Dominion Nuclear Connecticut, Inc.
Millstone Power Station
Rope Ferry Road
Waterford, CT 06385

Dominion

SEP 18 2003

Docket No. 50-245
B18972

RE: 10 CFR 50.90

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

Millstone Power Station, Unit No. 1
Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements, Technical Specification 4.2

Pursuant to 10 CFR 50.90, Dominion Nuclear Connecticut, Inc. (DNC), hereby proposes to amend Operating License DPR-21 by incorporating the attached proposed changes into the Technical Specifications of Millstone Unit No. 1.

DNC is proposing to change Design Features Technical Specification 4.2, "Fuel Storage." This Technical Specification Change implements the following proposed changes:

- Eliminates all credit for Boraflex as a neutron absorber.
- Reduces the number of fuel assemblies allowed to be stored in the spent fuel pool from 3229 to 2959. Fuel will be prohibited from being stored in 270 specific storage rack locations. This is necessary to support the elimination of all credit for Boraflex.
- Changes the required spent fuel pool k_{eff} to $\leq$ 0.95. This is necessary to support the elimination of all credit for Boraflex.
- Eliminates the Design Features requirements on new fuel storage, since Millstone Unit No. 1 is a plant that has ceased power operation and will no longer receive new fuel.

There are no physical changes in the plant hardware necessary to implement these changes.

Enclosure 1 provides a discussion of the proposed changes and the Safety Summary, including the analyses demonstrating the proposed changes do not involve a Significant Hazards Consideration. Attachments 1 and 2 provide marked-up and retyped versions of the current Millstone Unit No. 1 Technical Specifications respectively. Attachment 3 provides a summary of the criticality analysis. Attachment 4 provides the Criticality Benchmark and Determination of Upper Sub-critical Limit (USL) for the criticality calculations.

Site Operations Review Committee and Management Safety Review Committee

The Site Operations Review Committee and Management Safety Review Committee have reviewed and concurred with the determinations.

A001

Schedule

DNC requests approval of the proposed amendment by June 30, 2004, to support elimination of Boraflex testing requirements. Once approved, the amendment shall be implemented within 60 days.

State Notification

In accordance with 10 CFR 50.91(b), a copy of this License Amendment Request is being provided to the State of Connecticut.

There are no regulatory commitments contained within this letter.

If you have any questions or require additional information, please contact Mr. David W. Dodson at 860-447-1791, extension 2346.

Very truly yours,

DOMINION NUCLEAR CONNECTICUT, INC.

J. Alan Price
Site Vice President - Millstone

Sworn to and subscribed before me

this 18 day of September, 2003

Diane M. Phillipo
Notary Public

My Commission expires

DIANE M. PHILLIPO
NOTARY PUBLIC
MY COMMISSION EXPIRES 12/31/2005

cc: See next page

Enclosures:
1. Evaluation of Proposed Changes and Safety Summary

Attachments:
1. Proposed Technical Specification Changes (Mark-Up)
2. Proposed Technical Specification Pages (Retyped)
3. Criticality Analysis Summary
4. Criticality Benchmark and Determination of Upper Sub-critical Limit (USL) for Criticality Calculations

cc: H. J. Miller, Region I Administrator
D. G. Holland, NRC Project Manager, Millstone Unit No. 1
J. R. Wray, NRC Inspector, Region 1, Millstone Unit No. 1

Director
Bureau of Air Management
Monitoring and Radiation Division
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

ENCLOSURE 1

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements
Evaluation of Proposed Changes and Safety Summary

ENCLOSURE 1

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements
Evaluation of Proposed Changes and Safety Summary

Subject: Application for Amendment to Technical Specification (TS) 4.2, "Fuel Storage," to

- Eliminate All Credit For Boraflex As A Neutron Absorber
- Reduce The Allowable Number Of Fuel Assemblies To Be Stored In The Spent Fuel Pool
- Change The Required Spent Fuel Pool k_{eff} to $\leq$ 0.95
- Eliminate The Design Features Requirements On New Fuel Storage

1.0 DESCRIPTION

The proposed amendment would revise Millstone Power Station, Unit No. 1 (MP1) Design Features TS 4.2, "Fuel Storage," to address the following objectives:

- Eliminates all credit for Boraflex as a neutron absorber.
- Reduces the number of fuel assemblies allowed to be stored in the spent fuel pool from 3229 to 2959. Fuel will be prohibited from being stored in 270 specific storage rack locations. This is necessary to support the elimination of all credit for Boraflex.
- Changes the required spent fuel pool k_{eff} to $\leq$ 0.95. This is necessary to support the elimination of all credit for Boraflex.
- Eliminates the requirements on new fuel storage, since MP1 is a plant that has ceased power operation and will no longer receive new fuel.

There are no physical changes in the plant hardware necessary to implement these changes.

2.0 PROPOSED CHANGE

Specifically, the proposed changes would revise the following:

Design Features Section 4.2, "Fuel Storage," section 4.2.1

- Section 4.2.1 is proposed to be marked as "deleted." Since MP1 is a plant that has ceased power operation and will no longer receive new fuel, there is no need for any new fuel storage Design Features requirements.

Design Features Section 4.2, "Fuel Storage," Section 4.2.2

- Section 4.2.2 is proposed to have three changes. The first is to change the required k_{eff} from 0.90 to 0.95. The second change is to add the phrase "and with no fuel allowed in the storage locations shown in Figure 4.1." The third change is to add Figure 4.1.

  All of these changes are being made to be consistent with the criticality analysis submitted with this proposed amendment.

Design Features Section 4.2, "Fuel Storage," Section 4.2.3

- Section 4.2.3 is proposed to have one change, which changes the maximum number of fuel assemblies allowed to be stored in the spent fuel pool from 3229 to 2959.

  This change is being made to be consistent with the criticality analysis submitted with this proposed amendment.

3.0 BACKGROUND

MP1 was shut down for a normal refueling outage on November 4, 1995, and has not operated since. On November 19, 1995, transfer of all fuel assemblies from the reactor vessel into the spent fuel pool (SFP) was completed. On July 17, 1998, it was decided to permanently cease further operation of the plant. The Certification to the NRC of permanent cessation of operation and permanent removal of fuel from the reactor vessel in accordance with 10 CFR 50.82(a)(1)(i) & (ii) was filed on July 21, 1998, at which time the facility license no longer authorized operation of the reactor or placement of fuel in the reactor vessel.

The MP1 SFP holds fuel assemblies, control rods, and small vessel components. The spent fuel storage racks consist of two types of storage racks. The spent fuel storage racks for the spent fuel assemblies are designed to assure sub-criticality in the SFP. The storage racks are an interconnected honeycomb array of square stainless steel boxes forming individual cells for spent fuel storage. 1045 storage cells contain Boraflex sheets on four sides, and 2184 storage cells contain boron carbide (B_4C) plates for neutron adsorption. The MP1 Technical Specification Section 4.2 provides requirements for fuel storage (new and spent fuel).

The reasons for the proposed changes are:

- Boraflex is subject to long-term degradation, and elimination of credit for Boraflex as a neutron absorber is a conservative action to ensure that the pool is maintained in a safe sub-critical condition.
- Since MP1 is a plant that has ceased power operation and will no longer receive new fuel, there is no need for any new fuel storage Design Features requirements.
- The proposed changes will support elimination of Boraflex testing requirements.

4.0 TECHNICAL ANALYSIS

The MP1 spent fuel storage racks consist of two types of storage racks. About two thirds of the fuel storage cells use B_4C plates for reactivity control. About one third of the fuel storage cells use Boraflex for reactivity control. Proposed TS Figure 4.1 shows a general layout of the pool. In Figure 4.1, the section 1-6 racks use B_4C plates for neutron poison material, and the sections 7-10 racks use Boraflex neutron poison material. MP1 is a boiling water reactor that has an SFP with no soluble boron in the water.

Boraflex is subject to long-term degradation, and elimination of credit for Boraflex as a neutron absorber is conservative to ensure that the pool is maintained in a safe sub-critical condition. The modifications to Design Features sections 4.2.2 and 4.2.3 are necessary to end credit for Boraflex as a neutron absorber.

To accommodate the elimination of Boraflex credit, for the storage racks containing Boraflex, Transnuclear Incorporated performed a revised criticality analysis. A summary of this revised criticality analysis is provided in Attachment 3. Attachment 4 provides the Criticality Benchmark and Determination of Upper Sub-critical Limit (USL) for the criticality calculations, as documented by Transnuclear Incorporated.

The revised criticality analysis showed, for the fuel storage cells that currently use Boraflex for reactivity control, if fuel is limited to a 3-out-of-4 fuel storage configuration, k_{eff} of the racks will be maintained $\leq$ 0.95, on a 95/95 basis, without credit for any Boraflex. This criticality analysis conservatively assumes that all fuel in the SFP is at the most reactive condition possible, using the most reactive fuel design and at the most reactive normal operating temperature. Abnormal and accident conditions are also considered in the analysis. The revised criticality analysis for the Boraflex storage racks has no effect on the other storage racks in the SFP.

This revised criticality analysis therefore utilizes requirements which are different from the current Technical Specification requirements, in that the current Technical Specifications allow fuel to be stored in any storage location, and the SFP k_{eff} limit is $\leq$ 0.90.

Thus there are two changes that are being made in the proposed Design Features Technical Specifications to implement no Boraflex credit. First, the allowable k_{eff} of the SFP is being increased from 0.90 to 0.95. Second, as required by proposed TS Figure 4-1, 270 specific fuel storage locations will be designated as "non-fuel" storage locations.

The use of 0.95 as the SFP k_{eff} limit is an NRC accepted standard, as documented in the Standard Review Plan (section 9.1.2) and Regulatory Guide 1.13. Also, it is an accepted industry standard as documented in ANSI/ANS–57.2, "American National Standard Design Requirements for LWR Spent Fuel Storage Facilities at Nuclear Power Plants."

The requirement to designate 270 specific storage locations as "non-fuel" locations will be accomplished by administrative controls. Procedures will be revised to prohibit fuel storage in the 270 specific locations designated by proposed TS Figure 4-1. Fuel has already been removed from these 270 specific storage locations. Fuel movements in the MP1 SFP are performed in accordance with procedures that require any fuel movement to be tracked by Material Transfer Forms. These procedures and Material Transfer Forms require dual verification that the fuel assembly is being removed from, and placed into, the correct fuel storage location. Also, since MP1 is a plant that has ceased power operation and will no longer receive new fuel, the amount of fuel movement in the SFP is minimal, such that the likelihood of a fuel movement error is very low. The criticality analysis has considered the impact of a hypothetical single fuel assembly misloaded in the worst possible configuration. The criticality analysis shows that a single misloaded fuel assembly will not cause k_{eff} to exceed 0.95, on a 95/95 basis. The criticality analysis is especially conservative since it assumes that all fuel in the pool is at its maximum reactivity at any time in life. In fact, most of the fuel in the pool is fuel that has been discharged with very low reactivity.

The attached criticality analysis (Attachment 3), and proposed TS Figure 4.1, document that the 270 prohibited fuel storage locations are generally a repeating 3-out-of-4 pattern. There are two fuel locations that are an exception to this repeating 3-out-of-4 pattern, and the justification for

these two locations are explained in the attached criticality analysis. The attached criticality analysis also explains that while fuel is prohibited from these 270 "non-fuel" storage locations, non-fuel items may be stored in selected "non-fuel" locations.

The proposed change to the maximum number of fuel assemblies allowed to be stored in the SFP from 3229 to 2959 is made to reflect the reduction of 270 storage locations. Lowering the number of allowed fuel storage locations is a conservative action that will not impact any other storage rack or heat load analyses.

The deletion of the Design Features Section 4.2.1 requirements for new fuel storage is acceptable since MP1 is a plant that has ceased power operation, does not currently hold any new fuel, and will no longer receive new fuel. Since irradiated fuel cannot be removed from the SFP (due to radiological considerations) and placed into the new fuel racks, and new fuel can no longer be received, there is no possibility of fuel being placed in the new fuel storage racks, and hence no need for new fuel storage Design Features requirements.

In conclusion, the proposed changes do not impact the ability of the spent fuel storage racks to maintain their design function, to keep the fuel in a sub-critical and cooled condition under all normal conditions and postulated accidents.

5.0 Regulatory Safety Analysis

5.1 No Significant Hazards Consideration

Dominion Nuclear Connecticut, Inc. (DNC) has evaluated whether or not a Significant Hazards Consideration (SHC) is involved with the proposed changes by focusing on the three standards set forth in 10 CFR 50.92(c) as discussed below:

The proposed changes do not involve an SHC because the changes do not:

1. Involve a significant increase in the probability or consequences of an accident previously evaluated.

   Accidents previously evaluated are the fuel handling accidents described in the Decommissioned Safety Analysis Report (DSAR), and a seismic event, which is considered as part of the spent fuel rack design.

   Since there are no changes to plant hardware, nor any changes in how fuel is moved, there are no changes to the probability of a fuel handling accident. The consequences of a fuel handling accident are not affected, since none of the inputs to the fuel handling accident is affected.

   The proposed changes affect the criticality analysis of the spent fuel storage racks. The spent fuel racks will continue to be able to perform their design function, which is to maintain the stored fuel in a sub-critical and cooled condition under all normal and postulated accident conditions. There are no physical hardware changes to the plant from these proposed changes. The revised criticality analysis submitted with these proposed changes demonstrates that fuel will be maintained in a sub-critical condition during all normal and postulated accident conditions, including the seismic event. Since there is no change in the ability of the fuel storage racks to maintain a sub-critical condition due to a seismic event, there is no change in the probability or consequences of this accident.

Reducing the amount of fuel storage is a conservative action, and the spent fuel racks were designed and licensed to allow empty, partially filled, or completely full storage racks. Thus the fuel racks will continue to be able to perform their design function to maintain the fuel in a coolable condition.

The change to the new fuel storage racks is to delete the Technical Specification requirements for the new fuel storage k_{eff} limits. Since MP1 is a plant that has ceased power operation and will no longer receive new fuel, there is no need for these Technical Specification requirements. There are no new fuel related accidents previously analyzed, therefore this change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

In summary, the proposed changes do not involve an increase in the probability or consequences of an accident previously evaluated.

2. Create the possibility of a new or different kind of accident from any accident previously evaluated.

   Since there are no changes to the plant equipment, there is no possibility of a new or different kind of accident being initiated or affected by equipment issues.

   Reducing the number of fuel assemblies to be stored in the pool, and discontinuing credit for Boraflex are conservative changes that do not introduce any new or different kind of failure modes.

   The changes made primarily affect the nuclear criticality analysis and do not create a new or different kind of accident. Changes in eliminating Boraflex credit, restricting fuel in certain storage locations, and changing the allowable k_{eff} limit are all impacts to the nuclear criticality analysis for the SFP. The SFP criticality analysis is part of the basic design of the system and is not an accident. The ability to maintain the SFP k_{eff} less than or equal to 0.95, as well as within the 10 CFR 50 Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 62 "Prevention Of Criticality In Fuel Storage And Handling," (reference 6) criteria of sub-critical, have been evaluated. Criticality impacts are more appropriately discussed under the margin of safety criterion.

   The change to the new fuel storage racks is to delete the Technical Specification requirements for the new fuel storage k_{eff} limits. Since MP1 is a plant that has ceased power operation and will no longer receive new fuel, there is no need for these Technical Specification requirements. Since Millstone 1 currently has no new fuel and new fuel cannot be received, this change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

   In summary, the proposed changes do not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Involve a significant reduction in a margin of safety.

   The margin of safety relevant to the SFP is defined as (1) SFP k_{eff} remains sub-critical by an acceptable margin, and (2) the spent fuel in the SFP remains adequately cooled so that the fission product barriers remain intact.

The industry and regulatory accepted value for required sub-criticality margin in the SFP is to ensure that the k_{eff} of the SFP remains $\leq$ 0.95 under all normal and postulated accident conditions. This is documented in the Standard Review Plan, Regulatory Guide 1.13, and ANSI/ANS–57.2, "American National Standard Design Requirements for LWR Spent Fuel Storage Facilities at Nuclear Power Plants." The current MP1 Technical Specifications require a more conservative value of 0.90 for SFP k_{eff}. The proposed Design Features Technical Specification changes the maximum SFP k_{eff} from 0.90 to 0.95. This is not a *significant* reduction in the margin to safety since the proposed value of 0.95 is consistent with the accepted regulatory guidance for sub-criticality margin. The proposed criticality analysis demonstrates that the SFP k_{eff} remains $\leq$ 0.95 on a 95/95 basis under all normal and postulated accident conditions, thus the required margin of criticality safety has been maintained.

The proposed changes conservatively reduce the amount of fuel that can be stored, and therefore do not affect the SFP cooling analysis. Therefore, the spent fuel in the SFP remains adequately cooled so that the fission product barriers remain intact.

The removal of Technical Specification requirements for the new fuel storage k_{eff} limits does not affect the margin of safety since new fuel can no longer be received.

Therefore, based on the above, the proposed changes do not involve a significant reduction in a margin of safety.

In summary, in accordance with 10 CFR 50.92, DNC has reviewed the proposed changes and has concluded that they do not involve an SHC. The basis for this conclusion is that the three criteria of 10 CFR 50.92(c) are not compromised.

5.2 Applicable Regulatory Requirements/Criteria

5.2.1 Regulations

The regulatory basis for DESIGN FEATURES Section 4.2 Fuel Storage, is to ensure that stored fuel assemblies are maintained in a cool-able and sub-critical condition.

10 CFR Part 50 Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 62 "Prevention Of Criticality In Fuel Storage And Handling," (reference 6) requires that criticality in the fuel storage and handling system be prevented.

5.2.2 Design Bases (UFSAR)

DSAR Section 5.2

The MP1 design basis Fuel Handling Accident involves the dropping of a spent fuel assembly or other component onto the SFP storage area. The analysis assumes the rupture of all fuel rods in four fuel assemblies. Section 5.2 of the DSAR demonstrates that resulting doses are within 10 CFR Part 100 limits.

DSAR section 3.2.1.1

DSAR section 3.2.1.1 specifies the new fuel storage design bases. The principal design basis is to ensure that new fuel stored in the new fuel storage vault maintains a k_{eff} of less than 0.90 dry and k_{eff} of less than 0.95 in the flooded position.

DSAR section 3.2.1.2

DSAR section 3.2.1.2 specifies the spent fuel storage design bases. This section states the design basis is to ensure that the fuel stored in the SFP maintains a k_{eff} of less than 0.90 at all times, including postulated criticality accidents.

5.2.3 Approved Methodologies

NUREG-0800 (reference 1), U.S. NRC Standard Review Plan, Section 9.1.2, revision 3, provides guidance to the NRC staff on the acceptable spent fuel storage k_{eff} value.

Memorandum to T. Collins from L. Kopp, (reference 2), "Guidance On The Regulatory Requirements For Criticality Analysis Of Fuel Storage At LWR Power Plants", dated August 12, 1998, provides guidance concerning the regulatory requirements for criticality analysis, used by the Reactor System Branch, of new and spent fuel storage at light water reactors.

Regulatory Guide 1.13, revision 2 (draft) (reference 3), provides guidance to the NRC staff on the acceptable spent fuel storage k_{eff} value.

NUREG/CR-6361, "Criticality Benchmark Guide for LWR Fuel in Transportation and Storage Packages" (reference 4), 1997, provides information needed for determining the Upper Sub-critical Limit (USL).

5.2.4 Analysis

The criticality analysis performed to support these proposed changes use the SCALE-4.4, Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation for Workstations and Personal Computers, CCC-545, ORNL.

The maximum k_{eff} value of 0.95 for spent fuel storage is in accordance with NUREG-0800 (reference 1), Regulatory Guide 1.13, (reference 3), Memorandum to T. Collins from L Kopp, dated August 12, 1998, (reference 2), and ANSI/ANS-57.2-1983 (reference 5).

The criticality analysis provided is in accordance with GDC 62 (reference 6). This criticality analysis justifies discontinuation of Boraflex credit. As a result of the analysis, there is a reduction of 270 in the number of available fuel storage locations in the SFP.

The proposed change to the maximum number of fuel assemblies allowed to be stored in the SFP from 3229 to 2959 is made to reflect the reduction of 270 storage locations. Lowering the number of allowed fuel storage locations is a conservative action that will not impact any other storage rack or heat load analyses.

The deletion of the Design Features requirements for new fuel storage is acceptable since MP1 is a plant that has ceased power operation and will no longer receive new fuel. Since irradiated fuel cannot be removed from the SFP (due to radiological considerations) and placed into the new fuel racks, and new fuel can no longer be received, there is no possibility of fuel being

placed in the new fuel storage racks, and hence no need for new fuel storage Design Features requirements.

5.2.5 Conclusion

The criticality analysis demonstrates the MP1 SFP Boraflex racks can be maintained with a k_{eff} $\leq$ 0.95 on a 95/95 basis, without credit for Boraflex, provided fuel is stored in a 3-out-of-4 storage pattern. This k_{eff} value complies with 10 CFR 50 Appendix A, GDC 62.

The proposed change to the maximum number of fuel assemblies allowed to be stored in the SFP from 3229 to 2959, is a conservative action that will not impact any other storage rack or heat load analyses.

The deletion of the Design Features requirements for new fuel storage is acceptable since MP1 is a plant that has ceased power operation and will no longer receive new fuel.

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance 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 amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 <u>ENVIRONMENTAL CONSIDERATION</u>

DNC has evaluated the proposed change against the criteria for identification of licensing and regulatory actions requiring environmental assessment in accordance with 10 CFR 51.22. DNC has determined that the proposed changes meet the criteria for categorical exclusion set forth in 10 CFR 51.22(c). The proposed amendment also does not involve irreversible consequences in accordance with 10 CFR 50.92(b).

This determination is based on the fact that the changes are being proposed as an amendment to a license issued pursuant to 10 CFR 50 that changes a requirement with respect to use of a facility component located within the restricted area, as defined by 10 CFR 20, or that changes an inspection or a surveillance requirement, and the amendment requests meets the following specific criteria:

(i) *The proposed change involves no significant hazards consideration.*

As demonstrated above, the proposed changes do not involve a significant hazards consideration.

(ii) *There is no significant change in the types or significant increase in the amounts of any effluent that may be released off site.*

No changes are being made in the types or amounts of any radiological effluents that may be released offsite during normal operation and design basis accidents.

(iii) *There is no significant increase in individual or cumulative occupational radiation exposure.*

The proposed changes will not result in changes in the hardware of the facility. There will be no change in the level of controls or methodology used for processing radioactive effluents or handling of solid radioactive waste. There will be no change to the normal radiation levels within the plant. Therefore, there will be no increase in individual or cumulative occupational exposure resulting from the proposed changes.

7.0 REFERENCES

1 NUREG-0800, U.S. NRC Standard Review Plan, Section 9.1.2, revision 3.
2 Memorandum to T. Collins from L. Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at LWR Power Plants," August 12, 1998.
3 Regulatory Guide 1.13, revision 2 (draft), "Spent Fuel Storage Facility Design Basis."
4 NUREG/CR-6361, "Criticality Benchmark Guide for LWR Fuel in Transportation and Storage Packages," 1997.
5 ANSI/ANS-57.2-1983, "ANS Design Requirements for LWR Spent Fuel Storage Facilities at Nuclear Power Plants."
6 10 CFR Part 50 Appendix A Criteria 62, "Prevention of Criticality in Fuel Storage and Handling."

ATTACHMENT 1

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements

PROPOSED TECHNICAL SPECIFICATION CHANGES (MARK-UP)

Licensing Basis Document Change Request (LBDCR) 01-03-2
Marked Up Pages

Technical Specification Section Number	Title of Section	Page and Amendment Numbers	
4.2	Fuel Storage	4.0-1	Amendment 111
Figure 4.1	Millstone Unit No. 1 Spent Fuel Pool	4.0-2	

4.0 DESIGN FEATURES

4.1 Site Location The Unit 1 Reactor Building is located on the site at Millstone Point in Waterford, Connecticut. The nearest site boundary on land is 2063 feet northeast of the reactor building (1627 feet northeast of the elevated stack), which is the minimum distance to the boundary of the exclusion area as described in 10 CFR 100.3. No part of the site that is closer to the reactor building than 2063 feet shall be sold or leased except to Dominion Nuclear Connecticut, Inc. or its corporate affiliates for use in conjunction with normal utility operations.

4.2 Fuel Storage

replace with "deleted"

4.2.1 The new fuel storage facility shall be such that the K_{eff} dry is less than 0.90 and flooded is less than 0.95.

4.2.2 The K_{eff} of the spent fuel storage pool shall be less than or equal to 0.95 ← 0.90. This K_{eff} value is satisfied with fuel assemblies having a maximum k-infinity of 1.24 in the normal reactor configuration at cold conditions, and an average U-235 enrichment of 3.8 weight percent or less, and with no fuel allowed in the storage locations shown in Figure 4.1.

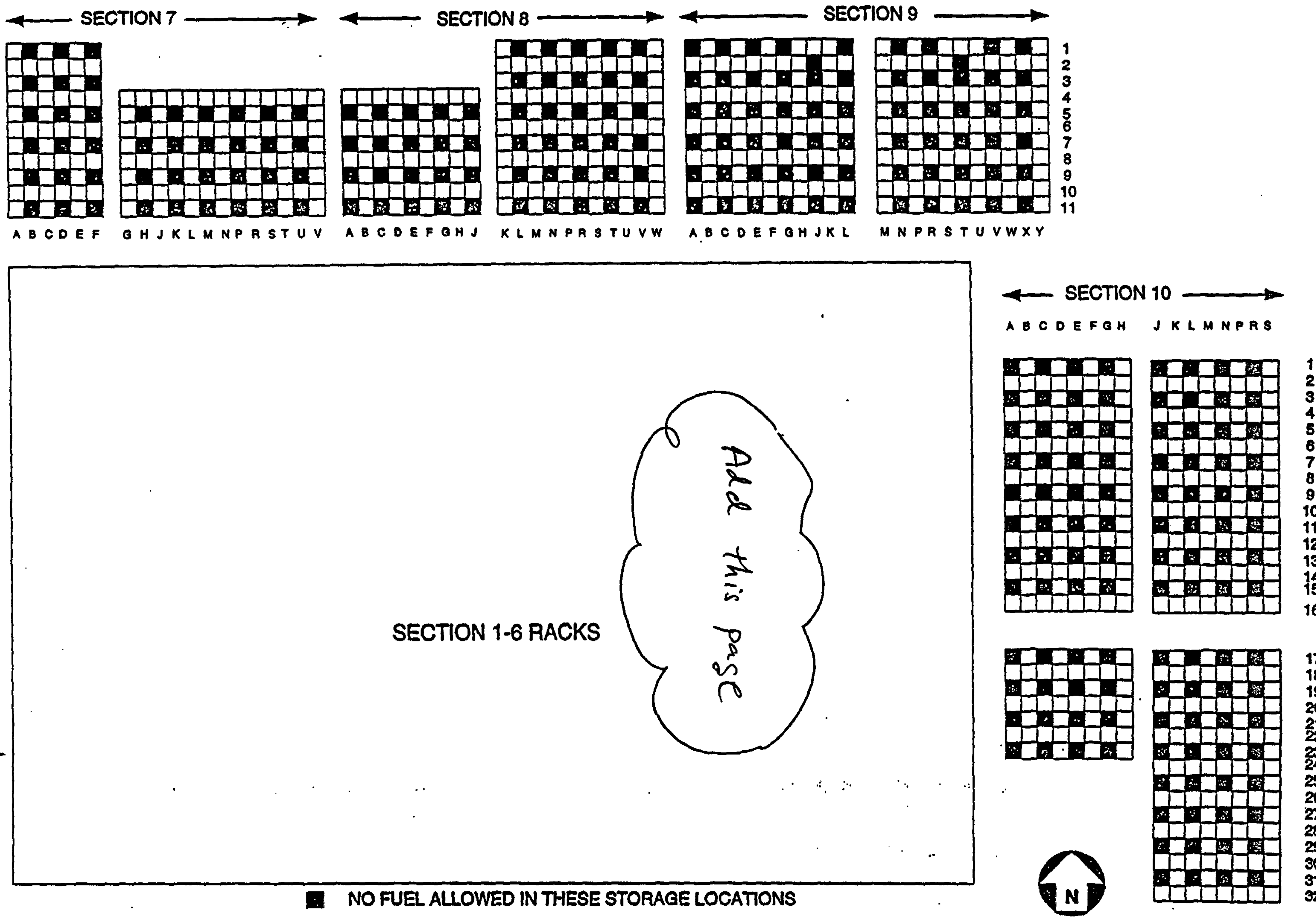
4.2.3 The number of fuel assemblies stored in the spent fuel storage pool shall not exceed 3229 bundles.

2959

Millstone Unit 1

FIGURE 4.1
MILLSTONE UNIT NO. 1 SPENT FUEL POOL

(NOT DRAWN TO SCALE)



4.0-2

Amendment No.

ATTACHMENT 2

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements

PROPOSED TECHNICAL SPECIFICATION PAGES (RETYPED)

4.0 DESIGN FEATURES

4.1 Site Location

The Unit 1 Reactor Building is located on the site at Millstone Point in Waterford, Connecticut. The nearest site boundary on land is 2063 feet northeast of the reactor building (1627 feet northeast of the elevated stack), which is the minimum distance to the boundary of the exclusion area as described in 10 CFR 100.3. No part of the site that is closer to the reactor building than 2063 feet shall be sold or leased except to Dominion Nuclear Connecticut, Inc. or its corporate affiliates for use in conjunction with normal utility operations.

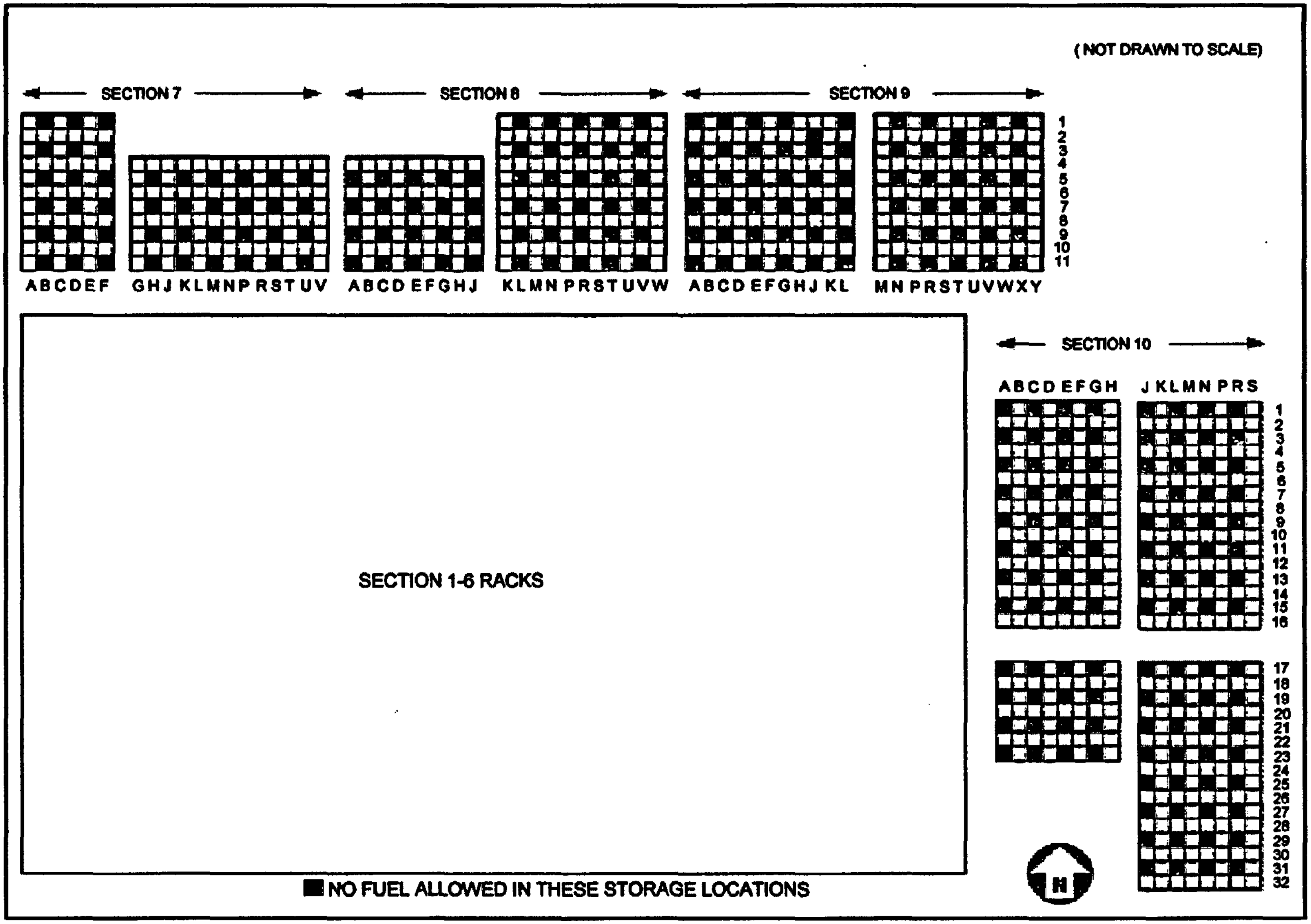
4.2 Fuel Storage

4.2.1 DELETED

4.2.2 The K_{eff} of the spent fuel storage pool shall be less than or equal to 0.95. This K_{eff} value is satisfied with fuel assemblies having a maximum k-infinity of 1.24 in the normal reactor configuration at cold conditions, and an average U-235 enrichment of 3.8 weight percent or less, and with no fuel allowed in the storage locations shown in Figure 4.1.

4.2.3 The number of fuel assemblies stored in the spent fuel storage pool shall not exceed 2959 bundles.

FIGURE 4.1
MILLSTONE UNIT NO. 1 SPENT FUEL POOL



ATTACHMENT 3

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements

Criticality Analysis Summary

ATTACHMENT 3

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements

Criticality Analysis Summary

Background

The Millstone Unit No. 1 (MP1) spent fuel storage racks consist of two types of storage racks. About two thirds of the fuel storage cells use boron carbide (B_4C) plates for reactivity control. About one third of the fuel storage cells use Boraflex for reactivity control. Figure 4.1 shows a general layout of the pool. In figure 4.1, the section 1-6 racks use B_4C plates for neutron poison material, and the sections 7-10 racks use Boraflex neutron poison material.

The fuel storage racks which contain Boraflex have a nominal center to center spacing of 6.30 inches, with a fuel storage cavity square dimension of 6.06 inches. The nominal rack thickness is 0.075 inches of Stainless Steel, with a 0.090 inch cavity between adjacent rack walls. The cavity between adjacent rack walls contains the Boraflex.

Purpose

To perform criticality calculations to demonstrate that the MP1 spent fuel racks which contain Boraflex, can be maintained with a $k_{eff} \leq 0.95$ on a 95/95 basis, without credit for Boraflex. Credit for Boraflex will not be necessary, provided the fuel is placed in a 3-out-of-4 fuel storage configuration, with every 4th storage location not containing any fuel. Figure 4.1 shows the 3-out-of-4 pattern, which results in 270 fuel storage locations being designated as "non-fuel" locations. Calculations will be performed using KENOVa from the SCALE-4.4 code package.

References

(1) SCALE-4.4, Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers, CCC-545, ORNL.

Assumptions

- An analysis of a fully reflected 11 x 11 fuel storage rack will bound all Boraflex fuel storage racks since it is the largest in the pool.
- The only credit taken for radial leakage will be a layer of water between the rack and the mirror boundary. The thickness of that layer will conservatively be half the minimum distance between adjacent racks in the pool.
- The volume normally containing Boraflex will be replaced and modeled as full density water. No credit will be taken for any Boron-10.

- The top end fitting, plenum and bottom end fitting is modeled as full density water. The water is a less efficient absorber while having an insignificant effect on reflection relative to the hardware. No credit is taken for axial leakage.
- The most reactive fuel assembly type will be used to represent all assemblies.
- The fuel inventory will be modeled using 95% density uranium dioxide (UO_2) with an effective enrichment based on a maximum assembly K-infinity of 1.24, in the cold in reactor lattice configuration. This will include the combined effects of burnup and burnable absorbers (like gadolinium) in the manufactured fuel, but still be conservative since each assembly will be at the maximum lifetime reactivity. The K-infinity value of 1.24 is based on the corresponding Technical Specification (TS) limit in the Design Section of TS. All fuel manufactured for MP1over its entire operational history has been designed to a maximum K-infinity of 1.24, in the cold in reactor lattice configuration.
- Nominal dimensions will be used and positive reactivity effects will be statistically combined (based on being independent) and added to the nominal k_{eff}. The following will be analyzed for possible increases in reactivity: manufacturing tolerances, eccentric assembly positioning, and channel swelling.
- The spent fuel pool k_{eff} is not to exceed 0.95.
- General Electric manufactured all fuel present in the pool, with the latest fuel design being GE-10.
- To neutronically isolate the Boraflex racks from the B_4C racks, each Boraflex rack face adjacent to a B_4C rack will have every other compartment empty of fuel.

<u>Methodology</u>

The criticality analysis is performed using the 44 group SCALE 4.4 code system for the MP1 Spent Fuel Pool (SFP). The analysis will be based on, and support the 3-out-of-4 fuel loading configuration shown in Figure 4-1.

The first step is to determine the most reactive assembly that exists. Using that assembly, an equivalent enrichment is determined that corresponds to a K-infinity of 1.24. The most reactive fuel assembly type with the effective uranium-235 (U-235) enrichment corresponding to the maximum K-infinity of 1.24 will be used to represent all fuel in the MP1 SFP.

The next step is to model a nominal 11 x 11 array in a 3-out-of-4 configuration and determine the value for the system k_{eff}. The 11 x 11 array is chosen because it represents the largest rack in the pool. The array will be set up such that at least one face will have every other compartment empty on the interface to the B_4C racks.

The model is then modified to account for abnormal conditions. Abnormal conditions include manufacturing tolerances, temperature changes, eccentric location of the assembly in the compartment, and zircalloy (Zr) channel swelling. Conditions regarding Boraflex are not included since no credit is taken for Boraflex. Fuel density is not included since the most reactive condition is used in the nominal analysis. Each condition is modeled independently so a delta-K for each abnormal condition is found. The positive reactivity changes are statistically combined by way of root mean square, since they are independent, and a net bias is obtained.

Several accident scenarios are then considered and the most limiting is determined. These conditions include abnormal moderator temperature, dropped assembly that becomes

positioned next to or on top of the rack, a seismic event, and single worst case mis-loaded fuel assembly.

The most limiting accident k_{eff} is then used in calculating the final results. The results are compared to the upper sub-critical limit (USL). The acceptance criteria is k_{eff} + net bias + 3sigma $\leq$ USL, where sigma is the statistical deviation associated with the Monte Carlo method in KENOVa.

Determination of Representative Fuel Assembly

Of the General Electric fuel types resident in the MP1 SFP, the 8 x 8 fuel assembly with two small waterholes and a channel of 100 mills yields the highest K-infinity and is therefore the most reactive fuel type. An effective enrichment that yields an in-core K-infinity of 1.24 is then determined through an iterative process. A nominal in-core assembly pitch of 6 inches is used with a mirror reflected boundary condition at all faces. The equivalent enrichment determined from this process is 2.085 w/o U-235.

The most reactive fuel assembly has the following dimensions:

- Fuel Pellet OD (outside diameter) is 0.411 inches of 95% Theoretical Density UO_2
- Clad OD is 0.483" of Zr
- Clad ID (inside diameter) is 0.419 inches
- Fuel Rod Pitch is 0.64 inches
- Fuel Channel is 5.48 inches square (Outer Dimension) with 0.1 inch wall thickness of Zr
- Fuel array is 8x8 with 62 fuel rods and 2 water rods

Pool Models

The first model developed is the nominal case that will be used to calculate the baseline k_{eff}. The largest rack in the pool, which is an 11 by 11 array, is modeled with a mirror boundary condition.

The nominal model differs from the actual storage rack in the following conservative ways:

- Boraflex is replaced with full density water.
- Each fuel assembly is replaced with the most reactive fuel assembly design at its most reactive state anytime in life.
- A reflective boundary condition is located at the top and bottom of the active fuel. The top end fittings, bottom fittings and plenum are not modeled.
- An operating temperature of 363 degrees K is used for the water and the water is at full density. This is greater than the maximum normal operating temperature (150 degrees F), and is conservative due to a positive temperature coefficient. The positive temperature coefficient is verified by a resultant increasing in reactivity in the boiling accident case.

Once the baseline k_{eff} is determined, the baseline case is modified in order to develop the independent bias models. There are 4 cases that will make up the biases. The first deals with the possibility of zircalloy channel swelling. The second and third models consider the effects associated with manufacturing tolerances in the pitch of the compartments in the rack, and the thickness of the stainless steel in the rack. Two models are developed at each range of pitch dimensions and the positive case is used as the delta-K. Likewise, two models are also

developed with a thinner and a thicker stainless steel dimension, and again the positive case is used as the delta-K. The final bias model is the most reactive effect of combined eccentric locations of the assemblies within their compartments. That is, the situation where the assemblies shift to a worst-case configuration. The determination of this basis requires several cases to ensure that the greatest delta-K is found. The 4 delta-K biases are combined by way of root mean square to obtain the net bias.

Three accident cases are modeled using nominal dimensions. For the first accident case, the baseline model is modified to show a positive moderator temperature coefficient exists by changing only the water temperature. Therefore, the maximum temperature effect on reactivity occurs with full density liquid solid (no voids) water at the saturation temperature that corresponds with the hydrostatic pressure at the bottom of the pool. The second accident case considers a dropped fuel assembly on top of, or adjacent to the rack. An assembly dropped on top of the rack need not be modeled because the combined distance of the plenum and top end fitting regions will neutronically isolate the assembly from the rack. The case where an assembly is dropped adjacent to the rack is bounded by an infinite nominal 3-out-of-4 lattice array. For this, a smaller array may be used with an even matrix of assemblies. The mirror boundary condition is replaced with a periodic boundary at all faces. This case also bounds the potential loss of spacing between adjacent racks due to a seismic event since no credit is taken for inter-rack spacing or radial leakage in this case. The final accident model is a worst-case single assembly misload. This is modeled by modifying the baseline model by removing a peripheral corner assembly and re-positioning it in the center of the array in a normally water filled compartment. The misload accident case yields the highest k_{eff}, and is the most limiting accident case that will be used to compare to, and meet the acceptance criteria.

Results

Table 1 shows the results from the KENOVa cases. All KENOVa cases are performed using 16 million neutron histories.

Table 1 KENOVa Results

Case	Description	k_{eff}	Sigma
1	Baseline – 3-out-of-4, Mirror Boundary Condition	0.8799	0.0002
2	Bias - Swelling of Channel	0.8973	0.0002
3	Bias - Pitch Tolerance	0.8829	0.0002
4	Bias - Stainless Steel Thickness Tolerance	0.8843	0.0002
5	Bias - Eccentric Positioning	0.8836	0.0002
6	Accident - Boiling Water	0.8857	0.0002
7	Accident - Dropped Fuel Assembly - 3-out-of-4 with Periodic Boundary Conditions	0.8805	0.0002
8	Accident - Mis-load	0.9174	0.0002

From the above table, case 1 shows that the baseline 3-out-4 fuel storage condition, with no Boraflex credit, results in a nominal k_{eff} of 0.8799. Cases 2, 3, 4 and 5 show the results of the bias cases. The net bias from abnormal conditions, cases 2 through 5, is a statistical combination of the delta-k values for each case. The delta-K is simply the difference between the positive reactivity change and the nominal case. Table 2 shows the delta-K values.

Table 2 Delta-K Values Used To Determine Net Bias

Case	Description	Delta-K
2	Channel Bulge	0.0174
3	Pitch	0.0030
4	SS Thickness	0.0044
5	Eccentric Position	0.0037
Net Bias (RMS)		0.0186

From Table 1, the most limiting accident case is the single misload of fuel assembly. The boiling condition and fuel assembly drop accidents are not limiting. Also, since case 7 models a 3-out-of-4 condition in a periodic boundary condition, no credit is taken for any spacing between racks. Thus there is no concern for a seismic event reducing the spacing between racks.

Proposed 3-out-of-4 Fuel Storage Pattern

Proposed Technical Specification Figure 4.1 shows the required 3-out-of-4 fuel storage pattern to ensure that the criticality analysis remains valid. As shown in Figure 4.1, spent fuel pool locations 9-1-J and 9-1-T allow fuel storage, and spent fuel pool locations 9-2-J and 9-2-T do not allow fuel storage. These locations do not have the repeating 3-out-of-4 pattern that is evident in the other Boraflex rack locations. This was necessary to avoid moving the 2 fuel assemblies from spent fuel pool locations 9-1-J and 9-1-T. It is difficult to move fuel from these 2 locations due to wall interferences. As a result, it was verified by additional KENOVa calculations that spent fuel pool locations 9-2-J and 9-2-T are adequate substitutes as "non-fuel" locations, instead of spent fuel pool locations 9-1-J and 9-1-T. KENOVa calculations performed by Dominion Nuclear Connecticut, Inc. (DNC) confirmed that there was no adverse effect due to this change.

Storage of "Non-Fuel" Components in "Non-Fuel" Locations

To minimize the effect of the loss of the 270 fuel storage locations, which are being designated as "non-fuel" locations by this proposed change, it is desirable to be able to store certain "non-fuel" components in certain "non-fuel" storage locations. Examples of such "non-fuel" components are dummy fuel assemblies. Additional KENOVa calculations were performed to demonstrate that storage of "non-fuel" components is acceptable in "non-fuel" locations that are in peripheral storage locations which are either next to a wall or where there is no adjacent storage rack. Locations, which meet these requirements are the "non-fuel" storage locations shown in Figure 4.1, in row 1 of sections 7, 8, 9 and 10. KENOVa calculations performed by DNC confirmed that there was no adverse effect on k_{eff} to allowing "non-fuel" components to be stored in these selected "non-fuel" locations.

In addition, there are 2 Boraflex coupon trees that were specifically evaluated with KENOVa to allow them to be stored in any "non-fuel" location. These coupon trees have a small amount of Stainless Steel and the Boraflex coupons. Specific KENOVa calculations performed by DNC showed that there was no adverse effect on k_{eff} to allowing these Boraflex coupon trees to be stored in any "non-fuel" location.

Procedural controls will be used to limit the storage of non-fuel components to the locations described above.

USL Determination

The USL for the spent fuel pool was determined as shown in the benchmarking information provided in Attachment 4. Table 3 shows the 6 independent variables used, the equations calculated from USLSTATS, the value of each variable that corresponds to the MP1 analysis model, and the USL result for each independent variable. The lowest USL result is used in the final calculation for the acceptance criterion.

Table 3

Variable	Equation	MS value (x)	USL
Enrichment	=0.9360 + (2.0656E-03) * X	2.08	0.9403
Pin Pitch	=0.9418 ($X \geq 1.505$)	1.6256	0.9418
Assembly Spacing	=0.9427 ($X \geq 7.404$)	16.002	0.9427
H/X	=0.9421 ($X \leq 255.997$)	137	0.9421
Water:Fuel Volume Ratio	=0.9417 ($1.6000 < X < 3.8830$)	2.087	0.9417
AEF	=0.9413 ($X \geq 0.130$)	0.15707	0.9413

The USL used for this analysis is 0.9403.

Conclusion

The acceptance criterion is the following:

Maximum k_{eff} = Most Limiting Accident k_{eff} + net bias + 3sigma < USL
Substituting the results obtained in this analysis:

$k_{eff} = (0.9174) + (0.0186) + 3\ (0.0002) < 0.9403$
$k_{eff} = 0.9366 < 0.9403$

The MP1 spent fuel pool Boraflex storage racks can be maintained with a $k_{eff} \leq 0.95$, on a 95/95 basis, without credit for Boraflex. To accomplish this, fuel storage is not allowed in the 270 storage locations designated in Figure 4-1.

ATTACHMENT 4

Millstone Power Station, Unit No. 1

Licensing Basis Document Change Request (LBDCR) 01-03-2
Fuel Storage Requirements

Criticality Benchmark and Determination of Upper Sub-critical Limit (USL) for Criticality Calculations

1. Purpose: To benchmark and determine the Upper Subcritical Limit (USL) for the Boraflex racks in the Millstone Unit 1 Spent Fuel Pool.

2. References:

1) NUREG/CR-6361, Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages, 1997
2) SCALE-4.4, Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers, CCC-545, ORNL
3) Transnuclear document E-16687, Test Report for Qualification of the SCALE 4.4 Program on the Transuclear PC With Windows NT 4.0
4) Transnuclear document E-16154, Test Report for Qualification of the USLSTATS Computer Program Version 1.3.4 on Transnuclear's Pentium-based Desktop Computers
5) NU Letter to USNRC, 5/5/88, B12844.
6) CSAS25 input/output files listed in Table 1 of this calculation.
7) USLSTATS input/output files listed in Table 2 of this calculation.

3. Method and Assumptions

The results for this benchmark will be used in the analysis of the Millstone Unit 1 Spent Fuel Pool. The input files for all benchmarks are taken from References 1. The files are run in the CSAS25 sequence of the SCALE4.4 computer code using the 44 group cross section library generated from ENDF/B-IV data (Reference 2) on PC with the Windows NT 4.0 operating system (Reference 3).

An upper subcritical limit (USL) will be determined as a function of several experimental variables. The values will then be applied using Method 1 "confidence band with administrative margin", described in Section 4.1.1 of Reference 1. The administrative margin will be 0.05, and the confidence level $1-\gamma_1$ will be 0.95. Excel spreadsheet functions and the ORNL program USLSTATS (Reference 4) version1.3.7 are used to do the statistical analysis of the data.

4. Critical experiment characteristics

Critical experiments were chosen to represent a well-moderated UO_2 fuel rod lattice without boron. A total of 95 experiments were found to be sufficient for this benchmark, and are listed in Table 1.

Six independent variables were used in the analysis: enrichment, pin pitch, water to fuel volume ratio, assembly spacing, Hydrogen to fissile material ratio (H/X), and the average energy of the fission-causing neutron (AEF).

5. Analysis of the Results

The data are analyzed to determine if there is a trend in the bias as a function of the independent variables. A least mean squares linear regression is performed to fit the data of K_{eff} as a function of the independent variable. This is done with both the ULSTATS program and with the Excel LINEST function. The results agree. The USLSTATS results can be found in Table 2. Table 2 also shows the USL value for each variable based on the parameter value corresponding to the Boraflex racks in the Millstone Unit 1 Spent Fuel Pool (Reference 5). Figures 1 through 6 show the Excel Plots.

Table 1: Critical Experiment Models and Results

Filename	Enrichment	Pitch (cm)	Water to Fuel Ratio	H/X	AEF	Spacing (cm)	KENOVa k-eff	σ
Ans33al1	4.74	1.350	2.302	138.4	0.233406	5.00	1.0063	0.0017
Ans33al2	4.74	1.350	2.302	138.4	0.196468	2.50	1.0102	0.0018
Ans33al3	4.74	1.350	2.302	138.4	0.173790	10.00	1.0046	0.0018
Ans33eb1	4.74	1.350	2.302	138.4	0.242133	2.50	0.9986	0.0018
Ans33eb2	4.74	1.350	2.302	138.4	0.206996	5.00	1.0078	0.0017
Ans33ep1	4.74	1.350	2.302	138.4	0.251432	2.50	0.9971	0.0018
Ans33ep2	4.74	1.350	2.302	138.4	0.223883	5.00	0.9972	0.0017
Ans33slg	4.74	1.350	2.302	138.4	0.195249	5.00	1.0000	0.0017
Ans33sty	2.46	1.410	2.302	138.4	0.264089	2.50	0.9940	0.0019
Bw1484c1	2.46	1.636	1.841	216.1	0.187696	1.64	0.9923	0.0016
Bw1484c2	2.46	1.636	1.841	216.1	0.147501	1.64	0.9928	0.0017
Bw1484sl	2.46	1.636	1.841	216.1	0.137700	6.54	0.9923	0.0015
Dsn399-1	4.74	1.350	2.302	138.2	0.228781	1.80	1.0081	0.0018
Dsn399-2	4.74	1.350	2.302	138.2	0.189871	5.80	0.9993	0.0018
P2438al	2.35	2.032	2.918	398.7	0.094854	8.67	0.9961	0.0015
P2438ba	2.35	2.032	2.918	398.7	0.114344	5.05	0.9979	0.0015
P2438cu	2.35	2.032	2.918	398.7	0.113884	6.62	0.9997	0.0016
P2438slg	2.35	2.032	2.918	398.7	0.094511	8.39	0.9973	0.0016
P2438ss	2.35	2.032	2.918	398.7	0.094766	6.88	0.9980	0.0015
P2438zr	2.35	2.032	2.918	398.7	0.094473	8.79	0.9994	0.0018
P2615al	4.31	2.540	3.883	256.1	0.113619	10.72	0.9995	0.0015
P2615ba	4.31	2.540	3.883	256.1	0.114344	6.72	0.9979	0.0015
P2615cd1	4.31	2.540	3.883	256.1	0.114824	7.82	0.9976	0.0017
P2615cd2	4.31	2.540	3.883	256.1	0.114877	5.68	0.9975	0.0018
P2615cu	4.31	2.540	3.883	256.1	0.113884	8.15	0.9997	0.0016
P2615ss	4.31	2.540	3.883	256.1	0.113472	8.58	0.9990	0.0016
P2615zr	4.31	2.540	3.883	256.1	0.112644	10.92	0.9975	0.0016
P2827l1	2.35	2.032	2.918	398.7	0.096719	13.72	1.0021	0.0015
P2827l2	2.35	2.032	2.918	398.7	0.094017	11.25	0.9991	0.0015
P2827l3.In	4.31	2.540	3.883	256.1	0.115864	20.78	1.0115	0.0017
P2827l4	4.31	2.540	3.883	256.1	0.114385	19.04	1.0065	0.0017
P2827slg	2.35	2.032	2.918	398.7	0.094010	8.31	0.9975	0.0014

P2827u1	2.35	2.032	2.918	398.7	0.211617	11.83	0.9962	0.0017
P2827u2	2.35	2.032	2.918	398.7	0.175625	14.11	0.9983	0.0014
P2827u3	4.31	2.540	3.883	256.1	0.384476	15.38	1.0009	0.0017
P2827u4	4.31	2.540	3.883	256.1	0.273686	15.32	1.0070	0.0016
P3314bs1	2.35	1.684	1.600	218.6	0.172238	3.86	0.9951	0.0016
P3314bs2	2.35	1.684	1.600	218.6	0.175347	3.46	0.9941	0.0015
P3314bs3	4.31	1.892	1.600	105.4	0.289730	7.23	0.9966	0.0016
P3314bs4	4.31	1.892	1.600	105.4	0.296121	6.63	1.0023	0.0017
P3314cd2	2.35	1.684	1.600	218.6	0.174323	3.04	0.9998	0.0020
P3314cu3	4.31	1.892	1.600	105.4	0.280592	10.36	0.9965	0.0016
P3314cu4	4.31	1.892	1.600	105.4	0.289876	7.61	1.0019	0.0016
P3314cu5	2.35	1.684	1.600	218.6	0.165325	5.24	0.9935	0.0017
P3314cu6	2.35	1.684	1.600	218.6	0.171740	2.60	0.9980	0.0014
P3314ss5	2.35	1.684	1.600	218.6	0.168590	7.80	0.9930	0.0018
P3602bb	4.31	1.892	1.600	105.4	0.299416	8.30	1.0053	0.0016
P3602bs1	2.35	1.684	1.600	218.6	0.176393	4.80	1.0013	0.0017
P3602bs2	4.31	1.892	1.600	105.4	0.295310	9.83	1.0053	0.0019
P3602cd1	2.35	1.684	1.600	218.6	0.179154	3.86	1.0030	0.0014
P3602cd2	4.31	1.892	1.600	105.4	0.300122	8.94	1.0039	0.0017
P3602cu1	2.35	1.684	1.600	218.6	0.171736	7.79	1.0017	0.0015
P3602cu2	2.35	1.684	1.600	218.6	0.175462	5.43	0.9996	0.0017
P3602cu3	4.31	1.892	1.600	105.4	0.290218	13.47	1.0056	0.0018
P3602cu4	4.31	1.892	1.600	105.4	0.298483	10.57	1.0045	0.0017
P3602n11	2.35	1.684	1.600	218.6	0.180150	8.98	1.0037	0.0016
P3602n12	2.35	1.684	1.600	218.6	0.173530	9.58	1.0039	0.0017
P3602n13	2.35	1.684	1.600	218.6	0.165750	9.66	1.0036	0.0016
P3602n14	2.35	1.684	1.600	218.6	0.160689	8.54	0.9973	0.0015
P3602n21	2.35	2.032	2.918	398.7	0.094630	10.36	0.9984	0.0016
P3602n22	2.35	2.032	2.918	398.7	0.098028	11.20	1.0009	0.0013
P3602n31	4.31	1.892	1.600	105.4	0.314546	14.87	1.0088	0.0019
P3602n32	4.31	1.892	1.600	105.4	0.304293	15.74	1.0072	0.0017
P3602n33	4.31	1.892	1.600	105.4	0.294242	15.87	1.0077	0.0017
P3602n34	4.31	1.892	1.600	105.4	0.286765	15.84	1.0070	0.0018
P3602n35	4.31	1.892	1.600	105.4	0.281898	15.45	1.0020	0.0018
P3602n36	4.31	1.892	1.600	105.4	0.273386	13.82	1.0004	0.0019
P3602n41	4.31	2.540	3.883	256.1	0.123201	12.89	1.0097	0.0016
P3602n42	4.31	2.540	3.883	256.1	0.116951	14.12	1.0072	0.0021
P3602n43	4.31	2.540	3.883	256.1	0.113131	12.44	1.0040	0.0017
P3602ss1	2.35	1.684	1.600	218.6	0.169699	8.28	1.0016	0.0016
P3602ss2	4.31	1.892	1.600	105.4	0.288965	13.75	1.0029	0.0016
P3926l1	2.35	1.684	1.600	218.6	0.173007	10.06	0.9993	0.0019
P3926l2	2.35	1.684	1.600	218.6	0.166382	10.11	1.0030	0.0016
P3926l3	2.35	1.684	1.600	218.6	0.158648	8.50	0.9984	0.0015
P3926l4	4.31	1.892	1.600	105.4	0.304508	17.74	1.0075	0.0017
P3926l5	4.31	1.892	1.600	105.4	0.294827	18.18	1.0077	0.0018
P3926l6	4.31	1.892	1.600	105.4	0.279892	17.43	1.0069	0.0016
P3926sl1	2.35	1.684	1.600	218.6	0.159064	6.59	0.9932	0.0015
P3926sl2	4.31	1.892	1.600	105.4	0.275653	12.97	1.0001	0.0017
P3926u1	2.35	1.684	1.600	218.6	0.405591	8.06	0.9948	0.0015
P3926u2	2.35	1.684	1.600	218.6	0.340984	9.50	0.9962	0.0017

P3926u3	2.35	1.684	1.600	218.6	0.258156	9.19	0.9991	0.0018
P3926u4	4.31	1.892	1.600	105.4	0.641460	15.33	1.0020	0.0017
P3926u5	4.31	1.892	1.600	105.4	0.510424	19.24	1.0038	0.0017
P3926u6	4.31	1.892	1.600	105.4	0.451978	18.78	1.0006	0.0020
P62ft231	4.31	1.891	1.600	105.0	0.358545	5.67	1.0013	0.0019
P71f14f3	4.31	1.891	1.600	105.0	0.373236	5.19	1.0023	0.0017
P71f14v3	4.31	1.891	1.600	105.0	0.367731	5.19	0.9987	0.0020
P71f14v5	4.31	1.891	1.600	105.0	0.365618	5.19	1.0011	0.0016
P71f214r	4.31	1.891	1.600	105.0	0.368163	5.19	0.9959	0.0020
Pat80l1	4.74	1.600	3.807	228.6	0.148334	2.00	1.0001	0.0017
Pat80l2	4.74	1.600	3.807	228.6	0.143004	2.00	0.9992	0.0020
Pat80ss1	4.74	1.600	3.807	228.6	0.148335	2.00	1.0020	0.0015
Pat80ss2	4.74	1.600	3.807	228.6	0.143878	2.00	0.9931	0.0022

Table 2: Results From USLSTATS

USLSTATS File name	Variable	Equation	MS Value (x)	USL
MSENR	Enrichment	= 0.9360 + (2.0656E-03)*X	2.08	0.9403
MSPITCH	Pin Pitch	= 0.9418 (X >= 1.505)	1.6256	0.9418
MSSPACE	Assembly Spacing	= 0.9427 (X >= 7.404)	16.002	0.9427
MSHX	H/X	= 0.9421 (X <=255.997)	137	0.9421
MSWF	Water:Fuel Volume Ratio	= 0.9417 (1.6000<X<3.8830)	2.087	0.9417
MSAEF	AEF	= 0.9413 (X >= 0.130)	0.15707	0.9413

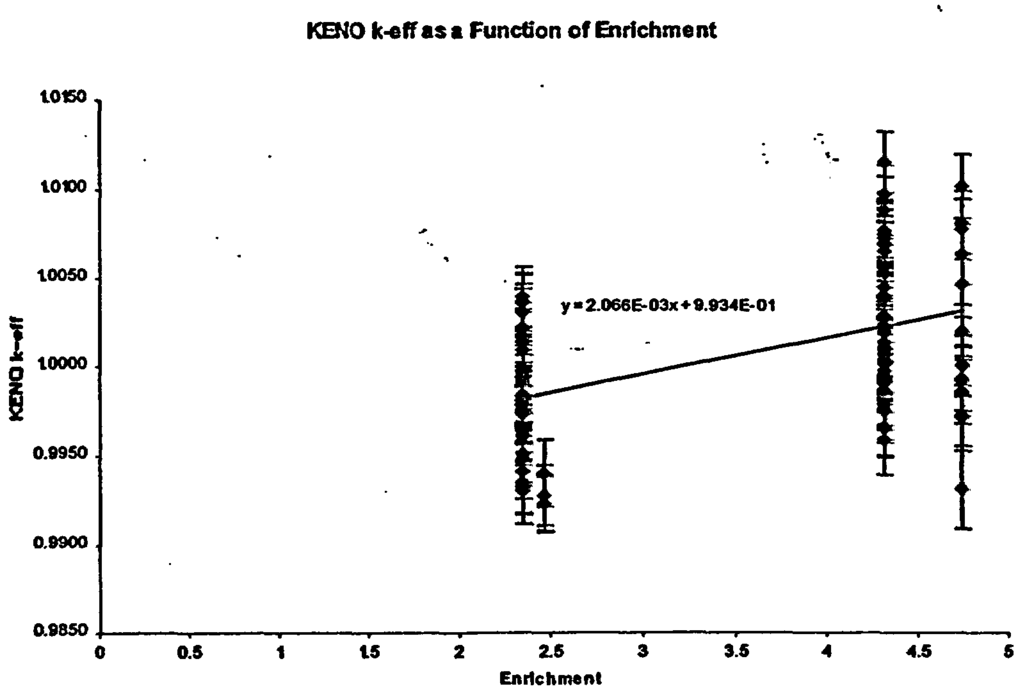


Figure 1: k-eff as a Function of Enrichment

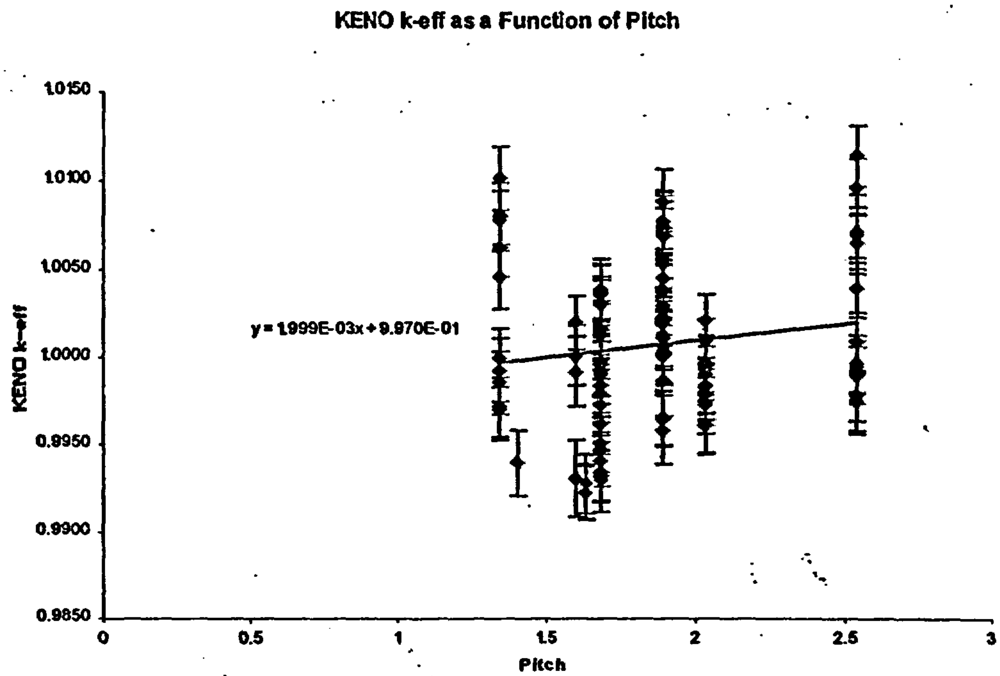


Figure 2: k-eff as a Function of Pin Pitch

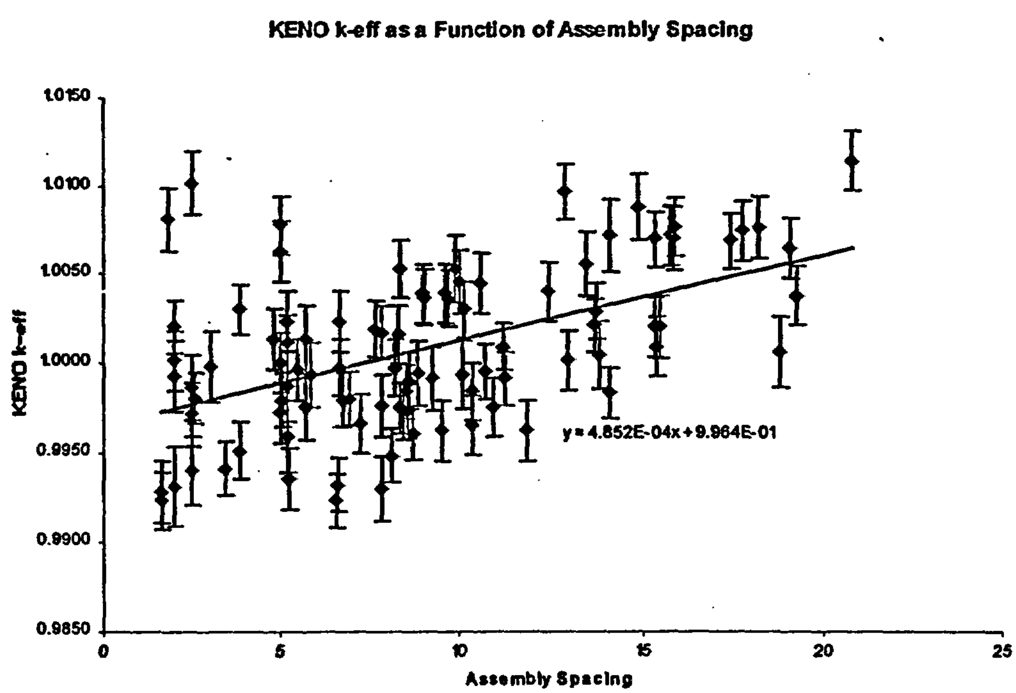


Figure 3: k-eff as a Function of Assembly Spacing

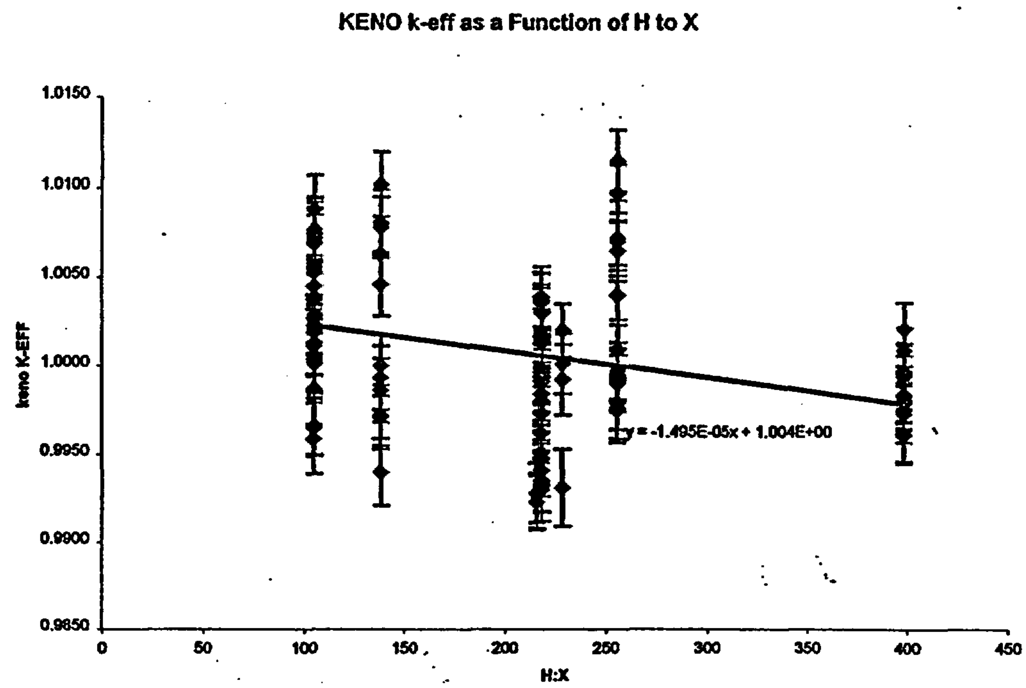


Figure 4: k-eff as a Function of H to X Ratio

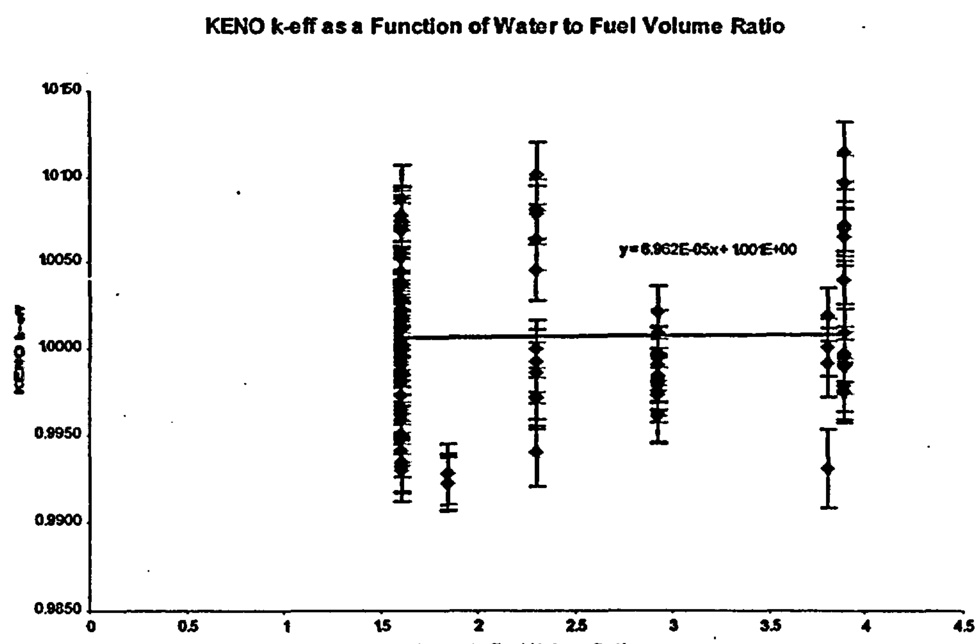


Figure 5: k-eff as a Function of Water to Fuel Volume Ratio

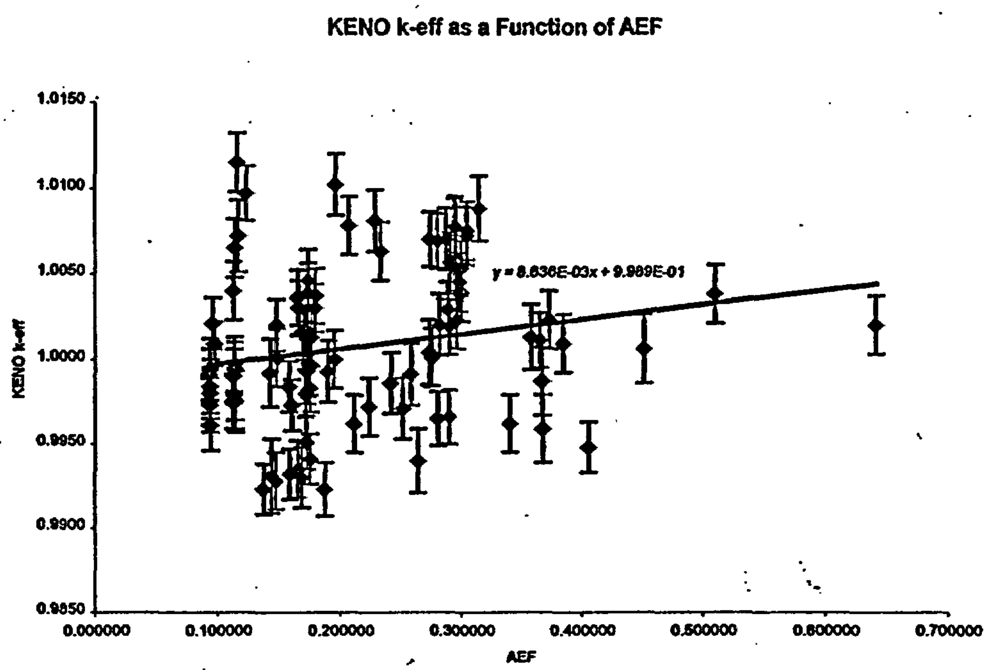


Figure 6: k-eff as a Function of AEF

6. Conclusions

The variable that yielded the lowest USL result was enrichment. The USL used for the Boraflex rack analysis in the Millstone Unit 1 Spent Fuel Pool will be 0.9403.

Appendix – Sample USLSTATS Output

uslstats: a utility to calculate upper subcritical
limits for criticality safety applications

```
*****************************************************************************
            Version 1.3.6, December 15, 1998
             Oak Ridge National Laboratory
*****************************************************************************
```

Input to statistical treatment from file:MSAEF.in

Title: PCBENCH AEF

Proportion of the population = .995
Confidence of fit = .950
Confidence on proportion = .950

TRANSNUCLEAR, INC.

PREPARED BY	DATE 01/04/01	TITLE Criticality Benchmark And Determination of USL for Millstone Unit 1 Spent Fuel Pool	SHEET 9 OF 11
CHECKED BY	DATE 3/28/01		CALC. NO 10970-01
			REV. 0

Number of observations = 95
Minimum value of closed band = 0.00
Maximum value of closed band = 0.00
Administrative margin = 0.05

independent variable - x	dependent variable - y	deviation in y	independent variable - x	dependent variable - y	deviation in y
2.33406E-01	1.00630E+00	1.70000E-03	2.95310E-01	1.00530E+00	1.90000E-03
1.96468E-01	1.01020E+00	1.80000E-03	1.79154E-01	1.00300E+00	1.40000E-03
1.73790E-01	1.00460E+00	1.80000E-03	3.00122E-01	1.00390E+00	1.70000E-03
2.42133E-01	9.98600E-01	1.80000E-03	1.71736E-01	1.00170E+00	1.50000E-03
2.06996E-01	1.00780E+00	1.70000E-03	1.75462E-01	9.99600E-01	1.70000E-03
2.51432E-01	9.97100E-01	1.80000E-03	2.90218E-01	1.00560E+00	1.80000E-03
2.23883E-01	9.97200E-01	1.70000E-03	2.98483E-01	1.00450E+00	1.70000E-03
1.95249E-01	1.00000E+00	1.70000E-03	1.80150E-01	1.00370E+00	1.60000E-03
2.64089E-01	9.94000E-01	1.90000E-03	1.73530E-01	1.00390E+00	1.70000E-03
1.87696E-01	9.92300E-01	1.60000E-03	1.65750E-01	1.00360E+00	1.60000E-03
1.47501E-01	9.92800E-01	1.70000E-03	1.60689E-01	9.97300E-01	1.50000E-03
1.37700E-01	9.92300E-01	1.50000E-03	9.46300E-02	9.98400E-01	1.60000E-03
2.28781E-01	1.00810E+00	1.80000E-03	9.80280E-02	1.00090E+00	1.30000E-03
1.89871E-01	9.99300E-01	1.80000E-03	3.14546E-01	1.00880E+00	1.90000E-03
9.48540E-02	9.96100E-01	1.50000E-03	3.04293E-01	1.00720E+00	1.70000E-03
1.14344E-01	9.97900E-01	1.50000E-03	2.94242E-01	1.00770E+00	1.70000E-03
1.13884E-01	9.99700E-01	1.60000E-03	2.86765E-01	1.00700E+00	1.80000E-03
9.45110E-02	9.97300E-01	1.60000E-03	2.81898E-01	1.00200E+00	1.80000E-03
9.47660E-02	9.98000E-01	1.50000E-03	2.73386E-01	1.00040E+00	1.90000E-03
9.44730E-02	9.99400E-01	1.80000E-03	1.23201E-01	1.00970E+00	1.60000E-03
1.13619E-01	9.99500E-01	1.50000E-03	1.16951E-01	1.00720E+00	2.10000E-03
1.14344E-01	9.97900E-01	1.50000E-03	1.13131E-01	1.00400E+00	1.70000E-03
1.14824E-01	9.97600E-01	1.70000E-03	1.69699E-01	1.00160E+00	1.60000E-03
1.14877E-01	9.97500E-01	1.80000E-03	2.88965E-01	1.00290E+00	1.60000E-03
1.13884E-01	9.99700E-01	1.60000E-03	1.73007E-01	9.99300E-01	1.90000E-03
1.13472E-01	9.99000E-01	1.60000E-03	1.66382E-01	1.00300E+00	1.60000E-03
1.12644E-01	9.97500E-01	1.60000E-03	1.58648E-01	9.98400E-01	1.50000E-03
9.67190E-02	1.00210E+00	1.50000E-03	3.04508E-01	1.00750E+00	1.70000E-03
9.40170E-02	9.99100E-01	1.50000E-03	2.94827E-01	1.00770E+00	1.80000E-03
1.15864E-01	1.01150E+00	1.70000E-03	2.79892E-01	1.00690E+00	1.60000E-03
1.14385E-01	1.00650E+00	1.70000E-03	1.59064E-01	9.93200E-01	1.50000E-03
9.40100E-02	9.97500E-01	1.40000E-03	2.75653E-01	1.00010E+00	1.70000E-03
2.11617E-01	9.96200E-01	1.70000E-03	4.05591E-01	9.94800E-01	1.50000E-03
1.75625E-01	9.98300E-01	1.40000E-03	3.40984E-01	9.96200E-01	1.70000E-03
3.84476E-01	1.00090E+00	1.70000E-03	2.58156E-01	9.99100E-01	1.80000E-03
2.73686E-01	1.00700E+00	1.60000E-03	6.41460E-01	1.00200E+00	1.70000E-03
1.72238E-01	9.95100E-01	1.60000E-03	5.10424E-01	1.00380E+00	1.70000E-03
1.75347E-01	9.94100E-01	1.50000E-03	4.51978E-01	1.00060E+00	2.00000E-03
2.89730E-01	9.96600E-01	1.60000E-03	3.58545E-01	1.00130E+00	1.90000E-03
2.96121E-01	1.00230E+00	1.70000E-03	3.73236E-01	1.00230E+00	1.70000E-03
1.74323E-01	9.99800E-01	2.00000E-03	3.67731E-01	9.98700E-01	2.00000E-03
2.80592E-01	9.96500E-01	1.60000E-03	3.65618E-01	1.00110E+00	1.60000E-03
2.89876E-01	1.00190E+00	1.60000E-03	3.68163E-01	9.95900E-01	2.00000E-03

1.65325E-01	9.93500E-01	1.70000E-03	1.48334E-01	1.00010E+00	1.70000E-03
1.71740E-01	9.98000E-01	1.40000E-03	1.43004E-01	9.99200E-01	2.00000E-03
1.68590E-01	9.93000E-01	1.80000E-03	1.48335E-01	1.00200E+00	1.50000E-03
2.99416E-01	1.00530E+00	1.60000E-03	1.43878E-01	9.93100E-01	2.20000E-03
1.76393E-01	1.00130E+00	1.70000E-03			

chi = 3.8947 (upper bound = 9.49). The data tests normal.

Output from statistical treatment

PCBENCH AEF

Number of data points (n)	95
Linear regression, k(X)	0.9989 + (8.6356E-03)*X
Confidence on fit (1-gamma) [input]	95.0%
Confidence on proportion (alpha) [input]	95.0%
Proportion of population falling above lower tolerance interval (rho) [input]	99.5%
Minimum value of X	0,0940
Maximum value of X	0.6415
Average value of X	0.21570
Average value of k	1.00074
Minimum value of k	0.99230
Variance of fit, s(k,X)^2	1.9900E-05
Within variance, s(w)^2	2.8562E-06
Pooled variance, s(p)^2	2.2757E-05
Pooled std. deviation, s(p)	4.7704E-03
C(alpha,rho)*s(p)	1.8501E-02
student-t @ (n-2,1-gamma)	1.66385E+00
Confidence band width, W	8.6681E-03
Minimum margin of subcriticality, C*s(p)-W	9.8329E-03

Upper subcritical limits: (9.40100E-02 <= X <= 0.64146)
***** ************ *******

USL Method 1 (Confidence Band with
Administrative Margin) USL1 = 0.9402 + (8.6356E-03)*X (X < 0.12988)
= 0.9413 (X >= 0.130)

USL Method 2 (Single-Sided Uniform
Width Closed Interval Approach) USL2 = 0.9804 + (8.6356E-03)*X (X < 0.12988)
= 0.9815 (X >= 0.130)

USLs Evaluated Over Range of Parameter X:
**** ********* **** ***** ** ********* **

X: 9.40E-2 0.17 0.25 0.33 0.41 0.49 0.56 0.64

USL-1: 0.9410 0.9413 0.9413 0.9413 0.9413 0.9413 0.9413 0.9413
USL-2: 0.9812 0.9815 0.9815 0.9815 0.9815 0.9815 0.9815 0.9815

****

Thus spake USLSTATS
Finis.