ENCLOSURE 4

APP-GW-GLR-029NP, Revision 2 (Reformatted)

AP1000 Spent Fuel Storage Racks Criticality Analysis

(Non-Proprietary)

APP-GW-GLR-029NP
Revision 2

September 2009
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AP1000 Spent Fuel Storage Racks Criticality Analysis

Non-Proprietary Version

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AP1000 RECORD OF CHANGES

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CHANGE NUMBER	PARAGRAPH NUMBER	CHANGE DESCRIPTION AND REASON	ENGINEER APPROVAL/DATE
1	General	Note: The initial revision of this document was revision 0 of APP-GW-GLR-029. When revision 1 was issued the document was split into 2 versions, a proprietary and a non-proprietary version, because the work was re-done by an outside agent; therefore revision 1 of the non-proprietary version of this document was renumbered as APP-GW-GLR-029-NP. This document, APP-GW-GLR-029NP, is revision 2 of the series, and it was renumbered again to meet the requirements of the AP1000 document numbering convention.	RJM/See EDMS
2	General	See page 6 for a general description of changes. Revision 2 of this document incorporates the response to RAI-SRP9.1.1-SRSB-07.	RJM/See EDMS
3	5.4	Added a reference to Table 5.16 and included that burnable absorbers were considered.	RJM/See EDMS
4	10.18	Added Reference 18.	RJM/See EDMS
5	Table 5.16	Added entire table, which includes proprietary information regarding the pyrex inserts that were considered in the analysis.	RJM/See EDMS

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CRITICALITY EVALUATION OF THE AP1000 SPENT FUEL STORAGE RACKS

FOR

WESTINGHOUSE

Holtec Report No: HI-2094327

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HOLTEC INTERNATIONAL

DOCUMENT ISSUANCE AND REVISION STATUS[1]

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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:

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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".

<u>Summary of Revisions:</u>

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

Table Of Contents

1. INTRODUCTION

1.1 Statement of Purpose

This report documents the criticality safety evaluation for the storage of PWR spent nuclear fuel in Holtec Region 1 & 2 style high-density spent fuel storage racks (SFSRs) for the AP1000 nuclear power plants. The objective of this analysis is to ensure that the effective neutron multiplication factor (k_{eff}) is less than or equal to 0.95 with the storage racks fully loaded with fuel of the highest permissible reactivity and the pool flooded with borated water at a temperature corresponding to the highest reactivity. In addition, it is demonstrated that k_{eff} is less than 1.0 under the assumed loss of soluble boron in the pool water, i.e., assuming unborated water in the spent fuel pool. The maximum calculated reactivities include a margin for uncertainty in reactivity calculations, including manufacturing tolerances, and are calculated with a 95% probability at a 95% confidence level [1]. Reactivity effects of abnormal and accident conditions have also been evaluated to assure that under all credible abnormal and accident conditions, the reactivity will not exceed the regulatory limit of 0.95.

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As part of the review process, the reviewer provides comments to the author either verbally or in writing. The reviewer only signs off on the document after having satisfied himself/herself that all of the comments communicated to the author have been adequately addressed.

Once a safety significant document, such as this report, completes its review and certification cycle, it should be free of any materially significant error and should not require a revision unless its scope of treatment needs to be altered. Except for regulatory interface documents (i.e., those that are submitted to the NRC in support of a license amendment and request), revisions to Holtec *safety significant* documents to amend grammar, to improve diction, or to add trivial calculations are not made unless such editorial changes are deemed necessary by the Holtec Project Manager to prevent erroneous conclusions from being inferred by the reader. In other words, the focus in the preparation of this document is to ensure correctness of the technical content rather than the cosmetics of presentation.

Among the numerous requirements that this document must fulfill to muster approval within the company's QA program are:

1) The preparer(s) and reviewer(s) are technically qualified to perform their activities per the applicable Holtec Quality Procedure (HQP);
2) The input information utilized in the work effort is drawn from referenceable sources;
3) Any assumed input data is so identified;
4) All significant assumptions are stated;
5) The analysis methodology is consistent with the physics of the problem;
6) Any computer code and its specific versions used in the work have been formally admitted for use within the company's QA system;
7) The format and content of the document is in accordance with the applicable Holtec quality procedure;
8) The material content of the report is understandable to a reader with the requisite academic training and experience in the underlying technical disciplines.

In summary, the principal criterion in the Q.A. validation process is to ensure that the conclusions presented in this report are guaranteed to be accurate; i.e.; the margin of safety will not vanish under any realistic scenarios of perturbations of parameters.

In accordance with the foregoing, this Calculation Package has been prepared pursuant to the provisions of Holtec Quality Procedures HQP 3.0 and 3.2, which require that all analyses utilized in support of the design of a safety-related or important-to-safety structure, component, or system be fully documented such that the analyses can be reproduced at *any time in the future* by a specialist trained in the discipline(s) involved. HQP 3.2 sets down a rigid format structure for the content and organization of Calculation Packages that are intended to create a document that is complete in terms of the exhaustiveness of content. The Calculation Packages, however, lack the narrational smoothness of a Technical Report, and are not intended to serve as a Technical Report.

Because of its function as a repository of all analyses performed on the subject of its scope, this document will require a revision only if an error is discovered in the computations or the equipment design is modified. Additional analyses in the future may be added as numbered supplements to this Package. Each time a supplement is added or the existing material is revised, the revision status of this Package is advanced to the next number and the Table of Contents is amended. Calculation Packages are Holtec proprietary documents. They are shared with a client only under strict controls on their use and dissemination.

This Calculation Package will be saved as a Permanent Record under the company's QA System.

2. METHODOLOGY

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[

]a,b,c

3. ACCEPTANCE CRITERIA

The high-density spent fuel PWR storage racks for the AP1000 are designed in accordance with the applicable codes and standards listed below. The objective of this analysis is to ensure that the effective neutron multiplication factor (k_{eff}) is less than or equal to 0.95 with the storage racks fully loaded with fuel of the highest permissible reactivity and the pool flooded with borated water at a temperature corresponding to the highest reactivity. In addition, it is demonstrated that k_{eff} is less than 1.0 under the assumed loss of soluble boron in the pool water, i.e. assuming unborated water in the spent fuel pool. The maximum calculated reactivities include a margin for uncertainty in reactivity calculations, including manufacturing tolerances, and are calculated with a 95% probability at a 95% confidence level [1].

Applicable codes, standard, and regulations or pertinent sections thereof, include the following:

- 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion 62, "Prevention of Criticality in Fuel Storage And Handling."

- USNRC Standard Review Plan, NUREG-0800, Section 9.1.1, Criticality Safety of Fresh and Spent Fuel Storage and Handling, Rev. 3 – March 2007.

- L. Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," NRC Memorandum from L. Kopp to

T. Collins, August 19, 1998 [7].

- ANSI ANS-8.17, Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors.
- Code of Federal Regulations, Title 10, Part 50, Section 68, "Criticality Accident Requirements", as referenced in Title 10, Part 52, Section 47.
- Regulatory Guide 1.13, Revision 2, "Spent Fuel Storage Facility Design Basis," March 2007.

4. ASSUMPTIONS

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]a,b,c

[

]a,b,c

5. INPUT DATA

5.1 Fuel Assembly Specification

The spent fuel storage racks are designed to accommodate the 17x17 fuel assembly used in the AP1000 reactor. The design parameters for this fuel assembly type that are used in the analyses are given in Table 5.1.

5.2 Core Operating Parameters

Core operating parameters are necessary for fuel depletion calculations performed with CASMO-4. The core parameters used for the depletion calculations are presented in Table 5.2. The boron letdown curve is presented in Table 5.3. Temperature and soluble boron values are conservatively high values. [

]a,b,c

5.3 Axial Burnup Distribution

The analyses use axial burnup profiles specified based on core locations and discharge cycle from [11, 12]. The bounding profile is presented in Table 5.11. [

]a,b,c

5.4 Burnable Absorbers

Most fuel assemblies for the AP1000 use fuel rods with IFBA and/or WABAs inserted into the guide tubes for reactivity and/or power control. Gray rod cluster assemblies (GRCAs), either Tungsten or AgInCd, are used for power distribution control. Finally, the AP1000 makes use of rod cluster control assemblies (RCCAs) during full power operation. Table 5.4 through Table 5.10 and Table 5.16 provide the specifications for the IFBA rods, WABAs, pyrex burnable absorbers, GRCAs and RCCAs. Additionally, an assembly insert may be used in more than one cycle (i.e. WABA in the first cycle followed by a GRCA in the second cycle). The various combinations of multiple inserts are provided in Table 5.15). The reactivity effect of these inserts (integral and inserted) is presented in Section 7.2.1.

5.5 Storage Rack Specification

The storage cell characteristics used in the criticality evaluations are summarized in Table 5.12 and Table 5.13. The composition of the neutron absorber is presented in Appendix C, which is calculated from [8].

5.5.1 Region 1 Style Storage Racks

The Region 1 storage cells are composed of stainless steel boxes separated by a water gap, with fixed neutron absorber panels centered on each side. The steel walls define the storage cells, and stainless steel sheathing supports the neutron absorber panel and defines the boundary of the flux-trap water-gaps used to augment reactivity control. Stainless steel channels connect the storage cells in a rigid structure and define the flux-trap between the neutron absorber panels. Neutron absorber panels are installed on all exterior walls where a fuel assembly could be mislocated. For those areas where there is insufficient space to misplace a fuel assembly between the Region 1 rack and the spent fuel pool wall, no neutron absorber is present. [ ]a,b,c

5.5.2 Region 2 Style Storage Racks

The Region 2 storage cells are composed of stainless steel boxes with a single fixed neutron absorber panel centered on each side, attached by stainless steel sheathing. The stainless steel boxes are arranged in an alternating pattern such that the connection of the box corners form storage cells between those of the stainless steel boxes. Neutron absorber panels are installed on all exterior walls where a fuel assembly could be mislocated. For those areas where there is insufficient space to misplace a fuel assembly between the Region 2 rack and the spent fuel pool wall, no neutron absorber is present on the exterior surfaces on the rack module. [ ]a,b,c

5.5.3 Defective Storage Locations

Rack module C1 (a Region 2 rack module) contains five locations to store defective fuel assemblies. These storage locations are separated from each other by a water gap, similar to the Region 1 racks. Additionally, they are separated from the Region 2 storage cells by a large water gap. [

]a,b,c

5.5.4 Rack Interfaces

[

]a,b,c

6. COMPUTER CODES

The following computer codes were used during this analysis.

- MCNP4a [2] is a three-dimensional continuous energy Monte Carlo code developed at Los Alamos National Laboratory. This code offers the capability of performing full three-dimensional calculations for the loaded storage racks. MCNP4a was run on the PCs at Holtec.

- CASMO-4, Version 2.05.14 [4-6] is a two-dimensional multigroup transport theory code developed by Studsvik of Sweden. CASMO-4 performs cell criticality calculations and burnup. CASMO-4 has the capability of analytically restarting burned fuel assemblies in the rack configuration. This code was used to determine the reactivity effects of tolerances and fuel depletion.

7. ANALYSIS

This section describes the calculations that were used to determine the acceptable storage criteria for the Region 1 and Region 2 style racks. In addition, this section discusses the possible abnormal and accident conditions.

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]a,b,c

[

]a,b,c

The following sections summarize the calculations that were performed. [ ]a,b,c

7.1 Region 1

The goal of the criticality calculations for the Region 1 style racks is to qualify the racks for storage of fuel assemblies with design specifications as shown in Table 5.1 and a maximum nominal initial enrichment of 4.95 wt% ^{235}U.

[ ]a,b,c

7.1.1 Eccentric Fuel Assembly Positioning

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]a,b,c

7.1.2 Uncertainties Due to Manufacturing Tolerances

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]a,b,c

[

]a,b,c

7.1.3 Temperature and Water Density Effects

[

]a,b,c

[ ]a,b,c

7.1.4 Calculation of Maximum k_{eff}

[

]a,b,c

7.1.5 Abnormal and Accident Conditions

The effects on reactivity of credible abnormal and accident conditions are examined in this section. This section identifies which of the credible abnormal or accident conditions will result in exceeding the limiting reactivity ($k_{eff} \leq 0.95$). For those accident or abnormal conditions that result in exceeding the limiting reactivity, a minimum soluble boron concentration is determined to ensure that $k_{eff} \leq 0.95$. [

]a,b,c

7.1.5.1 Abnormal Temperature

[

]a,b,c

7.1.5.2 Dropped Assembly - Horizontal

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]a,b,c

7.1.5.3 Dropped Assembly – Vertical Into a Storage Cell

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]a,b,c

[

]a,b,c

7.1.5.4 Misloaded Fresh Fuel Assembly

[

]a,b,c

7.1.5.5 Mislocated Fresh Fuel Assembly

[

]a,b,c

7.1.6 Summary

Calculations have been performed to qualify the Region 1 racks for storage of fuel assemblies with a maximum nominal initial enrichment of 4.95 wt% ^{235}U. The results of these calculations are summarized in Table 7.1 and Table 7.2. The calculations demonstrate that the maximum k_{eff} is less than 0.95 without credit for soluble boron. Furthermore, all reactivity effects of abnormal and accident conditions have also been evaluated to assure that under all credible abnormal and accident conditions, the reactivity will not exceed the regulatory limit of 0.95 with credit for soluble boron.

7.2 Region 2

The goal of the criticality calculations for the Region 2 style racks is to qualify the racks for uniform storage of spent fuel assemblies with design specifications as shown in Table 5.1 and a maximum nominal initial enrichment of 4.95 wt% ^{235}U. The purpose of the criticality calculations is to determine the initial enrichment and burnup combinations required for the uniform storage of spent fuel assemblies.

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]a,b,c

[

]a,b,c

7.2.2 Axial Burnup Distributions

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]a,b,c

[

]a,b,c

[

]a,b,c

7.2.3 Isotopic Compositions

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]a,b,c

7.2.4 Uncertainty in Depletion Calculations

[

]a,b,c

7.2.5 Eccentric Fuel Assembly Positioning

[

]a,b,c

7.2.6 Uncertainties Due to Manufacturing Tolerances

[

]a,b,c

[

]a,b,c

[

]a,b,c

7.2.7 Temperature and Water Density Effects

[

]a,b,c

7.2.8 Calculation of Maximum k_{eff}

[

]a,b,c

7.2.9 Determination of Burnup Versus Enrichment Values

[

]a,b,c

7.2.10 Soluble Boron Concentration for Maximum k_{eff} of 0.95

[

]a,b,c

7.2.11 Measured Burnup Uncertainty

[

]a,b,c

7.2.12 Abnormal and Accident Conditions

The effects on reactivity of credible abnormal and accident conditions are examined in this section. This section identifies which of the credible abnormal or accident conditions will result in exceeding the limiting reactivity ($k_{eff} \leq 0.95$). For those accident or abnormal conditions that result in exceeding the limiting reactivity, a minimum soluble boron concentration is determined to ensure that $k_{eff} \leq 0.95$. [

]a,b,c

7.2.12.1 Abnormal Temperature

[

]a,b,c

7.2.12.2 Dropped Assembly - Horizontal

[

]a,b,c

7.2.12.3 Dropped Assembly - Vertical

[

]a,b,c

7.2.12.4 Misloaded Fresh Fuel Assembly

[

]a,b,c

7.2.12.5 Mislocated Fresh Fuel Assembly

[

]a,b,c

7.2.13 Summary

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]a,b,c

7.3 Defective Fuel Storage Cells Attached to Region 2 Racks

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]a,b,c

7.4 Interfaces Between Racks

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]a,b,c

8. COMPUTER FILES

All input files for the calculations are stored in the directory [ ]a,b,c and its subdirectories on the Holtec server. [

]a,b,c

9. CONCLUSIONS

This report documents the criticality analysis for the storage of PWR spent nuclear fuel in the Region 1 and Region 2 style high-density spent fuel storage racks at the AP1000 nuclear power plant. The results of the analyses are summarized as follows:

- Region 1 racks can be loaded with fresh fuel of up to 4.95 wt% ^{235}U.
- For Region 2 racks a minimum burnup is required as a function of the initial enrichment. These minimum burnups are listed in Table 7.4.
- The damaged fuel cells can be loaded with fresh fuel of up to 4.95 wt% ^{235}U.
- Under accident conditions, a minimum soluble boron level of 800 ppm in the pool is required.

10. REFERENCES[3]

1. M.G. Natrella, Experimental Statistics, National Bureau of Standards, Handbook 91, August 1963.

2. J.F. Briesmeister, Editor, "MCNP - A General Monte Carlo N-Particle Transport Code, Version 4A," LA-12625, Los Alamos National Laboratory (1993).

3. "Lumped Fission Product and Pm148m Cross Sections for MCNP," Holtec Report HI-2033031, Rev 0, September 2003.

4. M. Edenius, K. Ekberg, B.H. Forssén, and D. Knott, "CASMO-4 A Fuel Assembly Burnup Program User's Manual," Studsvik/SOA-95/1, Studsvik of America, Inc. and Studsvik Core Analysis AB (proprietary), Revision 1, August 2001.

5. D. Knott, "CASMO-4 Benchmark Against Critical Experiments", SOA-94/13, Studsvik of America, Inc., (proprietary), December 1995.

6. D. Knott, "CASMO-4 Benchmark Against MCNP," SOA-94/12, Studsvik of America, Inc., (proprietary), December 1995.

7. L.I. Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," NRC Memorandum from L. Kopp to T. Collins, August 19, 1998.

8. Holtec Position Paper DS-292/WS-138, "Standardization of Metamic Specifications in Wet and Dry Storage, January 2004.

9. Holtec Rack Data Sheet, Project 1540, Revision 9.

10. Holtec Drawing 4743, Revision 1.

11. Westinghouse Letter NF-09-050, Rev. 2, "Transmittal of AP1000 Information for HOLTEC Criticality Analysis," May 14, 2009.

[3] Note: The revision status of Holtec documents cited above is subject to updates as the project progresses. This document will be revised if a revision to any of the above-referenced Holtec work materially affects the instructions, results, conclusions or analyses contained in this document. Otherwise, a revision to this document will not be made and the latest revision of the referenced Holtec documents shall be assumed to supercede the revision numbers cited above. The Holtec Project Manager bears the undivided responsibility to ensure that there is no intra-document conflict with respect to the information contained in all Holtec generated documents on a safety-significant project. The latest revision number of all documents produced by Holtec International in a safety significant project is readily available from the company's electronic network.

12. Westinghouse Letter NF-09-63, Rev. 1, "Transmittal of AP1000 MSHIM Rodded Operation Information for HOLTEC Criticality Analysis," May 14, 2009.

13. Westinghouse Letter NF-09-76, Rev 0, "Confirmation of Limiting Burnup Shape for HOLTEC Criticality Analysis," May 14, 2009.

14. Nuclides and Isotopes, 15th Edition, GE Co. and KAPL Inc, 1996.

15. S.E. Turner, "Uncertainty Analysis - Burnup Distributions", presented at the DOE/SANDIA Technical Meeting on Fuel Burnup Credit, Special Session, ANS/ENS Conference, Washington, D.C., November 2, 1988.

16. "Study of the Effect of Integral Burnable Absorbers for PWR Burnup Credit," NUREG/CR-6760, ORNL/TM-2000-321, March 2002.

17. "Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit", ORNL-TM-2000/373, NUREG/CR-6761, USNRC Office of Nuclear Regulatory Research, March 2002.

18. Westinghouse Letter NRFE-09-134, Rev 0, "Transmittal of DCD Rev. 17 PYREX Information for Holtec Criticality Analysis," August 26, 2009.

Table 5.1
Fuel Assembly Specification [11]

Fuel Rod Data		
Assembly type		**AP1000**
Fuel pellet outside diameter, in.		
Cladding inside diameter, in.		
Cladding outside diameter, in.		
Cladding material		
Stack density, g/cc		
Maximum enrichment, wt% ^{235}U		
Blanket Length, in		
Fuel Assembly Data		
Fuel rod array		
Number of fuel rods		
Fuel rod pitch, in.		
Number of guide tubes		
Guide Tube outside diameter, in.		
Guide Tube inside diameter, in.		
Number of instrument tubes		
Instrument Tube outside diameter, in.		
Instrument Tube inside diameter, in.		
Instrument Tube and Guide Tube Material		
Active fuel Length, in.		

a,b,c

Table 5.2
Core Operating Parameter for Depletion Analyses [11]

Parameter	Value
Reactor Specific Power, MW/MTU	power: 3400 MWt loading: 84.075 – 84.708 MTU
Core Average Fuel Temperature, °F	1200.1
Core Average Moderator Temperature at the Top of the Active Region, °F	616.4
In-Core Assembly Pitch, Inches	8.466
Cycle Average Soluble Boron, ppm	[ ]a,b,c

Table 5.3
Peak Boron Letdown Curve [11]

Burnup (MWD/MTU)	Boron Concentration (ppm)

a,b,c

Table 5.4: WABA Data [11]

Parameter	Value

a,b,c

Table 5.5: IFBA Data [11]

Parameter	Value

a,b,c

[

]a,b,c

Table 5.6: IFBA Patterns and Enrichments [11]

Enrichment	Blanket Enrichment	IFBA Patterns

a,b,c

Table 5.7 IFBA and WABA Combinations [11]

WABA Pattern	IFBA Patterns

a,b,c

[

]a,b,c

Table 5.8: GRCA Tungsten Dimensions [12]

Parameter	Value

a,b,c

Table 5.9: GRCA Inconel Spacer Tip Dimensions[5] [12]

Parameter	Value

a,b,c

Table 5.10: Ag-In-Cd GRCA Design [12]

Parameter	Value

a,b,c

[ ]a,b,c

Table 5.11
Bounding Axial Burnup Profile (see Appendix E)

Node Length	Relative Burnup

a,b,c

Table 5.12
Storage Rack Parameters ([9], [10])

Region 1	
Parameter	**Value**

a,b,c

Region 2	
Parameter	**Value**

a,b,c

[ ]a,b,c

Table 5.13
Damaged Fuel Cell Parameters ([10])

Region 1	
Parameter	**Value**

[a,b,c]

[ ][a,b,c]

Table 5.14
Analyzed Insert/IFBA Combinations for a Single Cycle

a,b,c

Insert	# of IFBA Rods

Table 5.15
Assembly Insert Combinations During AP1000 Core Operation [12]

a,b,c

1st Cycle	2nd Cycle	3rd Cycle

Table 5.16
Pyrex Inserts Design [18]

a,b,c

Parameter	Value

Table 7.1
Summary of the Criticality Safety Analysis for Region 1

Enrichment [wt% ^{235}U]	4.95
Uncertainties	
MCNP4a Bias Uncertainty (95%/95%)	± [ ]a,b,c
CASMO-4 Bias Uncertainty (95%/95%)	± [ ]a,b,c
Calculational Statistics (95%/95%, 2.0×σ)	± 0.0014
Fuel Eccentricity	Negative
Rack Tolerances	± [ ]a,b,c
Fuel Tolerances	± [ ]a,b,c
Statistical Combination of Uncertainties	± 0.0143
Reference k_{eff} (MCNP4a)	0.9028
Biases	
Temperature Bias	[ ]a,b,c
MCNP4a Bias (see Appendix A)	[ ]a,b,c
Maximum k_{eff}	**0.9207**
Regulatory Limiting k_{eff}	**0.9500**

Table 7.2

Region 1 Abnormal and Accident Conditions

Abnormal/Accident Condition	**Soluble Boron Requirement (ppm)**
Abnormal Temperature	None
Dropped Assembly – Horizontal	Negligible
Dropped Assembly – Vertical Into Storage Cell	Negligible
Misloaded Assembly	N/A
Mislocated Assembly	250

Table 7.3
Summary of the Criticality Safety Analysis for Region 2 Without Soluble Boron

Enrichment [wt% ^{235}U]	4.95
Burnup [GWD/MTU]	42.6
Uncertainties	
MCNP4a Bias Uncertainty (95%/95%)	± [ ]a,b,c
CASMO-4 Bias Uncertainty (95%/95%)	± [ ]a,b,c
Calculational Statistics (95%/95%, 2.0×σ)	± 0.0016
Fuel Eccentricity	± 0.0000
Rack Tolerances	± [ ]a,b,c
Fuel Tolerances	± [ ]a,b,c
Depletion Uncertainty	± [ ]a,b,c
Statistical Combination of Uncertainties	± 0.0177
Reference k_{eff} (MCNP4a)	0.9737
Biases	
Temperature Bias	[ ]a,b,c
MCNP4a Bias (see Appendix A)	[ ]a,b,c
Maximum k_{eff}	**0.9950**
Regulatory Limiting k_{eff}	**1.0000**

Table 7.4
Region 2 Burnup Versus Enrichment Curve

Enrichment (wt% U-235)	Minimum Burnup (GWD/MTU)
2.0	0.0
2.5	6.8
3.0	13.0
3.5	19.6
4.0	27.0
4.5	35.5
4.95	42.6

Table 7.5
Region 2 Abnormal and Accident Conditions

Abnormal/Accident Condition	Soluble Boron Requirement
Abnormal Temperature	None
Dropped Assembly – Horizontal	Negligible
Dropped Assembly – Vertical Into Storage Cell	Negligible
Misloaded Assembly	800 ppm
Mislocated Assembly	650 ppm

Table 7.6
[Reactivity Effect of Axial Burnup Distributions and Control Rod Bank Insertion][a,b,c]

a,b,c

Figure 5.1 IFBA Patterns [11]

a,b,c

Figure 5.2: Discrete Inserts Figure [12]

a,b,c

[ ]

1 - 6 = guide tubes or WABA
7 = instrumentation tube

12 WABA pattern [12] a,b,c

Ag-In-Cd GRCA Design [12] a,b,c

Tungsten with Inconel Tips GRCA Design [12] a,b,c

a,b,c

[ ]

Figure 5.3 Region 1 Calculational Model (MCNP)

a,b,c

Figure 5.4 Region 2 Calculational Model (MCNP)

a,b,c

[ ]

Figure 5.5: Region 1 Misplaced Assembly Model in MCNP (entire model not shown)

a,b,c

Figure 5.6: Region 2 Misloaded Assembly Model in MCNP (entire model not shown)

a,b,c

[ ]

Figure 5.7: Region 2 Misplaced Assembly Model in MCNP (entire model not shown)

a,b,c

Figure 5.8: Region 2 with Defective Fuel Model in MCNP4a (entire model not shown)

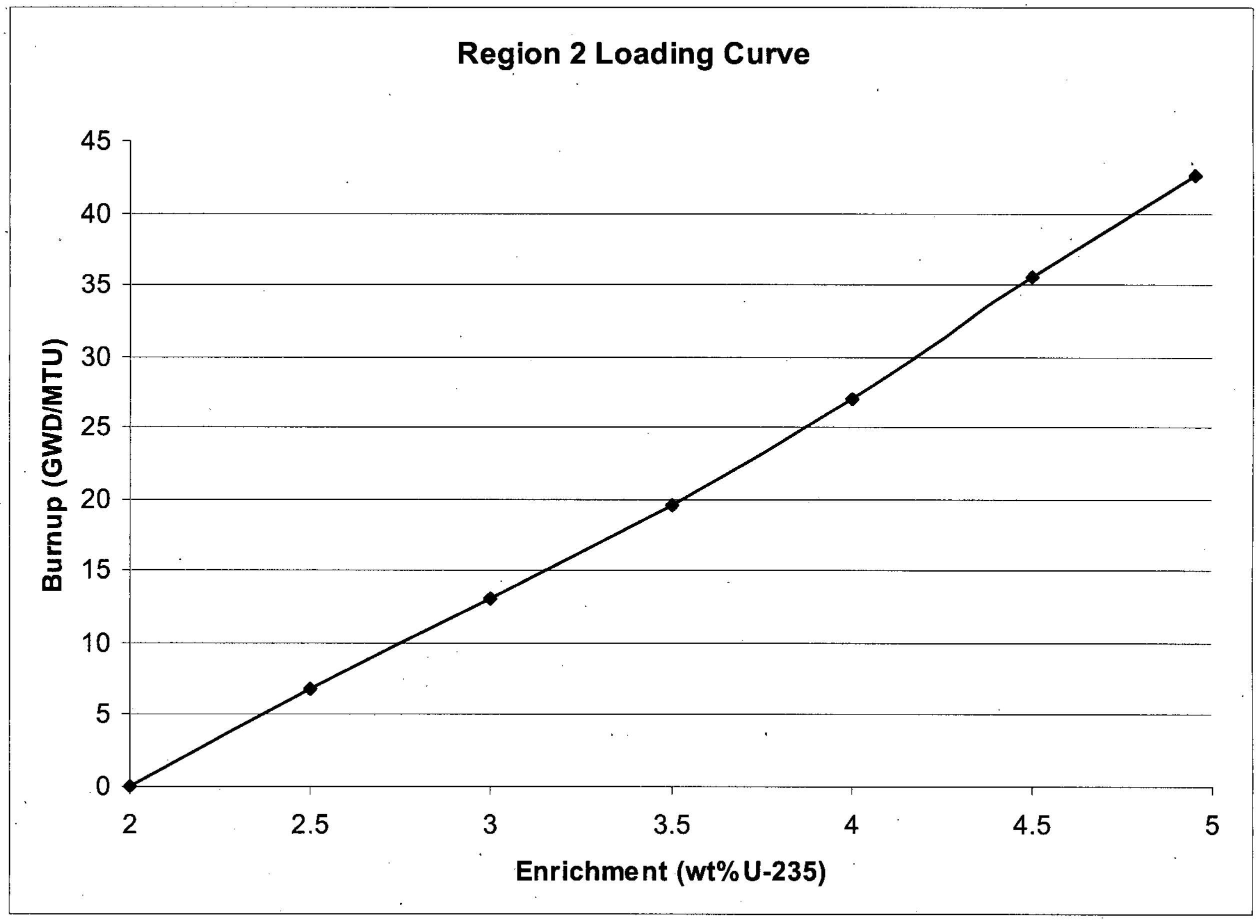

Figure 7.1 Loading Curve for Region 2 Racks

Appendix A
Benchmark Calculations

(total number of pages: 27 including this page)

[

]a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

[

]a,b,c

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]a,b,c

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]a,b,c

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[ ]a,b,c

a,b,c

a,b,c

[ ]a,b,c

[ ]a,b,c

[ ]a,b,c

a,b,c

a,b,c

[ ]

a,b,c

a,b,c

a,b,c

a,b,c

[ ]

a,b,c

Appendix B

CASMO-4 Benchmark

(total number of pages: 10 including this page)

[

]a,b,c

[

]a,b,c

[

]a,b,c

[

]a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

a,b,c

a,b,c

Appendix C

Metamic Composition

(total number of pages: 2 including this page)

a,b,c

[ ]

Appendix D

Region 1 MCNP4a Calculations

(total number of pages: 6 including this page)

Page Content

[

]a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

Appendix E

Axial Burnup Distributions

(total number of pages: 11 including this page)

Page Content

[

]a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[ ]

a,b,c

[ ]

a,b,c

[ ]

a,b,c

[ ]

a,b,c

a,b,c

a,b,c

[ ]

a,b,c

Appendix F

Region 2 Fuel Assembly Insert Calculations

(total number of pages: 8 including this page)

Page Content

[ ][a,b,c]

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

[ ]

a,b,c

Appendix G

Region 2 Tolerance and Temperature Calculations

(total number of pages: 7 including this page)

Page Content

[

]a,b,c

a,b,c

a,b,c

[ ]

a,b,c

[ ]

a,b,c

a,b,c

a,b,c

[ ]

Appendix H

Region 2 MCNP4a Calculations

(total number of pages: 8 including this page)

Page Content

[

]a,b,c

a,b,c

a,b,c

[ ]

a,b,c

a,b,c

[ ]

a,b,c

[ ]

a,b,c

[ ]

a,b,c

ENCLOSURE 5

Holtec – 3rd Party Affidavit for Analysis (Revision 1)

(Holtec Non-Proprietary)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk

AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, Evan Rosenbaum, state as follows:

(1) I am the Holtec International Project Manager for the AP1000 Spent Fuel Storage Racks Project and have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is Revision 1 of Holtec International Report HI-2094327, and selected input and output computer files listed therein, all containing Holtec Proprietary information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 4.a and 4.b, above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

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(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

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The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

Executed at Marlton, New Jersey, this 14th day of December, 2009.

Evan Rosenbaum
Holtec International