DCP_NRC_003133
March 3, 2011

ENCLOSURE 5

(Holtec Non-Proprietary)

Holtec International Report No. HI-2094327, Revision 2 (2/9/11), Criticality Evaluation of the AP1000® Spent Fuel Storage Racks (revised pages and new Supplement 1)
(Holtec Non-Proprietary)

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INTERNATIONAL

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CRITICALITY EVALUATION OF THE AP1000 SPENT FUEL STORAGE RACKS

FOR

WESTINGHOUSE

Holtec Report No: HI-2094327

Holtec Project No: 1540

Sponsoring Holtec Division: HTS

Report Class : SAFETY RELATED

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DOCUMENT ISSUANCE AND REVISION STATUS[1]

DOCUMENT NAME:	CRITICALITY EVALUATION OF THE AP1000 SPENT FUEL STORAGE RACKS
DOCUMENT NO.:	HI-2094327
PROJECT NO.:	1540

CATEGORY: ☐ GENERIC
☑ PROJECT SPECIFIC

Rev. No. [2]	Date Approved	Author's Initials	VIR #
2	2/9/2011	S.Anton	330632

DOCUMENT CATEGORIZATION

In accordance with the Holtec Quality Assurance Manual and associated Holtec Quality Procedures (HQPs), this document is categorized as a:

- ☑ Calculation Package[3] (Per HQP 3.2)
- ☐ Technical Report (Per HQP 3.2) (Such as a Licensing Report)
- ☐ Design Criterion Document (Per HQP 3.4)
- ☐ Design Specification (Per HQP 3.4)
- ☐ Other (Specify):

DOCUMENT FORMATTING

The formatting of the contents of this document is in accordance with the instructions of HQP 3.2 or 3.4 except as noted below:

DECLARATION OF PROPRIETARY STATUS

☐ Nonproprietary ☑ Holtec Proprietary ☐ Privileged Intellectual Property (PIP)

Notes

1. This document has been subjected to review, verification and approval process set forth in the Holtec Quality Assurance Procedures Manual. Password controlled signatures of Holtec personnel who participated in the preparation, review, and QA validation of this document are saved on the company's network. The Validation Identifier Record (VIR) number is a random number that is generated by the computer after the specific revision of this document has undergone the required review and approval process, and the appropriate Holtec personnel have recorded their password-controlled electronic concurrence to the document.

2. A revision to this document will be ordered by the Project Manager and carried out if any of its contents including revisions to references is materially affected during evolution of this project. The determination as to the need for revision will be made by the Project Manager with input from others, as deemed necessary by him.

3. Revisions to this document may be made by adding supplements to the document and replacing the ‘Table of Contents’, this page and the ‘Revision Log’.

Summary of Revisions:

Revision 0: Original Issue

Revision 1: Report updated to include pyrex burnable absorbers. Changes in Appendix F are noted with blue text. Revision to the main part of the report are denoted with revision bars

Revision 2: All revision bars from Revision 1 were removed. Supplement 1 was added. This supplement provides updated analyses that account for a different rack wall thickness of 0.090 inch instead of the 0.075 inch used in the main part of the report, and that correct several inconsistencies and inaccuracies in some of the calculations models. Except as specifically discussed in Supplement 1, all analyses in the main part are still considered valid, and applicable to both rack wall thicknesses.

Supplement 1

Additional Calculations for a Rack Cell Wall Thickness of 0.090 Inch

S1-1 Introduction
The main part of this report documents the criticality safety analyses performed for racks with a cell wall thickness of 0.075 inch. This supplement evaluates a different cell wall thickness of 0.090 inch. The goal of this supplement is to demonstrate that with this small difference in the wall thickness the regulatory requirements are still satisfied, even when using the burnup and soluble boron requirements that were established in the main part of the report for the 0.075 inch wall thickness.

S1-2 Methodology
The evaluations documented in this supplement use the same methodology as those in the main part of the report, which is discussed in Section 2 of the main report.

S1-3 Acceptance Criteria
The evaluations documented in this supplement use the same acceptance criteria as those in the main part of the report, which are discussed in Section 3 of the main report.

Additionally, the criticality safety criteria developed in the main part of the report, namely the burnup and soluble boron requirements listed in Tables 7.4 and 7.5, respectively, are used.

S1-4 Assumptions
The evaluations documented in this supplement use the same assumptions as those in the main part of the report, which are discussed in Section 4 of the main report.

S1-5 Input Data
The evaluations documented in this supplement use the same input data as those in the main part of the report (see Section 5), except for the different rack cell wall thickness. Consistent with the different thickness, the cell pitch is also changed, so that other dimensions, namely the cell ID for Region 1 and Region 2 cells, and the flux trap size for Region 1 cells, are unchanged from the values in the main part of the report. See Table S1-5.1 for details.

S1-6 Computer Codes

The evaluations documented in this supplement use the same computer codes and code versions as those in the main part of the report, which are discussed in Section 6 of the main report.

S1-7 Analysis

S1-7.1 Calculation Performed

Based on a review of the sensitivity studies performed to determine the tolerance effects in the main part of this report, it is expected that the different rack wall thickness will have a very small effect on the calculated results. Nevertheless, to demonstrate that with the different wall thickness, and the safety criteria from the main part of the report, the regulatory requirements are still met, the following analyses have been re-performed:

- Normal Conditions:
  - Region 1, borated and unborated water: Calculations in Table 7.1
  - Region 2
    - Unborated water: Calculations in Table 7.3 and on Pages H-2 and H-3 in Appendix H
    - Borated Water: Bounding case of calculations on Page H-4 in Appendix H
- Accident Conditions:
  - Several Region 1 and Region 2 accident conditions were considered in the main report. However, since the difference in the cell wall thickness has a small effect, it is sufficient to verify the bounding accident condition (Misloading accident in Region 2, Page H-6 in Appendix H), using the specified soluble boron level from Table 7.5.

The effect of the different wall thickness on other analyses documented in the main part of this report and its appendices (such as the uncertainty analyses, studies, eccentricity effects etc.) would be insignificant. Nevertheless, some of those analyses were re-performed to verify this. However, since these calculations essentially show the same results as those in the main part of the report and its appendices, these calculations are not documented here, and the results presented in the main part of this report and its appendices are considered applicable for the different wall thickness.

S1-7.2 Results

The results are presented in Tables S1-7.1 through S1.7-4 at the end of this supplement:

- Table S1-7.1 shows the calculation for Region 1 with fresh water. The maximum k-eff is slightly increased in comparison to Table 7.1 in the main report, but still well below the regulatory requirement.
- Table S1-7.2 shows the calculations for Region 2 with fresh water, for the same burnups as determined in the main part of the report. All maximum k-eff values are still well below the regulatory limit, with some of them increasing and some decreasing compared to the results in Appendix H.
- Table S1-7.3 shows the calculations for the bounding case for Region 2, at the limiting soluble boron requirement listed in the main report. The maximum k-eff value is well below the regulatory limit.
- Table S1-7.4 shows the calculations for the bounding accident case (misloading in Region 2), at the limiting soluble boron requirement listed in the main report. The maximum k-eff value is well below the regulatory limit.

In summary, the calculations confirm that with the different rack wall thickness, all maximum k-eff values are still well below the regulatory limits.

S1-7.3 Comparison with Results from the Main Report

To indicate the effect of the different rack wall thickness, the differences in the maximum k-eff values for all analyzed cases are summarized in Table S1-7.5. Note that the calculations with soluble boron were performed for soluble boron levels below those listed in Table 7.5. The k-eff comparison is then performed to the calculations here with that same lower soluble boron level, and with calculations at the soluble boron level listed in Table 7.5.

S1-8 Computer Files

All computer file names for cases with the different rack wall thickness are identical to those listed in the main part of this report. They are stored on the Holtec server in the directory \Projects\1540\Reports\HI-2094327\Rev 2\ and its subdirectories.

S1-9 References

None

Table S1-5.1
Storage Rack Parameters Different from those in Table 5.12

Region 1	
Parameter	**Value**
Cell Wall thickness, in	0.090 ± [ ]a,c
Cell Pitch, in	10.93 ± [ ]a,c
Region 2	
Parameter	**Value**
Cell Wall thickness, in	0.090 ± [ ]a,c
Cell Pitch, in	9.043 ± [ ]a,c

Table S1-7.1
Results of the Criticality Safety Analyses for Region 1, Normal Conditions

	AP1000
Region	1
Enrichment	4.95
Burnup	0.0
MCNP Filename	n1f5
k-calc	
stan dev	
Bias	
MCNP Bias	
Temperature	
Total Bias	
Uncertainties	
MCNP Bias Uncertainty	
CASMO Bias Uncertainty	
Calculational (2*sigma)	
Eccentricity	
Rack Tolerances	
Fuel Tolerances	
Depletion Uncertainty	
Total Uncertainties	
Total Addition	
Maximum k-eff	

a,c

Table S1-7.2

Results of the Criticality Safety Analyses for Region 2, Normal Conditions, Unborated Water

Plant	AP1000									
Region	2									
Cooling Time	0									
Enrichment	2	2.5			3			3.5		
Enrichment Code	a	b			c			d		
Burnup	**0.0**	5	10	**6.8**	10	15	**13.0**	15	20	**19.6**
Profile	flat	flat	flat		flat	flat		flat	seg	
Filename	ca0f	cb5f	cb10f		cc10f	cc15f		cd15f	cd20s	
k-calc										
stan dev										
Bias										
MCNP Bias										
Temperature										
Total Bias										
Uncertainties										
MCNP Bias Uncertainty										
CASMO Bias Uncertainty										
Calculational (2*sigma)										
Eccentricity										
Rack Tolerances										
Fuel Tolerances										
Depletion Uncertainty										
Total Uncertainties										
Total Addition										
Maximum k-eff										

a,c

Table S1-7.2 (Continued)

Results of the Criticality Safety Analyses for Region 2, Normal Conditions, Unborated Water

Plant	AP1000								
Region	2								
Cooling Time	0								
Enrichment	4			4.5			4.95		
Enrichment Code	e			f			g		
Burnup	25	30	**27.0**	35	40	**35.5**	40	45	**42.6**
Profile	seg	seg		seg	seg		seg	seg	
Filename	ce25s	ce30s		cf35s	cf40s		cg40s	cg45s	
k-calc									
stan dev									
Bias									
MCNP Bias									
Temperature									
Total Bias									
Uncertainties									
MCNP Bias Uncertainty									
CASMO Bias Uncertainty									
Calculational (2*sigma)									
Eccentricity									
Rack Tolerances									
Fuel Tolerances									
Depletion Uncertainty									
Total Uncertainties									
Total Addition									
Maximum k-eff									

a,c

Table S1-7.3
Results of the Criticality Safety Analyses for Region 2, Normal Conditions, Borated Water (Bounding Case)

Plant				
Region				
Cooling Time				
Enrichment	3.5			
Enrichment Code	d			
Burnup	15	15	15	[ ]a,c
Soluble Boron	0	400	800	
Soluble Boron Code		4	8	
Profile	flat	flat	flat	
Filename	cd15f	cd15f4	cd15f8	
k-calc	[			] a,c
stan dev				
Bias				
MCNP Bias				
Temperature				
Total Bias				
Uncertainties				
MCNP Bias Uncertainty				
CASMO Bias Uncertainty				
Calculational (2*sigma)				
Eccentricity				
Rack Tolerances				
Fuel Tolerances				
Depletion Uncertainty				
Total Uncertainties				
Total Addition				
Maximum k-eff				]

Table S1-7.4
Results of the Criticality Safety Analyses for Region 1 and Region 2 Accident Conditions
(Bounding Case)

Plant	AP1000			
Region	2			
Cooling Time	0			
Enrichment	3.5			
Enrichment Code	d			
Burnup	15	15	15	[ ] a,c
Soluble Boron	0	400	800	
Soluble Boron Code		4	8	
Profile	flat	flat	flat	
Filename	cd15fa	cd15fa4	cd15fa8	
k-calc	[			] a,c
stan dev				
Bias				
MCNP Bias				
Temperature				
Total Bias				
Uncertainties				
MCNP Bias Uncertainty				
CASMO Bias Uncertainty				
Calculational (2*sigma)				
Eccentricity				
Rack Tolerances				
Fuel Tolerances				
Depletion Uncertainty				
Total Uncertainties				
Total Addition				
Maximum k-eff				]

Table S1-7.5
Comparison of k-eff values for Rack Wall Thickness of 0.075 Inch (Main Report) and 0.090 Inch (This Supplement)

Item	Wall Thickness 0.075" (Main Report)	Wall Thickness 0.090" (This Supplement)	Difference
Region 1			
Max k-eff	[		]a,c
Region 2, Max. k-eff values for Fresh Water Conditions			
2% Enr., Fresh fuel			
2.5% Enr., 6.8 GWd/mtU			
3.0% Enr., 13.0 GWd/mtU			
3.5% Enr., 19.6 GWd/mtU			
4.0% Enr., 27.0 GWd/mtU			
4.5% Enr., 35.5 GWd/mtU			
4.95% Enr, 42.6 GWd/mtU			
Average			
Region 2, Max. k-eff values for Soluble Boron Requirements			
Normal Conditions			
Accident Conditions			

a,c

a,c

ENCLOSURE 7

(Holtec Non-Proprietary)

Holtec International Document ID#1540017 (09 February 2011), Letter Summary: Update of the AP1000® Spent Fuel Storage Racks Criticality Analyses to Reflect the Current Racks Design – Attachment 1 (Holtec Non-Proprietary)

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Mr. Scott Altmayer
AP1000 Licensing and Customer Interface
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230

09 February 2011

Subject: Update of the AP1000 Spent Fuel Storage Racks Criticality Analyses to Reflect the Current Racks Design

References:
1. Holtec Project 1540
2. Holtec Letter 1540016, "Comparison of Existing AP1000 SFSR Criticality Analysis Dimensions and Current Rack Design Dimensions," 28 January 2011.
3. "Criticality Evaluation of the AP1000 Spent Fuel Storage Racks," Holtec Report HI-2094327, Revision 1.
4. "Discrete Zone Two Region Spent Fuel Pool Rack Layout," Holtec Drawing 4743, Revision 4.
5. "Criticality Evaluation of the AP1000 Spent Fuel Storage Racks," Holtec Report HI-2094327, Revision 2.

Mr. Altmayer:

Approximately two weeks ago we provided (Reference 2) a comparison of the geometric differences between the spent fuel storage racks evaluated in our criticality analysis report (Reference 3) and the current racks design (Reference 4). This previous document indicated that the following changes were made to the racks design:

a. The thickness of the rack storage cell walls was increased slightly ($+\Delta t$).
b. The racks cell-to-cell pitch was increased ($+2\Delta t$ for Region 1 cells, $+\Delta t$ for Region 2 cells) to match the change in the thickness of the racks storage cell walls.

We have, in the intervening days, completed updating the criticality analyses to reflect the current racks design. These updated analyses are documented in a supplement added in a revision to the report (Reference 5). The revised report has been transmitted separately.

To facilitate review of the revised calculations by Westinghouse and NRC (and other affected parties), a summary of the effects of the dimensional changes on the criticality performance of the racks is presented in Attachment 1 of this letter. The impact of the dimensional changes is expressed in terms of changes in effective neutron multiplication factor (k-effective). Please note that the attachment contains Holtec Proprietary Information and is so labeled.

An affidavit requesting that Attachment 1 be withheld from disclosure to the public is also attached (Attachment 2). Please ensure that the affidavit is included with any submittal of this letter to the NRC.

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Please let us know if you have any questions on the information presented in this letter, including in either of the attachments.

Sincerely,

Evan Rosenbaum, P.E.
Project Manager

Attachments: 1. Effect of Racks Design Changes on Criticality Performance (3 pages)
2. Affidavit Pursuant to 10 CFR 2.390 (4 pages)

emcc: Steve Stipanovich (Westinghouse)
Stefan Anton (Holtec)
Bret Brickner (Holtec)

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Attachment 1 to Holtec Letter 1540017

Effect of Racks Design Changes on Criticality Performance

Calculations were performed to evaluate the effect of an increase in the cell wall thickness from 0.075" to 0.090" on the results documented in Revision 1 of Holtec Report HI-2094327. The following items were re-evaluated with the increased thickness and the results were compared to those for the wall thickness of 0.075":

Region 1

- Maximum Effective Multiplication Factor (k-effective)

Region 2

- Maximum Effective Multiplication Factor (k-effective) for all enrichment/burnup combinations (fresh water)
- Maximum Effective Multiplication Factor (k-effective) for the cases that establish the soluble boron conditions for normal and accident conditions
- Maximum Effective Multiplication Factor (k-effective) for the slightly higher soluble boron condition suggested by the calculation report

The results and differences are presented in the table at the end of this attachment, and can be summarized as follows:

Region 1 Results

- The maximum k-effective increases slightly with the increase in wall thickness, but is still well below the applicable regulatory limit of 0.95.

Region 2 Results

- Fresh (i.e., un-borated) Water
  - o The highest max k-effective is calculated for fuel with 2.5 wt% enrichment, where the value increases by [ ][a,c]
  - o For all other enrichments, changes in the max k-effective are within][a,c], with a highest max k-effective of [ ][a,c]
  - o On average the change in the max k-effective is less than [ ][a,c], which may indicate that the change in the wall thickness has an insignificant effect.

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- All resulting k-effective values are well below the applicable regulatory limit of 1.0.

- Borated Water
  - Maximum change in k-effective is an increase of [ ]^{a,c}, which is still well below the applicable regulatory requirement of 0.95.
  - At the recommended soluble boron concentration of 800 ppm, k-effective is reduced to [ ]^{a,c}, providing an even greater margin of safety compared to the applicable regulatory requirement of 0.95.
  - The credited soluble boron level is still well below the limit for the spent fuel pool.

In summary, the increase in cell wall thickness results only in minor changes to the calculated maximum k-effective values, and all those values still remain well below the applicable regulatory limits.

(Continued on Next Page)

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Attachment 1 to Holtec Letter 1540017

Item	Wall Thickness 0.075"	Wall Thickness 0.090"	Difference
Region 1			
Max k-effective	[		][a,c]
Region 2, Max. k-effective Values for Fresh Water Conditions			
2% Enr., Fresh fuel			
2.5% Enr., 6.8 GWd/mtU			
3.0% Enr., 13.0 GWd/mtU			
3.5% Enr., 19.6 GWd/mtU			
4.0% Enr., 27.0 GWd/mtU			
4.5% Enr., 35.5 GWd/mtU			
4.95% Enr, 42.6 GWd/mtU			
Average			
Region 2, Max. k-effective Values for Soluble Boron Requirements			
Normal Conditions [ ][a,c] 800 ppm			
Accident Conditions [ ][a,c] 800 ppm			

a,c

a,c

ENCLOSURE 8

DCD Markups to be included in Revision 19

Table 1.8-2 (Sheet 7 of 14)

SUMMARY OF AP1000 STANDARD PLANT COMBINED LICENSE INFORMATION ITEMS

Item No.	Subject	Subsection	Addressed by Westinghouse Document	Action Required by COL Applicant	Action Required by COL Holder
8.3-1	Grounding and Lightning Protection	8.3.3	N/A	Yes	–
8.3-2	Onsite Electrical Power Plant Procedures	8.3.3	N/A	Yes	–
9.1-1	New Fuel Rack	9.1.6.1	APP-GW-GLR-026	No	No
9.1-2	Criticality Analysis for New Fuel Rack	9.1.6.2	APP-GW-GLR-030	No	No
9.1-3	Spent Fuel Racks	9.1.6.3	APP-GW-GLR-033	No	No
9.1-4	Criticality Analysis for Spent Fuel Racks	9.1.6.4	APP-GW-GLR-029P	No	No
9.1-5	Inservice Inspection Program of Cranes	9.1.6.5	N/A	Yes	–
9.1-6	Radiation Monitor	9.1.6.6	N/A	Yes	–
9.1-7	Metamic Monitoring Program	9.1.6.7	N/A	No	Yes
9.2-1	Potable Water	9.2.11.1	N/A	Yes	–
9.2-2	Waste Water Retention Basins	9.2.11.2	N/A	Yes	–
9.3-1	Air Systems (NUREG-0933 Issue 43)	9.3.7	N/A	Yes	–
9.4-1	Ventilation Systems Operations	9.4.12	N/A	Yes	–
9.5-1	Qualification Requirements for Fire Protection Program	9.5.1.8.1	N/A	Yes	–
9.5-2	Fire Protection Analysis Information	9.5.1.8.2	N/A	Yes	–
9.5-3	Regulatory Conformance	9.5.1.8.3	N/A	Yes	–

Comment [tlw1]: 33

40. Nguyen, T. Q., et al., "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," WCAP-11596-P-A (Proprietary) and WCAP-11597-A (Nonproprietary), June 1988.

41. Mildrum, C. M., Mayhue, L. T., Baker, M. M., and Isaac, P. G., "Qualification of the PHOENIX/POLCA Nuclear Design and Analysis Program for Boiling Water Reactors," WCAP-10841 (Proprietary), and WCAP-10842 (Nonproprietary), June 1985.

42. Barry, R. F., "Nuclear Design of Westinghouse Pressurized Water Reactors with Burnable Poison Rods," WCAP-7806, December 1971.

43. Strawbridge, L. E., and Barry, R. F., "Criticality Calculation for Uniform Water-Moderated Lattices," Nuclear Science and Engineering 23, p. 58, 1965.

44. Persson, R., Blomsjo, E., and Edenius, M., "High Temperature Critical Experiments with H_2O Moderated Fuel Assemblies in KRITZ," Technical Meeting No. 2/11, NUCLEX 72, 1972.

45. Baldwin, M. N., and Stern, M. E., "Physics Verification Program Part III, Task 4: Summary Report," BAW-3647-20, March 1971.

46. Baldwin, M. N., "Physics Verification Program Part III, Task 11: Quarterly Technical Report January-March 1974," BAW-3647-30, July 1974.

47. Baldwin, M. N., "Physics Verification Program Part III, Task 11: Quarterly Technical Report July-September 1974," BAW-3647-31, February 1975.

48. Nodvik, R. J., "Saxton Core II Fuel Performance Evaluation Part II: Evaluation of Mass Spectrometric and Radiochemical Analyses of Irradiated Saxton Plutonium Fuel," WCAP-3385-56 Part II, July 1970.

49. Smalley, W. R., "Saxton Core II - Fuel Performance Evaluation Part I: Materials," WCAP-3386-56 Part I, September 1971.

50. Goodspeed, R. C., "Saxton Plutonium Project - Quarterly Progress Report for the Period Ending June 20, 1973," WCAP-3385-36, July 1973.

51. Crain, H. H., "Saxton Plutonium Project - Quarterly Progress Report for the Period Ending September 30, 1973," WCAP-3385-37, December 1973.

52. Melehan, J. B., "Yankee Core Evaluation Program Final Report," WCAP-3017-6094, January 1971.

53. APP-GW-GLR-029P, Revision 3, "AP1000 Spent Fuel Storage Racks Criticality Analysis," Westinghouse Electric Company LLC (Westinghouse Proprietary).

54. Not used.

Deleted: Edenius, M., Ekberg, K., Forssén, B. H., and Knott, D., "CASMO-4 A Fuel Assembly Burnup Program User's Manual," Studsvik/SOA-95/1, Studsvik of America, Inc. and Studsvik Core Analysis AB (Proprietary).

Comment [tlw1]: 14, 33

A gated opening connects the spent fuel pool and fuel transfer canal. The fuel transfer canal is connected to the in-containment refueling cavity by a fuel transfer tube. The spent fuel transfer operation is completed underwater, and the waterways are of sufficient depth to maintain a minimum of 8.75 feet of shielding water above the active fuel height of spent fuel assemblies. A metal gate with gasket assembly separates the spent fuel pool and fuel transfer canal. This allows the fuel transfer canal to be drained without reducing the water level in the spent fuel pool. During normal operation, this gate remains open and is only closed to drain the canal. The bottom of the fuel transfer canal has a drain connected to safety-related piping and isolation valves which prevents inadvertent draining after a seismic event. Subsection 9.1.3 further addresses the minimum water level in the spent fuel pool.

Next to the spent fuel pool and accessible by another gated, gasketed opening is a cask loading pit. The cask pit is a lined reinforced concrete structure of the auxiliary building fuel handling area. It is provided for underwater loading of fuel into a shipping cask and cask draining/decontamination prior to cask transshipment from the AP1000 site. The bottom of the cask loading pit has a drain connected to safety-related piping and isolation valve which prevents inadvertent draining after a seismic event. The gate between the spent fuel pool and the cask loading pit is normally closed and opened during refueling and cask loading options. The cask loading pit can be used as a source of water for low pressure injection to the reactor coolant system via the normal residual heat removal pumps during an event in which the reactor coolant system pressure and inventory decrease.

The fuel handling machine traverses the spent fuel pool, the fuel transfer canal, the cask loading pit, the new fuel storage pit, and the rail car bay. It is used in the movement of both new and spent fuel assemblies. The fuel handling machine is used to transfer new fuel assemblies from the new fuel storage rack into the spent fuel pool. A new fuel elevator in the spent fuel pool lowers the new fuel to an elevation accessible by the fuel handling machine.

The cask handling crane is used for operations involving the spent fuel shipping cask. The cask handling crane traverses the auxiliary building and a portion of the fuel handling area. The cask handling crane's path is designed such that the cask cannot pass over the spent fuel pool, new fuel pit, or fuel transfer canal. This precludes the movement of loads greater than fuel components over stored fuel in accordance with Regulatory Guide 1.13.

During fuel handling operations, a ventilation system removes gaseous radioactivity from the atmosphere above the spent fuel pool. Refer to subsection 9.4.3 for a discussion of the radiologically controlled area ventilation system, Section 11.5 for process radiation monitoring, subsection 9.1.3 for the spent fuel pool cooling system, and subsection 12.2.2 for airborne activity levels in the fuel handling area.

9.1.2.2.1 Spent Fuel Rack Design

A. Design and Analysis of Spent Fuel Racks

The spent fuel pool rack layout contains both Region 1 rack modules with a center-to-center spacing of nominally 10.93 inches and Region 2 rack modules with a center-to-center spacing of nominally 9.04 inches. Additionally, there are five defective fuel assembly storage cells with a center-to-center spacing of nominally 11.65 inches. These rack module

Comment [h2]: 14
Deleted: 11.62

Materials used in rack construction are compatible with the storage pool 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 pool 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 racks.

Design of the spent fuel storage facility is in accordance with Regulatory Guide 1.13. A discussion of the methodology used in the spent fuel pool criticality analysis is provided in APP-GW-GLR-029P (Reference 20).

Comment [tlw3]: 33

9.1.3 Spent Fuel Pool Cooling System

The spent fuel pool cooling system (SFS) is designed to remove decay heat which is generated by stored fuel assemblies from the water in the spent fuel pool. This is done by pumping the high temperature water from within the fuel pool through a heat exchanger, and then returning the water to the pool. A secondary function of the spent fuel pool cooling system is clarification and purification of the water in the spent fuel pool, the transfer canal, and the refueling water. A listing of the major functions of the spent fuel pool cooling system and the corresponding modes of operation is provided below:

- **Spent fuel pool cooling** - Remove heat from the water in the spent fuel pool during operation to maintain the pool water temperature within acceptable limits.
- **Spent fuel pool purification** - Provide purification and clarification of the spent fuel pool water during operation.
- **Refueling cavity purification** - Provide purification of the refueling cavity during refueling operations.
- **Water transfers** - Transfer water between the in-containment refueling water storage tank (IRWST) and the refueling cavity during refueling operations.
- **In-containment refueling water storage tank purification** - Provide purification and cooling of the in-containment refueling water storage tank during normal operation.

9.1.3.1 Design Basis

9.1.3.1.1 Safety Design Basis

The spent fuel pool cooling system has the safety-related function of containment isolation. See subsection 6.2.3 for the containment isolation system. Safety-related makeup to the spent fuel pool is discussed in subsection 9.1.3.4.3.

9.1.3.1.2 Power Generation Basis

The principal functions of the spent fuel pool cooling system are outlined above. The spent fuel pool cooling system is designed to perform its function in a reliable and failure tolerant manner.

reconciliation of loads imposed by the spent fuel racks on the spent fuel pool structure described in subsection 3.8.4.

9.1.6.4 Criticality Analysis for Spent Fuel Racks

The Combined License information requested in this subsection has been completely addressed in APP-GW-GLR-029P (Reference 20), and the applicable changes are incorporated into the DCD. No additional work is required by the Combined License applicant.

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The following words represent the original Combined License Information Item commitment, which has been addressed as discussed above:

> The Combined License applicant is responsible for a confirmatory criticality analysis for the spent fuel racks, as described in subsection 9.1.2.3. This analysis should address the degradation of integral neutron absorbing material in the spent fuel pool storage racks as identified in GL-96-04, and assess the integral neutron absorbing material capability to maintain a 5-percent subcriticality margin.

9.1.6.5 Inservice Inspection Load Handling Systems

The Combined License applicant is responsible for a program for inservice inspection of the light load handling system as specified in subsection 9.1.4.4 and the overhead heavy load handling system in accordance with ANSI B30.2, ANSI B30.9, ANSI N14.6, and ASME NOG-1 as specified in subsection 9.1.5.4.

9.1.6.6 Operating Radiation Monitor

The Combined License applicant is responsible to ensure an operating radiation monitor is mounted on any crane or fuel handling machine when it is handling fuel.

9.1.6.7 Coupon Monitoring Program

The Combined License holder will implement a spent fuel rack Metamic coupon monitoring program when the plant is placed into commercial operation. This program will include tests to monitor bubbling, blistering, cracking, or flaking; and a test to monitor for corrosion, such as weight loss measurements and or visual examination. The program will also include tests to monitor changes in physical properties of the absorber material, including neutron attenuation and thickness measurements.

9.1.7 References

1. ANSI N16.1-75, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.

2. ANSI N16.9-75, Validation of Calculational Methods for Nuclear Criticality Safety.

3. ANSI N210-76, Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations.

4. ANS 57.2-1983, Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants.

5. USNRC NUREG-0800, SRP 3.8.4, Revision 1, Appendix D, "Technical Position on Spent Fuel Pool Racks," July 1981.

6. ANS 57.1-1992, Design Requirements for Light Water Reactor Fuel Handling Systems.

7. Specifications for Electric Overhead Travelling Cranes CMAA, Specification 70 – 2000.

8. USNRC, "Control of Heavy Loads at Nuclear Power Plants," NUREG-0612, July 1980.

9. "Overhead and Gantry Cranes," ANSI/ASME B30.2-1990.

10. Not used.

11. USNRC, "Single-Failure-Proof Cranes for Nuclear Power Plants," NUREG-0554, May 1979.

12. "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)," ASME NOG-1-1998.

13. Not used.

14. "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More," ANSI N14.6-1993.

15. "Slings," ASME/ANSI B30.9-1996.

16. APP-GW-GLR-026, "New Fuel Storage Rack Structural/Seismic Analysis," Westinghouse Electric Company LLC.

17. APP-GW-GLR-030, "New Fuel Storage Rack Criticality Analysis," Westinghouse Electric Company LLC.

18. APP-GW-GLR-033, "Spent Fuel Storage Rack Structural/Seismic Analysis," Westinghouse Electric Company LLC.

19. Not used.

20. APP-GW-GLR-029P, Revision 3, "AP1000 Spent Fuel Storage Racks Criticality Analysis," Westinghouse Electric Company LLC (Westinghouse Proprietary).

21. USNRC, 10 CFR 50.68, "Criticality Accident Requirements," January 2003.

22. USNRC, Regulatory Guide 1.124, Revision 1, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," January 1978.

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4.0 DESIGN FEATURES

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum U-235 enrichment of 4.95 weight percent;

b. $k_{eff} \leq 0.95$ if flooded with unborated water which includes an allowance for uncertainties (Region 1 racks);

c. A nominal 10.93 inch center-to-center distance between fuel assemblies placed in Region 1, a nominal 9.04 inch center-to-center distance between fuel assemblies placed in Region 2 of the spent fuel storage racks, and a nominal 11.65 inch center-to-center distance between fuel assemblies placed in the Defective Fuel Cells;

d. New or partially spent fuel assemblies with any discharge burnup may be allowed unrestricted storage in Region 1 and the Defective Fuel Cells of Figure 4.3-1;

e. Partially spent fuel assemblies meeting the initial enrichment and burnup requirements of LCO 3.7.12, "Spent Fuel Pool Storage," may be stored in Region 2 of Figure 4.3-1; and

f. $k_{eff} < 1.0$ if flooded with unborated water and $k_{eff} \leq 0.95$ if flooded with borated water at a minimum soluble boron concentration described in the Bases for LCO 3.7.12 for normal and design basis criticality-related accident conditions, which includes an allowance for uncertainties (Region 2 racks).

4.3.1.2 The new fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum U-235 enrichment of 5.0 weight percent;

b. The maximum k_{eff} value, including all biases and uncertainties, shall be less than or equal to 0.95 with full density unborated water;

c. The maximum k_{eff} value, including all biases and uncertainties, shall be less than or equal to 0.98 with optimum moderation and full reflection conditions; and

d. A nominal 10.90 inch center-to-center distance between fuel assemblies placed in the new fuel storage racks.

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B 3.7 PLANT SYSTEMS

B 3.7.11 Fuel Storage Pool Boron Concentration

BASES

BACKGROUND

The water in the spent fuel storage pool normally contains soluble boron, which would result in large subcriticality margins under actual operating conditions. For storage of fuel in the spent fuel racks, the design basis for preventing criticality outside the reactor is that there is a 95 percent probability at a 95 percent confidence level, without soluble boron, that the effective multiplication factor (k_{eff}) of the fuel assembly array will be less than 0.997, including uncertainties and tolerances. The NRC guidelines specify a limiting k_{eff} of 1.0 for normal storage in the absence of soluble boron. Therefore, the design is based on the use of unborated water, which maintains a subcritical condition (Ref. 1). The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 2) allows credit for soluble boron under other abnormal or accident conditions, since only a single independent accident need be considered at one time. For example, the only accident scenario that has a potential for more than negligible positive reactivity effect is an inadvertent misplacement of a new fuel assembly. This accident has the potential for exceeding the limiting reactivity, should there be a concurrent and independent accident condition resulting in the loss of all soluble poison. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation with unborated water and no movement of assemblies may, therefore, be achieved by controlling the location of each assembly in accordance with LCO 3.7.12, "Spent Fuel Pool Storage." Prior to movement of an assembly, it is necessary to perform SR 3.7.12.1.

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APPLICABLE SAFETY ANALYSES

Although credit for the soluble boron normally present in the spent fuel pool water is permitted under abnormal or accident conditions, most abnormal or accident conditions will not result in exceeding the limiting reactivity even in the absence of soluble boron. The effects on reactivity of credible abnormal and accident conditions due to temperature increase, assembly dropped on top of a rack, and misplacement/misloading of a fuel assembly have been analyzed. The reactivity effects of bulk spent fuel pool temperature increase (>140°F) and steaming from the pool water surface or intramodule water gap reductions between the firmly interconnected cell and module arrays due to a seismic event are bounded by the fuel mishandling/misloading reactivity increases and therefore assessed as negligible. The spent fuel pool k_{eff} storage limit of 0.95 is maintained during these events by a minimum boron concentration of greater than or equal to 800 ppm

BASES

ACTIONS (continued)

A.1, A.2.1, and A.2.2

When the concentration of boron in the fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored simultaneously with suspending movement of fuel assemblies. An acceptable alternative is to verify by administrative means that the fuel storage pool verification has been performed since the last movement of fuel assemblies in the fuel storage pool. However, prior to resuming movement of fuel assemblies, the concentration of boron must be restored. This does not preclude movement of a fuel assembly to a safe position.

SURVEILLANCE REQUIREMENTS

SR 3.7.11.1

This SR verifies that the concentration of boron in the fuel storage pool is within the required limit. As long as this SR is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over such a short period of time.

REFERENCES

1. Sections 9.1.2, "Spent Fuel Storage" and 15.7.4, "Fuel Handling Accident."
2. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
3. APP-GW-GLR-029P, "AP1000 Spent Fuel Storage Racks Criticality Analysis," Westinghouse Electric Company LLC (Westinghouse Proprietary).

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B 3.7 PLANT SYSTEMS

B 3.7.12 Spent Fuel Pool Storage

BASES

BACKGROUND

The high density spent fuel storage racks are divided into two separate and distinct regions and include locations for storage of defective fuel as shown in Figure 4.3-1. Region 1, with a maximum of 243 storage locations and the Defective Fuel Cells, with 5 storage locations are designed to accommodate new fuel assemblies with a maximum enrichment of 4.95 weight percent U-235, or spent fuel assemblies regardless of the combination of initial enrichment and burnup. Region 2, with a maximum of 641 storage locations is designed to accommodate spent fuel assemblies in all locations which comply with the combination of initial enrichment and burnup specified in LCO Figure 3.7.12-1, Minimum Fuel Assembly Burnup Versus Initial Enrichment for Region 2 Spent Fuel Cells. Use of the IFE fuel rod storage canister is subject to the same storage requirements as the fuel assemblies.

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The water in the spent fuel storage pool normally contains soluble boron, which would result in large subcriticality margins under actual operating conditions. For storage of fuel in the spent fuel racks, the design basis for preventing criticality outside the reactor is that there is a 95 percent probability at a 95 percent confidence level, without soluble boron, that the effective multiplication faction (k_{eff}) of the fuel assembly array will be less than 0.997, including uncertainties and tolerances. The NRC guidelines specify a limiting k_{eff} of 1.0 for normal storage in the absence of soluble boron. Hence, the design is based on the use of unborated water, which maintains a subcritical condition for the allowed loading patterns.

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The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 1) allows credit for soluble boron under other abnormal and accident conditions, since only a single independent accident need be considered at one time. For example, the only accident scenario that has the potential for more than negligible positive reactivity effect is an inadvertent misplacement of a new fuel assembly. This accident has the potential for exceeding the limiting reactivity, should there be a concurrent and independent accident condition resulting in the loss of all soluble poison. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation with unborated water and no movement of assemblies may, therefore, be achieved by controlling the combination of initial enrichment and burnup in accordance with the accompanying LCO. Prior to movement of an assembly, it is necessary to perform SR 3.7.12.1.

APPLICABLE SAFETY ANALYSES

The hypothetical accidents can only take place during or as a result of the movement of an assembly (Refs. 2 and 3). For these accident occurrences, the presence of soluble boron in the spent fuel storage pool (controlled by LCO 3.7.11, "Fuel Storage Pool Boron Concentration") prevents criticality. By closely controlling the movement of each assembly and by checking the location of each assembly after movement, the time period for potential accidents may be limited to a small fraction of the total operating time. During the remaining time period with no potential for accidents, the operation may be under the auspices of the accompanying LCO.

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The configuration of fuel assemblies in the fuel storage pool satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

The restrictions on the placement of fuel assemblies within Region 2 of the spent fuel pool in the accompanying LCO, ensure the k_{eff} of the spent fuel storage pool will always remain < 0.997, assuming the pool to be flooded with unborated water and ≤ 0.95, with a boron concentration of greater than or equal to 800 ppm.

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Region 2 permits storage of spent fuel assemblies in any cell location provided the assembly meets the combination of initial enrichment and burnup shown in LCO Figure 3.7.12-1, Minimum Fuel Assembly Burnup Versus Initial Enrichment for Region 2 Spent Fuel Cells.

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APPLICABILITY

This LCO applies whenever any fuel assembly is stored in Region 2 of this fuel storage pool.

ACTIONS

LCO 3.0.3 is applicable while in MODE 1, 2, 3, or 4. Since spent fuel pool storage requirements apply in all MODES when fuel is stored in Region 2, the ACTIONS have been modified by a Note stating the LCO 3.0.3 is not applicable. Spent fuel pool storage requirements are independent of reactor operations. Entering LCO 3.0.3 while in MODE 1, 2, 3, or 4 would require the unit to be shutdown unnecessarily.

LCO 3.0.8 is applicable while in MODE 5 or 6. Since spent fuel pool storage requirements apply in all MODES when fuel is stored in Region 2, the ACTIONS have been modified by a Note stating the LCO 3.0.8 is not applicable. Spent fuel pool storage requirements are independent of shutdown reactor operations. Entering LCO 3.0.8 while in MODE 5 or 6 would require the optimization of plant safety, unnecessarily.

BASES

ACTIONS (continued)

A.1

The LCO is not met if spent fuel assemblies stored in Region 2 spent fuel assembly storage locations do not meet the applicable initial enrichment and burnup limits in accordance with Figure 3.7.12-1.

When the LCO is not met, action must be initiated immediately to make the necessary fuel assembly movement(s) in Region 2 to bring the storage configuration into compliance with Figure 3.7.12-1 by moving the affected fuel assemblies to Region 1 or the Defective Fuel Cells.

SURVEILLANCE REQUIREMENTS

SR 3.7.12.1

This SR verifies by administrative means that the initial enrichment and burnup of the fuel assembly is in accordance with Figure 3.7.12-1. Fuel assemblies stored in Region 2 that do not meet the Figure 3.7.12-1 enrichment and burnup limits shall be stored in Region 1–or Defective Fuel Cells.

REFERENCES

1. Double contingency principle ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).

2. APP-GW-GLR-029P, "AP1000 Spent Fuel Storage Racks Criticality Analysis," Westinghouse Electric Company LLC (Westinghouse Proprietary).

3. Sections 9.1.2, "Spent Fuel Storage" and 15.7.4, "Fuel Handling Accident."

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