrical power supply. The loading hall door is opened and towing equipment is connected to the SFCTM. The SFCTM is towed to the gantry crane. The cask is unlocked from the SFCTM, lifted with the gantry crane, and the SFCTM is towed away. The cask is placed on the transport trailer for disposition.

Fuel Handling Administrative Controls and Programs

The fuel handling operations are performed per approved plant procedures, which cover administrative, operating, emergency, testing and maintenance aspects.

The administrative control procedure and checklists are developed from a review of fuel handing related safety analysis and the fuel handling operations. The checklists assist in providing assurance that fuel handing safety analysis assumptions and initial conditions are not violated during the refueling and other fuel handling operations.

Administrative controls for fuel handling operations include the following:

1. Movement of the fuel assemblies from the core shall be started only after allowing for sufficient decay after the reactor shutdown.
2. At least two of the following safety-related, Seismic Category I, barriers will be retained closed while there is no cask attached to the SFCTF and fuel is in the SFP:
   - Cask loading pit slot gate.
   - Cask loading pit swivel gate.
   - Penetration assembly upper cover.
   - Penetration assembly lower cover.
3. Manual control of the handling equipment, such as, Refueling Machine, Spent Fuel Machine, New Fuel Elevator, and Auxiliary Crane shall be put under administrative control.

9.1.4.2.2 Component Description

The major components of the FHS are described in the following paragraphs. Table 3.2.2-1 provides the seismic and other design classifications for the components in the FHS. The FHS is designed in accordance with ANS 57.1 (Reference 1), ANS 57.2 (Reference 2), and ANS 57.3 (Reference 3). The transfer tube components are designed per ASME Boiler and Pressure Vessel Code, III (Reference 4).

Refueling Machine

The refueling machine (RM) moves fuel assemblies both within the reactor vessel and between the reactor vessel and the fuel transfer tube facility during outages. The RM is primarily designed for the underwater handling of fuel assemblies between the FTTF and the core during outages. The RM also provides access to fuel assemblies for detecting fuel cladding ruptures, visual core mapping, an operational platform for handling control rod drive shafts and instrumentation, and access to the upper internals of the reactor vessel.

The main components of the RM are shown in Figure 9.1.4-1—Refueling Machine.

A conceptual drawing of the fuel assembly hoisting mechanism is shown in Figure 9.1.4-2—Fuel Assemblies Hoisting Mechanism.

Fuel Transfer Tube Facility

The main purpose of the FTTF is to transfer fuel between the SFP and the refueling cavity. The fuel transfer tube is fitted with a blind flange on the RB side to provide containment isolation during power operations and with a manual gate valve on the FB side to allow isolation of the SFP from the refueling cavity. The fuel transfer tube is provided with expansion joints on the RB and FB side to accommodate the differential movement and provide leak tight sealing. An underwater conveyor car carries the fuel assemblies in a fuel container through the tube. Upenders provide the capability to tilt the fuel container.

The main components of the FTTF are shown in Figure 9.1.4-3—Fuel Transfer Tube Facility, Reactor Building and Figure 9.1.4-4—Fuel Transfer Tube Facility, Fuel Building.

New Fuel Elevator

The primary purpose of the new fuel elevator (NFE) is to lower new fuel assemblies to the bottom of the spent fuel storage pool for transfer via the spent fuel machine. The NFE supports and rotates the fuel assemblies, protects them from shock, and provides a means to inspect fuel assemblies when they are underwater.

The design of the NFE contains physical barriers, which prevent an inadvertent criticality resulting from the proximity of another fuel assembly that could be dropped on or moved near a new fuel assembly in the NFE. Refer to Section 9.1.4.3.1 for a further description of the physical barriers.

The main components of the NFE are shown in Figure 9.1.4-5—New Fuel Elevator.

Spent Fuel Machine

The spent fuel machine (SFM) is primarily designed for the underwater handling of fuel assemblies between the SFP and the FTTF. The SFM permits access to the fuel assemblies to detect fuel cladding ruptures. It also enables the loading of spent fuel into the shipping casks.

The design of the SFM incorporates provisions for manual operation of the machine in an emergency mode in case of power failure, which would allow manually lowering the fuel assembly into the cask. The SFM has a provision for manually traveling and traversing after manually opening the brake, and for manually lowering and raising the load, after manually opening the brake.

The main components of the SFM are shown in Figure 9.1.4-6—Spent Fuel Machine.

Auxiliary Crane

The auxiliary crane is used to handle new fuel containers, container covers, protection lids, new fuel assemblies, erection opening covers, canisters, slot gates, swivel gates, tilting basket, along with miscellaneous handling operations. The auxiliary crane is designed with buffers and shock-absorbing devices. The auxiliary crane bridge hoist uses the new fuel handling tool to handle new fuel assemblies for operations in air. For further details on the auxiliary crane, refer to Section 9.1.5.

Fuel Racks

The fuel racks are located underwater for irradiated fuel storage, and above water for new fuel storage. The racks are designed to store fuel in a manner that precludes criticality and maintains the irradiated fuel in a coolable geometry. Refer to Section 9.1.2 for the design of the new and spent fuel storage racks.

Spent Fuel Cask Transfer Facility

The SFCTF is functionally separated into four major parts: the SFCTM, the penetration assembly, the SFCTF fluid and pneumatic systems, and the biological lid handling station.

Spent Fuel Cask Transfer Machine

The SFCTM is a trolley that moves on rails and transports the spent fuel cask vertically within the stations of the SFCTF. Motive force is provided by an onboard electric motor. The SFCTM is designed to carry a maximum load of 253,530 lb (115,000 Kg). Instrumentation and controls (I&C) are provided to support safe operation, as described in Section 9.1.4.5. The SFCTM interfaces with the plant fluid systems that are required to support cask operations, such as filling and draining.

The SFCTM is designed to remain in place and support the cask while the cask is attached to the loading pit penetration and prevent a loss of water from the SFP during an SSE that could result in potential offsite exposures. The SFCTM also provides structural support to a cask containing spent fuel to preclude fuel damage or a criticality accident.

The SFCTM is designed to maintain its function of supporting the fuel cask, the penetration assembly, and the fluid boundary isolation components of the connected piping systems during and following the beyond design basis large commercial aircraft impact event.

The SFCTM is equipped with lateral guiding devices and anti-seismic locking devices. The lateral guiding device slides along the guiding rails, which are placed on the corbels of the loading hall.

During normal operation, the lateral guiding device along with the guiding rails and the sliding support of the traveling platform facilitates the limited lateral adjustment of the SFCTM. During an SSE or the beyond design basis large commercial aircraft impact event, the lateral guiding device prevents tilting of the SFCTM when it is not positioned at the handling opening station, the lid handling station, or the penetration station.

The anti-seismic locking devices fixed on two sides of the SFCTM structure consist of movable parts that engage in the openings in the guiding rails attached to the corbels of the loading hall. The movable parts are actuated by an irreversible screw/nut system connected to an electric motor, a reduction gear, and a torque limiter. The screw movement is not possible without an external action. The anti-seismic locking devices are also equipped with a manual backup for operation in case of loss of power. Sensors detect the position of the moveable parts (locked/unlocked). The anti-seismic locking devices secure the SFCTM to the FB at the handling opening station, the lid handling station, or the penetration station. The trolley must be exactly in the axis of the station to lock anti-seismic locking devices. The anti-seismic locking devices prevent any movement of the SFCTM when it is located at these stations in the event of an SSE, spurious behavior of the traveling drive system, or following the beyond design basis large commercial aircraft impact event.

SFCTM movements are stopped on a loss of power and the onboard brakes are engaged when de-energized.

The SFCTM includes a device to dock and undock the cask from the penetration, an elevator to lift and lower the penetration bottom cover, and a support to hold the biological lid during cask loading.

The penetration docking device is fixed on top of the SFCTM and is used to lower the penetration assembly bellows to connect the leak-tight flange to the cask mating surface. The penetration docking device consists of four identical assemblies, each of which includes a screw connected at its lower end to a bearing and whose upper end engages into a swiveled nut of the penetration docking flange. Each screw is moved upwards by an air cylinder and is rotated by an electric motor and a reduction gear that maintains its rotation. Each assembly is irreversible and equipped with a position sensor for a high and low travel. Each screw also has a revolution counter that maintains the balance of the four assemblies and provides for equal loading on the screws. The penetration docking device permits undocking of the cask even with two diametrically opposed assemblies. A manual backup operates the screws in case of loss of electric power. The docking mechanism is shown in Figure 9.1.4-10—Loading Penetration Docking Mechanism.

The elevator for the lower cover is fixed on the SFCTM. The elevator uses a screw/nut system for lifting and lowering the lower cover. The screw movement is not possible without an external action.

The SFCTM provides shielding for operators in abnormal conditions when loading hall entry is required before the biological lid is inserted into the cask to minimize occupational dose. The shielding is placed around the top of the cask and around equipment that may contain contaminated water or gas.

The SFCTM has an interlock with the external door of the loading hall, which precludes operation if the external door is open. The external door remains closed during cask loading operations. Mechanical stops are used to prevent inadvertent contact of the SFCTM with the loading hall door or wall.

To prevent damage to the penetration assembly seal, the SFCTM is interlocked to prevent moving within the loading hall. Unless the gripper of the biological lid handling station is in the upper position, the anti-seismic devices are unlocked, the penetration docking device is in the lower position, the penetration assembly is in the upper position (movements to and from the penetration station), and the handling area opening is closed (movements to and from the handling station).

The main structural assemblies of the SFCTM are shown in Figure 9.1.4-13—Spent Fuel Cask Transfer Machine - Main Structural Assemblies. The SFCTM is designed in accordance with the applicable portions of ASME NOG-1-2004 (Reference 5) as a single failure-proof Type I crane trolley. The structural parts of the SFCTM which are considered similar to component supports, such as the supporting shell and supports for the upper biological protection plates, are designed per guidance of ASME BPVC Section III, Division 1, Subsection NF for Class 3 component supports (Reference 4). The parts of the SFCTM which are considered similar to special lifting devices, such as the structural parts of the docking device and the grapple and screw/nut system for the elevator, as well as the cask upper trunnions blocking device, are designed per guidance of ANSI N14.6. The elevator vertical motorization for moving the screw is designed per guidance of ASME NOG-1, and it includes single failure-proof features to provide assurance that any credible failure of a single component would not result in the loss of capability to stop and hold the lower cover. The supports for ASME Class 3 fluid systems on the SFCTM conform to the requirements of ASME BPVC Section III, Division 1, Subsection NF for Class 3 component supports (Reference 4). Guidance in Appendix D to SRP Section 3.8.4 is used for loads and load combinations for the supporting shell, the docking device, and the supports for the upper biological protection plates.

The SFCTM is shown in Figure 9.1.4-7—Spent Fuel Cask Transfer Facility.

Penetration Assembly

The penetration assembly provides a leaktight connection between the loading pit and the internal cavity of the cask, an upper cover at the bottom of the loading pit, and a lower cover at the lower end of the penetration. The penetration assembly consists of a supporting structure, internal and external shells, double walled bellows, a leak-tightness flange, and a docking flange.

The upper cover of the penetration is equipped with a mechanism to maneuver and set the cover on the supporting structure seals, and a hoist for operation of the maneuvering mechanism. The hoist is a stationary lifting device and is provided above the loading pit. With the upper cover in the closed position, it forms a leak-tight closure of the penetration assembly. In the open position, it allows the loading of fuel assemblies into a connected cask.

The lower cover is bolted to the leak-tight flange of the penetration assembly. It is equipped with a nozzle for the recovery of drip-offs. The lower cover is designed to support the weight of the water in the loading pit in the event of an inadvertent opening of the upper cover of the penetration. The lower cover is manually unbolted and removed by the operators using the elevator of the SFCTM when performing cask loading operations.

The penetration assembly is equipped with dual seals at the interface locations shown in Figure 9.1.4-9—Loading Pit Penetration Assembly Seals. Theses are O-ring type seals made from EPDM rubber or other equivalent material and are designed to resist high levels of ionizing radiation. The O-rings will be environmentally-qualified in accordance with the requirements given in Table 3.10-1 and Section 3.11.2.2.

The integrity of the penetration seals is tested before loading the fuel assemblies. During the seal test and the loading of fuel assemblies, seal leaks between the cask and the docked penetration or of the bellows is detected by a pressure decrease of the compressed air enclosed between the two barriers. The compressed air pressure between the barriers is greater than the water column pressure in the loading pit. The leak-tightness of the penetration vent mechanism is tested separately. Maintenance and replacement of the seals is performed when the loading pit is empty and at intervals recommended by the seal manufacturer.

Two concentric seals on the upper part of the supporting structure maintain double barrier leak-tightness to the upper cover of the penetration when the upper cover is closed. The space between the two seals is pressurized with compressed air at a pressure greater than the loading pit water column pressure to avoid any concern of water leakage due to a seal failure. It also monitors the leak-tightness of the upper cover of the penetration in the main control room when the SFCTF is not in use. An alarm is generated in the SFCTF control room upon detection of a leak.

The internal and external shells are fixed to the supporting structure and provide protection for the bellows. The internal shell directs the flow of water and air in the penetration and the external shell guides the docking flange.

The double-walled bellows are provided with a flange at each end. The lower flange is connected to the docking flange and leak-tight flange, while the upper flange is connected to the supporting structure. The upper flange connection is equipped with two seals and the capability to monitor the space between the seals for leak-tightness.

The leak-tight flange is connected to the docking flange and the double-walled bellows flange at the upper end. The lower end of the leak-tight flange contacts the mating surface of the cask when the cask is docked to the penetration assembly. When the SFCTM is not in place under the penetration, the leak-tight flange is bolted with the lower cover of the penetration. The leak-tight flange is equipped with two seals each at the upper and the lower end and the capability to monitor the space between the seals for leak-tightness.

The docking flange is attached to the supporting structure by an arrangement that keeps the bellows in the upper position when it is in the storage position.

The penetration assembly maintains a leak tight boundary of the loading pit when the penetration is closed, and when the penetration is open and connected to a cask. The boundary serves as part of the safety-related cask loading pit fluid boundary to prevent drainage from the SFP and is maintained during and following an SSE to prevent a loss of water from the loading pit that could result in potential offsite exposures. A brief unseating of the normally leak-tight connection at the mating surface of the cask may occur during the SSE resulting in some seepage around the seals. The unseating would occur only for the duration of the SSE event. The duration of the SSE event is discussed in Section 3.7.1.1.2 - Design Ground Motion Time History. Any resulting seepage would be cyclical due to cyclic relaxing of the seal compression. This seepage is limited to the maximum leak rate for a complete 360 degree failure of both concentric seals at the cask mating surface which is calculated to be less than 250 gpm.

The penetration assembly is designed to maintain the SFP fluid boundary during and following the beyond design basis large commercial aircraft impact event. A brief unseating of the normally leak-tight connection at the mating surface of the cask may occur during an aircraft crash event resulting in some seepage around the seals but does not result in any significant loss of water inventory from the cask loading pit. The unseating would occur only for the duration of the shock waves generated due to the aircraft crash event. Any resulting seepage would be cyclical due to cyclic relaxing of the seal compression. This seepage is limited to the maximum leak rate for a complete 360 degree failure of both concentric seals at the cask mating surface, which is calculated to be less than 250 gpm.

An interlock precludes opening the penetration upper cover before the correct docking of the cask is checked, the anti-seismic locking of the SFCTM, and the correct cask water level. Likewise, an interlock prevents undocking the cask from the penetration unless the upper cover is closed.

To prevent damage to equipment or fuel in transit, the spent fuel machine is prevented, by interlock, from entering the loading pit unless the gates are open and the penetration upper cover is open. The upper cover is prevented from moving if the spent fuel machine is in the loading pit.

The penetration upper cover retains its ability to close the penetration for protection against SFP drainage following the beyond design basis large aircraft impact event, except when the SFM is operating in the cask loading pit.

The penetration assembly is shown in Figure 9.1.4-8—Cask Loading Pit Penetration Assembly.

ANSI/ANS-57.2-1983 provides design requirements for light water reactor spent fuel storage facilities at nuclear power plants. The design requirement presented in this standard is for a cask handling pool of a specific design configuration, wherein a penetration assembly design, similar to the one used in the U.S. EPR spent fuel cask transfer facility (SFCTF) used for fuel assembly loading, is not specifically addressed. However, Sections 6.1 and 6.2 of ANSI/ANS-57.2-1983 contain codes and standards that allow an acceptable level of oversight in the design and construction of spent fuel storage and cask handling pools, and spent fuel cask handling systems, respectively.

The design of the penetration fluid boundary parts satisfy the general design criteria specified in ND-3300 of the ASME Boiler and Pressure Vessel Code Section III, Division I - Subsection ND. The design of the penetration bellows meet the general design criteria specified in ND-3366, “Bellows Expansion Joint.” In addition, ASME Boiler and Pressure Vessel Code Section III, Division I - Appendices, mandatory Appendix XI, “Rules for Bolted Flange Connections for Class 2 and 3 Components and Class MC Vessels” and mandatory Appendix XII, “Article XII-1000, Design Consideration for Bolted Flange Connections” apply to the design of the penetration assembly.

Safety-related supports of the penetration fluid boundary parts meet the requirements of the ASME Boiler and Pressure Vessel Code Section III, Division 1- Subsection NF. This includes Subsection NF rules for the material, design, fabrication, examination, installation, and certification document (certificate of conformance) for supports, which are intended to conform to the requirements for ASME Class 3 supports. The design of the penetration assembly fluid boundary parts and supports satisfies Level B (Upset) Service Limit for all Level C (Emergency) and Level D (Faulted) Service Loadings.

The piping connected with the penetration assembly and cask up to and including the first valve (if a normally closed valve), or up to and including a second isolation valve (if a normally open valve with auto close or remote close capability) are designed in accordance with ASME Boiler and Pressure Vessel Code, Section III, Division 1, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, 2004 Edition. The process systems beyond the second isolation provision from the cask and the loading penetration are designed consistent with the design codes for the respective plant systems.

The hoist for the penetration assembly upper cover is a stationary lifting device and is designed in accordance with the applicable portions of ASME NOG-1 as a single failure-proof hoist (Type1).

The structural parts of the maneuvering and pressurization device are designed per guidance of ASME Section III, Division 1, Subsection NF for Class 3 component supports.

SFCTF Fluid and Pneumatic Systems

Fluid and pneumatic systems are provided in the SFCTF for filling, draining, and drying the cask and penetration assembly. These SFCTF systems are connected with the respective plant systems: compressed air system, demineralized water system, nuclear island drain/vent system, and fuel pool cooling and purification system.

These systems consist of process modules installed in a room adjacent to the SFCTF control room, on the SFCTM, and associated piping installed in the loading hall, and flexible hoses to connect the systems to the SFCTM. The process modules consist of pipes, valves, and process sensors. The process modules installed in the room check and monitor the seals and provide connections for the water supply to fill and drain the spent fuel cask and cask loading pit penetration assembly. The process module installed on the SFCTM contributes to the filling and draining of the cask, as well as the drying of the cask. Cask-specific valve adapters are used for connecting the internal cavity of the cask with the process modules. The valve adapter bodies are screwed to the cask; they are watertight and airtight. Cask-specific test adapters are provided to check the leak-tightness of the plugs that close the cask orifices and the leak-tightness of the biological lid and cask upper cover. The SFCTF can also fill the internal cavity of the spent fuel cask with nitrogen if the cask-specific design warrants. The nitrogen circuit also serves as a backup for the compressed air circuit.

The portions of SFCTF fluid and pneumatic systems piping directly connected to the penetration assembly, and cask are designed with isolation capability to prevent a loss of water from the SFP and loading pit during and following an SSE that could result in potential offsite exposure. This isolation capability is maintained during and following the beyond design basis large commercial aircraft impact event. The piping and valves up to the second isolation provision are designed to ASME Section III (Reference 4).

Fluid and pneumatic system valves required to isolate the cask and penetration assembly are closed on a loss of power.

Biological Lid Handling Station

The biological lid handling station is used for handling the biological lid from the cask to its support on the SFCTM and back to the cask after fuel assembly loading. The biological lid handling station consists of a supporting structure and a lifting mechanism. The biological lid handling station uses an irreversible screw design that prevents lid drop on a loss of power.

The biological lid handling station is remotely controlled from the SFCTF control room.

The biological lid handling station is designed in accordance with the applicable portions of ASME NOG-1-2004 Type 1 crane (Reference 5), ANSI N14.6-1993 (Reference 6) and AISC Manual of Steel Construction, 9th Edition (Reference 7). The screw jack and gripper are designed per guidance of ANSI N14.6-1993. The biological lid handling station vertical motorization for moving the screw jack is designed per guidance of ASME NOG-1, and it includes single failure-proof features to provide assurance that any credible failure of a single component would not result in the loss of capability to stop and hold the biological lid.

The biological lid handling station is shown in Figure 9.1.4-7.

9.1.4.2.3 Fuel Handling Tools Description

The new fuel handling tool and spent fuel handling manual tool are used to handle fuel assemblies one at a time, with or without a fuel assembly insert. The fuel assembly insert handling manual tool is used to handle fuel assembly inserts one at a time. The new fuel handling tool, spent fuel handling manual tool, and fuel assembly insert handling manual tool are manually operated, but handled by the auxiliary crane in the FB. The spent fuel handling manual tool can be handled by the polar crane in the RB. The fuel handling tools are designed in accordance with ANSI/ANS 57.1-1992, R1998, R2005 (R=Reaffirmed) (Reference 1). The new fuel handling tool, spent fuel handling manual tool, and fuel assembly insert handling manual tool are not handled by the refueling machine hoist or the spent fuel machine hoist.

New Fuel Handling Tool

The new fuel handling tool performs handling of a new fuel assembly in air with or without a fuel assembly insert between the new fuel container, new fuel examination area, new fuel storage racks, and new fuel elevator.

Spent Fuel Handling Manual Tool

The spent fuel handling manual tool performs underwater handling of a fuel assembly with or without a fuel assembly insert for positions of the underwater fuel storage racks, which are not accessible by the spent fuel machine and in case of a spent fuel machine failure. The spent fuel handling manual tool can be handled by the polar crane for underwater handling of fuel assemblies in the RB. The spent fuel handling manual tool performs underwater handling of a fuel assembly with sufficient water cover to provide adequate shielding.

Fuel Assembly Insert Handling Manual Tool

The fuel assembly insert handling manual tool performs underwater handling of fuel assembly insert in the spent fuel storage pool in case of a spent fuel machine failure. The fuel assembly insert handling manual tool is designed to handle different types of inserts, such as the rod cluster control assembly, thimble plug assembly, and neutron sources. The fuel assembly insert handling manual tool performs underwater handling of a fuel assembly insert with sufficient water cover to provide adequate shielding.

9.1.4.3 Safety Evaluation

- The safety-related portions of the FHS are located in the RB and FB. These buildings are designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other similar natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7, and Section 3.8 provide the bases for the adequacy of the structural design of these buildings.

- The safety-related portions of the FHS are designed to remain intact after an SSE. Section 3.7 provides the design loading conditions that were considered. Section 3.7.2 describes procedures used for developing seismic response spectra and Section 3.7.3 describes seismic analysis methodology. Section 3.5, Section 3.6, and Appendix 9A provide the required hazards analysis. The refueling machine, fuel transfer tube facility, NFE, SFM, SFCTM, penetration upper cover handling hoist, and biological lid handling hoist are designed to hold their maximum load during an SSE. See Section 9.1.5.2.3 for auxiliary crane design requirements.

- The portions of the FHS that provide containment boundary and containment isolation functions are safety-related. The fuel transfer tube penetrates the primary containment and is equipped with a blind flange in the RB that is closed during power operations. The leak-tight function of the fuel transfer tube is tested in accordance with 10 CFR 50, Appendix J programmatic requirements (refer to Section 6.2.6).

- The spent fuel assemblies and their inserts are handled with sufficient water cover to provide adequate shielding. Movement of fuel assemblies that could result in assembly grid contact or contact with other fuel assemblies takes place at low speed. Details regarding the specific assumptions, sequences, and analyses of fuel handling accidents are provided in Section 15.0.3.10.

The safety-related portions of the SFCTF are designed to remain intact following the beyond design basis large commercial aircraft impact event. Section 19.2.7 discusses the requirements for shock induced vibration analyses.

Details regarding criticality prevention measures for new and spent fuel storage are provided in Section 9.1.1. The fuel handling equipment is designed to handle one single fuel assembly at a time to protect against a criticality event during fuel handling operations.

The FHS is designed and arranged so that there are no loads which, if dropped, could result in damage leading to the release of radioactivity in excess of 10 CFR 100 guidelines, or impair the capability to safely shut down the plant. All spent fuel cask handling activities are performed below the SFP in the loading hall located at the ground elevation of the FB. Any lifting of a spent fuel cask is performed outside of the FB using appropriate handling equipment and lifting height limitations. At all times during spent fuel cask handling inside the FB, the cask height will not exceed 30 feet based on the design of the FB. The cask drop accident is addressed in Section 15.0.3.10. Details regarding new and spent fuel storage are provided in Section 9.1.1 and Section 9.1.2. Details regarding the specific assumptions, sequences, and analyses of fuel handling accidents are provided in Section 15.0.3.10.

The fuel storage pool, loading pit, and transfer pit are supplied by the fuel building ventilation system (FBVS) (Section 9.4.2). The loading hall is provided with a separate supply and exhaust duct. The FBVS is provided with isolation provisions which can isolate the fuel pool room and the loading hall from the rest of the building, if necessary. In the event radioactivity above limits is present in the FB during normal operation, the system is switched to filtration through the nuclear auxiliary building ventilation system (NABVS). Information on the NABVS is provided in Section 9.4.3.

Doses to operators are maintained ALARA by remote operation of the SFCTM. This precludes the need for operators to enter the loading hall containing a loaded cask until the biological lid is placed on the cask. To warn operators of an unexpected increase in radiation levels, a radiation monitor is located in the loading hall at the +0 foot elevation. The location of the monitor is in accordance with ANSI/ANS/HPSSC-6.8.1-1981 (Reference 27). Area radiation monitoring instrumentation is described in Table 12.3-3. The underpool loading design also precludes the need to decontaminate the outer surface of the cask after loading.

9.1.4.3.1 Safety Provisions for the Major Fuel Handling System Components

Refueling Machine

The refueling machine (RM) hoisting mechanism is equipped with an operational brake, an auxiliary brake, and a safety brake which acts on the drum in case of overspeed detection, chain failure, or reverse rotation. The brakes are designed to engage when de-energized. They engage in case of a malfunction of the loop drive train configuration.

The gripper mast assembly is suspended via two cables, with an equalizing system and break detector. A limit switch stops the lifting movement when the telescopic gripper mast reaches its upper end position. A load cell measures the weight of the suspended load and control circuits associated with the load cell allow for the brake actuation.

A load limiting device protects the fuel assembly during normal lifting movements in the core when contact occurs between two fuel assemblies. It limits the loads applied to the grids of the fuel assemblies and to the nozzles of the fuel assemblies.

During normal operation, the refueling machine can only travel within a defined “travel route”, thereby avoiding the possibility of inadvertent contacts. This route is determined by encoders and limit switches.

A limit switch prevents further lifting such that personnel exposure from an irradiated fuel assembly will not be > 2.5 mrem/hour. The RM is also provided with a dose rate measurement device and the lifting is stopped in case of exceeding the allowable dose rate limit.

The RM is provided with interlocks related to:

- Traveling or traversing.
- Lowering or lifting.
- Engaging or disengaging of the latches.
- Travel from one compartment of the pool to another.
- Preventing interference with the FTTF.

Fuel Transfer Tube Facility

The transfer tube is attached to the RB internal containment wall by means of a rigid and leak tight connection so as not to affect containment integrity. A metal expansion bellows welded to the transfer tube and to the frames of the building structure is provided at each end of the transfer tube. The bellows form close concentric volumes, which are equipped with a sensor for detecting leaks from the expansion joints. The sensors provide an alarm in the main control room.

The fuel transfer tube facility hoisting mechanism is equipped with an operational brake and a safety brake, which acts on the drum in case of overspeed, chain failure or reverse rotation. The winch is equipped with redundant cables that preclude the falling of a lifting frame to its horizontal position in the event of a cable failure. The brakes are designed to engage when de-energized. They engage in case of malfunction of the loop drive train configuration.

In case of an abnormal situation during fuel assembly transfer, the fuel assembly can be placed in a safe position. The fuel assembly can be moved by using either manual devices (hand wheels at the drives) or via the backup horizontal movement system of the conveyor car in case of an electrical or mechanical failure to place it in a safe state. The backup horizontal movement system can be used to return the conveyor car to the FB from any position in its normal travel in the event of control system malfunction. After returning the conveyor car, the fuel transfer tube gate valve can be closed manually.

A load cell is also provided, which prevents operation in the event of overloading or in case of a slack cable.

Each control desk is equipped with a manual switch which trips the main circuit breakers should the operator note a malfunction.

In addition to limit switches, the fuel transfer tube facility is provided with the following interlocks related to:

- Horizontal movement of the FTTF conveyor car.
- Tilting of the fuel container.

Spent Fuel Machine

The SFM hoisting mechanism is equipped with an operational brake, an auxiliary brake, and a safety brake, which acts on the drum in case of overspeed, chain failure or reverse rotation. The brakes are designed to be engaged when de-energized. They engage in case of malfunction of the loop drive train configuration.

The gripper mast assembly is suspended via two cables with an equalizing system and break detector. A limit switch stops the lifting movement when the telescopic gripper mast reaches the upper end position. A load cell prevents hoisting operation in the event of overload.

The spent fuel machine travel is limited to avoid a fuel assembly contacting the SFP walls, the FB transfer pit walls, and the loading pit walls.

The limit switch prevents further lifting such that personnel exposure from an irradiated fuel assembly will not be >2.5 mrem/hour. The SFM is also provided with a dose rate measurement device and the lifting is stopped in case of exceeding the allowable dose rate limit.

The SFM has provisions to manually move a fuel assembly in the event of an SFM malfunction or loss of power.

The SFM is provided with interlocks related to:

- Traveling or traversing.
- Lowering or lifting.
- Engaging or disengaging of the latches.
- Functioning of the FTTF, auxiliary crane, and NFE.
- Access to the fuel pool transfer pit.

New Fuel Elevator

The NFE hoisting mechanism is equipped with an operational brake, and a safety brake on the drum. The brakes are designed to be engaged when de-energized. The hoisting mechanism is provided with a cable equalizing system and a cable break detector. The movement is stopped if a cable break is detected. The hoisting mechanism is equipped with a load detection device and the movement is stopped in the event of a threshold overrun.

The NFE is designed to accommodate only one fuel assembly at a time and is provided with a radiation monitor that stops the NFE in the event of exceeding the radiation limits.

The design of the NFE contains physical barriers that maintain a minimum 12-inch spacing between any portion of a new fuel assembly in the NFE and any other fuel assembly, which could be dropped on or moved near a new fuel assembly in the NFE. This minimum distance prevents the occurrence of an inadvertent criticality during abnormal fuel movements or a fuel handling accident.

The NFE is provided with interlocks related to:

- Lowering or lifting.
- Functioning of the SFM.

Auxiliary Crane

Refer to Section 9.1.5 for safety provisions incorporated in the auxiliary crane.

Spent Fuel Cask Transfer Machine

The SFCTM is designed to remain in place and maintain structural support of the spent fuel cask, including during and following an SSE to prevent draining of the SFP. The supporting structure and other load bearing items of the machine are designed conservatively to maintain leak-tight integrity of the penetration assembly under design conditions, including the drop of the fuel assembly from the maximum handling height onto a connected cask.

A cask handling accident inside the FB is prevented by the design of the SFCTM. Anti-seismic locking devices engage the SFCTM with the walls of the loading hall when located at process stations to prevent movement during a seismic event. The lateral guiding device prevents tilting of the SFCTM when between stations in the loading hall. The SFCTM traveling motor brake is applied at every station prior to initiating cask handling activities at the respective station. Brakes are designed to be engaged when de-energized on a loss of power.

The anti-seismic locking devices maintain their status (locked/unlocked) during and after a large aircraft impact event and retain the operability for manual operation after the event.

SFCTM movements are stopped and fluid and pneumatic system valves required to isolate the cask and penetration assembly are closed on a loss of power.

Penetration Assembly

The penetration assembly is designed to maintain its leak-tight integrity following the drop of a fuel assembly from the maximum handling height of the spent fuel machine (Elevation 37' 7"). The double-walled bellows of the penetration is protected from impact by a protective shell. The radiological consequences of a fuel handling accident in the loading pit are bounded by the fuel handling accident analyzed in Section 15.0.3.10.

The penetration assembly is designed to perform safety-related functions during and following a SSE. The penetration assembly is designed to serve as part of the safety-related cask loading pit fluid boundary to prevent drainage of the SFP, both when the penetration is closed and when the penetration is connected to the cask. A brief unseating of the normally leak-tight connection at the mating surface of the cask may occur during the SSE, resulting in some seepage around the seals, but does not result in any significant loss of water inventory from the cask loading pit or SFP.

SFCTF Fluid and Pneumatic Systems

The portions of the SFCTF fluid and pneumatic systems connected to the cask and penetration up to the isolation provisions are designed to serve as part of the safety-related cask loading pit fluid boundary to prevent draining of the SFP including during and following a safe shutdown earthquake.

9.1.4.3.2 Safety Provisions for the Fuel Handling Tools

The new fuel handling tool is equipped with the ability to indicate proper resting of the tool on the fuel assembly top nozzle and the latched or unlatched status of the gripper. The new fuel handling tool is equipped with a mechanical locking system, which prevents unlatching of the gripper under load.

The spent fuel handling manual tool is equipped with means to indicate proper resting of the tool on the fuel assembly top nozzle and the latched or unlatched status of the gripper. The spent fuel handling manual tool is equipped with a mechanical locking system, which prevents unlatching of the gripper under load. The spent fuel handling manual tool is suspended from the crane by means of an extension piece, which confirms an acceptable amount of water shielding is present when the crane hook is in the upper position.

The fuel assembly insert handling manual tool is equipped with a mechanical locking system, which prevents unlatching of the gripper under load. The fuel assembly insert handling manual tool has an arrangement for guiding the fuel assembly insert during handling to avoid potential damage. The fuel assembly insert handling manual tool is equipped with means to indicate proper resting of the tool on the fuel assembly top nozzle. The fuel assembly insert handling manual tool is suspended from the auxiliary crane by means of an extension piece, which confirms an acceptable amount of water shielding is present when the crane hook is in the upper position.

Refer to Section 9.1.5 for safety provisions incorporated in the design of the auxiliary crane and polar crane for fuel handling.

9.1.4.3.3 Refueling Cavity Draindown Events

Rapid draindown of the refueling cavity resulting in fuel uncovery during refueling is not a credible event. The reactor vessel cavity ring is a permanently installed stainless steel assembly welded to the reactor vessel and the refueling cavity liner to prevent water leakage from the refueling cavity (Refer to Figure 9.1.4-12). The passive cavity ring design does not rely on active components such as pneumatic seals and is not susceptible to gross failure. Seals for openings in the refueling cavity liner do not rely on active components and do not pose a risk for rapid cavity draining.

The residual heat removal system and fuel pool cooling and purification system are potential paths for inadvertently draining the refueling cavity. For credible system misalignments, sufficient time is available to detect and isolate the drain path and to place a handled fuel assembly, if necessary, in a safe storage location.

Inadvertent draining of the refueling cavity is addressed by plant procedures. Key elements to be included in plant procedures to address inadvertent draining of the refueling cavity:

- Inspect accessible portion of the reactor cavity ring for damage at welds and the area that function as an expansion joint, including the protective cover (Refer to Figure 9.1.4-12), prior to filling the reactor cavity.

- Confirm that reactor cavity, connected pools, and systems have stable water levels and no evidence of abnormal leakage, prior to moving fuel.

- Continuously monitor water levels in reactor cavity, connected pools and IRWST during movement of fuel.

- Isolate system that is confirmed to be cause of inadvertent draining of refueling cavity.

- Identify and confirm availability of system(s) to make up water from the IRWST, if the cause of leakage is the reactor cavity ring or other leakage in the Reactor Building.

Any credible drainage from the refueling cavity will be detected visually or by installed instrumentation in adequate time to place a handled fuel assembly, if necessary, in a safe storage location. The safe storage location is either in the reactor core if an acceptable location is available or in the fuel transfer facility, where it can be positioned horizontally to increase shielding depth or can be transferred to the FB. Weirs in the RB and FB pools limit the loss of water in pool areas separated from the drain path by the weirs.

9.1.4.3.4 Cask Loading Pit Draindown Events

All cask loading pit (CLP) and SFCTF fluid boundary components and their supporting structures, which are required for maintaining the SFP water inventory, are classified safety-related and Seismic Category I. In addition, pressure retaining components, which are part of the fluid boundary, are classified Quality Group C and are constructed to ASME Section III Class 3 standards. Consequently, except for operator error, there are no design basis events that can result in draining the SFP, including seismic events.

The CLP and SFCTF operate in the following three basic configurations:

- CLP dry, with CLP slot and swivel gates closed, and the penetration assembly upper and lower cover closed.

- CLP flooded, with no cask attached to the penetration assembly; with the CLP slot and swivel gates open, and the penetration assembly upper and lower cover closed.

- CLP flooded, with a cask attached to the penetration assembly; with the CLP slot and swivel gates open, and the penetration assembly upper and lower cover open.

In all configurations the fluid retaining components and their supports are classified safety-related and Seismic Category I and are designed against a single active failure.

In addition, portions of the fluid boundary are designed against a single passive failure, such as the penetration assembly seals and bellows.

Beyond design basis events have been analyzed. In all cases, the SFP water level remains at least 10 feet above the active fuel in the spent fuel racks, except for the hypothetical worst case where both the CLP slot and gate valves are open and the penetration assembly upper and lower covers are open and the cask is not docked to the penetration assembly. In this hypothetical event, the SFP water level remains at least 2 feet above the top of the active fuel in the spent fuel racks.

The following U.S. EPR design features are available for the prevention, detection, and mitigation of leakage in the CLP and SFCTF:

Prevention Features

- Fluid boundary components and their supports are designated safety-related and Seismic Category I.
- Fluid boundary components, which are also pressure retaining, are designated Quality Group C.
- Leak tightness is tested prior to using the penetration assembly.
- Interlocks are provided that:
  - Prevent spurious movement of SFCTM during loading operations (Interlock CF12).
  - Prevent undocking of cask when penetration upper cover is open and water level in cask is outside the required range (Interlock CF15).
  - Confirm correct docking of cask to penetration. The anti-seismic devices on the SFCTM are locked and the seals between the penetration and cask are leak-tight prior to filling the penetration (Interlock CF16).
- Penetration assembly is designed to maintain leak-tight integrity following the drop of a fuel assembly.
- The SFCTF is designed to maintain the SFP fluid boundary during and following the beyond design basis large commercial aircraft impact event.
- Redundant active components:
  - CLP slot/swivel gate.
  - Penetration assembly top and bottom cover.
  - Normally-open valves in series.

Detection Features

- Monitor leak tightness of penetration assembly upper cover (Interlock CF18).
- Monitors baffle leakage.
- Monitors seal leakage.
- Monitors CLP level.

Mitigation Features

- Nuclear Island Drain/Vent System (NIVDS) is sized to accommodate volume of leakage.
- NIVDS diverts flow of leakage away from mitigation equipment.
- Available makeup water includes:
  - 25 gpm from safety-related, emergency-powered purification pump.
  - 400 gpm from purification pump suction from in-containment refueling water storage tank.

Draindown Events During Non-Cask Loading Operations

The two gates separating the SFP from the cask loading pit are described in Section 9.1.2.2.2. The gates do not rely on active equipment, such as inflatable seals, to maintain leak-tightness. The slot gate seals are compressed by the weight of the gate to create a leak tight barrier. The swivel gate has a locking mechanism which equally distributes pressure on the seal to create a leak tight barrier. The swivel gate is locked in both the open and closed positions. The gates are shown in Figure 9.1.2-9—Cask Loading Pit Gates. Unless spent fuel is being moved to the cask loading pit, both gates are closed. Failure of a single gate does not impact the water inventory in the spent fuel pool. During cask loading operations, the slot gate is removed, and the swivel gate is open to allow fuel movement into the cask loading pit.

The penetration assembly between the cask loading pit and the loading hall beneath the pit remains closed when cask handling operations are not occurring. The penetration assembly is closed by an upper cover at the bottom of the cask loading pit and a lower cover below the leak-tightness flange. The upper cover is a thick plate with a pressurization mechanism that pressurizes the cover uniformly and locks it closed for maintaining a leak tight seal. Two seals are provided to maintain leak-tightness between the upper cover and the supporting structure and compressed air is supplied between the two seals to monitor leak-tightness. A seismic locking device holds the upper cover in the closed position during and following an SSE as well as a beyond design basis large commercial aircraft impact event. The lower cover is a thick disk bolted to the leak-tightness flange of the penetration assembly with two seals providing leak-tightness. It is designed to support the weight of the water in the cask loading pit without the upper cover, which is an abnormal condition. In this condition, mechanical stops on the spring mounted devices shown in Figure 9.1.4-8—Cask Loading Pit Penetration Assembly, limit the displacement of the bottom cover.

Draindown Events During Cask Loading Operations

During cask loading operations, the cask loading pit is flooded, the slot gate is removed and the swivel gate is open to allow fuel movement into the cask loading pit. In this case, the spent fuel pool and cask loading pit are connected volumes. The cask loading pit is filled prior to opening the penetration assembly upper cover. The upper cover is prevented, by design, from opening if there is a pressure difference across the cover, thus preventing inadvertent opening before the penetration is filled. The docking system uses an irreversible screw design that prevents undocking on a loss of power.

When the penetration assembly is opened and the cask is connected (docked) to the cask loading pit, the pool boundary is extended to include the penetration assembly structure, the double-barrier bellows assembly, the leak-tightness flange, and the cask body. The penetration assembly, including the bellows and the leak-tightness flange, is a passive, safety-related, Seismic Category I component. Two concentric seals provide leak-tightness between the flange and the cask. A brief unseating of the leak-tight connection between the cask and the penetration is possible during a seismic event. This unseating would only exist for the brief period of the seismic event and may result in seepage around the sealing surfaces; however, it will not result in insufficient water inventory in the SFP. The connection will return to a leak-tight seal after the event.

A failure of one concentric seal will not cause leakage since a redundant seal is provided. A beyond-design-basis failure of both seals could result in leakage in the area between the top of the cask and the leak-tightness flange; however, because the cask is supported in place by the trolley, the gap from a failure of both seals would be very small. The leak rate would be slow enough to allow sufficient time for the operator to remove any fuel assembly in transit from the cask loading pit (lowering into the cask or returning it to the SFP) and to close the swivel gate between the SFP and the cask loading pit.

The postulated maximum flow rate from a beyond-design-basis failure of both seals is approximately 390 gpm. At this rate, it would take more than eight hours to drain the SFP and cask loading pit water volume to 10 ft above the top of the fuel assemblies, assuming no make-up capacity, initial operating water level of 62.3 ft, and no operator action. However, upon a visual detection of the seal failure or through the seal pressurization monitor, the operator would move any in transit fuel assemblies to a safe location in the SFP or cask and close the cask loading pit swivel gate. The operator actions could be completed within 30 minutes and would terminate the loss of SFP inventory. Make-up water is available via the in-containment refueling water storage tank (IRWST) and the SFP purification pump, which has a make-up capacity of 400 gpm. Therefore, there is sufficient time for operator intervention with minimal impact on SFP inventory and cooling.

There are four piping connections to the cask loading pit:

- Overflow piping (4 in line).
- Inlet purification piping (6 in line).
- Outlet purification piping (6 in line).
- Penetration structure piping (2 in line).

The overflow piping and the inlet purification piping enter the top of the cask loading pit. The inlet purification piping is 4.3 ft below the normal SFP level of 62.3 ft. If the cask loading pit were to drain to elevation 58 ft, there would be 24.7 ft of water above the top of the fuel assemblies in the SFP.

The outlet purification piping and the penetration structure piping are moderate energy lines. Per BTP 3-4, a pipe crack is assumed in each of these lines. The sum of the flowrate through these lines is approximately 75 gpm. Therefore, it would take >24 hours to drain the SFP to 10 ft above the top of the fuel assemblies, assuming no make-up capacity, initial operating water level of 62.3 ft, and no operator action. However, upon a visual detection of the piping failure or through level indicators in the pool, the operator would move any fuel assemblies in transit to a safe location in the SFP or cask and close the cask loading pit swivel gate. The operator actions could be completed within 30 minutes and would terminate the loss of SFP inventory. Make-up water is available via the IRWST and the SFP purification pump, which has a make-up capacity of 400 gpm. Therefore, there is sufficient time for operator intervention with minimal impact on SFP inventory and cooling.

The FB flooding analysis postulates a 6-inch pipe failure at the bottom of the cask loading pit. The release of water from this postulated failure would be detected by the operators performing the fuel transfer, as well as by level measurements. The released water volume is defined by a time period of 30 minutes. Since the FB flooding analysis assumes a 6-inch pipe failure, it bounds the postulated cracks in the 6-inch attached piping. Refer to Section 3.4.3.5 for a description of the FB flooding analysis.

9.1.4.4 Inspection and Testing Requirements

The safety-related components are located to permit preservice and inservice inspections. The FHS containment isolation function is testable. Refer to Section 14.2 (test abstracts #038 and #039) for initial plant testing of the FHS components. The performance and structural integrity of system components is demonstrated by continuous operation.

The fuel handling tools are load tested to 125 percent of the rated load prior to their initial use. Visual inspections are recommended for the fuel handling tools prior to use.

After installation of the SFCTF, inspections and testing are performed to confirm that components are correctly installed and operable. Before each cask loading campaign, the SFCTF is tested and inspected to confirm that the electrical and mechanical components will properly function during the cask loading campaign. Testing the functionality of the SFCTF components between cask loading campaigns is not necessary. However, the leak tightness of the SFCTF penetration assembly and CLP is continuously monitored between cask loading campaigns.

Pre-operational testing of the heavy load handling equipment is performed in accordance with Section 7420 of ASME NOG-1-2004. The required pre-operational tests include handling sequence tests, electrical circuit tests, leak-tightness tests and load tests. The handling sequence tests include placement of a dummy cask on the spent fuel cask transfer machine (SFCTM), removal of the biological lid, docking a dummy cask on the penetration assembly, opening the penetration assembly, undocking the dummy cask, and installation of the biological lid. Refer to Section 14.2.12.3.17 for a description of the pre-operational test of the SFCTF (Test #047).

The biological lid lifting station and the penetration upper cover hoist are load-tested to 125 percent of the rated load prior to their initial use.

Tests of the SFCTF equipment are performed before each cask loading campaign and include functional tests, overload protection tests, and leak tests. The tests include the following:

- The upper cover of the loading penetration assembly is tested for leak-tightness.
- Check of the geometry of the various components and functional clearances:
  - Straightness and alignment of the different components.
  - Position of guiding rails.
- Check of the motive parts (motors, brakes).
- Check of overload thresholds.
- Check of limit switches, overtravel switches, and speed and position sensors.

Refueling cavity ring and refueling cavity door seals will be inspected for leakage after filling the refueling cavity and before moving fuel to detect potential loss of refueling cavity water through passive barriers.

9.1.4.5 Instrumentation Requirements

In general, mechanical or electrical interlocks are provided, when required, to provide reasonable assurance of the proper and safe operation of the fuel handling equipment. The intent is to prevent a situation which could endanger the operator or damage the fuel assemblies and control components. The interlocks, setpoints, rules for handling fuel assemblies, and other devices that restrict undesired or uncontrolled movement are incorporated in the design. As a minimum, the interlocks specified in Table 1 of Reference 1 will be provided.

The spent fuel machine and new fuel elevator are remotely operated from their respective control desk on the FB floor. The refueling machine is remotely operated from a control desk located on the RB operating floor. The fuel transfer tube facility is provided with two control desks, one on the FB side and the other on the RB side. The refueling machine, spent fuel machine, new fuel elevator, and fuel transfer tube facility are provided with a safety feature, on their respective control desk, for an emergency shutdown of fuel movements. The spent fuel machine and refueling machine are equipped with an emergency stop provision on the equipment. The fuel transfer tube facility on the FB side has, on the fuel pool operating floor, a safety feature for an emergency stop. The new fuel elevator has a control box on the fuel pool operating floor.

SFCTF I&C Description

The SFCTF includes the following control panels:

- Main control panel in the SFCTF control room.
- Control panel on the SFCTM.
- Control panel on the operating floor for maneuvering the upper cover of the penetration assembly.
- Digital display for monitoring the water level in the cask and penetration assembly.

Instrumentation & control (I&C) devices, which provide interlocks and limit functions, are included in the design of the spent fuel cask transfer facility (SFCTF). However, these I&C devices do not perform any safety-related functions consistent with the requirements of U.S. EPR classification methodology for structures, systems and components (SSC) specified in Section 3.2. The I&C devices are provided for the protection of equipment and plant personnel. SFCTF I&C devices are located in the FB and on the SFCTM.

The following I&C devices are designed to the standards specified in References 9 through 26 and will be mounted to meet Seismic Category II requirements. They do not maintain their position during a seismic event.

- Position switches.
- Position limit switches.
- Travel limit detectors.
- Proximity detectors.
- Leak-tightness detectors.
- Electromagnetic or electronic relays.
- Over voltage relays.
- Under voltage relays.
- Level sensors.
- Programmable logic controllers (operational PLC and equipment protection PLC).
- Hardwired interlock devices.

The following I&C devices will be designed and mounted to meet Seismic Category I requirements:

- Accelerometers (two provided).

These devices will maintain their position during a seismic event.

There are two PLCs provided in the SFCTF I&C system. The operational PLC is used for normal control, operation and monitoring. The equipment protection PLC (non-safety-related) is used for monitoring movements and process statuses, and sensing failures, in order to stop cask movement and send alarms to the operator. The equipment protection PLC will have accelerometer inputs to alert the operator of a seismic event with alarms, and procedures will require operators to inspect input devices, sensors and mechanical components before power can be re-applied to the spent fuel cask transfer machine (SFCTM). In the case of a seismic event or system failure event, the equipment protection PLC outputs are set to zero or to the most conservative fail-safe state to stop operation of the SFCTF. If the equipment protection PLC and its sensors fail, the hardwired-interlock devices will stop the movements of the machinery. These hardwired interlock devices are used to generate emergency stops to stop cask movement and send hardwired alarm indications to the operator.

The following description identifies the priorities and interactions between the operational PLC, equipment protection PLC and the hardwired logic:

The operational PLC and equipment protection PLC both acquire SFCTF sensor signals. If the operational PLC fails or if sensor inputs are found to be invalid or failed, the equipment protection PLC assumes control of operation and initiates shutdown of the SFCTF machinery by applying the brakes and shutting off power to all motors. The equipment protection PLC always has priority over the operational PLC.

If the equipment protection PLC fails, the operational PLC is blocked and has no capability to move any parts of the SFCTF system. If the SFCTF machinery is still moving, the hardwired interlock logic takes over and stops the SFCTF machinery by removing power at the appropriate limit setting. The hardwired logic has priority over the operational PLC and the equipment protection PLC. The emergency stop switch is wired to the hardwired logic.

The hardwired logic has monitoring contacts wired such that if the hardwired logic fails, the brakes are applied and power is shut off to all motors.

The two redundant, Seismic Category I accelerometers have priority over all I&C devices, including both PLCs, and are wired to circuit breakers which remove the power to the SFCTF machinery when an SSE is detected. The circuit breakers are configured in series, so that either can remove power to the SFCTF machinery. These two circuit breakers will also be classified Seismic Category I.

In addition, the two accelerometers and the main circuit breakers are designed to the following standard:

- IEEE Std. 344-2004, “IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.”

The SFCTF interlocks and emergency stops are described in Table 9.1.4-2-SFCTF Non-Safety Related Interlocks and Emergency Stops.

Section 14.2.12.3.17 describes the preoperational test of the SFCTF and demonstrates the performance of I&C devices of the SFCTF during normal operation.

9.1.4.6 References

1. ANSI/ANS-57.1-1992; R1998; R2005 (R=Reaffirmed): “Design Requirements for Light Water Reactor Fuel Handling Systems,” American National Standards Institute/American Nuclear Society, 2005.

2. ANSI/ANS-57.2-1983: “Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants,” American National Standards Institute/American Nuclear Society, 1983.

3. ANSI/ANS-57.3-1983: “Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants,” American National Standards Institute/American Nuclear Society, 1983.

4. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Facility Components,” The American Society of Mechanical Engineers, 2004.

5. ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes,” The American Society of Mechanical Engineers, 2004.

6. ANSI N14.6, “Special Lifting Devices for Shipping Containers Weighing 10,000Pounds (4500 Kg) or More,” American National Standards Institute, 1993.

7. AISC Manual of Steel Construction, 9th Edition.

8. ASME B30.2-2005, “Overhead and Gantry Cranes ? Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist.”

9. IEEE C62.23-1995 (Revised 2001), IEEE Application Guide for Surge Protection of Electric Generating Plants.

10. IEEE C62.41.1-2002, “IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuit.”

11. IEEE C62.41.2-2002, “IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.”

12. IEEE Standard C62.45-1992, “IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.”

13. IEEE Std. 1050-1996, “IEEE Guide for Instrumentation Control Equipment Grounding in Generating Stations.” (this guidance will be used for non-safety I&C grounding in buildings where safety related cables and equipment are also installed).

14. IEEE Std. 1074-1995, “IEEE Standard for Developing Software Life Cycle Process.”

15. IEEE Std. 730-2002, “IEEE Standard for Software Quality Assurance Plans.”

16. IEEE Std. 828-1990, “IEEE Standard for Software Configuration Management Plans.”

17. IEEE Std. 829-1983, “IEEE Standard for Software Test Documentation.”

18. IEEE Std. 830-1993, “IEEE Recommended Practice for Software Requirements Specifications.”

19. IEEE Std. 1008-1987, "IEEE Standard for Software Unit Testing."

20. IEEE Std. 1012-1998, "IEEE Standard for Software Verification and Validation."

21. IEEE Std. 1016-1998, "IEEE Recommended Practice for Software Design Descriptions."

22. IEEE Std. 1028-1997, "IEEE Standard for Software Reviews and Audits."

23. IEEE Std. 1042-1987, "IEEE Guide to Software Configuration Management."

24. MIL-STD-461E, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment."

25. IEC 61000-Part 3, -Part 4 and -Part 6. Electromagnetic Compatibility (EMC).

26. EPRI TR-102323, "Guidelines for Electromagnetic Interference Testing of Power Plant Equipment," Revision 3.

27. ANSI/ANS/HPSSC-6.8.1-1981, "Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors," American National Standards Institute/American Nuclear Society, May 1981.

Table 9.1.4-1—Spent Fuel Cask Requirements

Type	Requirement
Dimensional Requirements	The dimensions of the cask are less than the following: • Height 5820 mm. • Diameter 2500 mm.
Dose Requirements	Dose rates from a loaded cask during cask handling operations do not exceed those identified in Section 12.3.
Cooling Requirements	The cask shall be capable of dissipating the decay heat from fuel assemblies loaded in the cask without supplemental cooling.
Material Requirements	The materials of construction of the cask are compatible with the operating environment including radiation, heat and borated water.
Support System Requirements	The cask shall have provisions for connecting process lines for water filling and draining, and drying of the cask. The mating surface of the cask maintains a leak-tight connection with the penetration assembly when the cask is connected to the penetration. The piping/valves that connect to the cask and serve as a fluid boundary to the cask loading pit up to and including the first valve (if a normally closed valve), or up to and including a second isolation valve (if a normally open valve with auto close or remote close capability) shall be designed in accordance with ASME Boiler and Pressure Vessel Code, Section III, The American Society of Mechanical Engineers, 2004.
Seismic Requirements	The cask shall be designed to withstand a site-specific safe shutdown earthquake (SSE), with seismic response spectra bounded by the generic response spectra shown in FSAR Figures 3.7.2-110, -111, and -112.
Structural Requirements	The loads transferred to the SFCTF components and FB structures under normal operating conditions are within the following: • Maximum weight of fully loaded cask, including spent fuel assemblies and water, is 115,000 kg. • Distributed loads on the walls of the loading hall do not exceed 25 psf during normal operation. • Distributed loads on the floor of the loading hall do not exceed 200 psf during normal operation. • Total dead weight load of the SFCTM and fully loaded cask on the floor of the loading hall does not exceed 858 kips during normal operation. The loads transferred to the SFCTF components and FB structures under a site-specific SSE and postulated drop of a fuel assembly from the maximum handling height in the cask loading pit onto a connected cask, are within the load capacity of the components and structures, and meet the leakage, dose and cooling requirements listed above.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 1 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 7	Interlock	Interlock of the penetration upper cover with SFM and the swivel gate.	The interlock prevents the movement of the upper cover of the penetration, when the SFM is in the loading pit and the swivel gate is open to prevent equipment damage.	• PLC and HSI display. • Limit switches.	• Switch 'off' the motor of the upper cover hoist. • Switch 'off' the operational and auxiliary brakes of the upper cover hoist.	Automatic – Alarm on SFCTF HSI display when the limit switches trip on 'open'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the limit switches trip on not 'open'.
CF 8	Interlock	Interlock of SFM with the upper cover.	This interlock prevents the movement of the SFM when the upper cover of the penetration is closed or partially opened to prevent equipment damage.	• PLC and HSI display. • Position switches. • Relays.	• Switch 'off' the SFM motor.	Automatic – Alarm on SFCTF HSI display when the position switches trip on 'open'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the position switches trip on not 'open'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 2 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 12	Interlock	[*Interlock the of the anti-seismic locking devices when the SFCTM is at the penetration station.*]*	This interlock prevents movement of the SFCTM during loading operations in the event of an SSE in order to prevent equipment damage.	• PLC and HSI display. • Limit switches. • Position switches.	• Switch 'off' the motor to the anti-seismic locking devices.	Automatic – Alarm on SFCTF HSI display when the position switches trip on 'open'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the position switches trip on not 'open'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 3 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 15	Interlock	Interlock of the penetration until upper cover is closed and the water level in the cask is within required range.	This interlock prevents undocking of the cask when the penetration upper cover is open and the water level in the cask is outside the required range to prevent water from leaking from the cask loading pit and water contamination in the Fuel Building.	• PLC and HSI display. • Limit switches. • Position switches. • Level sensors.	• Switch 'off' the undocking screw motors. • Switch 'off' the undocking screw electric brake.	Automatic – Alarm on SFCTF HSI display when the level sensor trips on 'high' or 'low' and position switches trip on 'open'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the level sensor trips on not 'high' or not 'low' and position switches trip on not 'open'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 4 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 16	Interlock	Interlock of the penetration until cask is correctly docked and monitoring the force on the seals between the penetration and the cask.	This interlock ensures correct docking of the cask to the penetration, the anti-seismic devices on the SFCTM are locked, and the seals between the penetration and cask are leak tight before filling the penetration to prevent water from leaking from the cask loading pit and water contamination in the Fuel Building.	• PLC and HSI display. • Limit switches. • Position switches. • Pressure sensor. • Relay. • Torque switches.	• 'Close' the valve used to perform leak tightness check.	Automatic – Alarm 'on' SFCTF HSI display when the torque switches trip on 'high', pressure sensor trips on 'high', and anti-seismic position switches trip on 'close'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the torque switches trip on not 'high', pressure sensor trips on not 'high', and anti-seismic position switches trip on not 'close'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 5 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF17	Interlock	Interlock the motion of the upper cover of the penetration with the cask water level.	This interlock ensures the correct water level is in the cask before opening the penetration upper cover to prevent water from leaking from the cask loading pit and water contamination in the Fuel Building.	• PLC and HSI display. • Temperature sensor. • Relay.	• Switch 'off' the motor of the upper cover hoist. • Switch 'off' the operational and auxiliary brakes of the upper cover hoist.	Automatic – Alarm on SFCTF HSI display when temperature sensor trips on 'high' or 'low'.	Alarm 'off' on the SFCTF HSI display (operator acknowledgement required) when temperature sensor trips on not 'high' or not 'low'.
CF 26	Interlock	[*Interlock of the SFCTM with loading hall door.*]*	This interlock prevents movement of the SFCTM when the loading hall door is open to protect against radiological releases.	• PLC and HSI display. • Limit switches.	N/A.	Automatic – Alarm on SFCTF HSI display when SFCTM electric brake limit switches trip on 'off' and loading hall door limit switch trips on 'open'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when SFCTM electric brake limit switches trip on 'on' and loading hall door limit switch trips on not 'open'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 6 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 2	Emergency Stop	Emergency stop in the loading hall.	After detecting an emergency stop push-button actuation in the loading hall, the SFCTM and associated fluid circuits are placed in a safe condition.	• PLC and HSI display. • Limit switches. • Position switches. • Relays.	• Switch 'off' the motor of the SFCTM. • Switch 'off' the electric brake of the SFCTM. • 'Close' the fluid circuit isolation valves.	Alarm on SFCTF HSI and MCR PICS displays when an emergency stop push-button is manually pressed.	Alarm 'off' on SFCTF HSI and MCR PICS displays (operator acknowledgement required) when the emergency stop-clear function button is pressed.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 7 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 3	Emergency Stop	General emergency stop in the SFCTF Control Room.	After detecting an emergency stop push-button actuation in the SFCTF control room, all electrically controlled equipment is placed in a safe condition.	• PLC and HSI display. • Limit switches. • Position switches. • Relays.	• Switch 'off' the motor of the SFCTM. • Switch 'off' the electric brake of the SFCTM. • Switch 'off' the motor of the upper cover hoist. • Switch 'off' the operational and auxiliary brakes of the upper cover hoist. • Switch 'off' the motor to the anti-seismic locking devices. • Switch 'off' all other electrical devices. • 'Close' the fluid circuit isolation valves.	Alarm on SFCTF HSI and MCR PICS displays when an emergency stop push-button is manually pressed.	Alarm 'off' on SFCTF HSI and MCR PICS displays (operator acknowledgement required) when the emergency stop-clear function button is pressed.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 8 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 10	Emergency Stop	Emergency stop of the upper cover penetration hoist.	After detecting an emergency stop push-button actuation for the upper cover penetration hoist, the upper cover hoist is placed in a safe position.	• PLC and HSI display. • Limit switches. • Position switches. • Relays.	• Switch 'off' the motor of the upper cover hoist. • Switch 'off' the operational and auxiliary brakes of the upper cover hoist. • Switch 'off' the motor to the anti-seismic locking device for the upper cover.	Alarm on SFCTF HSI and MCR PICS display when an emergency stop push-button is manually pressed.	Alarm 'off' on SFCTF HSI and MCR PICS displays (operator acknowledgement required) when the emergency stop-clear function button is pressed.
CF 5	Operational	Monitor cask water temperature.	The cask water temperature is monitored to prevent the fuel assemblies from overheating.	• PLC and HSI display. • Temperature sensor. • Relay.	N/A.	Automatic – Alarm on SFCTF HSI and MCR PICS displays when temperature sensor trips on 'high'.	Alarm 'off' on SFCTF HSI and MCR PICS displays (operator acknowledgement required) when moisture sensor trips on not 'high'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 9 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 18	Operational	Monitor leak tightness of upper cover.	The leak tightness of the upper cover is monitored to prevent fuel assembly overheating, water contamination in the Fuel Building, and increased dose rates.	• PLC and HSI display. • Level sensor.	N/A.	Automatic – Alarm on SFCTF HSI and MCR PICS displays when moisture sensor trips on 'high'.	Alarm 'off' on SFCTF HSI and MCR PICS displays (operator acknowledgement required) when level sensor trips on not 'high'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 10 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 19	Operational	Check the position of the upper biological protection plates and service elevator before travel of the SFCTM from the handling opening station to the lid handling station.	These conditions ensure the SFCTM has a clear path to move between the handling opening station and the lid handling station to prevent equipment damage.	• PLC and HSI display. • Limit switches. • Position switches.	• Switch 'off' the motor of the SFCTM. • Switch 'off' the electric brake of the SFCTM.	Automatic – Alarm on SFCTF HSI displays when SFCTM position switch trips on 'open', upper biological protection plate position switches trip on 'open', high-speed limit switch trips on 'on', and the service elevator position switch trips on 'low'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when SFCTM position switch trips on 'close', biological protection plate position switches trip on not 'open', high-speed limit switch trips on 'off', and the service elevator position switch trips on not 'low'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
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Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 21	Operational	Check position of the service elevator, of the lower plate, of the docking screws, if the upper biological protection plates, and of the penetration before travel of SFCTM from the lid handling station to penetration station and from the penetration to the lid handling station.	These conditions ensure the SFCTM has a clear path to move between the lid handling station and the penetration to prevent equipment damage.	• PLC and HSI display. • Limit switches. • Position switches. • Torque switches.	• Switch 'off' the motor of the SFCTM. • Switch 'off' the electric brake of the SFCTM.	Automatic – Alarm on SFCTF HSI displays when the SFCTM and lower plate limit switches trip on 'on', screw torque switches trip on 'low', upper biological protection plate limit switches trip on 'close', service elevator position switch trips on 'low', and high-speed limit switch trips on 'on'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the SFCTM and lower plate limit switches trip on 'off', screw torque switches trip on not 'low', upper biological protection plate limit switches trip on not 'close', service elevator position switch trips on 'high', and high-speed limit switch trips on 'off'.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
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Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF 27	Operational	[*Confirm SFCTM is placed in safe condition if an earthquake is detected.*]*	When the Seismic Category I accelerometers detect an earthquake, the main SFCTF circuit breakers are tripped, placing the electrically controlled equipment in a safe de-energized condition.	• PLC and HSI display. • Limit switches. • Position switches. • Accelerometers • Relays.	• Switch 'off' the motor of the SFCTM. • Switch 'off' the electric brake of the SFCTM. • Switch 'off' the motor of the upper cover hoist. • Switch 'off' the operational and auxiliary brakes of the upper cover hoist. • Switch 'off' the motor to the anti-seismic locking devices. • Switch 'off' all other electrical devices. • 'Close' the fluid circuit isolation valves.	Automatic – Alarm on SFCTF HSI displays when the accelerometers' limit switches trip on 'high'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) and hard-wired panel light when operator clears the alarm.

Table 9.1.4-2—SFCTF Non-Safety Related Interlocks and Emergency Stops
Sheet 13 of 13

Control Function	Control Type	Description	Function	I&C Components	Mechanical/ Electrical Actuations	Alarms (Initiation)	Alarms (Means of Clearance)**
CF28	Operational	Ensure the iodine extracting ventilation is operational prior to opening the biological lid.	This ensures the iodine extracting ventilation system is operational prior to opening the biological lid, preventing air contamination in the Fuel Building and increased dose rates.	• PLC and HSI display. • Limit switches. • Position switches.	N/A.	Automatic – Alarm on SFCTF HSI displays when the iodine extracting ventilation damper position sensor trips on 'off.'	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when the iodine extracting ventilation damper position sensor trips on 'on.'
CF 29	Operational	Monitor the leak tightness of the penetration assembly during cask loading operations.	The leak tightness of the penetration assembly is monitored to prevent water contamination in the Fuel Building and increased dose rates.	• PLC and HSI display. • Pressure sensor.	N/A.	Automatic – Alarm on SFCTF HSI displays when pressure sensor trips on 'high'.	Alarm 'off' on SFCTF HSI display (operator acknowledgement required) when pressure sensor trips on not 'high'.

**The alarms are displayed on the SFCTF HSI when the SFCTF is operational. The alarms are displayed on the MCR PICS during all modes of operation.

Figure 9.1.4-1—Refueling Machine

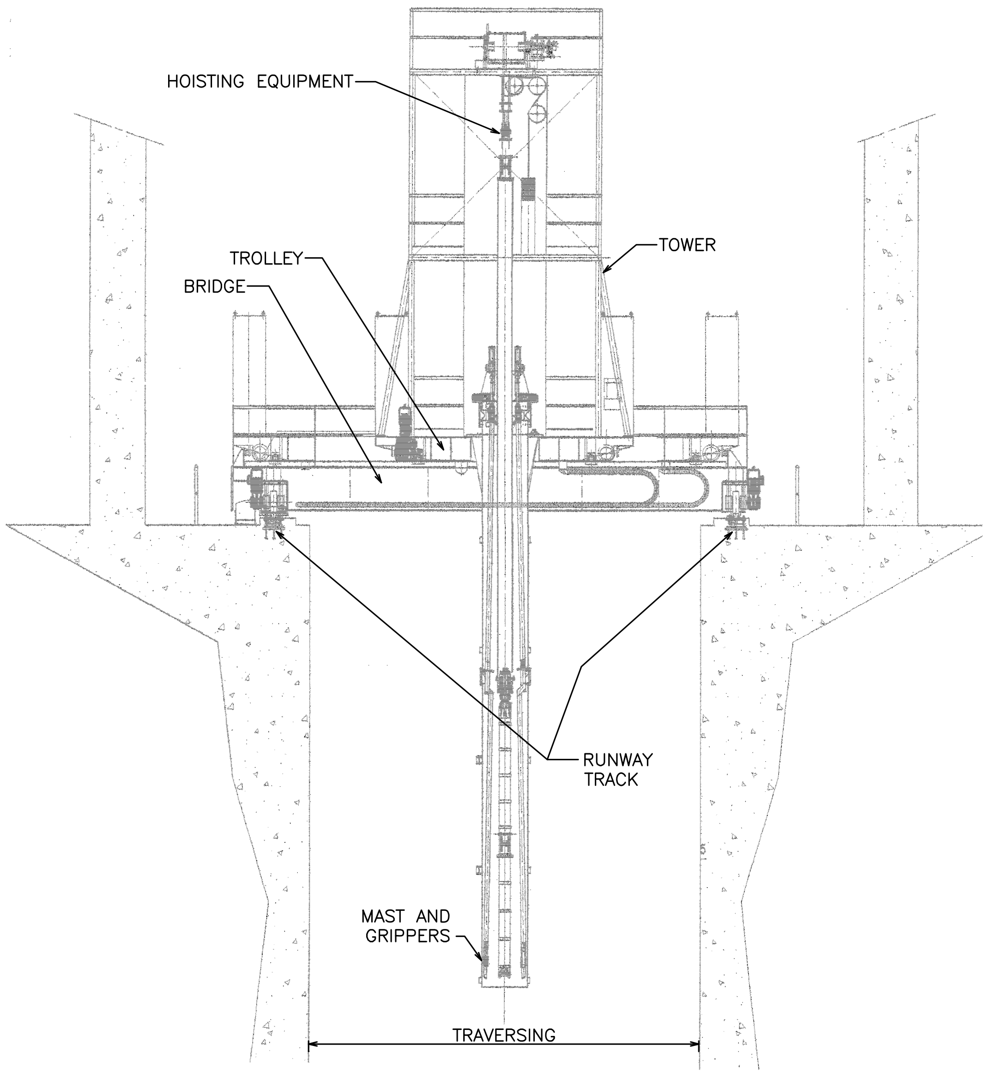

Figure 9.1.4-2—Fuel Assemblies Hoisting Mechanism

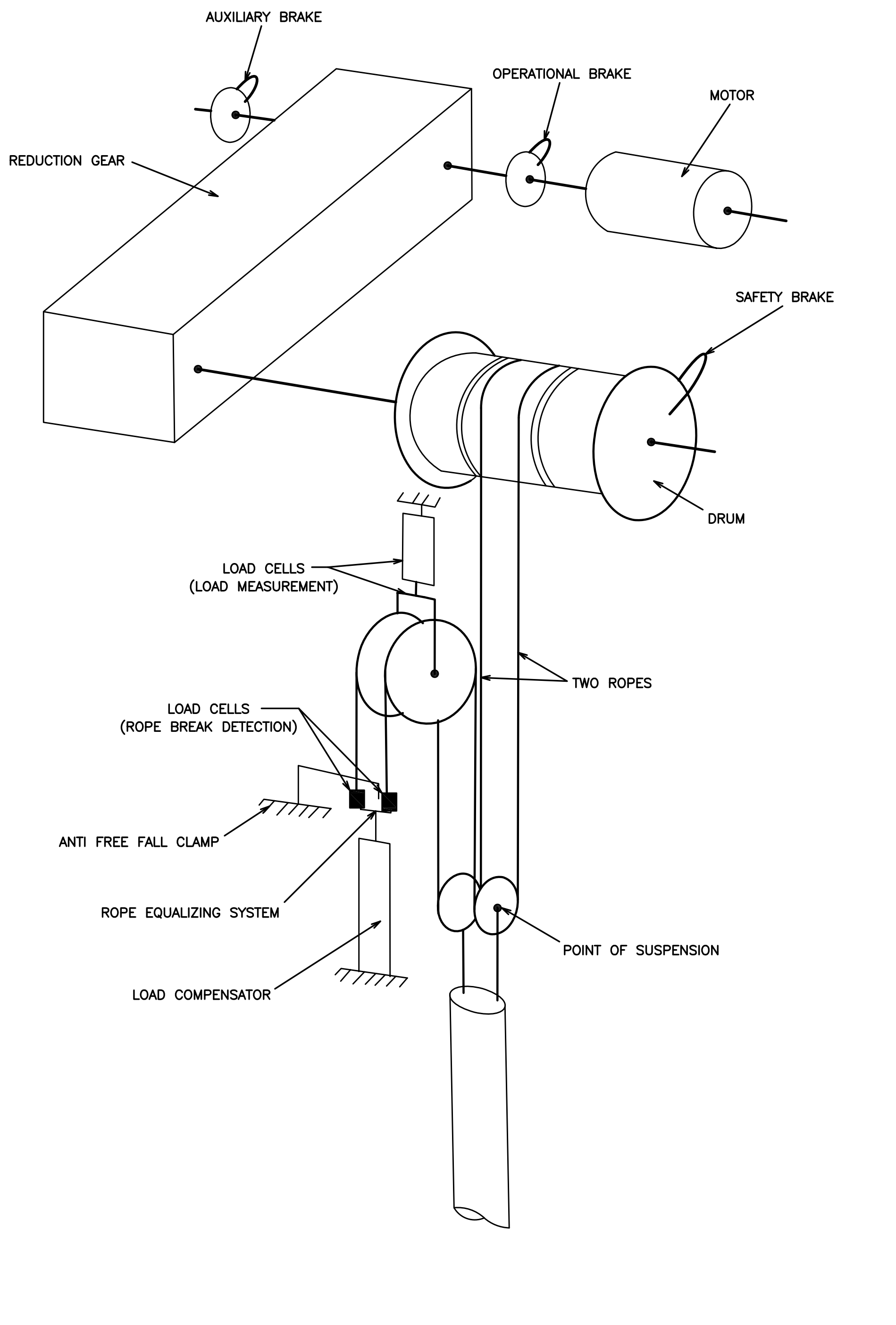

Figure 9.1.4-3—Fuel Transfer Tube Facility, Reactor Building

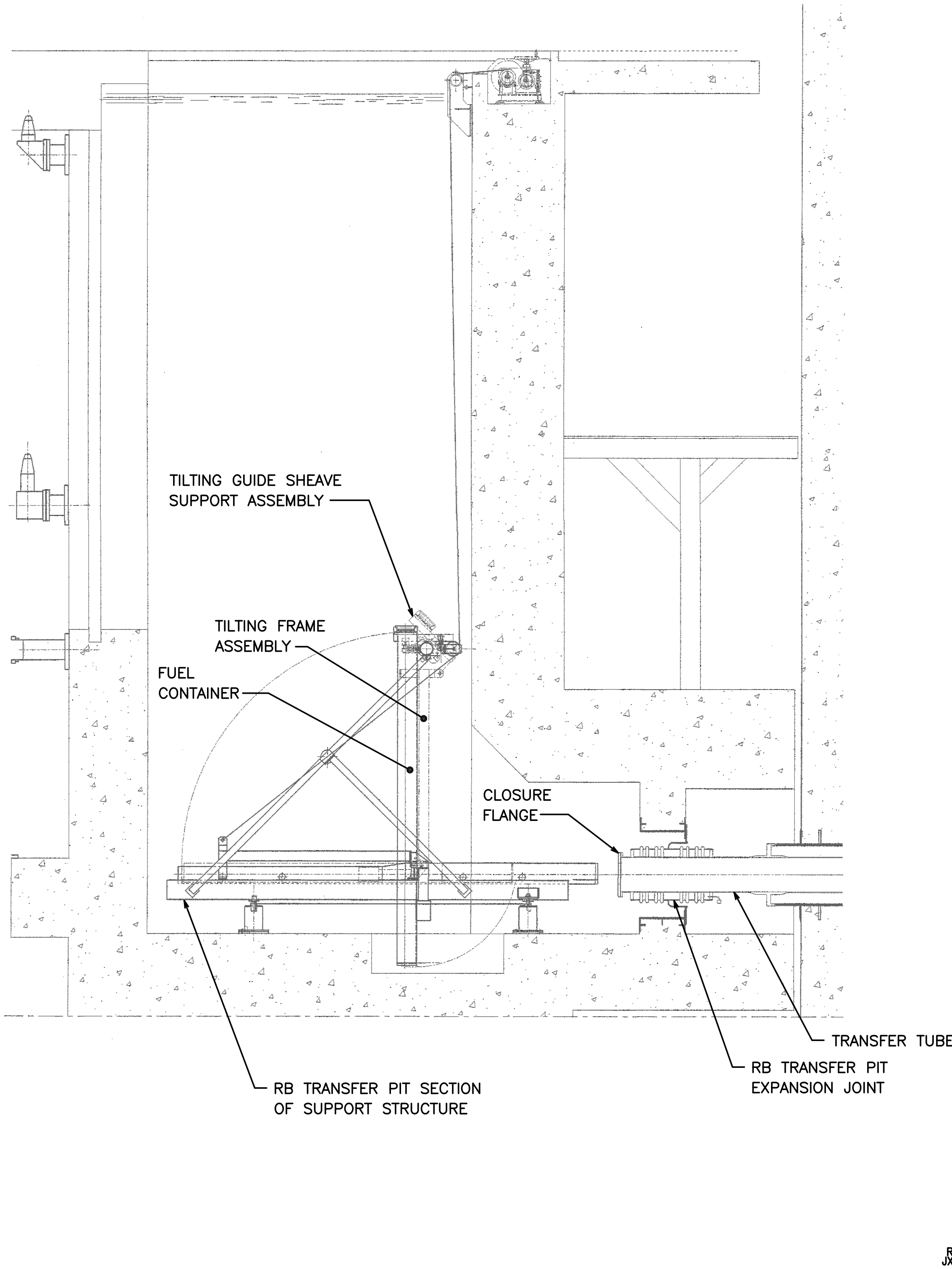

Figure 9.1.4-4—Fuel Transfer Tube Facility, Fuel Building

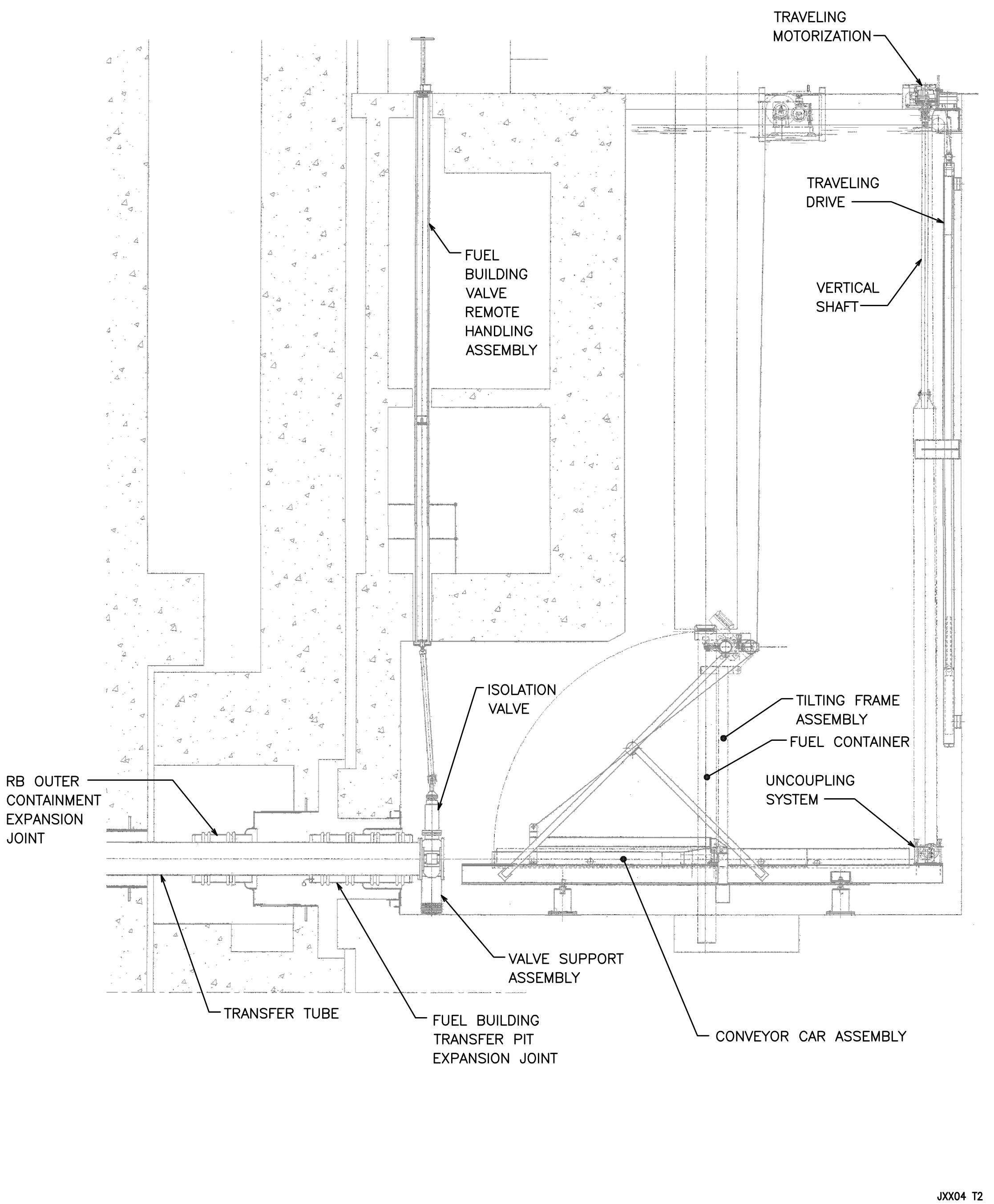

Figure 9.1.4-5—New Fuel Elevator

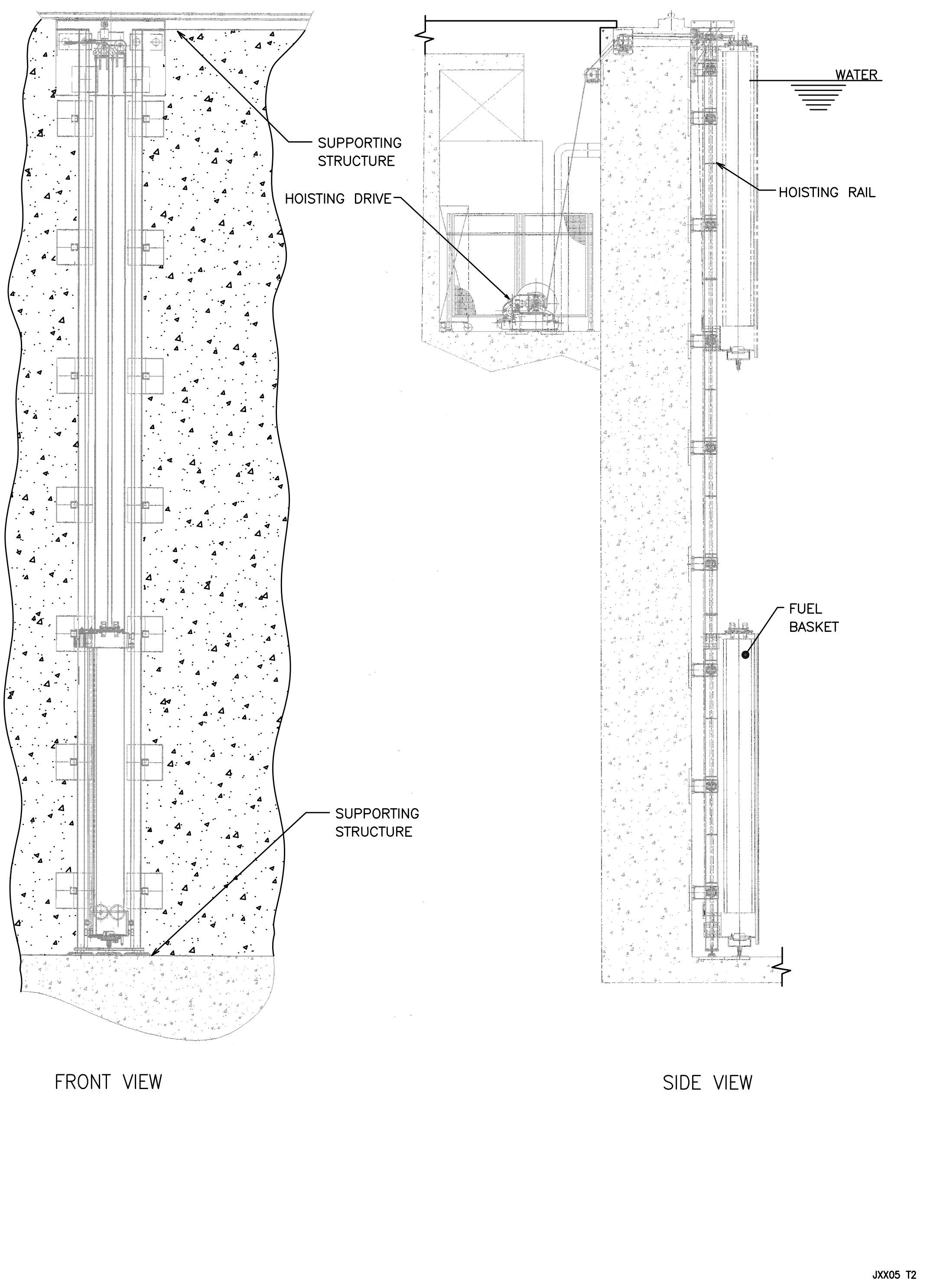

Figure 9.1.4-6—Spent Fuel Machine

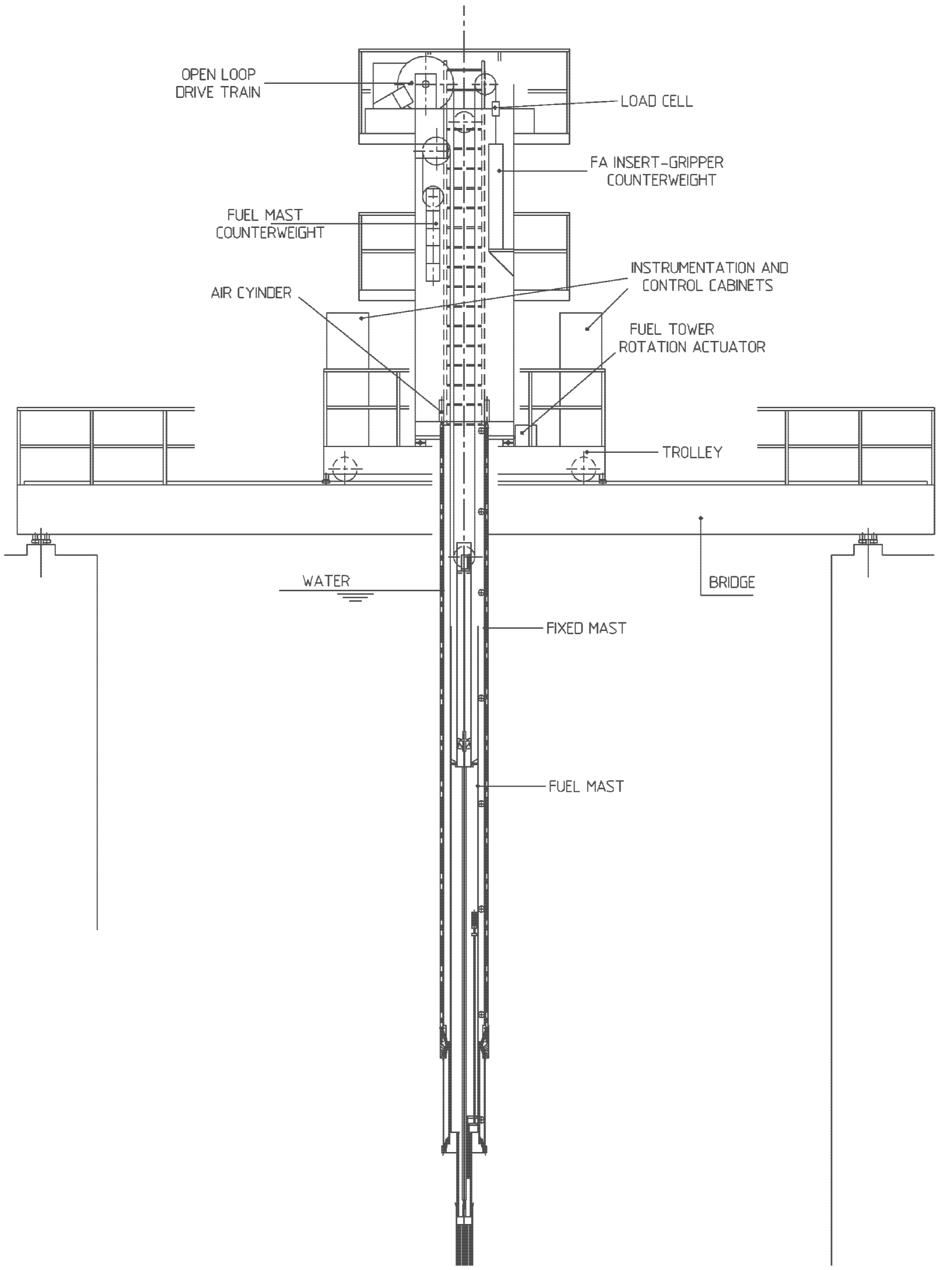

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Figure 9.1.4-7—Spent Fuel Cask Transfer Facility

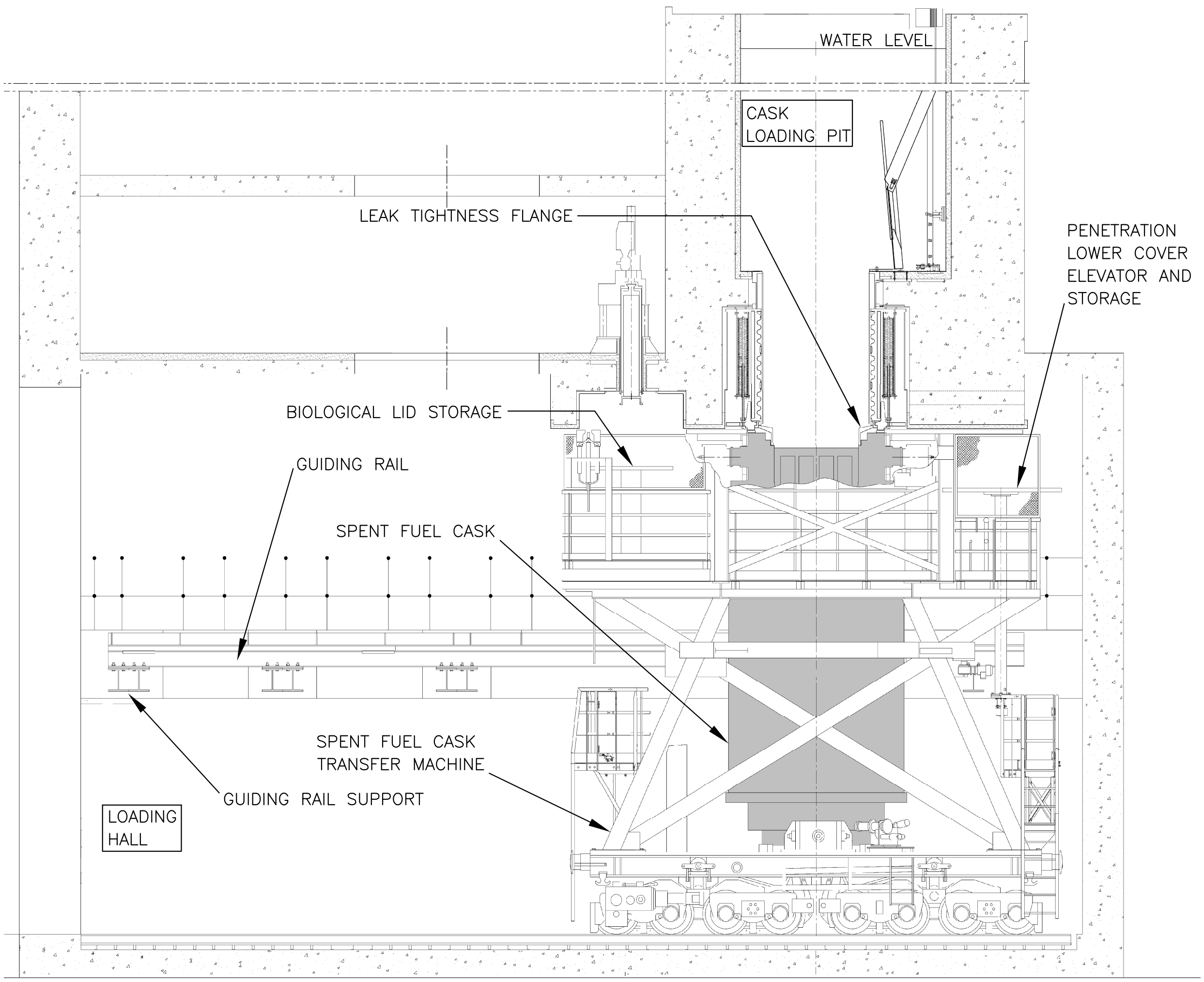

Figure 9.1.4-8—Cask Loading Pit Penetration Assembly

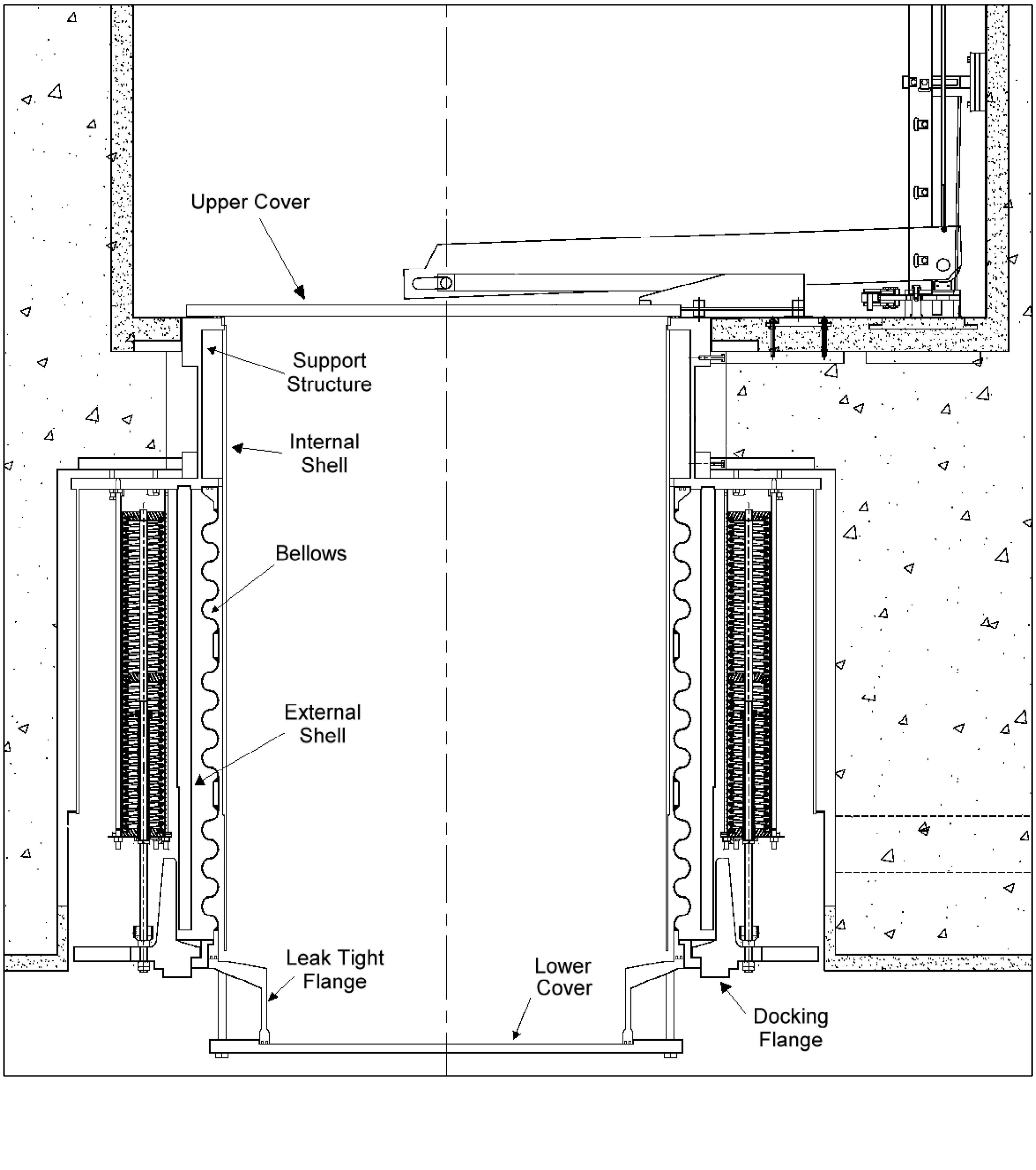

Figure 9.1.4-9—Loading Pit Penetration Assembly Seals

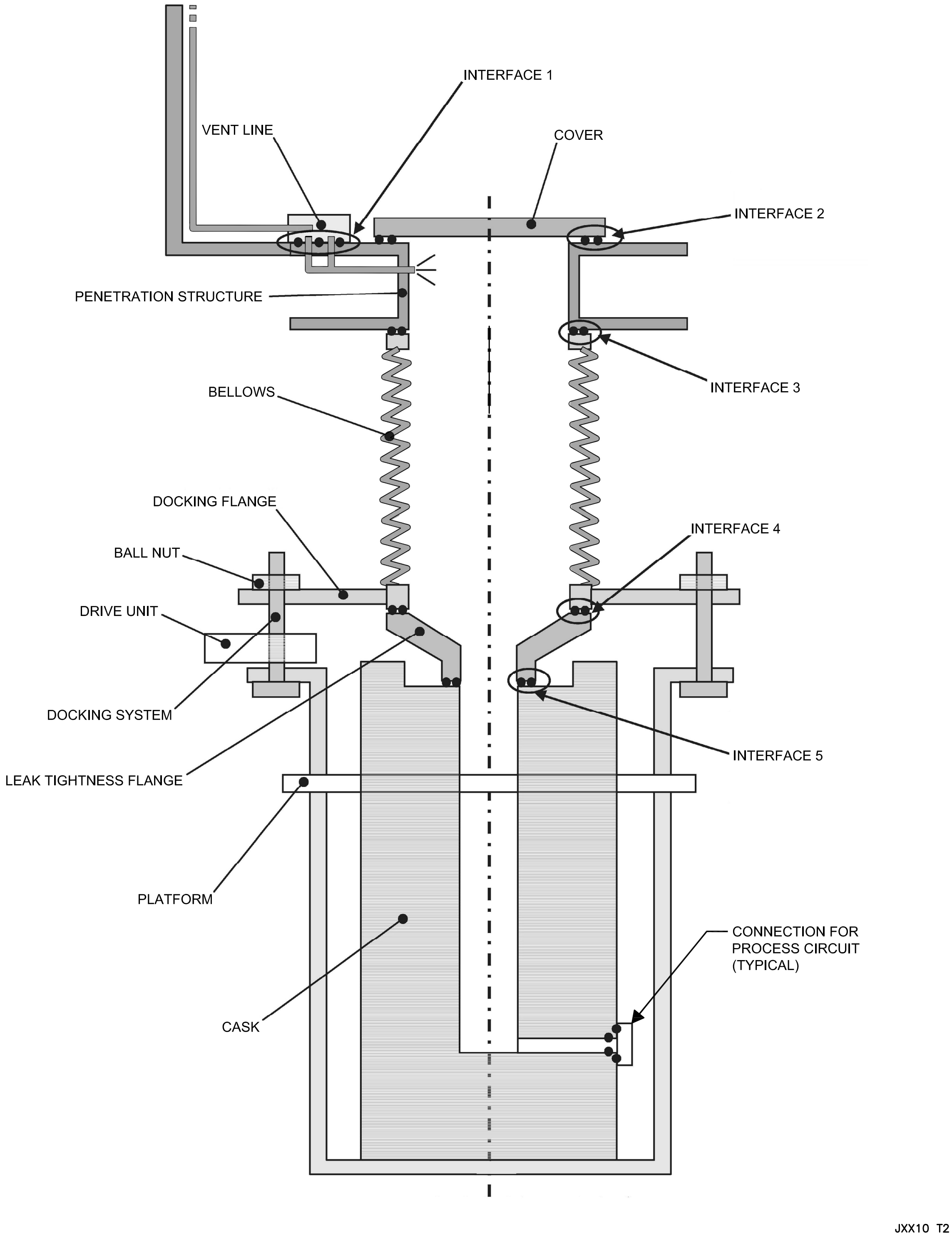

Figure 9.1.4-10—Loading Penetration Docking Mechanism

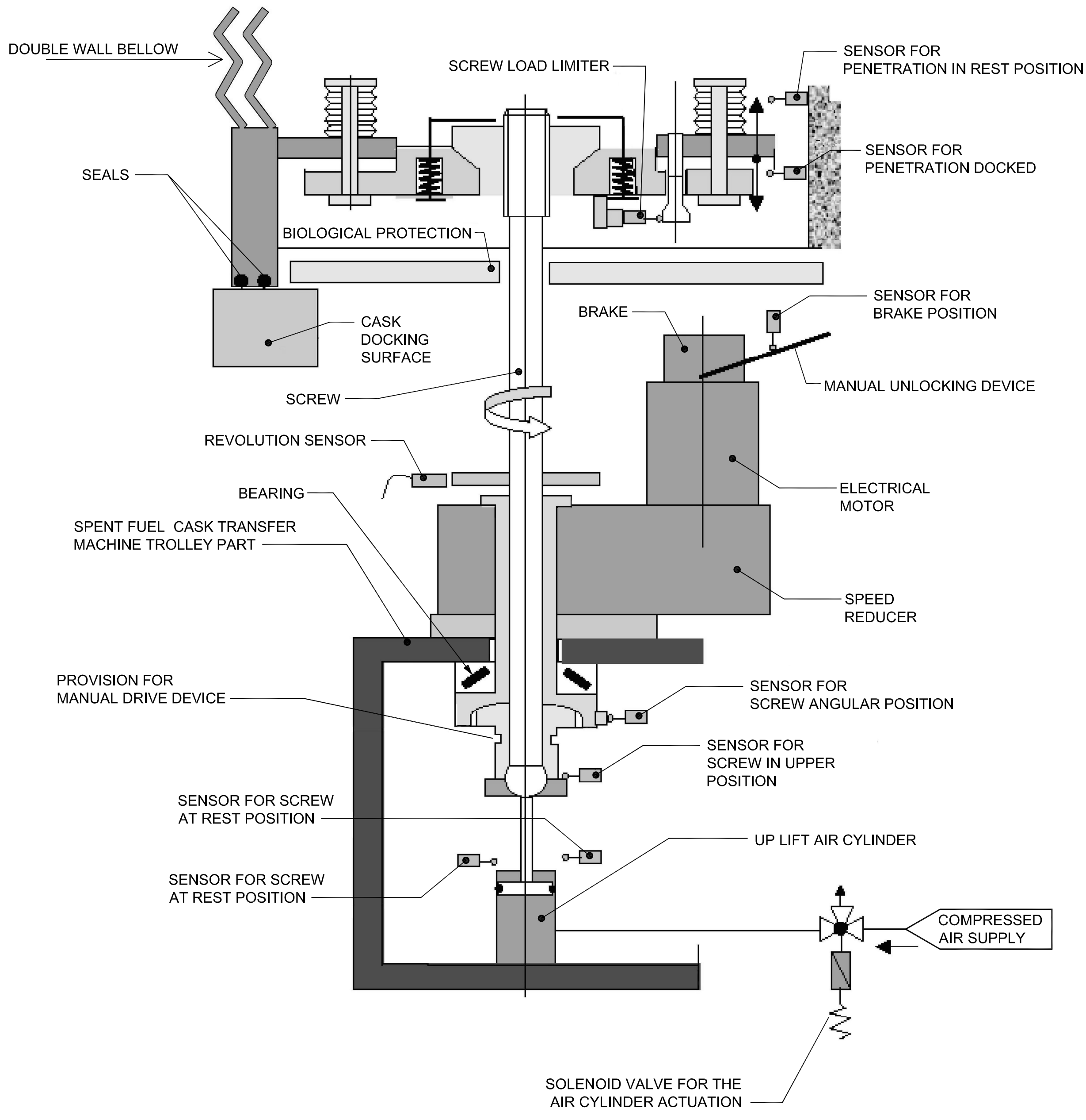

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Figure 9.1.4-11—Not Used

Figure 9.1.4-12—Permanent RPV Refueling Cavity Ring - General Configuration

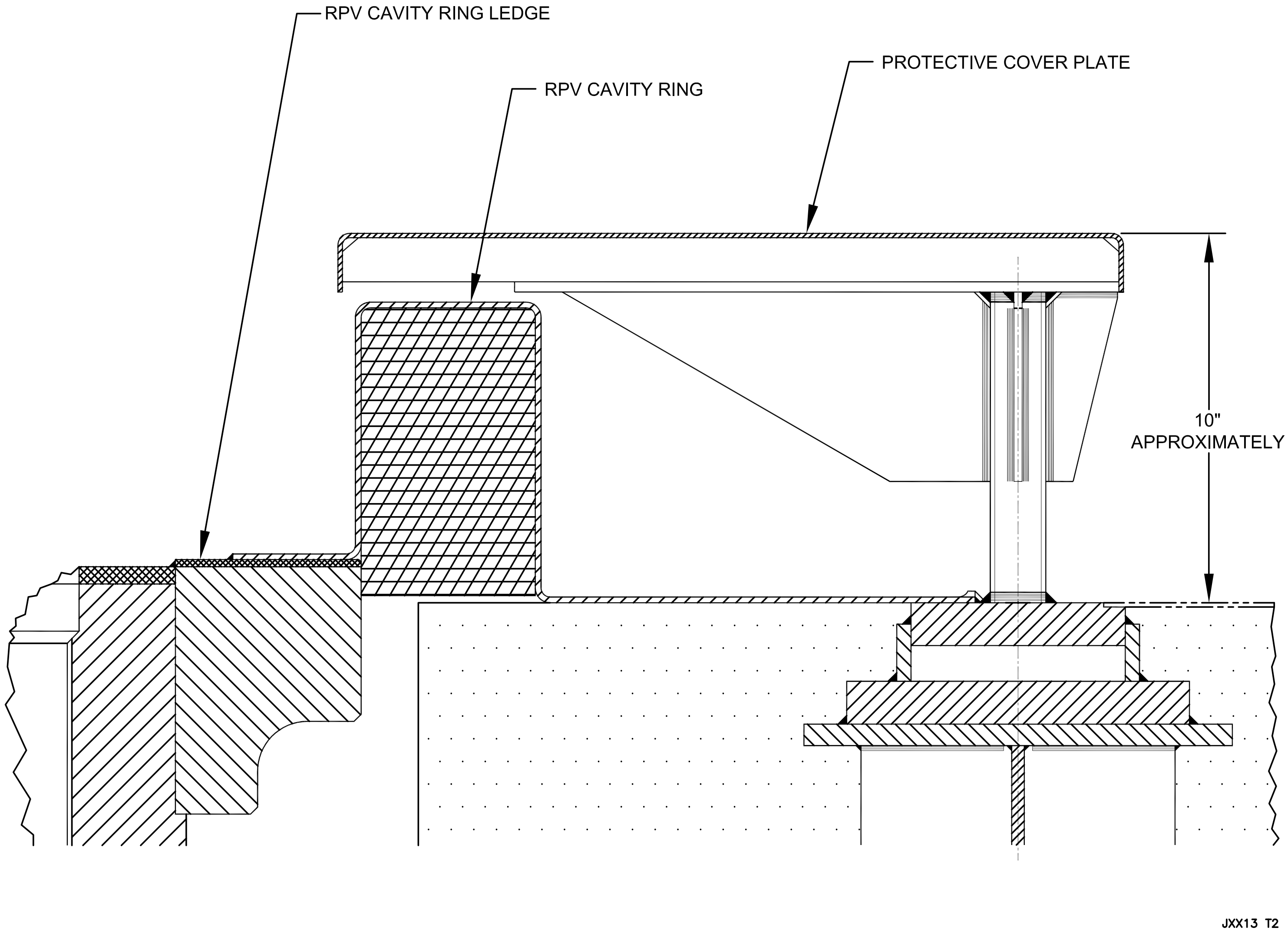
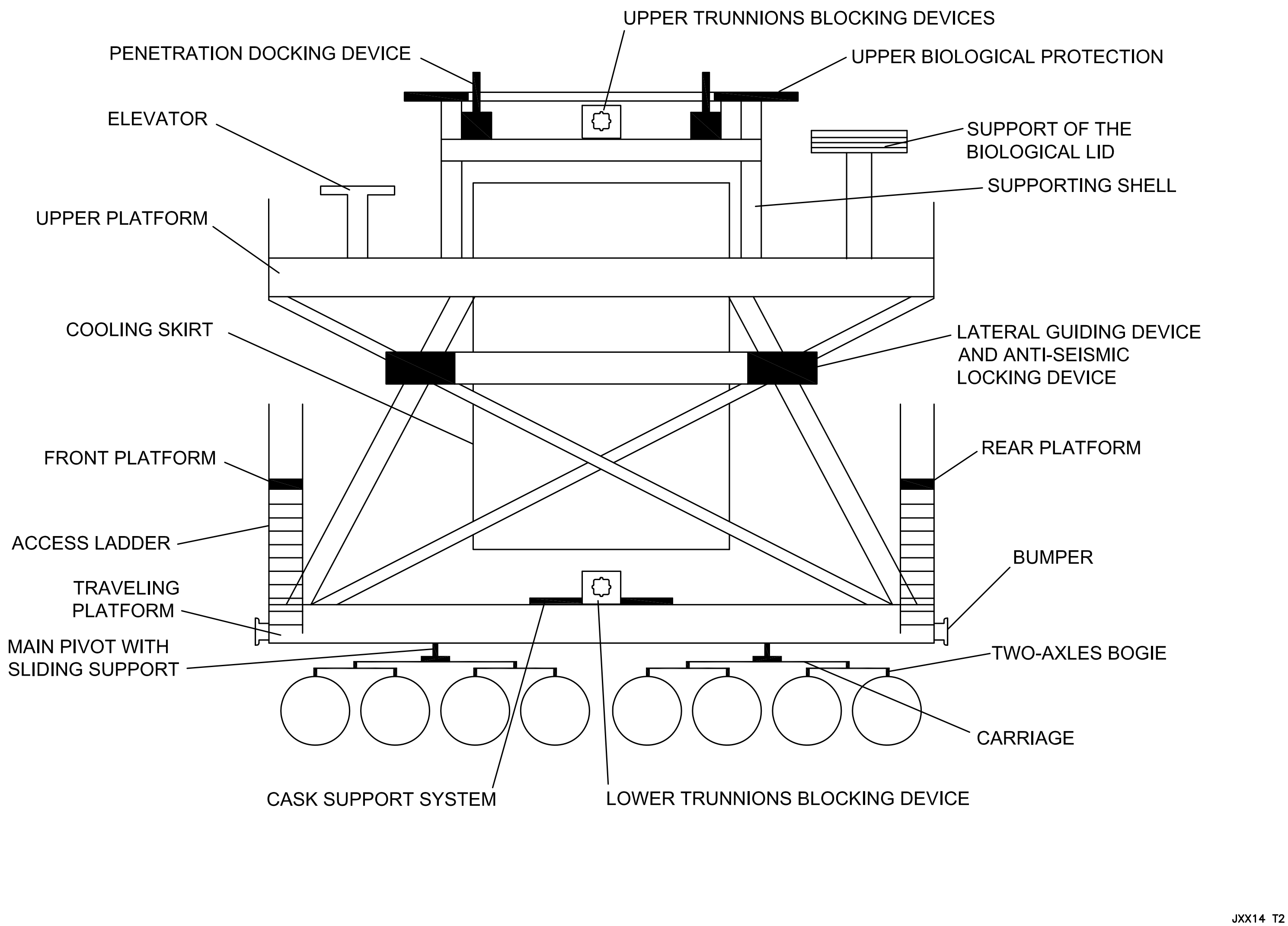


Figure 9.1.4-13—Spent Fuel Cask Transfer Machine - Main Structural Assemblies



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