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June 12, 2009

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Subject: Response to Request for Additional Information - Revision to Technical Specification 4.3.1.1.a Concerning k-infinity

References:

1) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "License Amendment Request – Revision to Technical Specification 4.3.1.1.a Concerning k-infinity," dated June 25, 2008

2) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Unit Nos. 2 and 3: Request for Withholding Information From Public Disclosure (TAC NOS. MD9154 and MD9155)" (concerning the Northeast Technology Corporation submittal), dated October 10, 2008

3) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Unit Nos. 2 and 3: Request for Withholding Information From Public Disclosure (TAC NOS. MD9154 and MD9155)" (concerning the Global Nuclear Fuel submittal), dated October 10, 2008

4) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information – Revision to Technical Specification 4.3.1.1.a Concerning k-infinity," dated November 6, 2008

5) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Unit Nos. 2 and 3: Request for Withholding Information From Public Disclosure (TAC NOS. MD9154 and MD9155)," dated December 29, 2008

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Attachments 3, 5 and 7 transmitted herewith contain Proprietary Information.
When separated from attachments, this transmittal document is decontrolled.

6) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Unit Nos. 2 and 3: Request for Proprietary Review of Request for Additional Information Regarding License Amendment Request to Revise Technical Specification 4.3.1.1.a Concerning K-Infinity (TAC NOS. MD9154 and MD9155)," dated January 21, 2009

7) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information - Revision to Technical Specification 4.3.1.1.a Concerning k-infinity," dated March 9, 2009

8) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Units 2 and 3: Request for Withholding Information From Public Disclosure (TAC NOS. MD9154 and MD9155)" (concerning NET-264-02, Rev. 1), dated May 13, 2009

9) Letter from J. D. Hughey (U.S. Nuclear Regulatory Commission) to P. B. Cowan (Exelon Generation Company, LLC), "Peach Bottom Atomic Power Station, Unit Nos. 2 and 3: Request for Withholding Information From Public Disclosure (TAC NOS. MD9154 and MD9155)" (concerning NET-264-02, Rev. 2, NET-264-03, Rev. 0, and Response to RAI), dated May 13, 2009

In the Reference 1 letter, Exelon Generation Company, LLC (Exelon) requested an amendment to Appendix A, Technical Specifications, of the Renewed Facility Operating Licenses DPR-44 and DPR-56. The proposed change would revise the maximum k-infinity value contained in Technical Specification 4.3.1.1.a for the storage of fuel assemblies in the spent fuel storage racks. The proposed maximum k-infinity value is 1.318.

References 2, 3, 4 and 5 concern proprietary information supplied to the U.S. Nuclear Regulatory Commission. In the Reference 6 letter, the U.S. Nuclear Regulatory Commission requested additional information. Reference 7 provided a response to that request.

In the Reference 8 and 9 letters, the U.S. Nuclear Regulatory Commission requested additional information concerning information that was requested to be withheld from public disclosure.

In response to the Reference 8 letter, the owner has reclassified Appendix A to NET-264-02 P, Revision 1, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2012," as non-proprietary. Attachment 1 contains a non-proprietary version of Appendix A as previously submitted in the Reference 4 letter.

In response to the Reference 9 letter, the following corrections have been made:

1) The average Boraflex degradation value has been deleted from Attachment 2 of the Reference 7 letter. The revised attachment is contained in this letter as Attachment 2.

The revision has been marked with a revision bar in "Step 1." This document is remaining non-proprietary and is being marked as Revision 1.

2) The average projected Boraflex degradation value contained on page 42 of NET-264-02 P, Revision 2, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2010" (Proprietary Version), has been marked as proprietary. The revised report is contained in this letter as Attachment 3. A non-proprietary version is provided in Attachment 4.

3) The maximum individual panel loss value contained in our response to RAI question 2 ("Response to Request for Additional Information – Revision to Technical Specification 4.3.1.1.a Concerning k-infinity (Proprietary Version))" is being resubmitted with a proprietary marking. The revised attachment is contained in this letter as Attachment 5. Also, to avoid confusion, references to analyses, which are being updated as a result of this submittal, have been deleted or revised as appropriate. Revision bars identify revisions to this attachment. A non-proprietary version is being submitted as Attachment 6. The maximum rack loss contained in NET-264-02 P, Revision 3, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2010" (Proprietary Version) on page 19 has also been marked with a proprietary marking and is being submitted as Attachment 3.

4) Also included in this response is NET-264-03, Revision 1, "Characterization of Boraflex Panel Degradation in the Peach Bottom Unit 2 Spent Fuel Pool Projected to May 2010" as Attachment 7. A non-proprietary version is provided in Attachment 8. This attachment is being included to correct inconsistencies in proprietary markings.

5) An affidavit supporting the submittal of the proprietary documents is contained in Attachment 9.

If any additional information is needed, please contact Tom Loomis at (610) 765-5510.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 12th of June 2009.

Respectfully,

Pamela B. Cowan
Director, Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachments: 1) Non-Proprietary Version of Appendix A to NET-264-02 P, Revision 1, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2012"

2) Five Year Spent Fuel Management Plans at Peach Bottom Atomic Power Station and Conservatisms in the Current License Amendment Request (Revision to Technical Specification 4.3.1.1.a), Revision 1
3) NET-264-02 P, Revision 3, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2010" (Proprietary Version)
4) NET-264-02 P, Revision 3, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2010" (Non-Proprietary Version)
5) Response to Request for Additional Information – Revision to Technical Specification 4.3.1.1.a Concerning k-infinity, Revision 1 (Proprietary Version)
6) Response to Request for Additional Information – Revision to Technical Specification 4.3.1.1.a Concerning k-infinity, Revision 1 (Non-Proprietary Version)
7) NET-264-03, Revision 1, "Characterization of Boraflex Panel Degradation in the Peach Bottom Unit 2 Spent Fuel Pool Projected to May 2010" (Proprietary Version)
8) NET-264-03, Revision 1, "Characterization of Boraflex Panel Degradation in the Peach Bottom Unit 2 Spent Fuel Pool Projected to May 2010" (Non-Proprietary Version)
9) Northeast Technology Corporation Affidavit

cc: S. J. Collins, Regional Administrator, Region I, USNRC
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Director, Spent Fuel and Decommissioning
Director, Site Engineering-PBAPS
Director, Site Training-PBAPS
Manager, Regulatory Assurance-PBAPS
Manager, Licensing
Manager, SNM and Fuel Pools
Commitment Coordinator - KSA 3-E
Records Management - KSA 1-N-1
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ATTACHMENT 1

Non-Proprietary Version of Appendix A to NET-264-02 P, Revision 1, "Criticality Analysis of the Peach Bottom Spent Fuel Racks for GNF 2 Fuel with Boraflex Panel Degradation Projected to May 2012"

Report No. 901-02-05

Benchmarking Computer Codes for Calculating the Reactivity State of Spent Fuel Storage Racks, Storage Casks and Transportation Casks

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Review/Approval Record

Rev.	Date	Prepared by:	Reviewed/Approved by:	Approved (QA) by:

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1.0 Introduction

This report documents the results of benchmark calculations of three computer codes used to compute the reactivity state of nuclear fuel assemblies in close-packed arrays. Such close-packed arrays include high density spent fuel storage racks, dry storage casks and casks for transporting nuclear fuel. The three computer codes, which were benchmarked and validated are:

- KENO V.a, which is a module of SCALE 5[1]
- MCNP5[2]
- CASMO-4[3]

Earlier versions of KENO and CASMO have been previously benchmarked and validated by NETCO.[4,5]

To benchmark and validate the codes for spent fuel racks and cask evaluations, KENO and MCNP were used to simulate a series of critical experiments. The calculated eigenvalues (k_{eff}) were then compared with the critical condition (k_{eff} = 1.0) to determine the bias inherent in the calculated values. For the KENO V.a calculation, the 238 energy group ENDF/B-V cross-section library was used. For the MCNP5 calculations, the continuous energy cross-section library based on ENDF/B-VI was used.

After determining the inherent biases associated with KENO V.a and MCNP5, both KENO V.a and CASMO-4 (with its own 70 energy group cross-section library) were used to model central arrays of select critical experiments. It is noted that CASMO-4 models an infinitely repeating array of fuel assemblies and is generally used to generate cross-sections for core simulator models. As such, it does not lend itself directly to finite arrays of fuel racks surrounded by a reflector, as is the case in the critical experiments considered. Accordingly, the central fuel arrays of five critical experiments were modeled as infinite arrays with both KENO V.a and CASMO-4. A comparison of the KENO V.a and CASMO-4 eigenvalues provides a means to determine the CASMO-4 bias.

For the purposes of benchmarking, a set of five Babcock and Wilcox (B&W) critical experiments (XIII, XIV, XV, XVII, and XIX)[6], were selected because they closely represent typical fuel/rack geometries with neutron absorber panels. In addition, the International Committee on the Safety of Nuclear Installations (CSNI) identified a sequence of benchmark problems[7] that closely replicate both fuel/rack and fuel/cask geometries, and included typical LW enrichments and $H/^{235}U$ ratios. The resulting models are representative of most fuel storage rack and fuel cask configurations used today.

All work completed for the benchmarking calculations was carried out under NETCO's Quality Assurance Program[8]. The methods employed have been patterned to comply with industry accepted standards[9,10,11] and with accepted industry criticality references[12, 13, 14, 15, 16].

2.0 BENCHMARKING - STANDARD PROBLEMS AND CONFIGURATION CONTROL

2.1 SCALE-5 and MCNP5 Configuration Control

The binary executable codes and associated batch files were provided by RSICC on CD-ROM for use on Intel Pentium based micro-computers running under the Windows operating system. In this form, the programs can not be altered or modified. In addition to the binary executable codes, there are several supporting files which contain cross-section sets, etc. The file name, file size, and creation date for each executable file is given in Appendix A*. Prior to executing either code sequence, the user will verify the file names, creation dates, and sizes to insure that they have not been changed. Appendix B contains two CD-ROMs, which include the as-received versions of all files required to execute these programs. In all applications described in this report and for all subsequent applications, the files listed in Appendix A are to be used. This appendix is not provided in the non-proprietary version of this report.

2.2 Sample Problems

A suite of input files with their corresponding output files were provided with each code. The input file names and batch files used to execute them are listed in Appendix A. These were executed on NETCO's host computer via batch files provided by RSICC and the resulting output files compared to those provided by RSICC on CD-ROM. Except for the date and time of execution stamps, the respective output files were identical. Each code uses a pseudo-random number generator that is initiated with a default seed value. Since the default value was used in each case, the sequences of random numbers were the same, leading to identical calculations. This verifies that the as-received versions of both codes are identical to the versions documented in the User's Manuals[1,2].

*(Appendices A, B, C, D and E are included in the proprietary version of this report.)

Examination of the sample input decks shows that the run modules in batch files exercise all of the code options used by this benchmarking exercise. Before and after each subsequent use of each code, one set of sample input modules are executed and the output files compared to the sample output files to verify that no system degradation has occurred. (All of these files are contained in Appendix B* at the end of this report). This appendix is not provided in the non-proprietary version of this report.

2.3 CASMO-4 Configuration Control

The version of CASMO-4 used for these analyses was developed for a RISCC workstation. Version 2.05.01 of CASMO-4 was used for this benchmarking work and subsequent users of CASMO-4 for NETCO will verify that Version 2.05.01 is being used. CASMO-4 and all versions are controlled by Studsvik of America under their Quality Assurance Program[17]. If a different version of CASMO-4 is used by NETCO for any subsequent analyses, the CASMO-4 analyses in Section 3.2 shall be repeated with the version in use.

*(Appendices A, B, C, D and E are included in the proprietary version of this report.)

3.0 BENCHMARK MODELING OF LWR CRITICAL EXPERIMENTS

An index of input and output files for each experiment modeled is contained in Appendices C* and D*. For each experiment, the input and output files are on 3.5 inch 1.44 MB diskettes which are also contained in Appendices C and D. Appendix E* contains the calculation notebook for this project and represents a permanent record of all hand calculations performed during input preparation. All input parameters are fully traceable to the appropriate source documents. These appendices are not provided in the non-proprietary version of this report.

3.1 BENCHMARKING OF SCALE-5 and MCNP5

The B&W experiments[6] include twenty (20) water moderated LWR fuel rod cores and close-packed critical LWR fuel storage arrays. Of these, five (5) used boron carbide/aluminum cermet poison plates (BORAL) in the closest possible packing geometry representing a 3 x 3 array of LWR fuel assemblies in high density fuel storage racks. These five (5) experiments have been modeled, as they most closely represent LWR fuel in high density fuel storage racks and cask configurations with neutron absorber panels. Table 3-1 summarizes some of the model parameters, including U-235 enrichment, moderator-to-fuel ratio and absorber macroscopic absorption cross-section.

The Committee on the Safety of Nuclear Installations (CSNI) has published a selection of critical experiments[7], which are a sequence of exercises arranged in order of increasing complexity, introducing one new parameter into the geometry and materials at a time. They were selected specifically to validate calculational methods for criticality safety assessments. The fuel is designed to simulate LWR fuel, is water moderated, and the lattices include BORAL plates between assemblies when neutron poisons are

*(Appendices A, B, C, D and E are included in the proprietary version of this report.)

included. The sequence starts with Experiment 1-1, a single array of 20 x 18, 2.35 w/o ^{235}U rods with a water reflector all around. Experiments 1-2-1 and 1-2-2 are also single water reflected arrays but are at a higher enrichment (4.74 w/o ^{235}U) and are at undermoderated (1-2-1) and optimum moderation (1-2-2) conditions. Experiment 2-1 has three square arrays of 2.35 w/o ^{235}U fuel separated by BORAL neutron absorber plates. Experiment 2-2 has a 2 x 2 array of four 4.74 w/o ^{235}U rod arrays also separated by BORAL plates. Experiments 3-A-1 and 3-B-1 are similar to experiment 2-1 but include, respectively, lead and steel reflecting walls. Experiment 3-A-2 is similar to Experiment 2-2 but also has a lead reflecting wall.

In each MCNP5 model of the criticals, 4,000,000 neutrons in 2,000 generations were tracked. In each KENO model of the criticals, at least 20,000,000 neutrons in at least 10,000 generations were tracked. The output files were always checked to insure that the fission source distribution had converged. A summary of the distribution of k_{eff} over all generations is automatically plotted in the output files and shows them to be approximately normally distributed. Thus, normal one-sided tolerance limits with appropriate 95% probability / 95% confidence factors (95/95) can be used. The calculated results for each critical experiment are given in Table 3-2, including the calculated k_{eff}, the one-standard-deviation statistical uncertainty of k_{eff}, denoted by σ, and the bias with respect to the critical state k_{eff} = 1.0.

The overall bias between the calculation eigenvalue and the experiments is calculated as follows. First, the variance-weighted mean is calculated as

$$k_m = \sum_{i=l}^{N} (k_i / \sigma_i^2) / \sum_{i=l}^{N} (1/\sigma_i^2) \qquad (3\text{-}1)$$

where N = 13 (for the 5 B&W and 8 CSNI criticals), k_i is the SCALE-5 calculated k_{eff} for critical i, and σ_i is the SCALE-5 calculated standard deviation of the distribution of k_{eff} for critical i. The standard deviation around k_m is given by

$$\sigma_m = \left[\frac{1}{N-1} \sum_{i=1}^{N} (k_i - k_m)^2 \right]^{1/2} \qquad (3\text{-}2)$$

The bias is calculated as k_m - 1, and has the same standard deviation as k_m. Based upon the results shown in Table 3-2, it is recommended that the 238 energy group ENDF/B-V library be used in all criticality analyses. For SCALE-5, the resulting mean bias for this library is -0.00782 ± 0.00361. For MCNP5, using the continuous energy cross-section library based on ENDF/B-VI, the resulting variance weighted mean bias is - 0.00574 ± 0.00509.

Correlations of bias with respect to moderator-to-fuel ratio (H / ^{235}U), number density ratio and absorber strength (Σ_a^{th}) were investigated and found to be not significant. The coefficient of determination for bias versus moderator-to-fuel ratio for the 238 group ENDF/B-V library was a negligible 2.6%, whereas for MCNP5 it was 4.1%, indicating that the method bias is not strongly dependent on moderator-to-fuel ratio. In all cases, the bias becomes less negative with decreasing moderator-to-fuel ratio (i.e., increasing enrichment). The coefficient of determination for bias versus absorber strength for the 238 Group ENDF/B-V library was an insignificant 6.1%, while for MCNP5, it was 37.1%. In all cases, the bias becomes less negative with increased absorber strength. These results are illustrated in Figures 3-1 and 3-2, respectively.

Table 3-1: B&W [6] and CSNI [7] Critical Experiments - Design Parameters

Reference	Experiment Number	Absorber Type	Absorber $\ni_a$ [cm^{-1}]	Enrichment w%	H/^{235}U Ratio
6	XIII	BORAL	1.871	2.459	216.43
6	XIV	BORAL	1.460	2.459	216.52
6	XV	BORAL	0.475	2.459	216.52
6	XVII	BORAL	0.293	2.459	216.54
6	XIX	BORAL	0.129	2.459	216.54
7	1-1	none	-	2.35	398.72
7	1-2-1	none	-	4.75	109.44
6	1-2-2	none	-	4.75	228.53
7	2-1	BORAL	30.6	2.35	398.72
7	2-2	BORAL	24.6	4.75	228.53
7	3-A-1	none	-	2.35	398.75
7	3-B-1	none	-	2.35	398.75
7	3-A-2	BORAL	24.6	4.75	228.53

Table 3-2 B&W[6] and CSNI[7] Critical Experiment Results

Reference	Experiment		SCALE 5			MCNP5	
		Keff	sigma	bias	Keff	sigma	bias
6	XIII	0.99341	0.00017	-0.00659	0.99422	0.00035	-0.00578
6	XIV	0.98989	0.00018	-0.01011	0.98997	0.00035	-0.01003
6	XV	0.98623	0.00017	-0.01377	0.98525	0.00035	-0.01475
6	XVII	0.98972	0.00016	-0.01028	0.98846	0.00034	-0.01154
6	XIX	0.99136	0.00018	-0.00864	0.99004	0.00035	-0.00996
7	1-1	0.99048	0.00017	-0.00952	0.99294	0.00032	-0.00706
7	1-2-1	0.99404	0.00020	-0.00596	1.00000	0.00030	0.00000
7	1-2-2	0.99774	0.00020	-0.00226	1.00000	0.00030	0.00000
7	2-1	0.98925	0.00017	-0.01075	0.99164	0.00032	-0.00836
7	2-2	0.99549	0.00020	-0.00451	1.00000	0.00030	0.00000
7	3-A-1	0.99390	0.00018	-0.00610	0.99012	0.00033	-0.00988
7	3-B-1	0.99287	0.00017	-0.00713	0.99590	0.00033	-0.00410
7	3-A-2	0.99904	0.00020	-0.00096	0.99746	0.00041	-0.00254
	Arithmetic Mean	0.99218			0.99426		
	Variance Weighted			-0.00782			-0.00574
	Standard Deviation			± 0.00361			± 0.00509

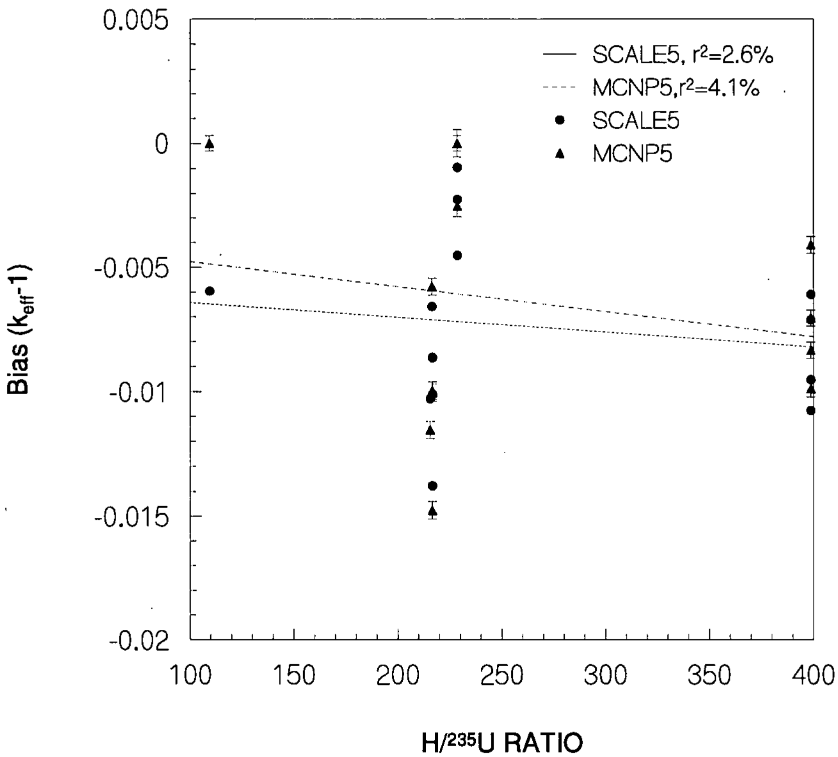

Figure 3-1: Variation of Bias (k_{eff} -1) with Moderator-to-Fuel Ratio

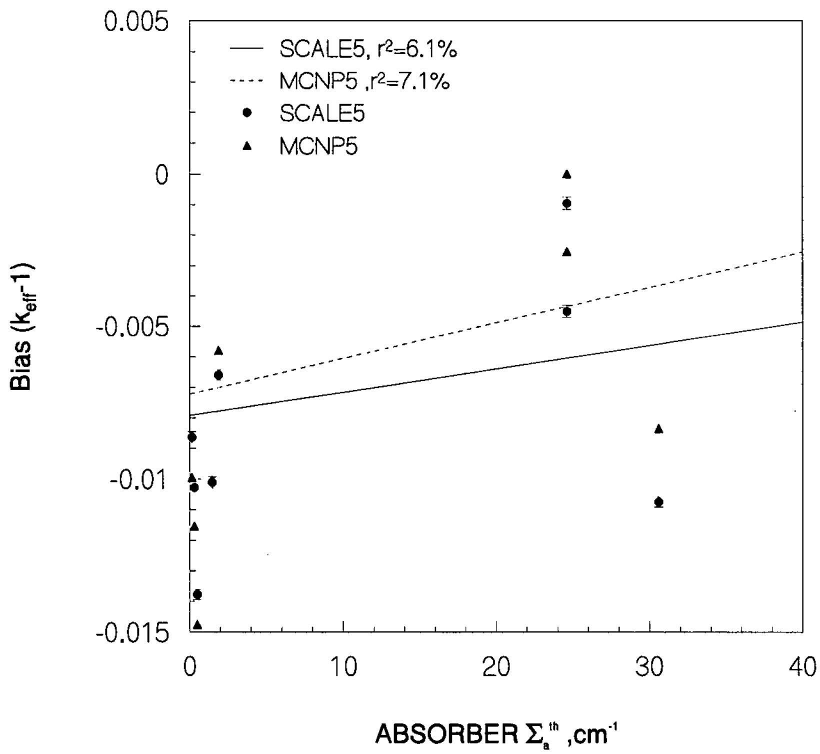

Figure 3-2: Variation of Bias (k_{eff}-1) with Absorber Strength

3.2 BENCHMARKING OF CASMO-4

This section compares SCALE-5[1] and CASMO-4[3] calculations for k_∞ of the same five B&W critical experiments[6] discussed in Section 3.1. CASMO-4 is limited in its ability to render a geometric model and can only be used for infinite arrays of assemblies. Thus, for this benchmark analysis, the central assembly of the 3 x 3 array of assemblies in the B&W critical experiments was modeled and then assumed to be infinitely reflected. The assembly pitch was preserved in the model, but the effect of the finite water reflector around the 3 x 3 array was lost, making the model supercritical.

SCALE-5 was also used to model the B&W critical experiments with exactly the same geometry as they were rendered in CASMO-4. Because the bias of SCALE-5 is known (see Section 3.1), it can be applied to the SCALE-5 result to obtain a best-estimate of the supercritical state of the infinitely reflected assembly model. The CASMO-4 result can then be compared with this best estimate to obtain a CASMO-4 bias.

The results of the SCALE-5 and CASMO-4 analyses are compared in Table 3-3. The CASMO-4 bias is calculated as

$$\text{bias}_{\text{CASMO-4}} = k_{\text{CASMO-4}} - k_{\text{SCALE-5, best estimate}}$$

where

$$k_{\text{SCALE-5, best estimate}} = k_{\text{SCALE-5}} - \text{bias}_{\text{SCALE-5}}$$

For CASMO-4 the resulting mean bias and standard deviation for the 238 Group ENDF/B-V library are -0.01028 and 0.00198 respectively.

Table 3-3: B&W Critical Experiments as CASMO Infinite Arrays - Results

Experiment	CASMO-4	SCALE-5 (bias corrected) 238GROUPNDF5		
		Keff	sigma	bias
XIII	1.08816	1.10160	0.00050	-0.01423
XIV	1.08860	1.10175	0.00049	-0.01523
XV	1.09832	1.10961	0.00045	-0.01280
XVII	1.10740	1.11732	0.00045	-0.00945
XIX	1.11614	1.12330	0.00043	-0.00832
			bias	-0.01028
			Sigma	± 0.00198

4.0 CONCLUSIONS

SCALE-5 and MCNP5 have been benchmarked by modeling five (5) Babcock and Wilcox critical experiments and eight (8) CSNI critical experiments representative of fuel storage rack and fuel cask geometries. At a 95% probability / 95% confidence level, the computed bias for SCALE-5 and MCNP5 are -0.01381 and -0.01460, respectively.

CASMO-4 has also been benchmarked by modeling the five (5) Babcock and Wilcox critical experiments as infinite arrays. Best estimates of k_∞ for the exact same geometry were calculated using SCALE-5 and applying the mean bias reported above. The CASMO-4 bias with respect to these values was calculated to be -0.01028 ±0.00198 (1-sigma). The comparison of SCALE-5 and CASMO-4 serves to verify the results of each with respect to the other.

It is therefore concluded that these calculational methods have been adequately benchmarked and validated. They may be used individually or in combination for the criticality analysis of spent fuel storage racks, fuel casks and fuel casks in close proximity to fuel storage racks, provided the appropriate biases are applied.

5.0 REFERENCES

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2. "MCNP – A General Monte Carlo N-Particle Transport Code, Version 5", Volumes 1 – 3, RSICC Computer Code Collection CCC-710, X-5 Monte Carlo Team, Los Alamos National Laboratory, Los Alamos, NM, April 24, 2003.

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Attachment 2

Five Year Spent Fuel Management Plans at Peach Bottom Atomic Power Station
and
Conservatisms in the Current License Amendment Request (Revision to Technical Specification 4.3.1.1.a)

Revision 1

A. Five-Year Spent Fuel Management Plans at Peach Bottom Atomic Power Station (PBAPS)

Spent fuel management at PBAPS consists of storage in high-density spent fuel pool racks and dry cask storage. The spent fuel pools for Units 2 and 3 are separate, and each unit's racks utilize Boraflex as a neutron absorber. In light of the Boraflex degradation experienced at PBAPS, a five-step approach to managing spent fuel storage needs over the next five years is under development. PBAPS provides the following for NRC's information and understanding as to how this request fits into Exelon's long-term plans for spent fuel management at PBAPS. The time frames for completion of the actions discussed below reflect the current schedules for anticipated completion dates and do not constitute regulatory commitment dates (except as discussed in Attachment 1 and item 3 below):

1. Complete and submit for NRC review, the revised criticality analysis documented herein. This revised analysis demonstrates continued operation of the spent fuel racks until approximately May 2010. (March 2009)

2. Evaluate long-term Boraflex mitigation strategies, including interim and permanent 3-of-4 storage configurations, neutron absorber cell inserts, spent fuel rack replacement and additional dry cask storage. (approximately September 2009)

3. Submit a revised criticality analysis to demonstrate operability of existing Boraflex spent fuel racks through the period required to implement the chosen long-term mitigation strategy (permanent 3-of-4 storage, cell inserts or rack replacement). (December 18, 2009)

4. Perform additional BADGER testing to benchmark/confirm RACKLIFE predictions of Boraflex degradation. (Unit 3 – approximately December 2009, Unit 2 – approximately February 2010)

5. Begin implementing long-term mitigation strategy for both spent fuel pools. (approximately March 2010 through May 2014)

PBAPS has utilized dry cask storage since 2000. In 2009, three casks will be loaded from the Unit 3 spent fuel pool. In 2010, up to eight casks will be loaded from the Unit 2 spent fuel pool, depending upon the outcome of the mitigation strategy study. In even number years, spent fuel is moved from the Unit 2 pool into dry storage, and in odd number years, from the Unit 3 spent fuel pool. Between three and five dry storage casks – each containing 68 assemblies – are normally loaded at each campaign.

The following is a discussion of the five (5) steps above:

Step 1

The revised analysis submitted herein allows continued storage in the PBAPS spent fuel pools, for Boraflex degradation. This analysis maintains significant, conservative margins to the regulatory criterion of $k_{eff} \leq 0.95$, as discussed in our attached response to the NRC's request for additional information and below. RACKLIFE modeling projections indicate this limiting Boraflex density loss will be reached in May 2010 in Unit 2. [Note: Unit 3 has shown less Boraflex degradation than Unit 2; the degradation in Unit 2 is the limiting condition.] As of the third quarter of 2008, the Unit 2 pool average Boraflex aerial density loss exceeded the current licensing basis value of 10%.

Step 2

Exelon has initiated a program to review the various technical options available to mitigate the loss of Boraflex neutron absorber. Ultimately, these options are premised on the long-term assumption that no credit is taken for Boraflex in the existing spent fuel racks. Business case studies are evaluating the following potential solutions:

1. Replacement of existing spent fuel racks. Partial and/or complete replacement of the existing spent fuel racks is an option. Exelon notes that approximately 30 months are required from the decision to implement until the new racks are installed. In conjunction, Exelon would submit a License Amendment Request for the new spent fuel racks.

2. 3-of-4 storage configuration. On either a temporary or permanent basis, 3-of-4 storage configurations are under consideration. This option would require significant, additional dry cask storage on site.

3. Neutron absorber inserts. Recent technological advances have been made with two-sided neutron absorber inserts, which when placed in spent fuel rack cells with degraded Boraflex, replace the negative reactivity lost with the dissolution of the original material. These inserts can be placed in degraded spent fuel rack locations on an as needed basis, and can be utilized in conjunction with 3-of-4 storage configurations to maximize spent fuel pool capabilities. Over a period of several years, all cells in a degraded spent fuel rack can be recovered with cell inserts coupled with a small area of permanent 3-of-4 storage configurations, as required for assemblies which will not fit into a cell with inserts.

Step 3

By December 18, 2009, PBAPS intends to submit a License Amendment Request (LAR) to further extend the life of the existing racks until a permanent solution can be implemented. This LAR will consider:

1. Recognizing and taking credit for some of the reactivity margin between the design basis fuel assembly, and actual fuel assembly designs to be used in the plants over the next several years or that have already been discharged to the spent fuel pool.

2. Utilizing the new design basis fuel assembly to demonstrate that regulatory criteria can be met for spent fuel stored in a 3-of-4 storage configuration.

3. Identifying a cell average Boraflex areal density loss, such that individual storage locations can be declared inoperable, and storage in them prevented until they are placed into a 3-of-4 storage configuration, or contain cell inserts to replace the lost negative reactivity.

Step 4

BADGER testing is intended to be performed in both spent fuel pools within the next year. This will provide assurance of the RACKLIFE predictions. Based upon experience at PBAPS, Exelon believes the BADGER testing will show the RACKLIFE predictions to be conservative (less Boraflex degradation than predicted). However, Exelon considers the ongoing testing at this time to be prudent, and to provide additional assurance that the overall management strategy is on track.

Step 5

A decision regarding long-term spent fuel management will be reached by approximately December 2009. A decision made by this time will provide sufficient time to procure the materials and construct new spent fuel racks, additional dry cask storage, and/or neutron absorber inserts – depending upon the strategy chosen. A decision made by December 2009 allows the implementation of any strategy to begin by approximately May 2012.

B. Conservatisms in the Current License Amendment Request (Revision to Technical Specification 4.3.1.1.a)

Exelon has not taken analysis credit in this LAR for three, large conservative assumptions, which are discussed below. The regulatory criticality criterion of $k_{eff} \leq 0.95$ provides substantial margin to ensure a criticality event will not occur. Exelon believes that, beyond the analyses presented by the NETCO study, the additional margin represented by these assumptions provide further evidence that criticality safety is ensured by this LAR.

First, the LAR seeks to change the maximum k-infinity of fuel stored in the spent fuel racks at Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, to no greater than 1.318. This value represents a conservative fuel bundle design, incorporating many conservative design parameters. In this way, Exelon can be assured that new bundle designs for future reload batches are capable of being stored in the spent fuel pool.

The next two refuel batches (through May 1, 2011, before being staged in the spent fuel pool in advance of a refueling outage) are anticipated to have a maximum k_{∞} design criterion of no greater than 1.25. The un-credited additional margin to criticality remains nearly 6% Δk through 2011.

Second, an assumed immediate shutdown of one unit at peak reactivity, requiring the core to be fully discharged to the spent fuel pool, is unlikely to result in any of the assemblies at peak reactivity being collocated with one another. This limitation occurs as a result of normally configuring the pool to meet B.5.b (Security Order) requirements. While Exelon has not quantified the additional margin to criticality as a result of this limitation, it clearly would result in a further reduction of k_{eff}.

Third, Exelon has reviewed all discharged fuel in the spent fuel pools at Units 2 and 3 for initial enrichment, with burnups less than 20,000 MWd/MTU. In the Unit 2 pool, only JLM675 (4.159 w/o, 9,987 MWd/MTU) and JLC746 (4.158 w/o, 16,488 MWd/MTU) are close to their peak reactivity. In the Unit 3 pool, there are no assemblies close to their peak reactivity. While Exelon recognizes this is a qualitative and not a quantitative analysis, it does demonstrate further conservatism in the current analysis in that it is unlikely any assembly discharged from the reactor at peak reactivity would be collocated with another assembly in the spent fuel pool at its peak reactivity.