AP1000DCDFileNPEm Resource

From: Altmayer, Scott A [altmaysa@westinghouse.com]
Sent: Tuesday, June 29, 2010 1:31 AM
To: Buckberg, Perry; Patel, Pravin
Cc: Stipanovich, Steven M; Loza, Paul G.; Morrow, Robert J.; Ritterbusch, Stanley E; Sanders, Mitchell P.; Bob Hirmanpour (bobhirman@live); Gary Becker; Mike Fanguy; David Waters (David.Waters@pgnmail.com)
Subject: New Fuel Rack RAIs - per Non-credible "drop" position
Attachments: OI-SRP9 1 4-SBPA-03 R3A NRC final draft.doc; RAI-TR44-01 R1C NRC final draft.doc; RAI-TR44-06 R2B NRC final draft.doc; RAI-TR44-08 R2B NRC final draft.doc; NFR-DCD noncredible.doc

Perry/Pravin,

Here is the series of four RAIs that discusses new fuel handling operations based on the unlikely/non-credible drop position discussed with NRC last Friday, 6/25.
That position presumes that the new fuel drop is an unlikely and non-credible accident scenario that credits the design/ops of the single failure proof hoist on the FHM.

The foundational response and proposed DCD changes are outlined and presented in OI-SRP9.1.4-SBPA-003 R3A.
This establishes the new design-basis position for a non-credible drop accident for a new fuel assembly at the new fuel pit.
The other RAIs use this basis and simply close the question directly.

NRC telecom on these and previous (agreed) RAIs is set for 9:30 am on Tuesday.
Thank you for your review and feedback as we continue forward.

--SCOTT ALTMAYER--
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Hearing Identifier: AP1000_DCD_Review
Email Number: 445

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Subject: New Fuel Rack RAIs - per Non-credible "drop" position
Sent Date: 6/29/2010 1:31:08 AM
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From: Altmayer, Scott A

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Files	**Size**	**Date & Time**
MESSAGE	954	6/29/2010 1:31:19 AM
OI-SRP9 1 4-SBPA-03 R3A NRC final draft.doc	203840	
RAI-TR44-01 R1C NRC final draft.doc	60480	
RAI-TR44-06 R2B NRC final draft.doc	97856	
RAI-TR44-08 R2B NRC final draft.doc	270912	
NFR-DCD noncredible.doc	105024	

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: OI-SRP9.1.4-SBPA~~A~~-03
Revision: 3~~2~~A

New Question: (Revision 3A)

During the June 2010 fuel rack technical audit, the NRC has questioned how the following limitation (that the fuel handling process precludes a fuel assembly from being dropped from a height in excess of 36" above the top of the New Fuel Storage Rack) is established in the DCD.

New Response: (Revision 3A)

The design, arrangement, operation, and restrictions of the single failure proof FHM hoist to handle new fuel assemblies in the new fuel pit are summarized in Revision 1 and Revision 2 below. The provisions to provide for safe handling of fuel assemblies and other components within the auxiliary building fuel handling area are also described in DCD Section 9.1.4.3.3 "Fuel Handling Machine". Based on the conservative design of this hoist and associated special lifting devices a load drop is unlikely and not considered a credible accident scenario.

Westinghouse concludes that the current design of the single failure proof FHM hoist protects and safeguards new fuel in the new fuel storage pit during normal hoist use based on administrative controls, safety interlocks, fail safe design features, and/or component redundancy. This hoist stops and holds a critical load following the credible failure of a single component. These features assure that the consequences of a load drop are acceptable per ANS 57.1-1992, NUREG-0612 and NUREG-0554 guidelines and criteria (References 1, 2, and 3). No evaluations are required for loads handled by this hoist since a load drop is unlikely.

The response below in Revision 2, Item #3, Bullet #2 for the non-single failure proof hoist operations is superseded and replaced by the following statement:

- the hoist shall be restricted from handling a load above the operating floor within a 15 ft. perimeter around the spent fuel pool. This perimeter includes and envelopes the location of the new fuel pit.

The response below in Revision 2, Item #4, Paragraph #1 for the non-single failure proof hoist operations is amplified by adding the following sentence:

"The non-single failure proof hoist is restricted from handling new fuel above the operating floor."

The response below in Revision 2, Item #4, Paragraph #3 for the non-single failure proof hoist operations is superseded and deleted.

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Westinghouse has clarified and amplified these fuel handling operations regarding applicability and use of the single failure proof hoist and removed the non-credible hypothetical new fuel assembly drop accident as changes to the DCD listed below.

Question: (Revision 1)

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In the June 26, 2008 response to RAI-SRP9.1.4-SBPB-04, the applicant stated that a single failure proof hoist and the new fuel handling tool will be used to handle new fuel and a non single failure proof hoist and the spent fuel handling tool will be used to handle spent fuel. The applicant also stated that the single failure proof hoist may also handle spent fuel, but it would not have access to all spent fuel handling/storage locations. In a March 18, 2009 meeting between the staff and the applicant, the use of the FHM single failure proof hoist and non-single failure proof hoist was discussed in detail.

The applicant stated that the new FHM will handle new fuel and spent fuel. In the June 26, 2008 response to RAI-SRP 9.1.4-SBPB-03, the applicant also stated, "The fuel handling machine is restricted to raising a fuel assembly to a height at which the water provides a safe radiation shield," and in response to RAI-SRP 9.1.4-SBPB-04 the applicant stated that "each FHM hoist will have a mechanical limit based on maximum hoist up travel and spent fuel handling tool length." Since the new FHM will be moving both new fuel and spent fuel, and new fuel is handled above deck level when it is transferred to the new fuel racks and transferred from the new fuel storage vault into the spent fuel pool, the applicant did not state in the DCD how the same cranes that are restricted in hoist up travel can handle new fuel above deck level. Use of the FHM hoist for new fuel also apparently conflicts with the revised Table 2.1.1-1 item 5 of ITAAC, which states, "FHM hoists are limited such that the minimum required depth of water shielding is maintained."

The applicant provided the staff with Revision 1 to its response to RAI-SRP 9.1.4-SBPB-04 in a letter dated May 20, 2009 and Revision 1 to its response to RAI-SRP 9.1.4-SBPB-03 in a letter dated June 4, 2009. Both of the applicant's revised RAI responses contain the same additional paragraph which states that spent fuel handling is restricted to using the non-single failure proof hoist of the FHM. The single failure proof hoist of the FHM is used for handling new fuel and other loads, with the exception of spent fuel, throughout the fuel handling area. The single failure proof hoist in conjunction with the spent fuel handling tool is not capable of raising spent fuel to a height that clears the spent fuel racks, fuel transfer system fuel basket, spent fuel shipping cask, or the new fuel elevator. The staff finds that the applicant's Revision 1 responses to RAI-SRP 9.1.4-SBPB-03 and 04 still do not adequately address how the single failure proof crane of the FHM with hoist up travel restrictions can handle new fuel above the deck level. **This is identified as OI-SRP 9.1.4-SBPA-03**. To close out this item a description of the fuel movement (new and spent) process for both FHM hoists using their handling tools, and a discussion of their interlocks need to be provided by the applicant. Currently, the proposed lift height ITAAC for FHM is inconsistent with allowing the use of FHM to move new fuel.

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Westinghouse Response: (Revision 1)

(The above question is from the Chapter 9 SER with Open Items received 10/19/09. Westinghouse initially answered this Open Item with the RAI-SRP9.1.4-SBPB-03 R2 response; and therefore Westinghouse considers this the Revision 1 OI response for tracking purposes.)

Additional questions were provided by phone conversation with the staff on 8/12/09. Westinghouse provided the RAI-SRP9.1.4-SBPB-03 R2 response via letter DCP/NRC2505 on 10/15/09, and also supported additional phone discussions to date with the staff. The topics requested in the OI have been covered, including intended use of each FHM hoist, safety interlocks, and fuel handling tools.

Westinghouse also received a email request from the staff on 2/2/10. It requested that Westinghouse incorporate into the DCD the additional paragraph mentioned above that was previously provided in the RAI responses. To close this issue, a DCD markup making this change is shown below.

Additional Question: (Revision 2)

Westinghouse indicates that in the past the operators were required to verify hoist up limits, indicating lights, etc…prior to translating, which is acceptable while using the correct hoist. However by using the incorrect crane, even with the hoist up limits or indicating lights, will allow inadvertently traversing (translating) of the hoists in the configuration where the bottom of a fuel assembly does not have adequate clearance from the spent fuel racks. This could result in fuel damage if traversing movement is allowed.

1. How does Westinghouse intend to address the issue above?

2. Elaborate on the comment, "[(from a previous W email discussion) Past fuel handling procedures require operators to verify hoist up limits via hoist position, indicating lights, etc., prior to clearing bridge-trolley interlocks and translating with a fuel assembly.] Being that there is approximately 20" difference between the two hook up limits, this condition should be detected by the operator." It is not clear to the staff how the operator would detect this.

3. What is their intended use of single and non-single failure proof hoists?

4. Which crane will carry what over the SFP and in fuel handling areas?

~~***Westinghouse Response: (Revision 1)***~~

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~~(The above question is from the Chapter 9 SER with Open Items received 10/19/09. Westinghouse initially answered this Open Item with the RAI-SRP9.1.4-SBPB-03 R2 response, and considers this the Revision 1 OI response for tracking purposes.)~~

~~Additional questions were provided by phone conversation with the staff on 8/12/09. Westinghouse provided the RAI-SRP9.1.4-SBPB-03 R2 response via letter DCP/NRC2505 on 10/15/09, and also supported additional phone discussions to date with the staff. The topics requested in the OI have been covered, including intended use of each FHM hoist, safety interlocks, and fuel handling tools.~~

~~Westinghouse also received a email request from the staff on 2/2/10. It requested that Westinghouse incorporate into the DCD the additional paragraph mentioned above that was previously provided in the RAI responses. To close this issue, a DCD markup making this change is shown below.~~

Westinghouse Additional Response: (Revision 2)

1. The control console for the fuel handling machine has a selector switch that is positioned to select either the South Hoist (Single Failure Proof) or North Hoist (non-Single Failure Proof). With North Hoist selected, the single failure proof hoist is locked out, incapable of movement. Warnings requiring operator acknowledgement will be built in to the fuel handling machine software such that if a load was suspended from the single failure proof hoist and bridge movement approached the spent fuel racks, the operator would be alerted that spent fuel is not to be raised using the spent fuel handling tool. Operating procedures will also be prepared with this precaution.

2. In the event that an operator set the abovementioned selector switch to South Hoist (Single Failure Proof), picked up the spent fuel handling tool with the single failure proof hoist and raised the hoist to the up limit, the digital hoist position indication would not meet the predetermined setpoint for the hoist up limit for handling spent fuel. (The bail on the handling tool would not have been at the expected elevation either.) Even though the hoist up limit light would be activated, the error in hoist position would be identified administratively by the verification of proper hoist up digital position readout. Operating procedures will be prepared with this requirement.

3. The single failure proof hoist will be used for:

   - primarily handling new fuel
   - the movement of loads <4000 lbs in the fuel handling area of the auxiliary building
   - a redundant hoist over the spent fuel pool for the handling of control components

   The non-single failure proof hoist will be used for:

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- handling fuel and control components in the spent fuel pool
- ~~the hoist shall be restricted from handling a load above the operating floor within 15 ft. of the spent fuel pool unless supported by future analysis.~~ (Superseded and replaced by statement in Revision 3)

4. The non-single failure proof hoist is primarily used for submerged handling activities. However, there are areas in the fuel handling area of the auxiliary building that the single failure proof hoist is not capable of accessing due to travel limitations. Therefore it is necessary for the non-single failure proof hoist to be used in areas other than the spent fuel pool. As mentioned above, the non-single failure proof hoist will be restricted from handling a load above the operating floor within 15 ft. of the spent fuel pool. The non-single failure proof hoist is restricted from handling new fuel above the operating floor. (Added in Revision 3)~~I, unless supported by future analysis~~~~The non-single failure proof hoist is restricted from handling new fuel above the operating floor.~~

The single failure proof hoist will be capable of handling loads in the new fuel handling area and the spent fuel handling area with operator warnings associated with the handling of spent fuel.

~~The previously supplied DCD markup wording is revised below to reflect the above answers.~~ (Superseded and deleted by statement in Revision 3)

References:

1. NUREG-0612, July 1980, “Control of Heavy Loads at Nuclear Power Plants”
2. NUREG-0554, May 1979, USNRC, "Single-Failure-Proof Cranes for Nuclear Power Plants"
3. ANS 57.1-1992, “Design Requirements for Light Water Reactor Fuel Handling Systems”

PRA Revision:
None

Technical Report (TR) Revision:
None

Design Control Document (DCD) Revision:

DCD Changes: (Revision 1, 2) - Superseded and replaced by Revision 3A

~~Modify DCD Section 9.1.4.2.4, “Component Description,” as follows:~~

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~~9.1.4.2.4 Component Description~~

~~A. Fuel Transfer Tube~~

~~The fuel transfer tube penetrates the containment and spent fuel area and provides a passageway for the conveyor car during refueling. During reactor operation, the fuel transfer tube is sealed at the containment end and acts as part of the containment pressure boundary. See subsection 3.8.2.1.5 for discussion of the fuel transfer penetration.~~

~~B. Fuel Handling Machine~~

~~The fuel handling machine performs fuel handling operations in the new and spent fuel handling area. It also provides a means of tool support and operator access for long tools used in various services and handling functions. The fuel handling machine is equipped with two 2-ton hoists, one of which is single failure proof.~~

~~The non-single failure proof hoist is primarily used for submerged handling activities. However, there are areas in the fuel handling area of the auxiliary building that the single failure proof hoist is not capable of accessing due to travel limitations. Therefore it is necessary for the non-single failure proof hoist to be used in areas other than the spent fuel pool. The non-single failure proof hoist will be restricted from handling a load above the operating floor. within 15 ft. of the spent fuel pool unless supported by future analysis. The non-single failure proof hoist is restricted from handling new fuel above the operating floor.~~

~~The single failure proof hoist will be capable of handling loads in the new fuel handling area and the spent fuel handling area with operator warnings associated with the handling of spent fuel.~~

DCD Changes: (Revision 3A)

Summary of DCD proposed changes is outlined below and annotated on the following pages:

~~PRA Revision:~~
~~None~~

~~Technical Report (TR) Revision:~~

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~~None~~

DCD Rev. 17 Section or Table	DCD Rev. 17 Page Number	Change Summary
Tier 1, Section 2.1.1, Item 7	2.1.1-1	Delete reference to new fuel rack design basis dropped assembly accident
Tier 1, Table 2.1.1-1, Item 7	2.1.1-3	Delete reference to new fuel rack design basis dropped assembly accident
9.1.1.2	9.1-2	Clarify paragraph #2 and #5 regarding use of the FHM and single failure proof crane to handle new fuel pit and new fuel assemblies.
9.1.1.2.1.A	9.1-3	Remove the fourth bullet loading combination for a fuel assembly drop accident since it is non credible
9.1.1.2.1.C	9.1-3 and 9.1-4	Add new first paragraph to clarify that dropping a new fuel assembly is not credible and is not a design basis accident.
9.1.1.3	9.1-4	Clarify wording in Paragraph #4 to be consistent with changes to 9.1.1.2 above.
9.1.1.3	9.1-5	Change criticality analysis reference directly to the proper new fuel rack technical report reference within DCD Chapter 9.1.
Table 9.1-1	9.1-52	Add note to load drop (F_d) load combination to state: "This load combination is not required for a new fuel assembly since it is not a credible accident."
Table 14.3-2 (pg. 10 of 17)	14.3-26	Change reference and statement to be the same as first paragraph to 9.1.1.2.1.C above.

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DCD changes to Tier 1, Section 2.1.1, Item 7

2.1.1 Fuel Handling and Refueling System

Design Description

The fuel handling and refueling system (FHS) transfers fuel assemblies and core components during fueling operations and stores new and spent fuel assemblies in the new and spent fuel storage racks. The refueling machine (RM) and the fuel transfer tube are operated during refueling mode. The fuel handling machine (FHM) is operated during normal modes of plant operation, including startup, power operation, cooldown, shutdown and refueling.
The component locations of the FHS are as shown in Table 2.1.1-2.

1. The functional arrangement of the FHS is as described in the Design Description of this Section 2.1.1.

2. The FHS has the RM, the FHM, and the new and spent fuel storage racks.

3. The FHS preserves containment integrity by isolation of the fuel transfer tube penetrating containment.

4. The RM and FHM/spent fuel handling tool (SFHT) gripper assemblies are designed to prevent opening while the weight of the fuel assembly is suspended from the grippers.

5. The lift height of the RM mast and FHM hoist(s) masts is limited such that the minimum required depth of water shielding is maintained.

6. The RM and FHM are designed to maintain their load carrying and structural integrity functions during a safe shutdown earthquake.

7. The new and spent fuel storage racks maintain the effective neutron multiplication factor less than the required limits during normal operation, design basis seismic events, and a design basis dropped spent fuel assembly accident. (Note: A postulated drop for a new fuel assembly accident is not required since it is a non-credible event.)

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.1.1-1 specifies the inspections, tests, analyses, and associated acceptance criteria for the FHS.

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DCD changes to Tier 1, Table 2.1.1-1, Item 7

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Table 2.1.1-1 (cont.) Inspections, Tests, Analyses, and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
7. The new and spent fuel storage racks maintain the effective neutron multiplication factor less than the required limits during normal operation, design basis seismic events, and a design basis dropped spent fuel assembly accident. (Note: A postulated drop for a new fuel assembly accident is not required since it is a non-credible event.)	i) Analyses will be performed to calculate the effective neutron multiplication factor in the new and spent fuel storage racks during normal conditions.	i) The calculated effective neutron multiplication factor for the new and spent fuel storage racks is less than 0.95 under normal conditions.
	ii) Inspection will be performed to verify that the new and spent fuel storage racks are located on the nuclear island.	ii) The new and spent fuel storage racks are located on the nuclear island.
	iii) Seismic analysis of the new and spent fuel storage racks will be performed.	iii) A report exists and concludes that the new and spent fuel racks can withstand seismic design basis dynamic loads and maintain the calculated effective neutron multiplication factor less than 0.95.
	iv) Analysis of the spent fuel storage racks under design basis dropped fuel assembly loads will be performed.	iv) A report exists and concludes that the spent fuel racks can withstand design basis dropped fuel assembly loads and maintain the calculated effective neutron multiplication factor less than 0.95.

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DCD change to Section 9.1.1

9.1.1 New Fuel Storage

9.1.1.1 Design Bases

New fuel is stored in a high density rack which includes integral neutron absorbing material to maintain the required degree of subcriticality. The rack is designed to store fuel of the maximum design basis enrichment. The rack in the new fuel pit consists of an array of cells interconnected to each other at several elevations and to a thick base plate at the bottom elevation. This rack module is not anchored to the pit floor.

The new fuel rack includes storage locations for 72 fuel assemblies. The rack layout and array center-to-center spacing is shown in Figure 9.1-1. This spacing provides a minimum separation between adjacent fuel assemblies which is sufficient to maintain a subcritical array even in the event the building is flooded with unborated water or fire extinguishant aerosols or during any design basis event. The design of the rack is such that a fuel assembly cannot be inserted into a location other than a location designed to receive an assembly. An assembly cannot be inserted into a full location. Surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel.

The requirements of ANS 57.1 are addressed in subsection 9.1.4. The rack is designed to withstand nominal operating loads and safe shutdown earthquake seismic loads defined in Table 9.1-1. The new fuel storage rack is designed to meet seismic Category I requirements of Regulatory Guide 1.29. Refer to subsection 1.9.1 for compliance with Regulatory Guides. The rack is also designed to withstand the maximum uplift force of the fuel handling machine.

AP1000 equipment, seismic and ASME Code classifications are discussed in Section 3.2. The requirements of ASME Code Section III, Division I, Article NF3000 are used as the criteria for evaluation of stress analysis. The materials are procured in accordance with ASME Code Section III, Division I, Article NF2000. Criticality analyses are performed in accordance with the requirements of ANSI N16.1-75, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors (Reference 1); and analysis codes are validated against the requirements of ANSI N16.9-75, Validation of Calculational Methods for Nuclear Criticality Safety (Reference 2).

The stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1 for components design by the linear elastic method (Reference 22).

9.1.1.2 Facilities Description

The new fuel storage facility is located within the seismic Category I auxiliary building fuel handling area. The facility is protected from the effects of natural phenomena such as earthquakes, wind, tornados, floods, and external missiles by the external walls of the auxiliary building. See Section 3.5 for additional discussion on protection from missiles. The facility is designed to maintain its structural integrity following a safe shutdown earthquake and to perform its intended function following a postulated event such as fire, internal missiles, or pipe break. The walls surrounding the fuel handling area and new fuel storage pit protect the fuel from missiles generated inside the auxiliary building. The fuel handling area does not contain a credible source of missiles. Refer to subsection 1.2.4.3 for a discussion of the auxiliary building. Refer to Section 3.8 for a discussion of the structural design of the new fuel storage area. Refer to subsection 3.5.1 for a discussion of missile sources and protection.

The dry, unlined, approximately 17-feet deep reinforced concrete pit is designed to provide support for the new fuel storage rack. The rack is supported by the pit floor. The walls of the new fuel pit are seismic Category I. The new fuel pit is normally covered to prevent foreign objects from entering the new fuel storage rack. The crane that is used to

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access the new fuel pit is the fuel handling machine. The fuel handling machine is equipped with a single failure proof hoist with a capacity of two tons. It is used to handle new fuel, control rod assembly, handling tool, control components within the spent fuel pool, or loads under 4,000 lbs located within the fuel handling area of the auxiliary building. The new fuel pit cover is not designed to protect the fuel assemblies from the effects of dropped heavy objects; because dropped heavy objects are not credible due to the use of a single failure proof hoist. Figures 1.2-7 through 1.2-10 show the relationship between the new fuel storage facility and other features of the fuel handling area.

The new fuel storage pit is drained by gravity drains that are part of the radioactive waste drain system (subsection 9.3.5), draining to the waste holdup tanks which are part of the liquid radwaste system (Section 11.2). These drains preclude flooding of the pit by an accidental release of water.

Nonseismic equipment in the vicinity of the new fuel storage rack is evaluated to confirm that its failure could not result in an increase of K_{eff} beyond the maximum allowable K_{eff}. Refer to subsection 3.7.3.13 for a discussion of the nonseismic equipment evaluation.

The fuel handling machine is used to handle new fuel assemblies in the rail car bay, new fuel rack, and new fuel elevator. The new fuel storage rack is not accessed by the cask handling crane. This precludes the movement of loads greater than fuel components over stored new fuel assemblies.

During fuel handling operations, a ventilation system removes gaseous radioactivity from the atmosphere above the new fuel pit. Refer to subsection 9.4.3 for a discussion of the fuel handling area HVAC system and Section 11.5 for process radiation monitoring. Security for the new fuel assemblies is described in separate security documents referred to in Section 13.6.

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9.1.1.2.1 New Fuel Rack Design

A. Design and Analysis of the New Fuel Rack

The new fuel storage rack array center-to-center spacing of nominally 10.9 inches provides a minimum separation between adjacent fuel assemblies sufficient with neutron absorbing material to maintain a subcritical array. The seismic and stress analyses of the new fuel rack consider the condition of full fuel assembly loadings. The rack is evaluated for the safe shutdown earthquake condition against the seismic Category I requirements. A stress analysis is performed to verify the acceptability of the critical load components and paths under normal and faulted conditions. The rack rests on the pit floor.

The dynamic response of the fuel rack assembly during a seismic event is the condition which produces the governing loads and stresses on the structure. The new fuel storage rack is designed to meet the seismic Category I requirements of Regulatory Guide 1.29.

Loads and Load Combinations

The applied loads to the new fuel rack are:

- Dead loads
- Live loads - effect of lifting the empty rack during installation

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- [removed]
- Seismic forces of the safe shutdown earthquake
- Fuel handling machine uplift while over the new fuel rack - postulated stuck fuel assembly

Table 9.1-1 shows loads and load combinations considered in the analyses of the new fuel rack.

The margins of safety for the rack in the multi-direction seismic event are produced using loads obtained from the seismic analysis based on the simultaneous application of three statistically independent, orthogonal accelerations.

B. Fuel Handling Machine Uplift Analysis

An analysis is performed to demonstrate that the rack can withstand a maximum uplift load of 4000 pounds. This load is applied to a postulated stuck fuel assembly. Resultant rack stresses are evaluated against the stress limits and are demonstrated to be acceptable. It is demonstrated that there is no change in rack geometry of a magnitude which causes the criticality criteria to be violated.

C. Fuel Assembly Drop Accident Analysis

Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. Therefore, no additional evaluations are required for loads handled by this hoist.

D. Failure of the Fuel Handling Machine

The fuel handling machine is a seismic Category II component. The fuel handling machine is evaluated to show that the machine does not fall into the new fuel pit during a seismic event.

E. Internally Generated Missiles

The fuel handling area does not contain any credible sources of internally generated missiles.

Stress analyses are performed by the vendor using loads developed by the dynamic analysis. Stresses are calculated at critical sections of the rack and compared to acceptance criteria referenced in ASME Section III, Division I, Article NF3000.

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9.1.1.3 Safety Evaluation

The rack, being a seismic Category I structure, is designed to withstand normal and postulated dead loads, live loads, loads resulting from thermal effects, and loads caused by the safe shutdown earthquake event.

The design of the rack is such that K_{eff} remains less than or equal to 0.95 with new fuel of the maximum design basis enrichment. For a postulated accident condition of flooding of the new fuel storage area with unborated water, K_{eff} does not exceed 0.98.

The criticality evaluation considers the inherent neutron absorbing effect of the materials of construction, including fixed neutron absorbing "poison" material.

The new fuel rack is located in the new fuel storage pit, which has a cover to protect the new fuel from debris. No loads are required to be carried over the new fuel storage pit while the cover is in place. The cover is designed such that it will not fall and damage the fuel or fuel rack during a seismic event. Administrative controls are utilized when the cover is removed for new fuel transfer operations to limit the potential for dropped object damage.

Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. Handling equipment (cask handling crane) capable of carrying loads heavier than fuel components is prevented from traveling over the fuel storage area. The fuel storage rack can withstand an uplift force of 4000 pounds.

Materials used in rack construction are compatible with the storage pit environment, and surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel. Structural materials are corrosion resistant and will not contaminate the fuel assemblies or storage pit environment. Neutron absorbing "poison" material used in the rack design has been qualified for the storage environment. Venting of the neutron absorbing material is considered in the detailed design of the storage rack.
The new fuel assemblies are stored dry. The rack structure is designed to maintain a safe geometric array for normal and postulated accident conditions. The fixed neutron absorbing "poison" material maintains the required degree of subcriticality for normal and postulated accident conditions such as flooding with pure water and low density optimum moderator "misting."

A discussion of the methodology used in the new fuel rack criticality analysis is provided in APP-GW-GLR-030 (Reference 17).

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DCD change to Table 9.1-1

Table 9.1-1 **LOADS AND LOAD COMBINATIONS FOR FUEL RACKS**	
Load Combination	**Service Level**
D + L D + L + T_o	Level A
D + L + T_a D + L + T_o + P_f	Level B
D + L + T_a + E'	Level D
D + L + F_d	The functional capability of the spent fuel racks should be demonstrated. (Note: This load combination is not required for a new fuel assembly since it is not a credible accident)

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel racks are freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations are those used in NUREG-0800, Section 3.8.4 (including Appendix D) of the Standard Review Plan (SRP):

D = Dead weight induced loads (including fuel assembly weight)
L = Live load (not applicable to fuel racks since there are no moving objects in the rack load path)
F_d = Force caused by the accidental drop of the heaviest load from the maximum possible height
P_f = Upward force on the racks caused by postulated stuck fuel assembly
E' = Safe shutdown earthquake (SSE)
T_o = Differential temperature induced loads based on the most critical transient or steady-state condition under normal operation or shutdown conditions
T_a = Differential temperature induced loads based on the postulated abnormal design conditions

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DCD change to Table 14.3-2

Table 14.3-2 (Sheet 10 of 17)

DESIGN BASIS ACCIDENT ANALYSIS

Reference	Design Feature	Value
Section 7.4.3.1	If temporary evacuation of the main control room is required because of some abnormal main control room condition, the operators can establish and maintain safe shutdown conditions for the plant from outside the main control room through the use of controls and monitoring located at the remote shutdown workstation.	
Section 7.4.3.1.1	The remote shutdown workstation equipment is similar to the operator workstations in the main control room and is designed to the same standards. One remote shutdown workstation is provided.	
Section 7.4.3.1.3	The remote shutdown workstation achieves and maintains safe shutdown conditions from full power conditions and maintains safe shutdown conditions thereafter.	
Section 7.5.4	The protection and safety monitoring system provides signal conditioning, communications, and display functions for Category 1 variables and for Category 2 variables that are energized from the Class 1E uninterruptible power supply system.	
Section 7.6.1.1	An interlock is provided for the normally closed motor-operated normal residual heat removal system inner and outer suction isolation valves. Each valve is interlocked so that it cannot be opened unless the reactor coolant system pressure is below a preset pressure.	
Section 8.2.2	Following a turbine trip during power operation, the reverse-power relay will be blocked for a minimum time period (sec).	≥ 15
Section 8.3.2.1.2	The non-Class 1E dc and UPS system (EDS) consists of the electric power supply and distribution equipment that provides dc and uninterruptible ac power to nonsafety-related loads.	
Section 9.1.1.2.1.C	Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. Therefore, no additional evaluations are required for loads handled by this hoist.	
Section 9.1.3.5	The spent fuel pool is designed such that a water level is maintained above the spent fuel assemblies for at least 7 days following a loss of the spent fuel cooling system using only on-site makeup water sources (See Table 9.1-4).	

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-01
Revision: 1C~~1A~~

Question: (Revision 0)

Section 2.8.5 indicates that both drop scenarios are from 36 inches above the top of the AP1000 New Fuel Storage Rack. Describe the fuel handling operation that leads to this drop height.

Westinghouse Response: (Revision 0)

Fuel handling operations associated with new fuel drop scenarios in Section 2.5 deal with receipt inspection of new fuel, moving new fuel into the new fuel rack or removing it to place in the spent fuel pool. These operations are performed by a new fuel handling crane. The conservative drop height of 36 inches is used, however it is unlikely that the drop height will ever be 36 inches as the top of the rack is only six inches below the floor elevation and the fuel assembly will be close to the floor. Administrative control will be put in place to prevent raising the fuel assembly over 36 inches over the New Fuel Storage Rack.

New Question: (Revision 1C)

During the June 2010 fuel rack technical audit, the NRC has questioned how the following limitation (that the fuel handling process precludes a fuel assembly from being dropped from a height in excess of 36" above the top of the New Fuel Storage Rack) is established in the DCD.

Westinghouse New Response: (Revision 1C)

Based on considerations and responses noted in OI-SRP9.1.4-SBPA-03 R3A regarding fuel handling hoist operations and drop scenarios involving the new fuel and new fuel pit, the only hoist capable of moving new fuel above the operating floor is a single failure proof hoist. Per NUREG-0612 (Reference 4) guidelines, drops from a single failure proof hoist are deemed unlikely and non-credible and do not require further analysis. Westinghouse has taken this position for the postulated new fuel assembly drop accident scenario.
~~The drop of a new fuel assembly, control component, and/or the associated handling tool onto the new fuel rack in the new fuel storage pit is currently analyzed for a maximum credible height of 3 feet (36" inches) above the top of the new fuel rack. This is discussed in DCD Section 9.1.1.2.1 Item C. The top of the new fuel rack is also even with the fuel handling operating floor elevation of 135' 3".~~

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Westinghouse concludes that the current design of the single failure proof ~~(SFP)~~ hoist ~~FHM hoists i~~indeed ~~p~~protects and safeguards new fuel in the new fuel storage pit during handling ~~or credible drop accidents~~ using administrative controls, safety interlocks, fail safe design features, and/or component redundancy. ~~as discussed below for 1) normal hoist and 2) off-normal hoist use.~~

~~1)~~ During normal fuel handling operations~~use of~~, the single failure proof ~~(SFP)~~ hoist ~~the~~ maximum height limit is controlled by design. This ~~SFP~~ hoist is required to operate over a large range of elevations and locations as specified in DCD Rev 17, Section 9.1.4.3.3, “Fuel Handling Machine” (FHM) which discusses safety interlocks, fail safe design features, and component redundancy to assure safe handling of fuel assemblies and other components within the auxiliary building fuel handling area. Operations that could endanger the operator or damage the fuel are prevented by mechanical or failure tolerant electrical ~~interlocks,~~interlocks, or by redundant electrical interlocks and are explicitly designated for clarity using an asterisk (*).

Specifically, Section 9.1.4.3.3, Part A, and Paragraph *2, requires that the hoist be raised to the maximum “up” limit before traversing to other locations in the fuel handling area:

“When the hoist load weighing system detects a load greater than the spent fuel assembly handling tool, the machine cannot traverse unless the hoist is at the up limit. For new fuel handling, the load is greater than the new fuel handling tool.”

With the single failure proof ~~SFP hoist~~ hoist at the maximum “up” limit, the bottom of a new fuel assembly has about seven feet ~~approximately 6-7 feet~~ of clearance over the top of the new fuel storage rack. ~~Although this value is larger than the 36” value being discussed, D~~Dropping a load from this ~~height (or any h~~height~~)~~ is a non-credible scenario for the following reasons:

a. The new fuel handling tool (NFHT) incorporates the same design features as the spent fuel handling tool (SFHT) such that the gripper assembly is designed to prevent opening while the weight of the fuel assembly and control component is suspended from the grippers.

b. The hoist is single failure proof with inherent redundancy

~~Therefore, changing tool handling design or crane limits is not needed or preferred.~~ Safety is assured by redundancy and equipment design. Therefore, changing tool handling design or crane limits is not needed or preferred. ~~For example, lengthening the NFHT to reduce the clearance down to 3 feet would lead to human performance issues associated with the handling of this tool. Lowering the hoist “up” limit would also lead to other undesirable conditions associated with the operation of this hoist throughout the fuel handling area.~~

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~~To close this issue, a DCD markup making clarification changes is shown below.~~

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44~~,~~ TR44)
2. APP-FS02-Z0C-001, Revision 0, "~~"~~Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"

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Design Control Document (DCD) Revision:
None
~~(Rev. 0) none~~

~~DCD Changes (Revision 1C):~~

~~Update DCD Section 9.1.1.2, "Facilities Description," (as follows):~~

~~**9.1.1.2 Facilities Description**~~

~~Clarify second (paragraph is unchanged)~~

~~"The dry, unlined, approximately 17-feet deep reinforced concrete pit is designed to provide support for the new fuel storage rack. The rack is supported by the pit floor. The walls of the new fuel pit are seismic Category I. The new fuel pit is normally covered to prevent foreign objects from entering the new fuel storage rack. Since the only crane that can access the new fuel pit does not have the capacity to lift heavy objects, as defined in subsection 9.1.5, The crane that is used to access the new fuel pit is the fuel handling machine. The fuel handling machine is equipped with a single failure proof hoist that is used to handle new fuel and control components and has a capacity of two tons. The new fuel pit cover is not designed to protect the fuel assemblies from the effects of dropped heavy objects. Dropped heavy objects are not credible due to the use of a single failure proof hoist. Figures 1.2-7 through 1.2-10 show the relationship between the new fuel storage facility and other features of the fuel handling area."~~

~~Update Section 9.1.1.2.1, "Fuel Rack Design," Item C (as follows):~~

~~C. Fuel Assembly Drop Accident Analysis~~

~~(3 paragraphs unchanged)~~

~~Although a 3 foot drop over the new fuel rack has been analyzed, no additional evaluations or restrictions are necessary for the drop of new fuel handled by the fuel handling machine single failure proof hoist."~~

PRA Revision:
None

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Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-006
Revision: 2B

Question: (Revision 0)

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A vertical movement of 2 inches of a fuel assembly is defined as the criticality limit in Section 2.8.5, and the impact analysis shows that quite a number of fuel assemblies will have more than 2 inches displacement. It appears that a rack design with only a 2 inches space between the bottom of the baseplate and the top of the floor would eliminate this risk. Please explain why the design has a space larger than 2 inches.

Staff Assessment (Revison 1): Response similar to response for spent fuel racks. See RAI-TR54-10.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-10, to the new fuel rack.

New Question: (Revision 2B)

Evaluate New Fuel Rack (NFR) mechanical accident calculation conclusions due to dropping a fuel assembly (and associated handling tool) from a 36" height over the top of the New Fuel Rack and impacting the baseplate directly over a pedestal location or justify why this evaluation is not necessary.

Westinghouse Response:

Westinghouse Response: (Revision 2B)

The 193.5" cell length reported in RAI Revision 0 response was increased to 199.5" to reflect the current design as shown in Reference 1 and the DCD Rev. 17.

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Based on considerations and responses noted in OI-SRP9.1.4-SBPA-03 R3A regarding fuel handling hoist operations and drop scenarios involving the new fuel and new fuel pit, the only hoist capable of moving new fuel above the operating floor is a single failure proof hoist. Per NUREG-0612 (Reference 4) guidelines, drops from a single failure proof hoist are deemed unlikely and non-credible and do not require further analysis. Westinghouse has taken this position for the postulated new fuel drop accident scenario.

Because a new fuel assembly drop into the new fuel pit and onto the new fuel racks is not credible, it is unnecessary to evaluate other drop scenarios for the new fuel storage rack. However, for structural completeness and reference, calculation APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents" was completed for a "deep drop" impact onto the baseplate directly over a pedestal location. The resulting force is a nominal 500 kip load at the bearing plate/concrete floor interface.

Based on the non-credible nature of the new fuel assembly drop accident, the next revision of TR44 will remove all detailed discussions, tables, and figures that reference applicability of the new fuel pit drop accident scenarios. This information will be retained in the legacy analysis (Reference 2).

~~The 193.5" cell length reported in Revision 0 of this RAI response was increased to 199.5" to reflect the current design as currently shown in Reference 1 and the DCD Rev. 17.~~

~~Based on considerations and responses noted in OI-SRP9.1.4-SBPA-03 R3A regarding fuel handling hoist operations and drop scenarios involving the new fuel and new fuel pit, the only hoist capable of moving new fuel above the operating floor is a single failure proof hoist. Per NUREG-0612 (Reference 4) guidelines, drops from a single failure proof hoist are deemed unlikely and non-credible and do not require further analysis. Westinghouse has taken this position for the postulated new fuel drop accident scenario.~~

~~Because a new fuel assembly drop into the new fuel pit and onto the new fuel racks is not credible, it is unnecessary to evaluate other drop scenarios for the new fuel storage rack. However, for structural completeness and reference, calculation APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents" was completed for a "deep drop" impact onto the baseplate directly over a pedestal location. The resulting force is a nominal 500 kip load at the bearing plate/concrete floor interface.~~

~~Based on the non-credible nature of the new fuel assembly drop accident, the next revision of TR44 will remove all detailed discussions, tables, and figures that reference applicability of the new fuel pit drop accident scenarios. This information will be retained in the legacy analysis (Reference 2).~~

Response: (~~Revison~~Revision 0 and 1)

Each storage cell is ~~193.5~~ 199.5 inches (per Revision 2B) in length and rests on top of a base plate whose top is 5 inches above the concrete floor. Note that each Metamic poison panel is 172 inches long and has a bottom elevation that is 6.23 inches above the top of the base plate. The active fuel region of each fuel assembly begins at an elevation 8.23 inches above the base plate. Therefore, the bottom elevation of the Metamic poison panel is positioned to be two inches lower than the bottom elevation of the active fuel.

Therefore, the results of the criticality analyses are bounding even if the fuel assembly is vertically displaced downward by up to two inches as a result of the hypothetical fuel assembly drop. The two inch vertical displacement of the fuel assemblies, mentioned in Technical Report 44 is not a criticality limit.

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The criticality analyses summarized in COL Technical Report APP-GW-GLR-030 Rev.0 "New Fuel Storage Rack Criticality Analysis" addressed the hypothetical fuel assembly drop in subsection 2.4.2 as follows:

"The resulting deformation on the base plate following a drop of fuel assembly straight through an empty cell impacting the rack baseplate is discussed in subsection 2.8.5 of Reference 4. To conservatively bound the deformation results for the base plate, the bottom elevations of 25 fuel assemblies were lowered by 5 inches. (Note that the base plate is 3/4 inches thick and is normally 4.25 inches above the floor.) This is a five-by-five array of fuel assemblies centered on the empty cell impacted by the dropped fuel assembly (refer to Figure 2-10 of Reference 4). Even with the bottom elevation of the active fuel in 25 fuel assemblies lowered by 5 inches, the criticality design limits given in Section 2.1 are still met."

Since the criticality analysis demonstrates that the stored fuel assemblies remain subcritical following a hypothetical fuel assembly drop, the space between the bottom of the baseplate and the new fuel storage vault floor is not designed to control criticality, but to prevent the new fuel vault floor from an impact strike. In other words, the rack baseplate is raised high enough above the new fuel storage vault floor (4.25") to prevent the baseplate from contacting the floor when it deforms under impact.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

The hypothetical drop, wherein a fuel assembly travels downward through an empty storage cell and impacts the baseplate was re-analyzed in Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents" for the new fuel rack. The new analysis model incorporates the following changes (as discussed in the RAI responses to TR44-03, TR44-05, and TR44-07): (1) the baseplate is modeled with thick shell elements, (2) the effect of the stored fuel assemblies is accounted for by increasing the mass density of the baseplate, and (3) strain rate effects are considered for the welds only. Based on the re-analyses, the maximum vertical displacement of the new fuel rack baseplate is 2.41", which is less than the 5" displacement considered in the criticality analysis. Therefore, the existing criticality analysis remains bounding.

These improvements were reviewed in Revision 1 of APP-FS02-Z0C-001 by the NRC staff and found to be technically acceptable for the similar spent fuel RAI-TR54-10 during the May 21 and 22 technical review. As a result of that technical review, this item was resolved for the spent fuel racks. Because Westinghouse applied the same approach for the new fuel racks and obtained conservative results and the NRC staff has already reviewed and accepted Revision 1 of APP-FS02-Z0C-001, which also applies to the new fuel rack, Westinghouse considers this item to be resolved for the new fuel rack as well.

Figure 2-10 of TR44 was revised to reflect the updated results of the drop analysis; see the Technical Report Revision section for details.

References:

1. APP-GW-GLR-026, Revision ~~3~~4a, “New Fuel Storage Rack Structural/Seismic Analysis,” (Technical Report Number 44, TR44)
2. APP-FS02-Z0C-001, Revision 2a, ”Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents”
3. APP-GW-GLR-030 Revision 0, “New Fuel Storage Rack Criticality Analysis,” (Technical Report Number 67, TR67)
4. NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants.”

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:

TR Changes: (Revision 2B)
The figure change below ~~form~~ from Revision 1 is obsolete. The next revision of TR44 will remove all detailed discussions, tables, and figures that reference applicability of the new fuel assembly ~~pit~~ drop accident scenarios~~.~~.

TR Changes: (Revision 1) ~~–~~ (Removed ~~S~~by ~~UPERSEDED~~Revision 2B)
~~Yes - Figure 2-10 was replaced by the following figure:~~

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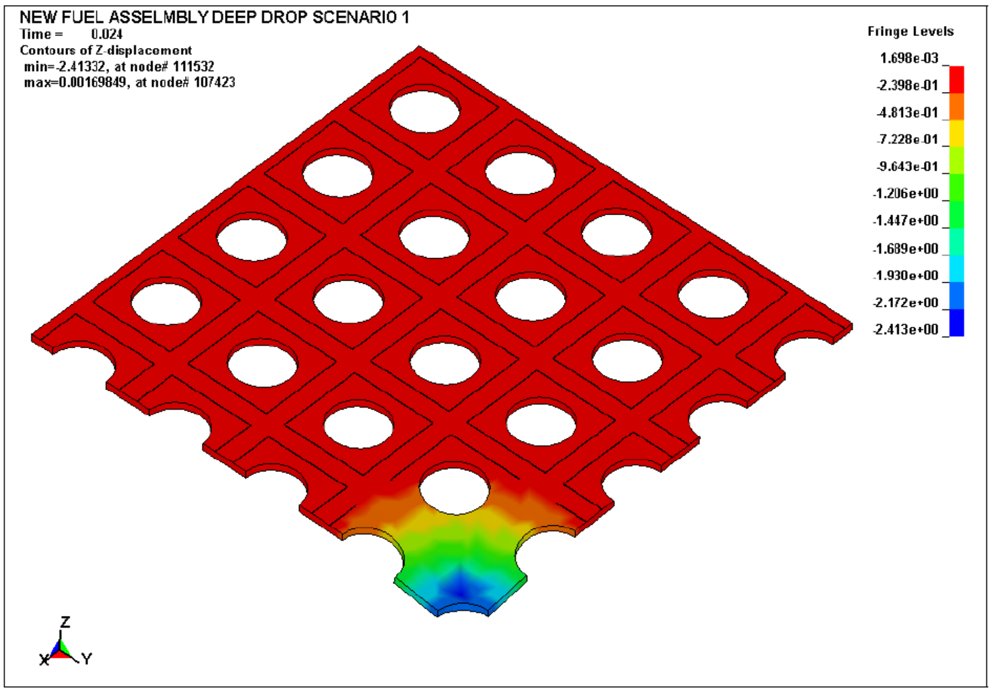

~~Figure 2-10 Baseplate Deformation Resulting from Fuel Assembly Drop onto Baseplate (2.41 inch Maximum Displacement Directly under Impact Location~~ (Removed by Revision 2B)

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-008
Revision: ~~2B~~ 2B

***Question:* (Revision 0)**

As indicated in Table 2-3 of the report and the markup for DCD Table 9.1-1, one of the fuel handling accident loads that need to be considered is uplift force on the rack caused by a postulated stuck fuel assembly. Section 2.8.3 of the report states: "An evaluation of a stuck fuel assembly, leading to an upward load of 2,000 lb has been performed. The results from the evaluation show that this is not a bounding condition because the local stresses do not exceed 2,500 psi." The information provided is not sufficient for the staff to reach a conclusion that this load has been adequately considered. Please provide a detailed description of the assumptions, the analyses conducted, the results obtained, and the basis for the conclusion that this is not a bounding condition.

Staff Assessment (Revision 1): Response similar to response for spent fuel racks. See RAI-TR54-14.

Following the submittal of the Westinghouse Revision 1 response to RAI-TR54-14, the NRC staff requested additional information:

The following information is needed to ensure that the calculation in Westinghouse's response is adequate:

(1) Explain how the effective b_e and t_e are determined.

(2) Provide a calculation on the adequacy of the vertical welds along the height between adjoining cells and the horizontal welds at the base (cell walls to baseplate). If the stress levels are higher than those currently presented in the response, then revise the Technical Report accordingly.

(3) The two sentence description of the stuck fuel assembly is presented in Section 2.8.3- "Dead Load Evaluation" of the Technical Report. A more detailed description comparable to the information given in the RAI response should be included in a more appropriate section of the Technical Report since this loading is a fuel handling accident condition not a dead load evaluation.

(4) Explain why the Technical Report and the response describes the uplift force equal to 2,000 pounds is used, while DCD Section 9.1.2.2.1 indicates that an uplift force of 5,000 pounds is used in the analysis.

Additional Question: (Revision 2B)

Clarify why the proposed DCD change quoted below from ~~in~~ RAI Revision 1 was never implemented: ~~. The proposed DCD change stated:~~

"Item Q, 'New Fuel Handling Crane', of Section 9.1.4.2.4, 'Component Description', is revised as follows:

> *'The new fuel handling crane is located in the fuel handling area. It is a standard commercial crane with an "L" shaped frame and an electric operated hoist. It is used to move the new fuel from the new fuel storage position to the new fuel elevator. The crane is positioned so that it cannot reach the spent fuel storage positions. The crane capacity is limited to a 4000 pound load.' "*

Westinghouse Response:

Westinghouse Response: (Revision 2B)

~~The~~ The piece of equipment above called the New Fuel Handling Crane has been superseded by design and operations changes, ~~,~~limitations, and commensurate DCD changes as discussed in OI-SRP9.1.1-SBPA-03 R3A. As noted in revisions to DCD Section 9.1.4.2.4 Item B, the Fuel Handling Machine now performs fuel handling operations in the new and spent fuel handling area. The FHM is equipped with two 2-ton hoists, one of which is single failure proof.

Drops from a single failure proof hoist are deemed unlikely and non-credible and do not require further analysis. Westinghouse has taken this position for the postulated new fuel drop accident scenario.

Therefore, the proposed DCD change noted in RAI Revision 1 to add an Item Q discussing this obsolete crane was never implemented. Also,

~~As noted in revisions to DCD Section 9.1.4.2.4 Item B, the Fuel Handling Machine performs fuel handling operations in the new and spent fuel handling area. The FHM is equipped with two 2-ton hoists, one of which is single failure proof. The single failure proof hoist is the only hoist used to move new fuel in the new fuel pit.~~

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Westinghouse Response: (Revision 0)

A nearly empty rack with one corner cell occupied is subject to an upward load of 2000 lbf, which is assumed to be caused by the fuel sticking while being removed. The ramification of the loading is two-fold:

1) The upward load creates a force and a moment at the base of the rack;

2) The loading induces a local tension in the cell wall.

The following calculation determines the maximum stress in the rack cell structure due to a postulated stuck fuel assembly. The terms p, Nx, Ny, Ixx2, and Iyy2 are defined as the cell pitch, the number of storage cells in the horizontal x-direction, the number of storage cells in the horizontal y-direction, the moment of inertia of the rack cell structure about the x-axis, and the moment of inertia of the rack cell structure about the y-axis, respectively.

Calculation of the Effect of a Stuck Fuel Assembly

$P_{stuck} := 2000 \cdot lbf$ Per Westinghouse design input

Compute maximum stress at base of rack cell structure assuming rack behaves as a cantilever beam

$X := N_x \cdot \frac{p}{2}$ $X = 4.087\,ft$ $I_{xx2} = 6.653 \times 10^4\,in^4$

$Y := N_y \cdot \frac{p}{2}$ $Y = 3.633\,ft$

$$\sigma_{grid} := P_{stuck} \cdot \frac{X^2}{I_{xx2}} + P_{stuck} \cdot \frac{Y^2}{I_{yy2}} \qquad \sigma_{grid} = 118.032\,psi$$

It is clear that the global stress due to a stuck fuel assembly is insignificant. Now, check local stress in cell in tension. Conservatively using the effective width

$$A_{celllocal} := 4 \cdot b_e \cdot t_e \qquad A_{celllocal} = 0.991\,in^2$$

$$\sigma_{local} := \frac{P_{stuck}}{A_{celllocal}} \qquad \sigma_{local} = 2.018 \times 10^3\,psi$$

This local stress is well below the yield stress of the cell wall material (i.e., 30,000 psi per Table 2-5.)

Westinghouse Supplemental Response from May 21 and 22, 2008 Technical Review: (Revision 1)

Item 1: During the October 8-12, 2007 audit, Westinghouse showed the NRC staff Appendix D (pg. D-13) of the equivalent structural/seismic calculation for the spent fuel racks, APP-FS02-S3C-002, Rev. 0, where the calculation of b_e and t_e was performed. The equations for the calculation of the effective width were taken from the ASME Code, Section III, Subsection NF, NF-3222.2, and the methodology used in the new fuel rack structural/seismic analysis is the same.

The effective thickness for a spent fuel rack cell uses one-half the actual thickness because each cell wall is shared by the adjacent two cells. During the May 21 and 22, 2008 technical review the NRC staff reviewed Revision 1 of APP-FS02-S3C-002, and determined that the calculation for the effective width is based on the provisions in the ASME Code, Section III, Subsection NF, and the effective wall thickness corresponds to one-half of the true wall thickness. Therefore, item 1 of RAI-TR54-14 for the spent fuel racks was found to be technically acceptable by the NRC staff.

The same approach was used in the new fuel rack structural/seismic analysis, APP-FS01-S3C-001, Revision 1; therefore, Westinghouse considers this item to be technically acceptable for the new fuel rack as well.

Item 2: The following calculations demonstrate the adequacy of the vertical welds along the height between adjoining cells and the horizontal welds at the base (cell walls to baseplate) to resist the stuck fuel assembly load.

Field Code Changed

<u>Cell to cell welds</u>

Each storage cell in the new fuel rack is welded vertically along its height to the adjoining cells by a combination of 3" and 6" long intermittent fillet welds. The minimum length of weld over the height of a storage cell, along <u>one</u> corner of the cell, is 6". Therefore, for conservatism, the entire stuck fuel assembly load is assumed to be resisted by only two 3" long fillet welds at the very top of the rack. Based on this approach, the stress in the cell to cell welds is calculated as follows:

Stuck fuel assembly load $P_{stuck} := 4000 \cdot lbf$

Length of intermittent fillet weld $L_{weld} := 3 \cdot in$

Size of intermittent fillet weld $t_{weld} := \frac{1}{16} \cdot in$

Number of fillet welds that resist load $N := 2$

Effective throat area of fillet welds $A_{weld} := N \cdot L_{weld} \cdot \frac{t_{weld}}{\sqrt{2}}$

$$A_{weld} = 0.265\, in^2$$

Shear stress in fillet welds $\tau := \frac{P_{stuck}}{A_{weld}}$

$$\tau = 15085\, psi$$

Per Section 2.3.4.1 of TR-44, the allowable weld stress under normal conditions is 0.3 times the material ultimate strength. From Table 2-5 of TR-44, the ultimate strength of SA240-304 material at 100F is 75,000 psi. Therefore, the allowable weld stress under normal conditions is 0.3 x 75,000 psi = 22,500 psi, which is greater than the weld stress calculated above.

Cell to baseplate welds

Each storage cell in the new fuel rack is welded to the base plate by four 7" (min.) long fillet welds. Since the total length of weld associated with cell to baseplate connection (28") is greater than the length considered in the above cell to cell weld evaluation (6"), and the weld size is the same (1/16"), the stress in the cell to baseplate welds is bounded by the preceding stress calculation for the cell to cell welds.

Item 3: The description of the stuck fuel assembly evaluation will be deleted from Section 2.8.3 of the Technical Report and will be replaced by a more detailed description in the newly added Section 2.8.6 (Stuck Fuel Assembly Evaluation). See the Technical Report Revision section below.

Item 4: This item is not directly applicable to the new fuel racks as it is currently worded; however, in the TR an uplift force of 2,000 pounds was stated, but in Section 9.1.1.2.1 of the DCD it is stated that an uplift force of 2,027 will be evaluated. The uplift force was reevaluated in Revision 1 of the new fuel rack structural/seismic analysis, APP-FS01-S3C-001, for 4,000 pound because the hoist on the fuel handling machine is rated at 4,000 pounds. The resultant stress on the rack is within the allowable; the max stress is 4,046 psi (see below calculation) compared to an allowable stress of 30,000 psi. The consideration of a 4,000 lbf uplift force will be reflected revised in TR44 and the DCD; see the Technical Report and DCD Revision sections below.

Calculation of the Effect of a Stuck Fuel Assembly

$P_{stuck} := 4000 \cdot lbf$ Per Westinghouse design input

Compute maximum stress at base of rack cell structure assuming rack behaves as a cantilever beam

$X := N_x \cdot \frac{p}{2}$ $X = 4.087\, ft$ $I_{xx2} = 6.644 \times 10^4\, in^4$

$Y := N_y \cdot \frac{p}{2}$ $Y = 3.633\, ft$ $I_{yy2} = 8.306 \times 10^4\, in^4$

$\sigma_{grid} := P_{stuck} \cdot \frac{X^2}{I_{xx2}} + P_{stuck} \cdot \frac{Y^2}{I_{yy2}}$ $\sigma_{grid} = 236.391\, psi$

It is clear that the global stress due to a stuck fuel assembly is insignificant. Now, check local stress in cell in tension. Conservatively using the effective width

$A_{celllocal} := 4 \cdot b_e \cdot t_e$ $A_{celllocal} = 0.989\, in^2$

$\sigma_{local} := \frac{P_{stuck}}{A_{celllocal}}$ $\sigma_{local} = 4045.588\, psi$

This local stress is well below the yield stress of the cell wall material (i.e., 30,000 psi per Table 2-5 of TR44.)

References:

~~1. APP-GW-GLR-026, Revision 4a, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44, TR44)~~

~~2.~~1. APP-FS02-S3C-002, Revision ~~1~~0, "Spent Fuel Storage Rack Structural/Seismic Analysis"

~~3.~~2. APP-FS01-S3C-001, Revision ~~1~~0, "New Fuel Storage Rack Structural/Seismic Analysis"

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Design Control Document (DCD) Revision:

DCD Changes: (Revision 1)

Item B, "New Fuel Handling Crane Uplift Analysis", of Section 9.1.1.2.1, "New Fuel Rack Design", is revised as follows:

An analysis is performed to demonstrate that the rack can withstand a maximum uplift load of 4000 pounds. This load is applied to a postulated stuck fuel assembly. Resultant rack stresses are evaluated against the stress limits and are demonstrated to be acceptable. It is demonstrated that there is no change in rack geometry of a magnitude which causes the criticality criterion to be violated.

Section 9.1.1.3, "Safety Evaluation", is revised as follows:

~~The rack is also designed with adequate energy absorption capabilities to withstand the impact of a dropped fuel assembly from the maximum lift height of the new fuel handling crane.~~ (Superseded and deleted by Revision 2B) Handling equipment (cask handling crane) capable of carrying loads heavier than fuel components is prevented from traveling over the fuel storage area. The fuel storage rack can withstand an uplift force greater than or equal to the uplift capability of the new fuel handling crane (4000 pounds).

~~Item Q, "New Fuel Handling Crane", of Section 9.1.4.2.4, "Component Description", is revised as follows:~~

~~The new fuel handling crane is located in the fuel handling area. It is a standard commercial crane with an "L" shaped frame and an electric operated hoist. It is used to move the new fuel from the new fuel storage position to the new fuel elevator. The crane is positioned so that it cannot reach the spent fuel storage positions. The crane capacity is limited to a 4000 pound load.~~ (Superseded and deleted by Revision 2B)

DCD Changes: (Revision 2B)

The Section 9.1.1.3 sentence and Section 9.1.4.2.4 Item Q description noted above are ~~is~~ superseded, obsolete, and deleted by strikeout. ~~, as follows:~~

~~Item Q, "New Fuel Handling Crane", of Section 9.1.4.2.4, "Component Description", is revised as follows:~~

~~The new fuel handling crane is located in the fuel handling area. It is a standard commercial~~

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~~crane with an "L" shaped frame and an electric operated hoist. It is used to move the new fuel from the new fuel storage position to the new fuel elevator. The crane is positioned so that it cannot reach the spent fuel storage positions. The crane capacity is limited to a 4000 pound load.~~

PRA Revision:

None

Technical Report (TR) Revision:

TR Changes: (Revision 1)

The two sentence description of the stuck fuel assembly evaluation in Section 2.8.3 of the Technical Report was replaced by the following newly added section:

2.8.6 Stuck Fuel Assembly Evaluation

A nearly empty rack with one corner cell occupied is subject to an upward load of 4,000 lbf, which is assumed to be caused by the fuel sticking while being removed. The ramification of the loading is two-fold:

1. The upward load creates a force and a moment at the base of the rack;
2. The loading induces a local tension in the cell wall and shear stresses in the adjacent welds.

Strength of materials calculations have been performed to determine the maximum stress in the rack cell structure due to a postulated stuck fuel assembly. The results are summarized in Table 2-16.

Table 2-16 was added to the Technical Report:

Table 2-16 Results from Stuck Fuel Assembly Evaluation

Item	Calculated Stress (psi)	Allowable Stress (psi)	Safety Factor
Tensile Stress in Cell Wall	4,046	30,000	7.41
Shear Stress in Cell-to-Cell Weld	15,085	22,500	1.49

OI-SRP9.1.1-SBPA-03, R3A

Summary of DCD proposed changes is outlined below and is annotated on the following pages:

DCD Rev. 17 Section or Table	**DCD Rev. 17 Page Number**	**Change Summary**
Tier 1, Section 2.1.1, Item 7	2.1.1-1	Delete reference to new fuel rack design basis dropped assembly accident
Tier 1, Table 2.1.1-1, Item 7	2.1.1-3	Delete reference to new fuel rack design basis dropped assembly accident
9.1.1.2	9.1-2	Clarify paragraph #2 and #5 regarding use of the FHM and single failure proof crane to handle new fuel pit and new fuel assemblies.
9.1.1.2.1.A	9.1-3	Remove the fourth bullet loading combination for a fuel assembly drop accident since it is non credible
9.1.1.2.1.C	9.1-3 and 9.1-4	Add new first paragraph to clarify that dropping a new fuel assembly is not credible and is not a design basis accident.
9.1.1.3	9.1-4	Clarify wording in Paragraph #4 to be consistent with changes to 9.1.1.2 above.
9.1.1.3	9.1-5	Change criticality analysis reference directly to the proper new fuel rack technical report reference within DCD Chapter 9.1.
Table 9.1-1	9.1-52	Add note to load drop (F_d) load combination to state: "This load combination is not required for a new fuel assembly since it is not a credible accident."
Table 14.3-2 (pg. 10 of 17)	14.3-26	Change reference and statement to be the same as first paragraph to 9.1.1.2.1.C above.

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DCD changes to Tier 1, Section 2.1.1, Item 7

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2.1.1 Fuel Handling and Refueling System

Design Description

The fuel handling and refueling system (FHS) transfers fuel assemblies and core components during fueling operations and stores new and spent fuel assemblies in the new and spent fuel storage racks. The refueling machine (RM) and the fuel transfer tube are operated during refueling mode. The fuel handling machine (FHM) is operated during normal modes of plant operation, including startup, power operation, cooldown, shutdown and refueling.

The component locations of the FHS are as shown in Table 2.1.1-2.

1. The functional arrangement of the FHS is as described in the Design Description of this Section 2.1.1.

2. The FHS has the RM, the FHM, and the new and spent fuel storage racks.

3. The FHS preserves containment integrity by isolation of the fuel transfer tube penetrating containment.

4. The RM and FHM/spent fuel handling tool (SFHT) gripper assemblies are designed to prevent opening while the weight of the fuel assembly is suspended from the grippers.

5. The lift height of the RM mast and FHM hoist(s) masts is limited such that the minimum required depth of water shielding is maintained.

6. The RM and FHM are designed to maintain their load carrying and structural integrity functions during a safe shutdown earthquake.

7. The new and spent fuel storage racks maintain the effective neutron multiplication factor less than the required limits during normal operation, ~~,~~design basis seismic events, ~~,~~and a design basis dropped spent fuel assembly accident~~s~~. (Note: A postulated drop for a new fuel assembly accident is not required since it is a non-credible event.)

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Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.1.1-1 specifies the inspections, tests, analyses, and associated acceptance criteria for the FHS.

DCD changes to Tier 1, Table 2.1.1-1, Item 7

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Table 2.1.1-1 (cont.) Inspections, Tests, Analyses, and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
7. The new and spent fuel storage racks maintain the effective neutron multiplication factor less than the required limits during normal operation, design basis seismic events, and ~~a~~ design basis dropped spent fuel assembly accident~~s~~. (Note: A postulated drop for a new fuel assembly accident is not required since it is a non-credible event.)	i) Analyses will be performed to calculate the effective neutron multiplication factor in the new and spent fuel storage racks during normal conditions.	i) The calculated effective neutron multiplication factor for the new and spent fuel storage racks is less than 0.95 under normal conditions.
	ii) Inspection will be performed to verify that the new and spent fuel storage racks are located on the nuclear island.	ii) The new and spent fuel storage racks are located on the nuclear island.
	iii) Seismic analysis of the new and spent fuel storage racks will be performed.	iii) A report exists and concludes that the new and spent fuel racks can withstand seismic design basis dynamic loads and maintain the calculated effective neutron multiplication factor less than 0.95.
	iv) Analysis of the ~~new and~~ spent fuel storage racks under design basis dropped fuel assembly loads will be performed.	iv) A report exists and concludes that the ~~new and~~ spent fuel racks can withstand design basis dropped fuel assembly loads and maintain the calculated effective neutron multiplication factor less than 0.95.

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DCD change to Section 9.1.1

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9.1.1 New Fuel Storage

9.1.1.1 Design Bases

New fuel is stored in a high density rack which includes integral neutron absorbing material to maintain the required degree of subcriticality. The rack is designed to store fuel of the maximum design basis enrichment. The rack in the new fuel pit consists of an array of cells interconnected to each other at several elevations and to a thick base plate at the bottom elevation. This rack module is not anchored to the pit floor.

The new fuel rack includes storage locations for 72 fuel assemblies. The rack layout and array center-to-center spacing is shown in Figure 9.1-1. This spacing provides a minimum separation between adjacent fuel assemblies which is sufficient to maintain a subcritical array even in the event the building is flooded with unborated water or fire extinguishant aerosols or during any design basis event. The design of the rack is such that a fuel assembly cannot be inserted into a location other than a location designed to receive an assembly. An assembly cannot be inserted into a full location. Surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel.

The requirements of ANS 57.1 are addressed in subsection 9.1.4. The rack is designed to withstand nominal operating loads and safe shutdown earthquake seismic loads defined in Table 9.1-1. The new fuel storage rack is designed to meet seismic Category I requirements of Regulatory Guide 1.29. Refer to subsection 1.9.1 for compliance with Regulatory Guides. The rack is also designed to withstand the maximum uplift force of the fuel handling machine.

AP1000 equipment, seismic and ASME Code classifications are discussed in Section 3.2. The requirements of ASME Code Section III, Division I, Article NF3000 are used as the criteria for evaluation of stress analysis. The materials are procured in accordance with ASME Code Section III, Division I, Article NF2000. Criticality analyses are performed in accordance with the requirements of ANSI N16.1-75, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors (Reference 1); and analysis codes are validated against the requirements of ANSI N16.9-75, Validation of Calculational Methods for Nuclear Criticality Safety (Reference 2).

The stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1 for components design by the linear elastic method (Reference 22).

9.1.1.2 Facilities Description

The new fuel storage facility is located within the seismic Category I auxiliary building fuel handling area. The facility is protected from the effects of natural phenomena such as earthquakes, wind, tornados, floods, and external missiles by the external walls of the auxiliary building. See Section 3.5 for additional discussion on protection from missiles. The facility is designed to maintain its structural integrity following a safe shutdown earthquake and to perform its intended function following a postulated event such as fire, internal missiles, or pipe break. The walls surrounding the fuel handling area and new fuel storage pit protect the fuel from missiles generated inside the auxiliary building. The fuel handling area does not contain a credible source of missiles. Refer to subsection 1.2.4.3 for a discussion of the auxiliary building. Refer to Section 3.8 for a discussion of the structural design of the new fuel storage area. Refer to subsection 3.5.1 for a discussion of missile sources and protection.

The dry, unlined, approximately 17-feet deep reinforced concrete pit is designed to provide support for the new fuel storage rack. The rack is supported by the pit floor. The walls of the new fuel pit are seismic Category I. The new fuel pit is normally covered to prevent foreign objects from entering the new fuel storage rack. The crane that is used to access the new fuel pit is the fuel handling machine. The fuel handling machine is equipped with a single failure proof hoist with a capacity of two tons. It is used to handle new fuel, control rod assembly, handling tool, control components within the spent fuel pool, or loads under 4,000 lbs located within the fuel handling area of the auxiliary building. ~~Since the only crane that can access the new fuel pit does not have the capacity to lift heavy objects, as defined in subsection 9.1.5, T~~the new fuel pit cover is not designed to protect the fuel assemblies from the effects of dropped heavy objects; because ~~-~~dropped heavy objects are not credible due to the use of a single failure proof hoist. Figures 1.2-7 through 1.2-10 show the relationship between the new fuel storage facility and other features of the fuel handling area.

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The new fuel storage pit is drained by gravity drains that are part of the radioactive waste drain system (subsection 9.3.5), draining to the waste holdup tanks which are part of the liquid radwaste system (Section 11.2). These drains preclude flooding of the pit by an accidental release of water.

Nonseismic equipment in the vicinity of the new fuel storage rack is evaluated to confirm that its failure could not result in an increase of K_{eff} beyond the maximum allowable K_{eff}. Refer to subsection 3.7.3.13 for a discussion of the nonseismic equipment evaluation.

The fuel handling machine is used to handle new fuel assemblies in the rail car bay, new fuel rack, and new fuel elevator. ~~The capacity of the fuel handling machine, while over the new fuel storage rack, is limited to lifting a fuel assembly, control rod assembly, and handling tool.~~ The new fuel storage rack is not accessed by the cask handling crane. This precludes the movement of loads greater than fuel components over stored new fuel assemblies.

During fuel handling operations, a ventilation system removes gaseous radioactivity from the atmosphere above the new fuel pit. Refer to subsection 9.4.3 for a discussion of the fuel handling area HVAC system and Section 11.5 for process radiation monitoring. Security for the new fuel assemblies is described in separate security documents referred to in Section 13.6.

9.1.1.2.1 New Fuel Rack Design

A. Design and Analysis of the New Fuel Rack

The new fuel storage rack array center-to-center spacing of nominally 10.9 inches provides a minimum separation between adjacent fuel assemblies sufficient with neutron absorbing material to maintain a subcritical array. The seismic and stress analyses of the new fuel rack consider the condition of full fuel assembly loadings. The rack is evaluated for the safe shutdown earthquake condition against the seismic Category I requirements. A stress analysis is performed to verify the acceptability of the critical load components and paths under normal and faulted conditions. The rack rests on the pit floor.

The dynamic response of the fuel rack assembly during a seismic event is the condition which produces the governing loads and stresses on the structure. The new fuel storage rack is designed to meet the seismic Category I requirements of Regulatory Guide 1.29.

Loads and Load Combinations

The applied loads to the new fuel rack are:

- Dead loads
- Live loads - effect of lifting the empty rack during installation
- Seismic forces of the safe shutdown earthquake
- ~~Fuel assembly drop accident~~
- Fuel handling machine uplift while over the new fuel rack - postulated stuck fuel assembly

Table 9.1-1 shows loads and load combinations considered in the analyses of the new fuel rack.

The margins of safety for the rack in the multi-direction seismic event are produced using loads obtained from the seismic analysis based on the simultaneous application of three statistically independent, orthogonal accelerations.

B. Fuel Handling Machine Uplift Analysis

An analysis is performed to demonstrate that the rack can withstand a maximum uplift load of 4000 pounds. This load is applied to a postulated stuck fuel assembly. Resultant rack stresses are evaluated against the stress limits and are demonstrated to be acceptable. It is demonstrated that there is no change in rack geometry of a magnitude which causes the criticality criteria to be violated.

C. Fuel Assembly Drop Accident Analysis

Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. Therefore, no additional evaluations are required for loads handled by this hoist.

~~In the unlikely event of dropping a fuel assembly, accidental deformation of the rack is determined and evaluated in the criticality analysis to demonstrate that it does not cause the criticality criterion to be violated. The analysis considers only the case of a dropped new fuel assembly.~~

~~For the analysis of a dropped fuel assembly, two accident conditions are postulated. The first accident condition conservatively assumes that the weight of a fuel assembly, control rod assembly, and handling tool (2027 pounds total) impacts the top of the fuel rack from a drop height of 3 feet above the top of the rack. Both a straight drop and an inclined drop are included in the assessment. Calculations are performed to demonstrate that the impact energy is absorbed by the dropped fuel assembly, the rack cells, and the rack base plate assembly.~~

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~~The second accident condition assumes that the dropped assembly, control rod assembly, and handling tool (2027 pounds) falls straight through an empty cell and impacts the rack base plate from a drop height of 3 feet above the top of the rack. An analysis is performed that demonstrates the impact energy is absorbed by the fuel assembly and the rack base plate. The resulting rack deformations are evaluated in the criticality analysis to demonstrate that the criticality criteria are not violated.~~

D. Failure of the Fuel Handling Machine

The fuel handling machine is a seismic Category II component. The fuel handling machine is evaluated to show that the machine does not fall into the new fuel pit during a seismic event.

E. Internally Generated Missiles

The fuel handling area does not contain any credible sources of internally generated missiles.

Stress analyses are performed by the vendor using loads developed by the dynamic analysis. Stresses are calculated at critical sections of the rack and compared to acceptance criteria referenced in ASME Section III, Division I, Article NF3000.

9.1.1.3 Safety Evaluation

The rack, being a seismic Category I structure, is designed to withstand normal and postulated dead loads, live loads, loads resulting from thermal effects, and loads caused by the safe shutdown earthquake event.

The design of the rack is such that K_{eff} remains less than or equal to 0.95 with new fuel of the maximum design basis enrichment. For a postulated accident condition of flooding of the new fuel storage area with unborated water, K_{eff} does not exceed 0.98.

The criticality evaluation considers the inherent neutron absorbing effect of the materials of construction, including fixed neutron absorbing "poison" material.

The new fuel rack is located in the new fuel storage pit, which has a cover to protect the new fuel from debris. No loads are required to be carried over the new fuel storage pit while the cover is in place. The cover is designed such that it will not fall and damage the fuel or fuel rack during a seismic event. Administrative controls are utilized when the cover is removed for new fuel transfer operations to limit the potential for dropped object damage.

Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. ~~The rack is also designed with adequate energy absorption capabilities to withstand the impact of a dropped fuel assembly from the maximum lift height of the fuel handling machine.~~ Handling equipment (cask handling crane) capable of carrying loads heavier than fuel components is prevented from traveling over the fuel storage area. The fuel storage rack can withstand an uplift force of 4000 pounds.

Materials used in rack construction are compatible with the storage pit environment, and surfaces that come into contact with the fuel assemblies are made of annealed austenitic stainless steel. Structural materials are corrosion resistant and will not contaminate the fuel assemblies or storage pit environment. Neutron absorbing "poison" material used in the rack design has been qualified for the storage environment. Venting of the neutron absorbing material is considered in the detailed design of the storage rack.

The new fuel assemblies are stored dry. The rack structure is designed to maintain a safe geometric array for normal and postulated accident conditions. The fixed neutron absorbing "poison" material maintains the required degree of subcriticality for normal and postulated accident conditions such as flooding with pure water and low density optimum moderator "misting."

A discussion of the methodology used in the new fuel rack criticality analysis is provided in APP-GW-GLR-030 (Reference 17). ~~subsection 4.3.2.6.~~

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Table 9.1-1 **LOADS AND LOAD COMBINATIONS FOR FUEL RACKS**	
Load Combination	**Service Level**
D + L D + L + T_o	Level A
D + L + T_a D + L + T_o + P_f	Level B
D + L + T_a + E'	Level D
D + L + F_d	The functional capability of the spent fuel racks should be demonstrated. (Note: This load combination is not required for a new fuel assembly since it is not a credible accident)

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel racks are freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations -are those used in NUREG-0800, Section 3.8.4 (including Appendix D) of the Standard Review Plan (SRP):

D = Dead weight induced loads (including fuel assembly weight)
L = Live load (not applicable to fuel racks since there are no moving objects in the rack load path)
F_d = Force caused by the accidental drop of the heaviest load from the maximum possible height
P_f = Upward force on the racks caused by postulated stuck fuel assembly
E' = Safe shutdown earthquake (SSE)
T_o = Differential temperature induced loads based on the most critical transient or steady-state condition under normal operation or shutdown conditions
T_a = Differential temperature induced loads based on the postulated abnormal design conditions

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Table 14.3-2 (Sheet 10 of 17)

DESIGN BASIS ACCIDENT ANALYSIS

Reference	Design Feature	Value
Section 7.4.3.1	If temporary evacuation of the main control room is required because of some abnormal main control room condition, the operators can establish and maintain safe shutdown conditions for the plant from outside the main control room through the use of controls and monitoring located at the remote shutdown workstation.	
Section 7.4.3.1.1	The remote shutdown workstation equipment is similar to the operator workstations in the main control room and is designed to the same standards. One remote shutdown workstation is provided.	
Section 7.4.3.1.3	The remote shutdown workstation achieves and maintains safe shutdown conditions from full power conditions and maintains safe shutdown conditions thereafter.	
Section 7.5.4	The protection and safety monitoring system provides signal conditioning, communications, and display functions for Category 1 variables and for Category 2 variables that are energized from the Class 1E uninterruptible power supply system.	
Section 7.6.1.1	An interlock is provided for the normally closed motor-operated normal residual heat removal system inner and outer suction isolation valves. Each valve is interlocked so that it cannot be opened unless the reactor coolant system pressure is below a preset pressure.	
Section 8.2.2	Following a turbine trip during power operation, the reverse-power relay will be blocked for a minimum time period (sec).	≥ 15
Section 8.3.2.1.2	The non-Class 1E dc and UPS system (EDS) consists of the electric power supply and distribution equipment that provides dc and uninterruptible ac power to nonsafety-related loads.	
Section 9.1.1.2.1.C	Based on the conservative design and operation of the single failure proof FHM hoist and associated lifting tools to handle unirradiated new fuel assemblies, dropping a new fuel assembly is unlikely and is not considered a credible accident. Therefore, no additional evaluations are required for loads handled by this hoist.~~In the unlikely event of a dropping of an unirradiated fuel assembly, accidental deformation of the fuel rack is determined and evaluated in the criticality analysis to demonstrate that it does not cause criticality criterion to be violated.~~	
Section 9.1.3.5	The spent fuel pool is designed such that a water level is maintained above the spent fuel assemblies for at least 7 days following a loss of the spent fuel cooling system using only on-site makeup water sources (See Table 9.1-4).	