9.1.2 New and Spent Fuel Storage

Since the design of the new and spent fuel storage racks is the responsibility of the COL applicant (see COL items identified in Section 9.1.2.2.1 and Section 9.1.2.2.2), the description of these items in this section is typical or representative. The NFSF and SFSF are both located within the reinforced concrete structure of the Fuel Building (see Section 3.8.4). The NFSF provides onsite dry storage for new fuel assemblies required for refueling the reactor. The SFSF provides onsite underwater storage for spent fuel assemblies and optional underwater storage of some of the new fuel assemblies. The SFSF provides storage locations for a minimum of 1020 spent fuel assemblies in a single fuel storage pool, which is constructed of reinforced concrete with a stainless steel lining. For a typical (based on an 18-month fuel cycle) refueling outage, approximately 96 fuel assemblies are offloaded into the spent fuel pool (SFP).

9.1.2.1 Design Bases

The functions of the NFSF and SFSF are to maintain new and spent fuel in a safe and subcritical array during all anticipated operating and accident conditions and to limit offsite exposures in the event of release of radioactive materials from the fuel. The spent fuel facility will also keep spent fuel assemblies adequately cooled during all anticipated operating and accident conditions. The safety-related functions and requirements related to the general design criteria (GDC) are as follows:

1. The NFSF and SFSF are protected from the effects of natural phenomena, including earthquakes, tornadoes, hurricanes, floods, and external missiles (GDC 2). The facility components meet the guidance presented in RG 1.13, positions C.1 and C.2, RG 1.29, RG 1.117, Reference 2, and Reference 1.

2. The NFSF and SFSF will remain functional after an SSE and will perform their intended function following postulated hazards such as fires, internal missiles, or pipe break (GDC 4). The facility components meet the guidance presented in RG 1.13, positions C.2 and C.3, RG 1.115, and RG 1.117.

3. Structures, systems, and components of the NFSF and SFSF that are important to safety are not shared with other units (GDC 5).

4. The NFSF and SFSF are designed with the capability to permit periodic inspections (GDC 61). The NFSF meets the applicable design requirements of Reference 1. The SFSF meets the applicable design guidance of RG 1.13 and the design requirements of Reference 2.

5. The depth of shielding water over the spent fuel will be sufficient to limit the radiation dose to acceptable levels (GDC 61). Details of the dose assessment are provided in Section 12.3.5.

6. The NFSF and SFSF provide appropriate containment, confinement, and filtering capability (GDC 61).

7. The SFSF provides adequate residual heat removal capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal (GDC 61).

8. Electrical and mechanical interlocks are provided to prevent the movement of loads over stored spent fuel.

9. Fuel pool radiation, water level, and water temperature monitoring are provided for the protection of personnel and to detect conditions that could result in the loss of decay heat removal capabilities. Alarms and communication systems are provided to alert personnel in fuel storage areas of excessive radiation levels (GDC 63). The SFSF meets position C.7 of RG 1.13 and the design requirements of Reference 2. For the NFSF, the design prevents an increase in effective multiplication factor (k_{eff}) beyond safe limits based on the requirements in 10 CFR 50.68(b). (Refer to Section 9.1.1.3).

10. The new fuel and spent fuel storage racks are designed for the following loads and combinations thereof:

    A. Dead loads.

    B. Live loads (fuel assemblies).

    C. Crane uplift load.

    D. Safe shutdown earthquake (SSE) loads.

    E. Operating basis earthquake loads.

    F. Handling impact loads.

11. The SFSF is designed to prevent the loss of cooling water within the pool that could uncover the stored fuel assemblies or prevent cooling capability (GDC-61). A redundant Seismic Category I emergency makeup water supply is provided.

12. The new fuel and spent fuel storage rack design precludes the placement of more than one fuel assembly in a single storage cell or inserting a fuel assembly between two storage cells.

Other important non-safety related design criteria for the NFSF and SFSF are also included, as discussed below:

- In accordance with the requirements of 10 CFR 20.1101(b), engineering controls are provided to keep radiation doses in the NFSF and SFSF to as low as reasonably achievable (ALARA) levels. Refer to Section 12.1 for further ALARA design details. A discussion of how the design meets the requirements of RG 8.8, section C.2, with regard to provisions for decontamination is provided in Section 12.3.1.

- Gaseous radioactivity above the SFP is maintained below the limits as defined in 10 CFR 20, Appendix B, table 1, column 1.

- A leak chase and collection system is provided for the detection of leaks in the spent fuel pool liner plate.

9.1.2.2 Facilities Description

9.1.2.2.1 New Fuel Storage

The NFSF is enclosed by the reinforced concrete structure of the Fuel Building. New fuel storage racks are located in the new fuel dry storage area inside the Fuel Building. These racks are designed to provide vertical storage of new fuel assemblies, either with or without rod cluster control assemblies. The design of the new fuel storage racks are the responsibility of the COL applicant. A COL applicant that references the U.S. EPR design certification will describe the new fuel storage racks, including a description of confirmatory structural dynamic and stress analyses. The racks must be shown to meet Seismic Category I requirements.

The new fuel storage rack location is shown in Figure 9.1.2-1—New Fuel and Spent Fuel Storage Rack Representative Layout. These representative new fuel storage racks provide support for the fuel assemblies and incorporate guide funnels at the top to facilitate insertion of the new fuel assemblies. Figure 9.1.2-2—Typical New and Spent Fuel Storage Rack Cross-Sections, provides a typical sketch of the new and spent fuel storage racks. Fuel assemblies are handled using the auxiliary crane equipped with the new fuel handling tool, as detailed further in Section 9.1.4.

Building features such as door thresholds, curbs, and floor openings are provided to prevent entry of water or other moderation media into the NFSF.

Refer to Section 3.2 for the seismic and system quality group classification of the new fuel racks. Non-safety-related equipment or structures not designed to Seismic Category I criteria that are located in the vicinity of the NFSF are evaluated to confirm that their failure could not cause an increase in the k_{eff} value beyond the maximum allowable.

9.1.2.2.2 Spent Fuel Storage

The spent fuel pool provides storage space for a minimum of 10 years worth of irradiated fuel assemblies, plus the capability for a full core offload from the reactor. The pool is a reinforced concrete structure (refer to Section 3.8.4) with a stainless steel liner having a nominal depth of 45 feet, 7 inches (29 feet above the tops of the stored fuel assemblies). Borated water is used in the spent fuel pool and is maintained at 1700 ppm. The concentration required for sub-criticality for spent fuel is approximately 1334 ppm (nominal enriched boron at ≥37 percent B-10). Figure 3.8-42 through Figure 3.8-46 and Figure 3.8-50 through Figure 3.8-52 show the spent fuel pool and other related fuel handling areas. Fresh unirradiated fuel assemblies are either stored in the NFSF or in the fuel storage pool (or both). Unirradiated rod control clusters and thimble plug assemblies are normally stored in the fuel assemblies in the SFP.

The underwater fuel storage racks are located in the spent fuel storage pool inside the Fuel Building. The design of the spent fuel storage racks are the responsibility of the COL applicant. A COL applicant that references the U.S. EPR design certification will describe the spent fuel storage racks, including a description of confirmatory structural dynamic and stress analyses and thermal-hydraulic cooling analyses. The racks must be shown to meet Seismic Category I requirements. Spent fuel rack materials will be compatible with the pool storage environment. Rack structural materials must be corrosion-resistant and compatible with the expected water chemistry of the SFP.

Figure 9.1.2-1 shows the spent fuel rack storage location within the spent fuel pool.

Figure 9.1.2-2 provides a typical sketch of the new and spent fuel storage racks. The rack modules will be designed as cellular structures so that each storage cell has a square opening with conforming lateral support and a flat horizontal bearing surface. Each storage cell will have a hole in or near the bottom and a rectangular opening on the top of the cell to allow cooling water to flow through the storage cell. To provide reasonable assurance that no fuel can be damaged, each storage cell will be designed to prevent any portion of a fuel assembly or core component from extending above the top of the rack. The spent fuel storage racks will also be designed to withstand the impact resulting from a falling fuel assembly under normal loading and unloading conditions and will be designed to meet Seismic Category I requirements.

The design of the SFP is such that inadvertent draining of water from the pool is prevented (see Section 9.1.3). The concrete structures for the SFP, SFP liner, and fuel transfer canal are designed in accordance with the criteria for Seismic Category I structures contained in Section 3.7 and Section 3.8. As such, they are designed to maintain leak-tight integrity to prevent the loss of cooling water from the pool. In addition, all piping penetrations into the pool are designed to preclude draining the pool down to an unacceptable limit, as described in Section 9.1.3.

The spent fuel pool liner leak chase system consists of either half pipes, structural steel channels, or similar configurations embedded in the concrete, segregated into sectors, and interconnected to the exterior side of the pool liner. Leakage, if any, from the stainless steel pool liner plate welds is monitored and routed to collection areas in order to determine the amount of leakage, its location, and proper disposal. The design of the system is such that it provides easy accessibility for inspections, removal of blockages, and testing. The stainless steel liner plate welds are tested for leak-tightness during fabrication, after erection, and during plant life at discreet intervals.

Borated demineralized reactor makeup water is used to fill and to supplement water inventory in the spent fuel pool, but boration is not essential for maintaining the subcriticality of the stored fuel assemblies.

Adjacent to the SFP is a separate spent fuel cask loading pit. This pit is used when the spent fuel is to be shipped offsite. The pit area is only filled with water during spent fuel removal procedures. A gate separates the cask loading pit from the SFP, and is opened only for cask loading operations.

The Reactor Building and the Fuel Building are connected by a fuel transfer tube. This tube is fitted with a blind flange, two gate valves, one on each end.

The Fuel Pool Cooling and Purification System (FPCPS) functions to limit the spent fuel storage pool temperature to 140°F during non-refueling plant conditions, and to remove impurities from the water to improve visual clarity. A description of the FPCPS is provided in Section 9.1.3.

During fuel handling operations, a controlled and monitored ventilation system removes gaseous radioactivity from the atmosphere above the spent fuel pool and processes it through high efficiency particulate air (HEPA) filters and charcoal adsorber units to the unit vent. Refer to Section 9.4.2 for a description of the spent fuel pool area ventilation system operation and to Section 11.5 for the process ventilation monitors.

Section 9.1.4 details the load-bearing capability of the cranes serving the SFSF. Section 9.1.4 also provides an evaluation that demonstrates that the maximum uplift force is due to the SFP bridge crane and the maximum impact load is due to a dropped fuel assembly. The racks will be designed to withstand the maximum uplift force and the maximum impact load with no increase in k_{eff}.

Refer to Section 3.2 for the seismic and system quality group classification of the spent fuel racks. Non-safety-related equipment or structures not designed to Seismic Category I criteria that are located in the vicinity of the SFSF will be evaluated to confirm that their failure could not cause an increase in the k_{eff} value beyond the maximum allowable k_{eff}.

9.1.2.3 Safety Evaluation

As discussed in Section 9.1.2.2, the COL applicant will provide a summary of the structural dynamic and stress analyses associated with the fuel racks.

The safety evaluation that follows corresponds to the safety-related functions and requirements associated with the GDCs in Section 9.1.2.1:

1. The NFSF and SFSF are located within the Fuel Building, a Seismic Category I structure. The Fuel Building is designed to withstand shipping, handling and normal operating loads, as well as the effects of external hazards such as earthquakes, tornadoes, hurricanes, floods, and external missiles. 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 the building.

2. The NFSF and SFSF are designed to remain functional after an SSE. Section 3.7 and Section 3.9 provide the design loads that were applied. The results of the hazards analyses are presented in Section 9.5.1 (fire), Section 3.5, and Section 3.6 and show that the NFSF and SFSF can perform their intended function following postulated internal hazards.

3. The NFSF and SFSF are capable of storing the required number of fuel assemblies, in accordance with the design basis. Structures, systems and components (SSC) are not shared with other units.

4. The NFSF does not require any shielding and is accessible for periodic inspections. Access to the SFSF is provided for periodic inspection as shown in Figure 3.8-42 through Figure 3.8-46 and Figure 3.8-50 through Figure 3.8-52.

5. A minimum of 23 feet of water above the tops of the spent fuel pool assemblies in the spent fuel racks provides sufficient shielding to limit radiation doses to personnel in the spent fuel pool area to minimal values in keeping with the ALARA approach described in Section 12.1.

6. Containment and confinement are provided in the SFSF by the spent fuel pool liner and by the ventilation system for the Fuel Building (see Section 9.4.2). The joint welds that require initial testing and subsequent monitoring of weld integrity will be provided with a leak chase system. A monitoring system is provided for the leak chase system. Any water collected is directed to the floor and equipment drain system and transferred to the liquid radwaste system for processing. Filtering of the spent fuel pool water is provided by the FPCPS (see Section 9.1.3). For the NFSF, appropriate confinement of the new fuel assemblies is provided by the new fuel storage racks located inside the concrete structure of the new fuel vault.

7. The FPCPS maintains the spent fuel pool water temperature and water level within prescribed limits by removing decay heat generated by the stored spent fuel assemblies (see Section 9.1.3).

8. As described in Section 9.1.4.5 for the fuel handling system (FHS), instrumentation, and electrical and mechanical interlocks are provided to prevent movement of loads over the spent fuel.

9. Instrumentation is provided to monitor the pool water level and water temperature (see Section 9.1.3) to provide indication of the loss of decay heat removal and to warn personnel of potentially unsafe conditions. In addition, area radiation monitors are provided near the SFP which will provide a distinct audible

and visual alarm to alert personnel in the vicinity of the need to take appropriate action. Refer to Section 12.3.4 for further details on the area radiation monitors.

10. Stresses in the fully loaded new fuel and spent fuel racks must not exceed stresses specified by ASME Code, Section III, Division I, Part NF, as well as guidance given in RG 1.124. The racks will be designed to withstand the maximum uplift force of the auxiliary crane.

11. The spent fuel is stored within a stainless steel lined concrete pool which has no penetrations that can result in an unacceptable loss of water. As described in Section 9.1.3, the FPCPS provides makeup water for the SFP. The concrete structures for the SFP and fuel transfer canal are designed to maintain leak-tight integrity to prevent the loss of cooling water from the pool. All piping penetrations into the pool are designed to preclude draining the pool down to an unacceptable limit, as described in Section 9.1.3.

12. The rack will be designed so that it is impossible to insert or jam a fuel assembly between two adjacent storage positions.

9.1.2.4 Inspection and Testing Requirements

Refer to Section 14.2 (test abstract #038) for initial plant startup test program related to the proper operation of the fuel handling equipment, including the spent fuel storage rack positions.

9.1.2.5 Instrumentation Requirements

Instrumentation is provided to monitor the pool water level and water temperature (see Section 9.1.3) to provide indication of the loss of water and degradation of the decay heat capability. As described in Section 12.3.4, area radiation monitors are placed near the NFSF and the SFSF which provide a clear audible and visual alarm to alert personnel in the vicinity of abnormal radiation levels and the need to evacuate the area.

9.1.2.6 References

1. 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.

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.

Figure 9.1.2-1—New Fuel and Spent Fuel Storage Rack Representative Layout

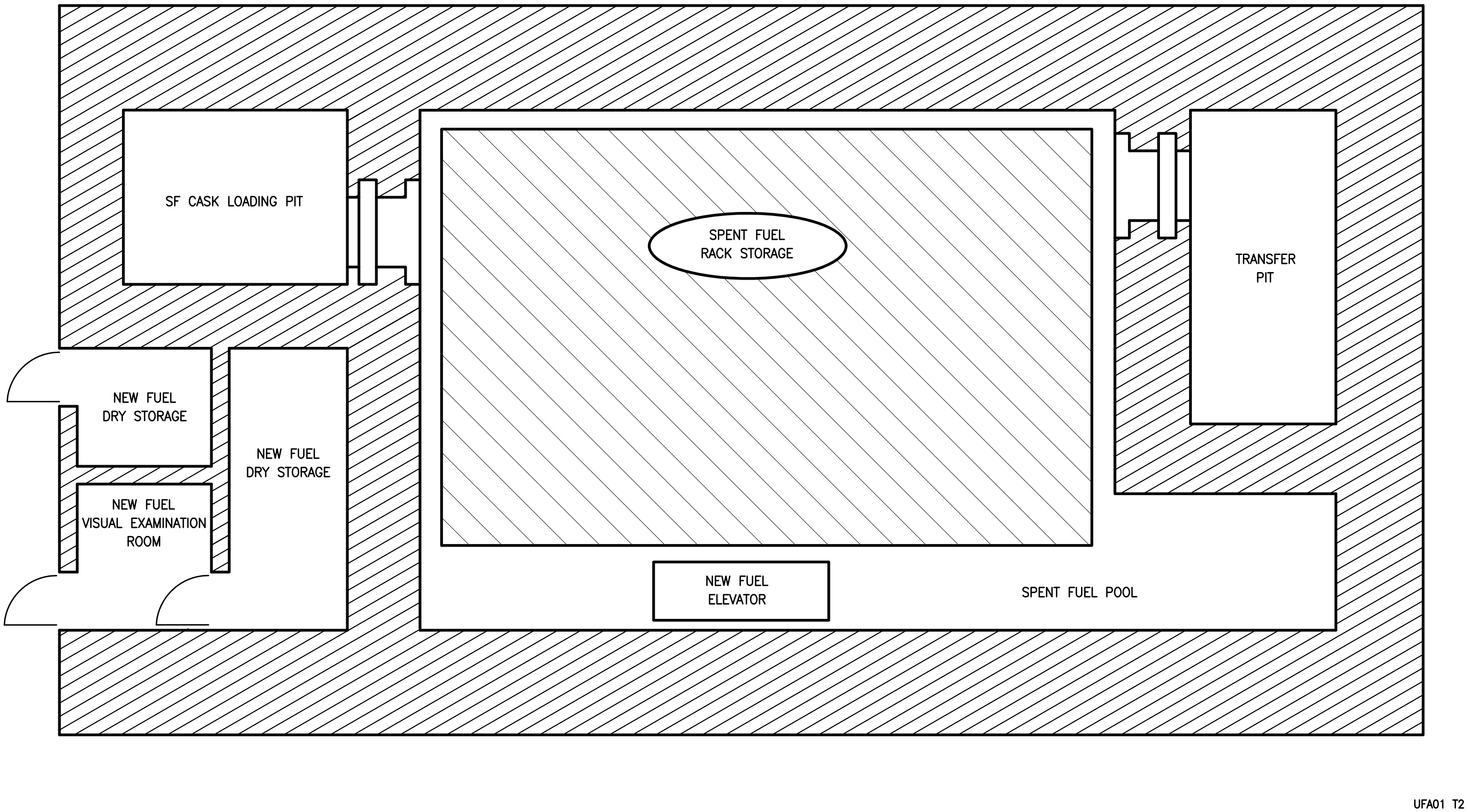
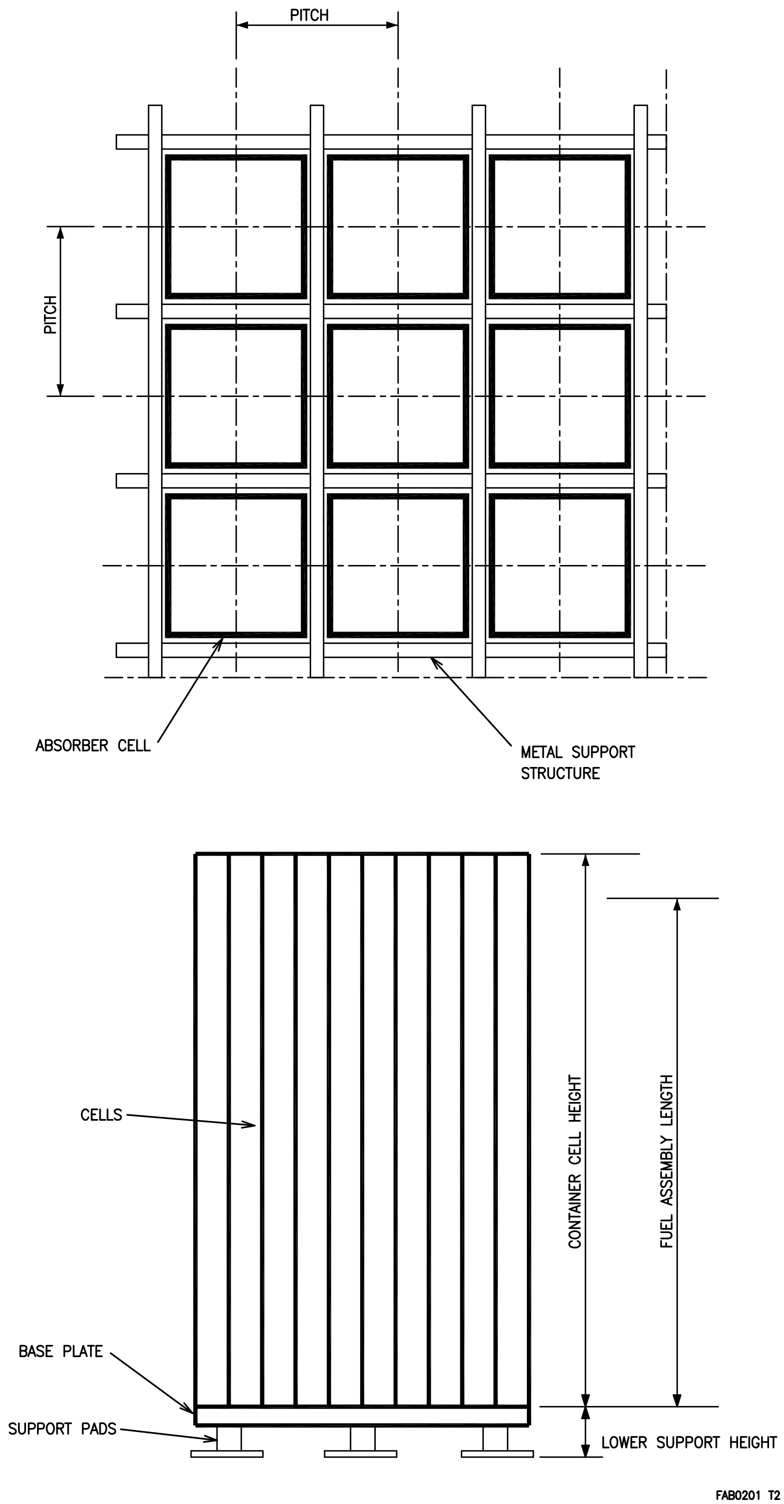


Figure 9.1.2-2—Typical New and Spent Fuel Storage Rack Cross-Sections



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