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May 31, 2002
L-02-070

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

Subject: Beaver Valley Power Station, Unit No. 2
Docket No. 50-412, License No. NPF-73
License Amendment Request No. 165

Pursuant to 10 CFR 50.90, FirstEnergy Nuclear Operating Company (FENOC) requests an amendment to the above license in the form of a change to the technical specifications. The proposed amendment modifies Design Feature 5.3.1, Criticality, to increase the new fuel (fresh fuel) storage racks enrichment limit to 5.00 weight percent (w/o). The proposed change is consistent with the spent fuel storage pool enrichment limit recently approved for Beaver Valley Power Station (BVPS) Unit No. 2 in Amendment No. 128. The proposed change is also consistent with the new fuel storage racks enrichment limit approved for BVPS Unit No. 1 in Amendment No. 204.

It is anticipated that future cycles of operation will require a maximum enrichment greater than 4.85 w/o to meet future core energy requirements. The proposed change allows for improved fuel cycle management through increased flexibility in core design.

The safety analysis and no significant hazards evaluation are presented in the Enclosure. The proposed technical specification changes are presented in Attachment A. Attachment B indicates that there are no new commitments made in this submittal. Attachment C provides the criticality analysis of the BVPS Unit No. 2 new (fresh) fuel racks.

This change has been reviewed by the Beaver Valley review committees. The change was determined to be safe and does not involve a significant hazard consideration as defined in 10 CFR 50.92 based on the attached safety analysis and no significant hazard evaluation.

FENOC requests approval of the proposed amendment by April 1, 2003, in order to support the next Unit 2 core design and manufacturing of fuel assemblies for the BVPS Unit No. 2 refueling outage 10 (2R10). Once approved, the amendment will be implemented within 60 days.

A001

If there are any questions concerning this matter, please contact Mr. Larry R. Freeland, Manager, Regulatory Affairs/Corrective Action at 724-682-5284.

I declare under penalty of perjury that the foregoing is true and correct. Executed on May 31, 2002.

Sincerely,

M. P. Pearson

Enclosure: FENOC Evaluation of the Proposed Change

Attachments:

A. Proposed Technical Specification Changes (mark-ups)
B. List of Regulatory Commitments
C. Criticality Analysis of the Beaver Valley Power Station Unit No. 2 Fresh Fuel Racks

c: Mr. D. S. Collins, Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

ENCLOSURE

Beaver Valley Power Station, Unit No. 2
License Amendment Request No. 165

FirstEnergy Nuclear Operating Company Evaluation

Subject: Application for Amendment of Technical Specification 5.3.1.2 to Increase the New Fuel Storage Racks Enrichment Limit to 5.00 Weight Percent

Attachments

1. DESCRIPTION

FirstEnergy Nuclear Operating Company (FENOC) requests to amend Operating License NPF-73 for Beaver Valley Power Station (BVPS) Unit No. 2.

The proposed amendment would revise the BVPS Unit No. 2 Technical Specification (TS) Design Feature 5.3.1, Criticality, where the new fuel (fresh fuel) racks enrichment limit specified in Section 5.3.1.2.a would be increased to 5.00 weight percent (w/o) from its current 4.85 w/o limit.

2. PROPOSED CHANGE

The proposed change will affect BVPS Unit No. 2 Technical Specifications 5.3.1.2.a. The new fuel storage racks maximum enrichment limit specified in TS 5.3.1.2.a would be increased to 5.00 w/o and the Specification would be modified by adding the words "with a tolerance of + 0.05 weight percent." The proposed changes are shown in Attachment A.

3. BACKGROUND

TS Design Feature 5.3.1.2 provides the current new fuel storage racks design limits as approved by BVPS Unit No. 2 TS Amendment No. 83, dated April 14, 1997. The current enrichment limit for new fuel storage is 4.85 w/o. As described in Section 9.1.1 of the BVPS Unit No. 2 Updated Final Safety Analysis Report (UFSAR), the new fuel racks provide dry storage for 70 fuel assemblies arranged in a 5 x 14 array with a 21 inch lattice spacing.

It is anticipated that future cycles of operation will require a maximum enrichment greater than 4.85 w/o to meet future core energy requirements. The BVPS Unit No. 2 spent fuel storage pool has already been evaluated and approved to address fuel enriched to 5.00 w/o U-235 in BVPS Unit No. 2 Technical Specification Amendment No. 128, issued February 11, 2002. Therefore, a new fuel criticality analysis was initiated to provide a basis for increased new fuel enrichment by taking credit for the margin available between the current analyzed maximum K_{eff} and the new fuel storage rack K_{eff} limits. The proposed amendment would revise the BVPS Unit No. 2 TS Design Feature 5.3.1, Criticality, where the new fuel racks enrichment limit specified in Section 5.3.1.2.a would be increased to 5.00 w/o from its current 4.85 w/o.

BVPS Unit No. 1 TS 5.3.1.2 new fuel storage racks enrichment was previously increased to 5.00 w/o with a tolerance of + 0.05 w/o in BVPS Unit No. 1 License Amendment No. 204, dated May 28, 1997.

4. TECHNICAL ANALYSIS

Future core designs may feature higher capacity factors and ultimately may require higher enriched fuel assemblies in order to meet core energy requirements. BVPS Unit 2 Amendment 128, issued February 11, 2002 approved an increase in the maximum enrichment of fuel assemblies located in the spent fuel storage pool from 4.85 w/o to 5.00 w/o. This BVPS Unit No. 2 License Amendment Request No. 165 is needed to allow new fuel with enrichments up to 5.00 w/o to be placed into the new fuel storage area prior to their being moved to the spent fuel storage pool location.

Current TS 5.3.1.2.a limits fuel assembly storage in the new fuel racks to fuel assemblies enriched to 4.85 w/o consistent with the criticality analysis of record. A new analysis has been performed to justify increasing the new fuel storage racks enrichment limit to 5.00 w/o with a tolerance + 0.05 w/o, as shown in Attachment C, "Criticality Analysis of the Beaver Valley 2 Fresh Fuel Racks." The analysis results demonstrate that for fuel enriched to 5.00 w/o + 0.05 w/o for both the full density (1.0 gm/cm3) and the optimum moderation (0.075 gm/cm3) conditions, the maximum K_{eff} including uncertainties at the 95/95 probability/confidence level is maintained less than the limit 0.95. UFSAR Section 4.3.2.6 describes the methods to calculate the specified K_{eff}. The methods used conform with ANS N18.2-1973, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants", Section 5.7; ANSI 57.2-1983, "Design Objectives for LWR Spent Fuel Storage Facilities at Nuclear Power Stations", Section 6.4.2; ANSI/ANS 8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors"; NRC Standard Review Plan, Section 9.1.1, "New Fuel Storage"; NRC Standard Review Plan, Section 9.1.2, "Spent Fuel Storage"; ANSI 57.3-1983, Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants.

UFSAR Section 9.1.1.2 states that new fuel assemblies are stored dry in a steel and concrete structure within the fuel building. No changes to the facility's new fuel storage physical configuration are proposed by this amendment request. The new fuel storage racks consist of a stainless steel support structure into which 70 stainless steel fuel guide assemblies are bolted in 14 parallel rows of five fuel guide assemblies each. The necessary minimum spacing between nearby fuel assemblies is ensured by the design of the fuel guide supporting structure. The accumulation of liquid in the new fuel storage area is prevented by a 4-inch floor drain located in the area. Because no physical changes are proposed to the size of a new fuel assembly nor for the physical storage arrangements of a new fuel assembly with the proposed new fuel enrichment limit, the physical storage facilities for new fuel assemblies at BVPS Unit 2 remain unchanged and continue to meet the physical storage design requirements as described in the UFSAR.

The spacing of the new fuel assemblies, located in the new fuel guide assemblies, is a minimum of 21 inches center-to-center. This will maintain the fuel in a subcritical condition with $K_{eff} \leq 0.95$, for both the full density (1 gm/cm3) and for the low density (0.075 gm/cm3) optimum moderation conditions. The analysis methodology used to evaluate the potential for new fuel storage racks criticality is detailed in WCAP-14416, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology." This report describes the computer codes, benchmarking and methodology used to calculate the criticality safety limits for the new fuel storage racks. The new criticality analysis for the new fuel storage racks indicates the maximum K_{eff} including uncertainties at the 95/95 probability/confidence level is 0.92839 for full density and 0.94745 for optimum moderation conditions. Therefore, increasing the maximum fuel assembly enrichment to 5.00 w/o + 0.05 w/o complies with the ANSI Standard N18.2 limits. The maximum enrichment limit has been further modified by adding the words "with a tolerance of + 0.05 weight percent" to ensure this limit is adequately defined to account for manufacturing differences.

Based on the new criticality analysis, the proposed change has been determined to be safe and will not reduce the safety of the plant.

5. REGULATORY SAFETY ANALYSIS

FirstEnergy Nuclear Operating Company (FENOC) proposes to amend the Operating License for Beaver Valley Power Station (BVPS) Unit No. 2. This License Amendment Request proposes to revise the new fuel storage racks maximum enrichment limit specified in Technical Specification (TS) 5.3.1.2.a to 5.00 weight percent (w/o) and the Specification would be modified by adding the words "with a tolerance of + 0.05 weight percent."

5.1 No Significant Hazards Consideration

FENOC has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?

   No. The proposed change to the new fuel storage racks enrichment limit does not introduce an initiator of any design basis accident. The text change on tolerance is added for clarification of the criteria associated with new fuel enrichment limit. The proposed changes do not adversely affect accident initiators or precursors nor alter the configuration of the facility or the manner in which the plant is maintained.

Thus, the proposed changes do not involve a significant increase in the probability of an accident previously evaluated.

The proposed changes do not alter or prevent the ability of structures, systems, and components (SSCs) from performing their intended function to mitigate the consequences of an initiating event within the assumed acceptance limits. The proposed changes are consistent with the safety analyses assumptions and resultant consequences. Accident analyses potentially affected by the proposed change have been reviewed and all applicable acceptance criteria continue to be met. Thus, the proposed changes do not involve a significant increase in the consequences of an accident previously evaluated.

Therefore, the proposed changes do not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?

   No. The proposed change to the new fuel storage racks enrichment limit and its associated text clarifications do not involve a physical alteration of the plant (i.e., no new or different type of equipment will be installed). Subsequently, no new or different failure modes or limiting single failures are created. The plant will not be operated in a different manner due to the proposed change. All SSCs will continue to function as currently designed. Thus, the proposed changes do not create any new or different accident scenarios.

3. Does the proposed change involve a significant reduction in a margin of safety?

   No. The proposed change to the new fuel storage racks enrichment limit and its associated text clarifications do not involve revisions to any safety limit or safety system settings that would adversely impact plant safety. The proposed amendment does not alter the functional capabilities assumed in a safety analysis for any SSCs important to the mitigation and control of design basis accident conditions within the facility.

   All of the applicable acceptance criteria for each of the analyses affected by the proposed changes continue to be met. The conclusions of the Updated Final Safety Analysis Report (UFSAR) remain valid. Thus, since the operating parameters and system performance will remain within design requirements and safety analysis assumptions, safety margin is maintained.

Based upon the above, FENOC concludes that the proposed amendment present no significant hazards consideration under the standard set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

5.2 Applicable Regulatory Requirements/Criteria

Applicable criteria and acceptance limits as they are related to the proposed changes are described below.

General Design Criteria		Assessment
2	Protection from Natural Phenomena	No Impact
5	Shared SSCs Important to Safety	No Impact
61	Fuel Storage	No Impact
62	Prevention of Criticality	No Impact

Regulatory Guides		Assessment
1.29	Seismic Design Classification	No Impact

The above criteria is listed in Section 9.1.1.1 of the BVPS Unit No. 2 UFSAR as design criteria for the new fuel storage area. The requested revisions to Technical Specifications 5.3.1.2.a would allow for storing new fuel with an enrichment up to 5.00 weight percent (w/o). The proposed change would not impact the design or performance characteristics of the new fuel storage facility since this modification does not include any physical changes to the current new fuel storage rack facility. Hence the new fuel storage racks will continue to meet the criteria for GDC 2, GDC 5, 61 and Reg. Guide 1.29. GDC 62 continues to be met as demonstrated by a criticality analysis which determines that K_{eff} of 0.95 will not be exceeded for new fuel with enrichments up to 5.00 w/o stored in the BVPS Unit 2 new fuel storage racks.

In conclusion, based upon the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the proposed amendment will not be inimical to the common defense and security or to the health and safety of the public.

6. ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement.

Increasing the new fuel storage racks enrichment limit does not change the release of effluents or change the radiation exposure to individuals. Site effluents are unaffected. There is no change to the release of effluents resulting from the new fuel storage racks enrichment limit. This request does not involve a significant change in the types or a significant increase in the amount of any effluents that may be released offsite and does not cause a significant increase in individual or cumulative occupational radiation exposure; thus, the categorical exclusion criteria of 10 CFR 50.22(c)(9) is satisfied. Therefore, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure.

Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7. REFERENCES

1. Beaver Valley Power Station Unit No. 2 Updated Final Safety Analysis Report

2. CAC-02-133, Criticality Analysis of the Beaver Valley Unit 2 Fresh Fuel Racks, Westinghouse Electric Company, January, 2002.

3. Beaver Valley Power Station Unit No. 2 License Amendment 83, dated April 14, 1997, letter signed by D. S. Brinkman.

4. Beaver Valley Power Station Unit No. 2 License Amendment 128, dated February 11, 2002, letter signed by D. S. Collins.

5. Beaver Valley Power Station Unit No. 1 License Amendment 204, dated May 28, 1997, letter signed by D. S. Brinkman.

6. W.D.Newmyer, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, WCAP-14416-NP-A, Revision 1, November 1996.

ATTACHMENT A

Beaver Valley Power Station, Unit No. 2
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Proposed Technical Specification Changes (mark-ups)

The following is a list of the affected pages:

5-2

c. $K_{eff} \leq 0.95$ if fully flooded with water borated to 450 ppm, which includes an allowance for uncertainties as described in UFSAR Section 9.1;

d. A minimum center to center distance between fuel assemblies placed in the fuel storage racks of 10.4375 inches;

e. Fuel assembly storage shall comply with the requirements of Specification 3.9.14.

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

a. Fuel assemblies having a maximum U-235 enrichment of ~~4.85~~ 5.00 weight percent with a tolerance of + 0.05 weight percent;

b. $K_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in UFSAR Section 9.1;

c. $K_{eff} \leq 0.95$ if moderated by aqueous foam, which includes an allowance for uncertainties as described in UFSAR Section 9.1;

d. A nominal 21 inch center to center distance between fuel assemblies placed in the storage racks.

5.3.2 DRAINAGE

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 751′-3".

5.3.3 CAPACITY

The fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1088 fuel assemblies.

ATTACHMENT B

Beaver Valley Power Station, Unit No. 2
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Commitment List

The following list identifies those actions committed to by FirstEnergy Nuclear Operating Company (FENOC) for Beaver Valley Power Station (BVPS) Unit Nos. 1 and 2 in this document. Any other actions discussed in the submittal represent intended or planned actions by Beaver Valley. These other actions are described only as information and are not regulatory commitments. Please notify Mr. Larry R. Freeland, Manager, Regulatory Affairs/Corrective Actions, at Beaver Valley on (724) 682-5284 of any questions regarding this document or associated regulatory commitments.

Commitment	Due Date
None	None

ATTACHMENT C

Beaver Valley Power Station, Unit No. 2
License Amendment Request No. 165

Criticality Analysis of the Beaver Valley Power Station Unit No. 2 Fresh Fuel Racks

Criticality Analysis of the Beaver Valley Unit 2 Fresh Fuel Racks

Westinghouse Electric Company LLC

CAD-02-133

Criticality Analysis of the Beaver Valley Unit 2 Fresh Fuel Racks

April, 2002

M. J. Hone

Prepared: ____________________
M. J. Hone
Criticality Services Team

Verified: ____________________
J. O'Hare
Criticality Services Team

Approved: ____________________
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1.0 Introduction

This report presents the results of a criticality analysis[7] for the storage of fresh Westinghouse 17x17 fuel assemblies enriched up to 5.0 w/o ^{235}U in the Beaver Valley Unit 2 fresh fuel storage rack. The fresh fuel rack design considered herein is an existing array of storage cells with the configuration shown in Figure 1 on page 12 (which is taken from reference 8). Figure 2 on page 13 shows a detailed view of four storage cells in the rack. The analysis assumes all available storage cells are occupied with fresh 5.0 w/o ^{235}U 17x17 fuel assemblies. This analysis bounds all current Westinghouse 17x17 fuel assembly designs by modeling the most reactive designs with no axial blankets, and with no credit taken for the absorption effects of burnable absorbers, grids, or sleeves. The results of this analysis support the storage of all Westinghouse 17x17 fresh assemblies enriched to a maximum of 5.0 w/o ^{235}U, with or without components (i.e., discrete burnable absorbers, Rod Control Cluster Assemblies, or new secondary neutron source assemblies).

The Beaver Valley Unit 2 fresh fuel rack analysis is based on maintaining $K_{eff} \leq 0.95$ under full water density conditions and under low water density (optimum moderation) conditions. The optimum moderation condition applies only to fresh fuel racks since these racks are used to store fuel in a dry environment.

1.1 Design Description

The Beaver Valley Unit 2 fresh fuel rack layout is depicted in Figures 1 and 2.

The fuel parameters utilized in this analysis are given in Table 1 on page 10. The Westinghouse 17x17 Optimized Fuel Assembly (OFA) and standard (STD) fuel assembly design parameters were utilized in this analysis in order to bound all other Westinghouse 17x17 fuel assembly designs. The assemblies were conservatively modeled without grids, sleeves, axial blankets, and burnable absorbers in order to maximize reactivity, and bound all current advanced fuel assembly designs. The fuel rod, guide thimble, and instrumentation thimble tube cladding are modeled as zircaloy in this analysis. This is conservative with respect to the Westinghouse ZIRLO™ product which is a zirconium alloy containing additional elements including niobium. Niobium has a small absorption cross section which causes slightly more neutron capture in the cladding resulting in a lower reactivity. Therefore, future fuel assembly upgrades do not require a criticality analysis if the fuel parameters specified in Table 1 continue to remain bounding.

1.2 Design Criteria

Criticality of fuel assemblies in a fuel storage rack is prevented by the design of the rack which limits fuel assembly interaction. This is done by fixing the minimum separation between fuel assemblies.

The design basis for preventing criticality outside the reactor is that, including uncertainties, there is a 95 percent probability at a 95 percent confidence level that the effective neutron multiplication factor, K_{eff}, of the fuel assembly array will be less than 0.95 as recommended by ANSI 57.2-1983[1], ANSI 57.3-1983[2], and NRC guidance[3].

2.0 Analytical Methods

2.1 Criticality Calculation Methodology

The criticality calculation method and cross-section values are verified by comparison with critical experiment data for fuel assemblies similar to those for which the racks are designed. This benchmarking data is sufficiently diverse to establish that the method bias and uncertainty will apply to rack conditions which include strong neutron absorbers, large water gaps and low moderator densities.

The design method which ensures the criticality safety of fuel assemblies in the fuel storage rack is described in detail in the Westinghouse Spent Fuel Rack Criticality Analysis Methodology topical report[4]. This report describes the computer codes, benchmarking, and methodology which are used to calculate the criticality safety limits presented in the report for the Beaver Valley Unit 2 fresh fuel storage racks.

As determined in the benchmarking in the topical report, the method bias using the described methodology of NITAWL-II, XSDRNPM-S and KENO-Va is 0.00770 ΔK. There is a 95 percent probability at a 95 percent confidence level that the uncertainty in reactivity, due to the method, is no greater than 0.00300 ΔK. These values will be used in the final evaluation of the 95/95 basis K_{eff} in this report.

Since the fresh fuel racks are normally maintained in a dry condition, the criticality analysis will show that the rack 95/95 K_{eff} is less than or equal to 0.95 for the accidental full density water flooding scenario and for the accidental low water density (optimum moderation) flooding scenario.

The fresh fuel racks are analyzed under "worst case" scenarios (maximum enrichments with no pellet dishing and minimum center to center spacings are considered). The "worst case" scenarios conservatively account for fuel parameter variability and tolerances on rack dimensions. The KENO results for the "worst case" model are then used to develop the maximum 95/95 Keff which is compared to the criticality safety limit of 0.95 for the full density water condition and the optimum moderation condition.

The following equation is used to develop the maximum 95/95 K_{eff}:

$$K_{eff} = K_{worst} + B_{method} + \sqrt{ks_{worst}^2 + ks_{method}^2}$$

where:

K_{worst}	=	worst case KENO K_{eff}
B_{method}	=	method bias determined from benchmark critical comparisons
ks_{worst}	=	95/95 uncertainty in the worst case KENO K_{eff}
ks_{method}	=	95/95 uncertainty in the method bias

3.0 Criticality Analysis Of Fresh Fuel Storage Racks

This section describes the analytical techniques and models employed to perform the criticality analysis for the storage of fresh fuel in the Beaver Valley Unit 2 fresh fuel racks. The complete criticality analysis of the fresh fuel racks is analyzed by employing the methodology outlined in Section 2 of this report. Details of this analysis are outlined in Sections 3.1 and 3.2 for the full density water flooding condition and optimum moderation condition, respectively.

3.1 Full Density Moderation Analysis

The following assumptions were used to develop the KENO model for the storage of fresh fuel in the Beaver Valley Unit 2 fresh fuel storage racks under the full density moderation condition:

1. The fuel assembly parameters relevant to the criticality analysis are based on the most reactive Westinghouse 17x17 design. Under the fully flooded condition, the OFA design was determined to be more reactive than the STD design (see Table 1 on page 10 for fuel parameters). Although Beaver Valley currently uses the STD design, the use of the OFA design in this part of the analysis is conservative and allows for maximum flexibility in the future.
2. All fuel rods contain uranium dioxide at a maximum enrichment of 5.0 w/o over the entire length of each rod. No credit is taken for any natural or reduced enrichment axial blankets. The enrichment actually used in the KENO model was increased to 5.05 w/o in order to account for manufacturing tolerances.
3. The fuel pellets are modeled assuming a UO_2 density which is 97% of theoretical density with no dishing fraction (0%) for "worst case" conditions.
4. No credit is taken for any ^{234}U or ^{236}U in the fuel.
5. No credit is taken for any spacer grids or spacer sleeves.
6. No credit is taken for any burnable absorber in the fuel rods or guide tubes.
7. The moderator is assumed to be pure water (no boron) at a temperature of 68°F. A limiting value of 1.0 gm/cm^3 is used for the density of water.
8. The minimum center to center spacing (including tolerance) of 20.9375 inches is used between all storage cells, in order to maximize neutron interaction between the storage cells.
9. The maximum cell inner dimension (ID) (including tolerance) of 9.031 inches is used in all storage cells. This was determined to be more reactive under fully flooded conditions, when compared to using the minimum cell ID.
10. The minimum box wall thickness (including tolerance) of 0.109375 inches is used in all storage cells to minimize neutron absorption in the box wall.
11. All assemblies in the storage cells are assumed to be symmetrically placed in the middle of each storage cell. Studies of asymmetric positioning of assemblies within storage cells have shown that symmetric placement results in a higher K_{eff}.

12. The array is modeled as infinite in lateral (x and y) and axial (z) extent, which precludes any neutron leakage from the model. This is accomplished by simulating a single storage cell and using reflective boundary conditions in KENO on all edges of the cell model. In the axial direction, the model includes 12 inches (effectively infinite) of full density water on the top and bottom of the fuel.

A KENO model was set up using the above limiting fuel and rack parameters and resulted in a K_{eff} of 0.91681 with a 95 percent probability/95 percent confidence level uncertainty of +0.00246 ΔK.

Substituting calculated values in the equation described in Section 2.1, the result is:

$$K_{eff} = (0.91681) + (0.0077) + \sqrt{0.00246^2 + 0.0030^2} = 0.92839$$

Since K_{eff} is less than 0.95 including uncertainties at a 95/95 probability/confidence level, the acceptance criteria for criticality is met for the Beaver Valley Unit 2 fresh fuel storage racks under full density water flooding conditions for storage of Westinghouse 17x17 fuel assemblies with maximum enrichments up to 5.0 w/o ^{235}U.

3.2 Low Density Optimum Moderation Analysis

The following assumptions were used to develop the KENO model for the storage of fresh fuel assemblies in the Beaver Valley Unit 2 fresh fuel storage racks under low density optimum moderation condition:

1. The fuel assembly parameters relevant to the criticality analysis are based on the most reactive Westinghouse 17x17 design. Under the optimum moderation condition, the STD design was determined to be more reactive than the OFA design (see Table 1 on page 10 for fuel parameters).
2. All fuel rods contain uranium dioxide at a maximum enrichment of 5.0 w/o over the entire length of each rod. No credit is taken for any natural or reduced enrichment axial blankets. The enrichment actually used in the KENO model was increased to 5.05 w/o in order to account for manufacturing tolerances.
3. The fuel pellets are modeled assuming a UO_2 density which is 97% of theoretical density with no dishing fraction (0%) for "worst case" conditions.
4. No credit is taken for any ^{234}U or ^{236}U in the fuel.
5. No credit is taken for any spacer grids or spacer sleeves.
6. No credit is taken for any burnable absorber in the fuel rods or guide tubes.
7. The moderator is assumed to be low density water (no boron) at a temperature of 68°F. The optimum moderation occurred at 0.075 gm/cm^3 water density. A water density range between 0.055 and 0.09 gm/cm^3 was analyzed.
8. A minimum center to center spacing of 20.9375 inches is used between storage cells,

except between rows 2 and 3, where a minimum center to center spacing of 29.875 inches is used. This reflects the actual geometry of the rack (see Figure 1 on page 12) with appropriate allowances made for tolerances to maximize neutron interaction between the cells.

9. The minimum cell ID (including tolerance) of 8.906 inches is used in all storage cells. This was determined to be more reactive under optimum moderation conditions, when compared to using the maximum cell ID.
10. The minimum box wall thickness (including tolerance) of 0.109375 inches is used in all storage cells to minimize neutron absorption in the box wall.
11. All assemblies in the storage cells are assumed to be symmetrically placed in the middle of each storage cell. Studies of asymmetric positioning of assemblies within storage cells have shown that symmetric placement results in a higher K_{eff}.
12. One half of the actual rack geometry is modeled and a reflective boundary condition is used in KENO to simulate interaction with the other half of the rack (which is symmetrical). This effectively produces a model of the entire 70 cell rack. Zero flux boundary conditions were used on all other sides of the model. Figure 3 on page 14 shows a cross-sectional view of the model used for the optimum moderation analysis
13. The rack is assumed to be surrounded by concrete walls in all directions. The distances between the concrete walls and the rack were minimized using the appropriate nominal dimensions and tolerances in order to maximize the amount of neutron reflection from the concrete. For simplicity, the concrete wall thicknesses were assumed to be 36 inches in all directions. This thickness is different from the actual concrete wall thicknesses. However, the use of a 36 inch concrete reflector has essentially the same effect on rack K_{eff} as modeling an infinite concrete reflector, and is therefore conservative. In addition, the model included a close fitting slab of concrete directly above and below the active fuel column, which is extremely conservative relative to the actual configuration. Under low water density conditions, the presence of concrete is conservative because neutrons are reflected back into the fuel array more efficiently than they would be with just low density water.

The resulting KENO K_{eff}'s and standard deviations for both STD and OFA fuel are tabulated in Table 2 on page 11. The highest rack K_{eff} under low density moderation condition was determined to be 0.93610 with a 95 percent probability/95 percent confidence level uncertainty of +0.00208 ΔK at 0.075 gm/cm^3 water density for STD fuel.

Substituting calculated values in the equation described in Section 2.1, the result is:

$$K_{eff} = (0.93610) + (0.0077) + \sqrt{0.00208^2 + 0.0030^2} = 0.94745$$

Since K_{eff} is less than 0.95 including uncertainties at a 95/95 probability/confidence level, the acceptance criteria for criticality is met for the Beaver Valley Unit 2 fresh fuel storage racks under optimum moderation condition for storage of Westinghouse 17x17 fuel assemblies with maximum enrichments up to 5.0 w/o ^{235}U.

4.0 Discussion of Postulated Accidents

Under normal conditions, the fresh fuel racks are maintained in a dry environment. The introduction of water into the fresh fuel rack area is the worst case accident scenario. The full density water and optimum moderation cases analyzed in this report are the bounding accident situations which result in the most conservative fuel rack K_{eff}.

Other accidents can be postulated involving fuel assembly interaction, which could cause a reactivity increase in the fresh fuel racks. These are a fuel assembly drop on top of the rack, and setting a fuel assembly down outside of a normal storage position (i.e., a misload), such that it interacts with other fuel assemblies stored in the rack. It should be noted that the racks are designed to physically prevent misloading a fuel assembly in anything other than a normal storage position. For the fuel assembly drop on top of the rack and the misload assembly accident, the double contingency principle(5) is applied. This states that assumption of two unlikely, independent, concurrent events is not required to ensure protection against a criticality accident. Thus, for the case of the fuel assembly drop on top of the rack and the misloaded assembly accident, the absence of a moderator in the fresh fuel storage racks can be assumed as a realistic initial condition since assuming the presence of moderator would be a second unlikely, independent event.

Experience has shown that the maximum reactivity increase associated with a fuel assembly drop on top of the rack and the misloaded assembly accident is less than 10 % ΔK under the full water density condition.

Therefore, since the normal, dry fresh fuel rack reactivity for Beaver Valley Unit 2 is relatively low, less than 0.65, and the maximum reactivity increase for the fuel assembly drop on top of the rack and the misloaded assembly accident for the dry condition would be much less than 10 percent ΔK, the maximum rack K_{eff} for the fuel assembly drop accident and the misloaded assembly accident will meet the licensing bases.

5.0 Summary of Criticality Results

The acceptance criteria for criticality requires the effective neutron multiplication factor, K_{eff}, in the fresh fuel storage rack to be less than or equal to 0.95, including uncertainties, under the flooded and optimum moderation condition.

This report shows that the acceptance criteria is met for the Beaver Valley Unit 2 fresh fuel storage racks for the storage of Westinghouse 17x17 (OFA, STD, and various advanced products) fuel assemblies with maximum enrichment up to 5.00 w/o ^{235}U.

The analytical methods employed herein conform with ANSI N18.2-1973[6], "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," Section 5.7, Fuel Handling System; ANSI 57.3-1983[2], "Design Requirements for New Fuel Storage Facilities at Light Water Reactor Plants"; and ANSI/ANS-8.1-1983[5], Section 4.3,"Validation of a Calculational Method"

Table 1. Fuel Parameters Employed in the Criticality Analysis

Parameter	W 17x17 OFA	W 17x17 STD
Number of Fuel Rods per Assembly	264	264
Rod Cladding O.D. (inch)	0.360	0.374
Cladding Thickness (inch)	0.0225	0.0225
Fuel Pellet O.D.(inch)	0.3088	0.3225
Fuel Pellet Density (% of Theoretical)	97	97
Fuel Pellet Dishing Factor (%)	0	0
Rod Pitch (inch)	0.496	0.496
Number of Guide Tubes	24	24
Guide Tube O.D. (inch)	0.474	0.482
Guide Tube Thickness (inch)	0.016	0.016
Number of Instrument Tubes	1	1
Instrument Tube O.D. (inch)	0.474	0.482
Instrument Tube Thickness (inch)	0.016	0.016

Table 2. K-effective Results from the Optimum Moderation and Full Density Moderation Analysis

Water Density (g/cc)	W 17x17 OFA	W 17x17 STD
.055	0.91926+/- 00127	0.92829+/- .00127
.060	0.92715+/- .00129	0.93296+/- .00126
.065	0.92825+/- .00130	0.93572+/- .00127
.070	0.93153+/- .00121	0.93554+/- .00132
.075	0.93214+/- .00127	**0.93610+/- .00126**
.080	0.92635+/- .00126	0.93484+/- .00121
.085	0.92468+/- .00126	0.92909+/- .00128
.090	0.91496+/- .00126	0.92636+/- .00126
1.000	**0.91681+/- .00149**	0.90991+/- .00149

Figure 1 **Radial Cross-Sectional View of the Beaver Valley Unit 2 Fresh Fuel Storage Rack**

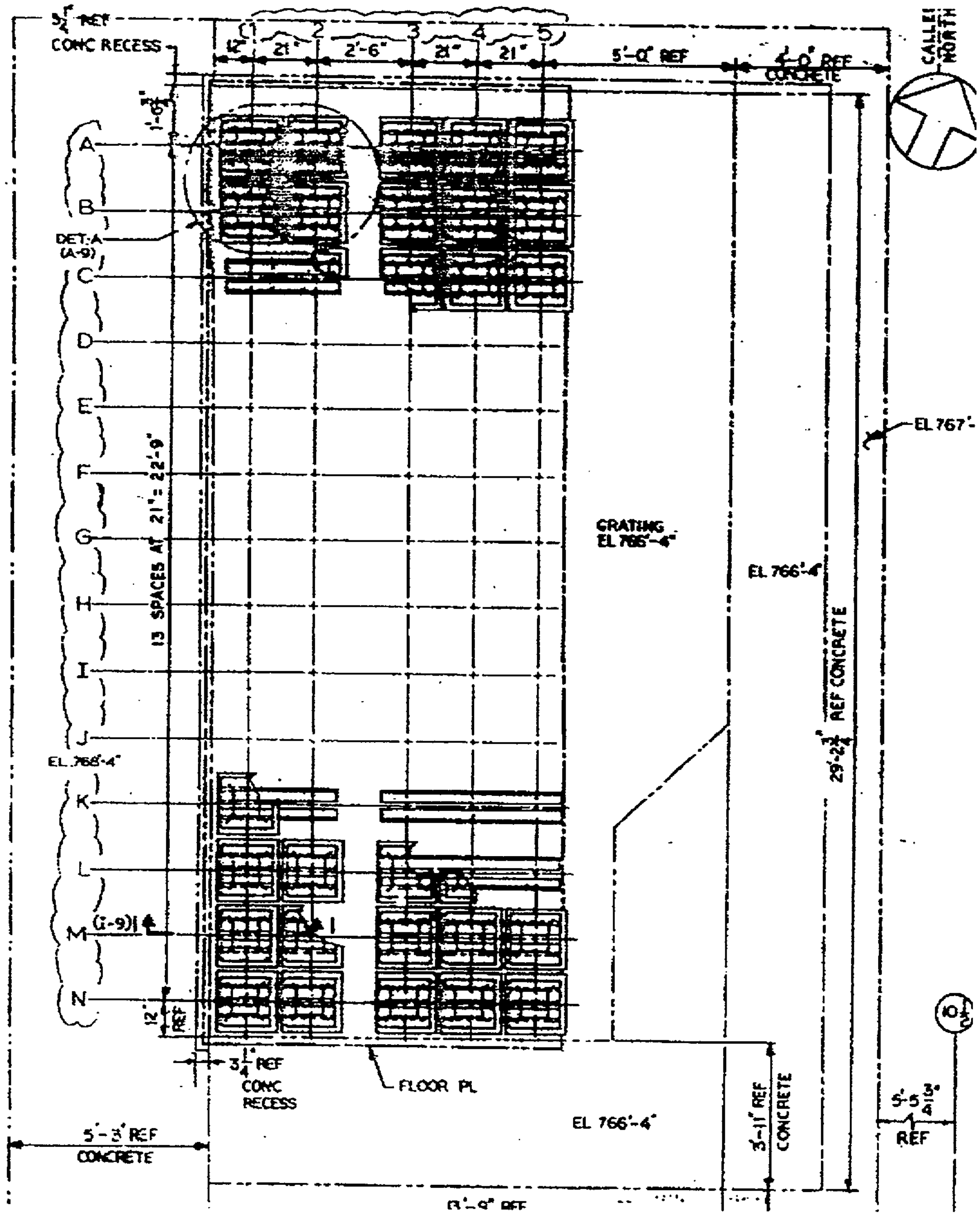


Figure 2 **Detailed View of Four Storage Cells in the Beaver Valley Unit 2 Fresh Fuel Storage Rack**

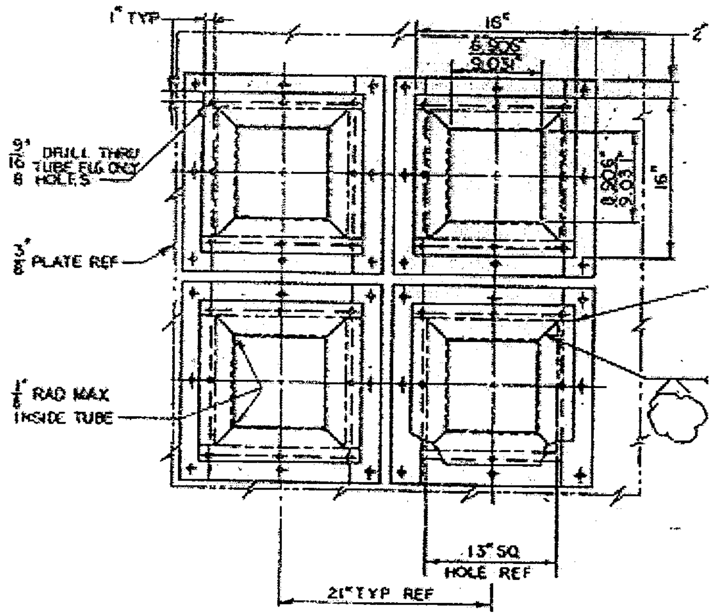
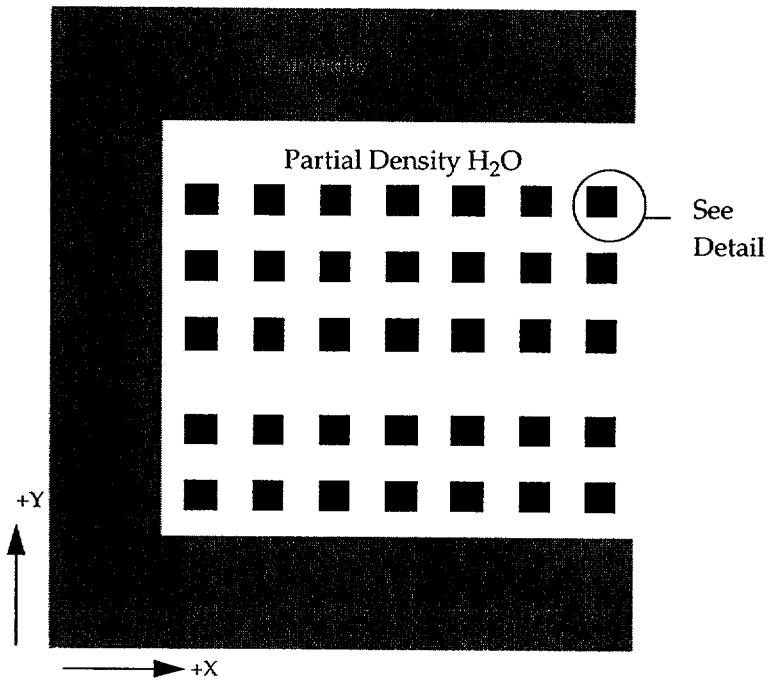
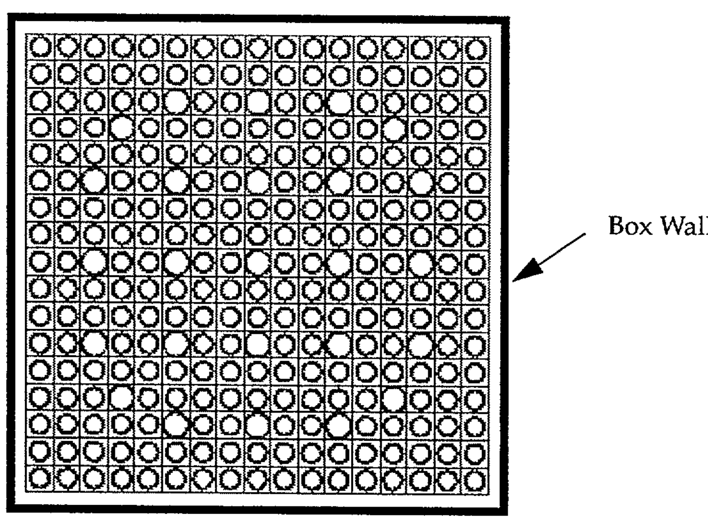


Figure 3 **Cross-Sectional View of the KENO Model Used in the Optimum Moderation Analysis**



Note: Not Drawn to Scale

Reflective Boundary Condition Applied on +X side



Detail of single storage cell

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