UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 19, 2000

Mr. J. A. Scalice
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2 - ISSUANCE OF AMENDMENTS REGARDING BORON CREDIT IN SPENT FUEL POOL (TAC NOS. MA9884 AND MA9885) (TSC 99-17)

Dear Mr. Scalice:

The Commission has issued the enclosed Amendment No. 265 to Facility Operating License No. DPR-77 and Amendment No. 256 to Facility Operating License No. DPR-79 for the Sequoyah Nuclear Plant (SQN), Units 1 and 2, respectively. These amendments are in response to your application dated August 31, 2000 (TSC 99-17), in which Tennessee Valley Authority requested changes to the Sequoyah Nuclear Plant (SQN), Units 1 and 2, Technical Specifications (TS) to allow the use of credit for soluble boron in the spent fuel pool criticality safety analyses and, therefore, receive approval for different fuel pool physical arrangements. The request is based on analysis presented in two Holtec International topical reports, which were reviewed and approved by the U.S. Nuclear Regulatory Commission staff in a letter dated November 3, 2000.

A copy of the Safety Evaluation is also enclosed. Notice of Issuance will be included in the Commission's next biweekly Federal Register notice.

Sincerely,

Ronald W. Hernan

Ronald W. Hernan, Senior Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-327 and 50-328

Enclosures: 1. Amendment No. 265 to License No. DPR-77
2. Amendment No. 256 to License No. DPR-79
3. Safety Evaluation

cc w/enclosures: See next page

NRR-058

December 19, 2000

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/RA/
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cc w/enclosures: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-327

SEQUOYAH NUCLEAR PLANT, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 265
License No. DPR-77

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Tennessee Valley Authority (the licensee) dated August 31, 2000, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Facility Operating License No. DPR-77 is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendices A and B, as revised through Amendment No. 265 , are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance and shall be implemented within 45 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Richard P. Correia, Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: December 19, 2000

ATTACHMENT TO LICENSE AMENDMENT NO. 265

FACILITY OPERATING LICENSE NO. DPR-77

DOCKET NO. 50-327

Replace the following pages of the Appendix A Technical Specifications with the attached pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
Index Page IX	Index Page IX
Index Page XIV	Index Page XIV
--	3/4 7-42 (new page)
--	3/4 7-43 (new page)
3/4 9-1a	3/4 9-1a
--	B 3/4 7-9 (new page)
--	B 3/4 7-10 (new page)
--	B 3/4 7-11 (new page)
--	B 3/4 7-12 (new page)
--	B 3/4 7-13 (new page)
--	B 3/4 7-14 (new page)
--	B 3/4 7-15 (new page)
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5-5b	5-5b
5-5c	5-5c (Figure 5.6-1)
5-5d	5-5d (Figure 5.6-1a)
5-5e	5-5e (Figure 5.6-2)
5-5f	5-5f (Figure 5.6-3)
--	5-5g (Figure 5.6-4)
--	5-5h (new Table 5.6-1)
--	5-5i (new Table 5.6-2)
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SURVEILLANCE REQUIREMENTS (Continued)

4.9.1.3 One of the following valve combinations shall be verified closed under administrative control at least once per 72 hours:

Combination A	Combination B	Combination C	Combination D
a. 1-81-536	a. 1-81-536	a. 1-81-536	a. 1-81-536
b. 1-62-922	b. 1-62-922	b. 1-62-907	b. 1-62-907
c. 1-62-916	c. 1-62-916	c. 1-62-914	c. 1-62-914
d. 1-62-933	d. 1-62-940	d. 1-62-921	d. 1-62-921
	e. 1-62-696	e. 1-62-933	e. 1-62-940
	f. 1-62-929		f. 1-62-929
	g. 1-62-932		g. 1-62-932
	h. 1-FCV-62-128		h. 1-62-696
			i. 1-FCV-62-128

3/4.7.13 SPENT FUEL POOL MINIMUM BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.7.13 The spent fuel pool boron concentration shall be ≥ 2000 ppm.

APPLICABILITY: Whenever fuel assemblies are stored in the spent fuel storage racks.

ACTION:

With the requirements of the specification not satisfied, suspend all movement of fuel assemblies and initiate action to restore spent fuel storage pool boron concentration to within limit. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.7.13.1 Verify at least once per 7 days the spent fuel pool boron concentration is within limit.

4.7.13.2 Verify at least once per 72 hours during fuel movement the spent fuel pool boron concentration is within limit and until the configuration of the assemblies in the storage rack is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.c.

3/4.7.14 CASK PIT POOL MINIMUM BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.7.14 The cask pit pool boron concentration shall be ≥ 2000 ppm.

APPLICABILITY: Whenever fuel assemblies are stored in the cask pit rack.

ACTION:

With the requirements of the specification not satisfied, suspend all movement of fuel assemblies and initiate action to restore cask pit pool boron concentration to within limit. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.7.14.1 Verify at least once per 7 days the cask pit pool boron concentration is within limit.

4.7.14.2 Verify at least once per 72 hours during fuel movement the cask pit pool boron concentration is within limit and until the configuration of the assemblies in the storage rack is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.d.

PLANT SYSTEMS

BASES

3/4.7.13 SPENT FUEL POOL MINIMUM BORON CONCENTRATION

BACKGROUND

The spent fuel racks have been analyzed in accordance with the Holtec International methodology contained in Holtec Report HI - 992349 (Ref. 1). This methodology ensures that the spent fuel rack multiplication factor, k_{eff} is less than or equal to 0.95, as recommended by the NRC guidance contained in NRC Letter to All Power Reactor Licensees from B.K. Grimes, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", April 14, 1978 and USNRC Internal Memorandum from L. Kopp, "Guidance On The Regulatory Requirements For Criticality Analysis Of Fuel Storage At Light-Water Reactor Power Plants", August 19, 1998 (Refs. 2 & 3). The codes, methods, and techniques contained in the methodology are used to satisfy the k_{eff} criterion. The spent fuel storage racks were analyzed using Westinghouse 17x17 V5H fuel assemblies, with enrichments up to 4.95 ±0.05 w/o U-235 and configurations which take credit for checkerboarding, burnup, soluble boron, integral fuel burnable absorbers (such as IFBA or gadolinia), and cooling time to ensure that k_{eff} is maintained ≤ 0.95, including uncertainties, tolerances, and accident conditions. In addition, the SFP k_{eff} is maintained < 1.0, including uncertainties, tolerances on a 95/95 basis without any soluble boron. Calculations were performed to evaluate the reactivity of fuel types used at SQN. The results show that the Westinghouse 17x17 V5H fuel assembly exhibits the highest reactivity, thereby bounding all fuel types utilized and stored at SQN.

In the high density Spent Fuel Storage Rack design (Refs. 1 and 4), the spent fuel storage pool is divided into three separate and distinct regions which, for the purpose of criticality considerations, are considered as separate pools. Region 1 is designed to accommodate new fuel with a maximum enrichment of 4.95 ± 0.05 wt% U-235, or spent fuel regardless of the discharge fuel burnup in a 1-in-4 checkerboard arrangement of 1 fresh assembly with 3 spent fuel assemblies with enrichment, burnup and cooling times in accordance with Design Features 5.6.1.1.c.1. Region 2 is designed to accommodate fuel which have 4.95 ± 0.05 wt% U-235 initial enrichment burned to at least 30.27 MWD/KgU (assembly average), or fuel of other enrichment with a burnup yielding an equivalent reactivity in the fuel racks in accordance with Design Features 5.6.1.1.c.2. Region 3 is designed to accommodate fuel of 4.95 ± 0.05 wt% U-235 initial enrichment or fuel assemblies of any lower reactivity in a 2-out-of-4 checkerboard arrangement with water-filled cells and in accordance with Design Features 5.6.1.1.c.3.

The water in the spent fuel storage pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of < 1.0 be evaluated in the absence of soluble boron. Hence, the design of all regions is based on the use of unborated water, which maintains each region in a subcritical condition during normal operation with the regions fully loaded.

(continued)

PLANT SYSTEMS

BASES

BACKGROUND (continued)

The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 5) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the accidental mishandling of a fresh fuel assembly face adjacent to a fresh fuel assembly of Region 3. This could potentially increase the criticality of Region 3. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. The soluble boron concentration required to maintain $k_{eff} \leq 0.95$ under normal conditions is 300 ppm and 700 ppm under the most severe postulated fuel mis-location accident. Safe operation of the spent fuel storage racks may therefore be achieved by controlling the location of each assembly in accordance with Design Features 5.6 FUEL STORAGE. During fuel movement, it is necessary to perform Surveillance Requirement 4.7.13.2.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of any one of the three regions. Examples of these accident conditions are the loss of cooling and the dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble boron in the storage pool prevents criticality in all regions. The most limiting postulated accident with respect to the storage configurations assumed in the spent fuel rack criticality analysis is the misplacement of a nominal 4.95 ± 0.05 w/o U-235 fuel assembly into an empty storage cell location in the Region 3 checkerboard storage arrangement. The amount of soluble boron required to maintain k_{eff} less than or equal to 0.95 due to this fuel misload accident is 700 ppm (Ref. 1).

A spent fuel boron dilution analysis was performed to ensure that sufficient time is available to detect and mitigate dilution of the spent fuel pool prior to exceeding the k_{eff} design basis limit of 0.95 (Ref. 6). The spent fuel pool boron dilution analysis concluded that an inadvertent or unplanned event that would result in a dilution of the spent fuel pool boron concentration from 2000 ppm to 700 ppm is not a credible event.

The concentration of dissolved boron in the spent fuel storage pool satisfies Criterion 2 of the NRC Policy Statement.

LCO

The spent fuel storage pool boron concentration is required to be $\geq$ 2000 ppm. The specified concentration of dissolved boron in the spent fuel storage pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 7. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel storage pool.

(continued)

PLANT SYSTEMS

BASES (continued)

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel storage pool.

ACTIONS

Action a:

When the concentration of boron in the spent fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored along with suspending movement of fuel assemblies.

Action a is modified by a provision indicating that LCO 3.0.3 does not apply. If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. Moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4 is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

Surveillance 4.7.13.1

This Surveillance Requirement verifies that the concentration of boron in the spent fuel storage pool is within the required limit. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no significant replenishment of pool water is expected to take place over such a short period of time. (Ref. 6)

Surveillance 4.7.13.2

This Surveillance Requirement verifies that the concentration of boron in the spent fuel storage pool is within the required limit during fuel movement until the final configuration of the assemblies in the storage racks is verified to be correct. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 72 hour Frequency provides additional assurance that the maximum k_{eff} remains below the 0.95 limit under the postulated accident condition. (Ref. 8)

(continued)

PLANT SYSTEMS

BASES (continued)

REFERENCES

1. Stanley E. Turner (Holtec International), "Criticality Safety Analyses of Sequoyah Spent Fuel Racks with Alternative Arrangements," HI-992349

2. B. K. Grimes (NRC GL78011), "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", April 14, 1978

3. L. Kopp, "Guidance On The Regulatory Requirements For Criticality Analysis Of Fuel Storage At Light-Water Reactor Power Plants", August 19, 1998

4 UFSAR, Section 4.3.2.7, "Critically of Fuel Assemblies"

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

6. K. K. Niyogi (Holtec International), "Boron Dilution Analysis," HI-992302

7. FSAR, Section 15.4.5

8. NRC letter to TVA dated August 1, 1990, " Increase Fuel Enrichment to 5.0 Weight Percent (TAC Nos. 76074, 76075, 76774, 76775) (TS 90-12) - Sequoyah Nuclear Plant, Units 1 and 2"

PLANT SYSTEMS

BASES

3/4.7.14 CASK PIT POOL MINIMUM BORON CONCENTRATION

BACKGROUND

The Sequoyah cask pit pool consists of a deep pool with adjacent shelf area. The cask pit pool is connected to the spent fuel pool through a weir gate. The cask pit is intended to be used for spent fuel shipment activities.

High density spent fuel storage racks have been approved for addition and use in the cask loading area of the cask pit (Ref. 1) but presently are not installed. The 15 x 15 module could store 225 fuel assemblies and is designed to maintain stored fuel having an initial enrichment of up to 5 wt % U-235, in a safe, coolable, and sub-critical configuration during normal discharge, full core offload storages and postulated accident conditions. Fuel assemblies shall be stored in accordance with paragraph 5.6.1.1.d in Design Features 5.6, Fuel Storage.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of the cask pit. Examples of accident conditions are the loss of cooling and the dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble boron in the cask pit pool prevents criticality. The most limiting postulated accident bounding the cask pit pool has been determined to occur in the spent fuel pool. The postulated accident with respect to the storage configurations assumed in the spent fuel rack criticality analysis is the misplacement of a nominal 4.95 ± 0.05 w/o U-235 fuel assembly into an storage cell location in the Region 2 checkerboard storage arrangement for an irradiated fuel assembly. The amount of soluble boron required to maintain k_{eff} less than or equal to 0.95 due to this fuel misload accident is 700 ppm (Ref. 2).

The concentration of dissolved boron in the fuel storage pool satisfies Criterion 2 of the NRC Policy Statement.

LCO

The cask pit pool boron concentration is required to be ≥ 2000 ppm. The specified concentration of dissolved boron in the cask pit pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 3. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the cask pit pool.

(continued)

PLANT SYSTEMS

BASES (continued)

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the cask pit pool.

ACTIONS

Action a:

When the concentration of boron in the cask pit pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored along with suspending movement of fuel assemblies.

Action a is modified by a provision indicating that LCO 3.0.3 does not apply. If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. Moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4 is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

Surveillance 4.7.14.1

This Surveillance Requirement verifies that the concentration of boron in the cask pit pool is within the required limit. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no significant replenishment of pool water is expected to take place over such a short period of time. (Ref. 4)

Surveillance 4.7.14.2

This Surveillance Requirement verifies that the concentration of boron in the cask pit pool is within the required limit during fuel movement until the final configuration of the assemblies in the storage racks is verified to be correct. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 72 hour Frequency provides additional assurance that the maximum k_{eff} remains below the 0.95 limit under the postulated accident condition. (Ref. 1)

(continued)

PLANT SYSTEMS

BASES (continued)

REFERENCES

NRC letter to TVA dated April 28, 1993, "Issuance of Amendments (TAC Nos. M83068 and M83069)"

Stanley E. Turner (Holtec International), "Criticality Safety Analyses of Sequoyah Spent Fuel Racks with Alternative Arrangements," HI-992349

FSAR, Section 15.4.5

K. K. Niyogi (Holtec International), "Boron Dilution Analysis," HI-992302

5.6 FUEL STORAGE

CRITICALITY - SPENT FUEL

5.6.1.1 The spent fuel storage racks are designed for fuel enriched to 5 weight percent U-235 and shall be maintained with:

a. A k_{eff} less than critical when flooded with unborated water and a k_{eff} less than or equal to 0.95 when flooded with water containing 300 ppm soluble boron.*

b. A nominal 8.972 inch center-to-center distance between fuel assemblies placed in the storage racks.

c. Arrangements of one or more of three different arrays (Regions) or sub-arrays as illustrated in Figures 5.6-1 and 5.6-1a. These arrangements in the spent fuel storage pool have the following definitions:

1. Region 1 is designed to accommodate new fuel with a maximum enrichment of 4.95 ± 0.05 wt% U-235, (or spent fuel regardless of the fuel burnup), in a 1-in-4 checkerboard arrangement of 1 fresh assembly with 3 spent fuel assemblies with enrichment-burnup and cooling times illustrated in Figure 5.6-2 and defined by the equations in Table 5.6-1. Cooling time is defined as the period since reactor shutdown at the end of the last operating cycle for the discharged spent fuel assembly. The presence of a removable, non-fissile insert such as a burnable poison rod assembly (BPRA) or either gadolinia or integral fuel burnable absorber (IFBA) in a fresh fuel assembly does not affect the applicability of Figure 5.6-2 or Table 5.6-1.

   Two alternative storage arrays (or sub-arrays) are acceptable in Region 1 if the fresh fuel assemblies contain rods with either gadolinia or integral fuel burnable absorber (IFBA). For these types of assemblies, the minimum burnup of the spent fuel in the 1-of-4 sub-array are defined by the equations in Table 5.6-2.

   Restrictions in Region 1

   Any of the three sub-arrays illustrated in Figure 5.6-1a may be used in any combination provided that:

   1) Each sub-array of 4 fuel assemblies includes, in addition to the fresh fuel assembly, 3 assemblies with enrichment and minimum burnup requirements defined by the equations in Tables 5.6-1 and 5.6-2, as appropriate.

   2) The arrangement of Region 1 sub-arrays must not allow a configuration with fresh assemblies adjacent to each other.

   3) If Region 1 arrays are used in conjunction with Region 2 or Region 3 arrangements (see below), the arrangements shall not allow fresh fuel assemblies to be adjacent to each other (see also Figure 5.6-1).

*For some accident conditions, the presence of dissolved boron in the pool water may be taken into account by applying the double contingency principle which requires two unlikely, independent, concurrent events to produce a criticality accident.

5.6 FUEL STORAGE

2. Region 2 is designed to accommodate fuel of 4.95±0.05 wt% U-235 initial enrichment burned to at least 30.27 MWD/KgU (assembly average), or fuel of other enrichment with a burnup yielding an equivalent reactivity in the fuel racks. The minimum required assembly average burnup in MWD/KgU and cooling time is given by the equations in Table 5.6-3 in terms of E, where E is the initial enrichment in the axial zone of highest enrichment (wt% U-235). The minimum required burnups are illustrated in Figure 5.6-3 in terms of the initial enrichment and cooling time.

Restrictions in Region 2

The following restrictions apply to the storage of spent fuel in the Region 2 cells:

1) The spent fuel shall conform to the minimum burnup requirements defined by the equations in Table 5.6-3. Linear interpolation between cooling times may be made if desired.

2) For the interface with Region 1 storage cells, fresh fuel in Region 1 shall not be stored adjacent to spent fuel assemblies in the Region 2 storage cells.

3. Region 3 is designed to accommodate fuel of 4.95±0.05 wt% U-235 initial enrichment (or fuel assemblies of any lower reactivity) in a 2-out-of-4 checkerboard arrangement with water-filled cells. The water-filled cells shall not contain any components bearing any fissile material, but may accommodate miscellaneous items or equipment.

Restrictions in Region 3

1) For the interface between Region 1 and Region 3 storage regions, fresh fuel assemblies shall not be stored adjacent to each other.

2) If miscellaneous items or equipment are stored in the water cells of Region 3, the total volume of the miscellaneous items shall be no more than 75% of the storage cell volume.

3) No fuel rods, assemblies, or items containing fissile material shall be stored in the water cells of Region 3.

An empty cell is less reactive than any cell containing fuel and therefore may be used as a Region 1, Region 2, or Region 3 cell in any arrangement.

d. Region 2 array described above may be used in the 15 x 15 storage rack module in the cask loading area of the cask pit.

e. A nominal concentration of 2000 ppm boron in the pool water. This concentration of soluble boron provides a margin sufficient to allow timely detection of a boron dilution accident and corrective action before the minimum concentration (700 ppm) required to protect against the most severe postulated fuel handling accident or before the minimum concentration (300 ppm) required to maintain the storage configuration design basis (k_{eff} less than 0.95) is reached.

5.6 FUEL STORAGE

CRITICALITY - NEW FUEL

5.6.1.2 The new fuel pit storage racks are designed for fuel enriched to 5.0 weight percent U-235 and shall be maintained with the arrangement of 146 storage locations shown in Figure 5.6-4. The cells shown as empty cells in Figure 5.6-4 shall have physical barriers installed to ensure that inadvertant loading of fuel assemblies into these locations does not occur. This configuration ensures k_{eff} will remain less than or equal to 0.95 when flooded with unborated water and less than or equal to 0.98 under optimum moderation conditions.

DRAINAGE

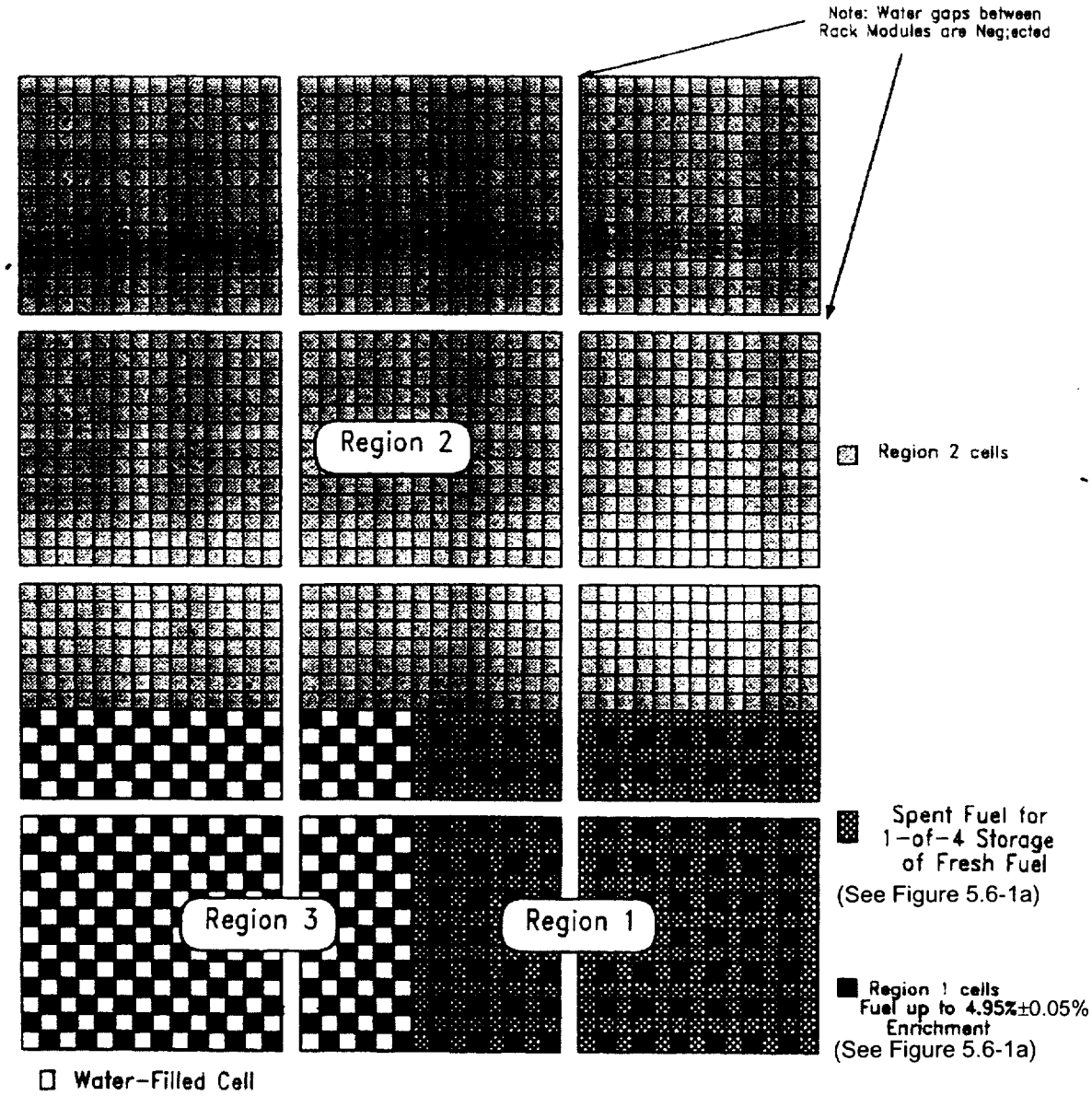
5.6.2 The spent fuel pit is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 722 ft.

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 2091 fuel assemblies. In addition, no more than 225 fuel assemblies will be stored in a rack module in the cask loading area of the cask pit.

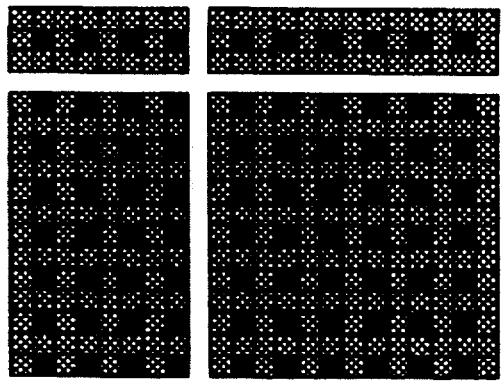
5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.



Note: The edges of the sketch above are not necessarily the edges of the pool. The Regions may appear anywhere in the pool and in any orientation, subject to the restriction in Design Feature 5.6.1.1.c.

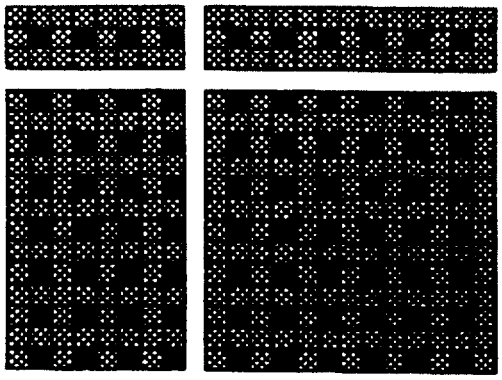
Figure 5.6-1
Arrangements of Fuel Storage Regions in the Sequoyah Spent Fuel Storage Pool



Spent Fuel for Region 1 Storage 1-of-4 Pattern

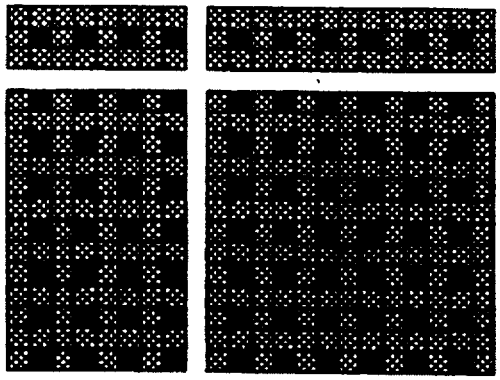
Fresh Fuel for Region 1 cells No Gd or IFBA

NOTE: WHEN CREDIT IS TAKEN FOR GADOLINIA OR IFBA RODS IN FRESH ASSEMBLIES THE SPENT FUEL ASSEMBLIES NEED NOT HAVE CONTAINED GADOLINIA OR IFBA RODS..



Spent Fuel for Region 1 Storage 1-of-4 Pattern

Fresh Fuel for Region 1 cells With Gadolinia



Spent Fuel for Region 1 Storage 1-of-4 Pattern

Fresh Fuel for Region 1 cells with IFBA Rods

Figure 5.6-1a
Acceptable Spent Fuel Pool Loading Patterns for Checkerboard Storage of Fresh and Spent Fuel Assemblies - Example

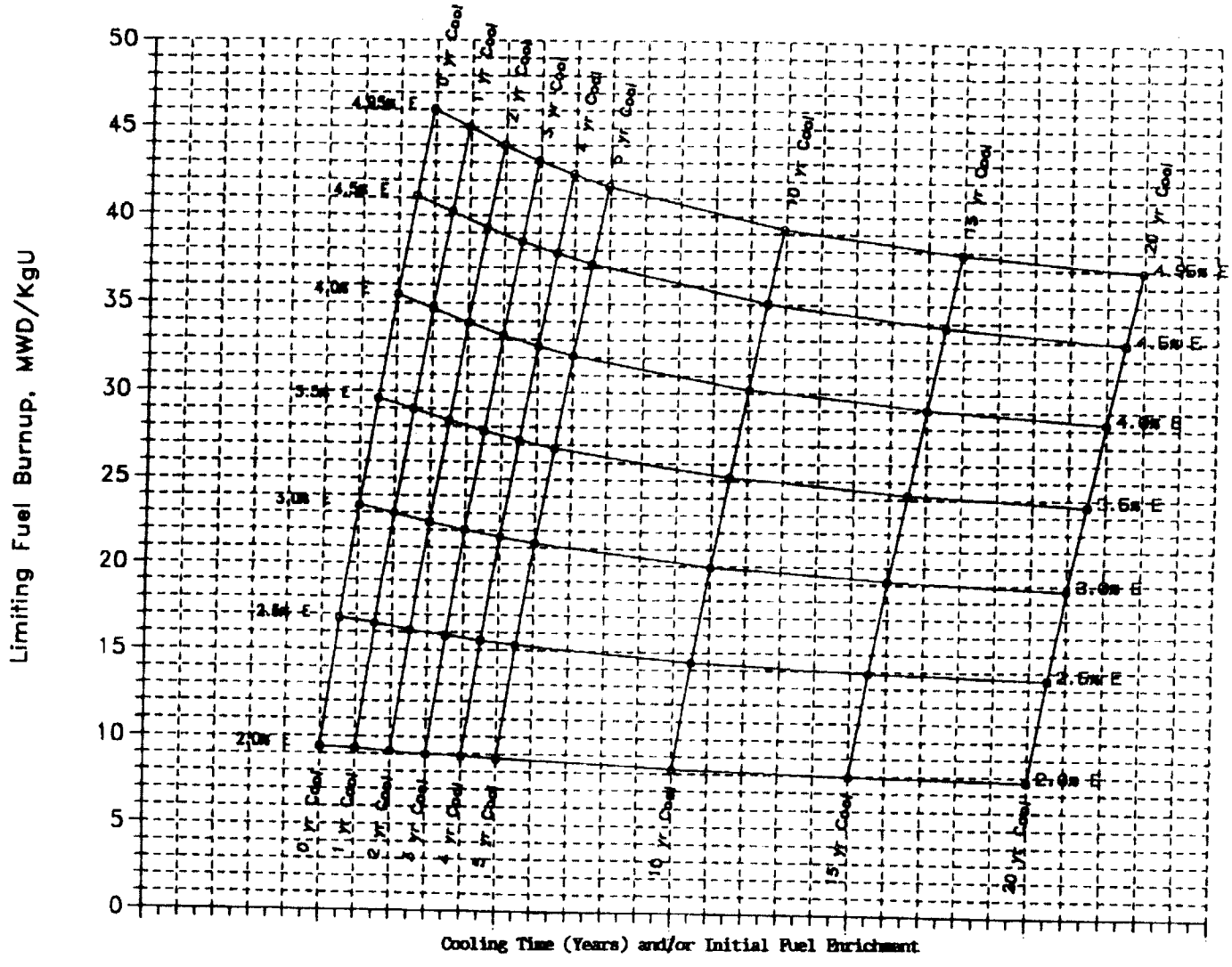


Fig. 5.6-2 3-Dimensional Plot of Minimum Fuel Burnups in Region 1 for Enrichments and/or Cooling Times

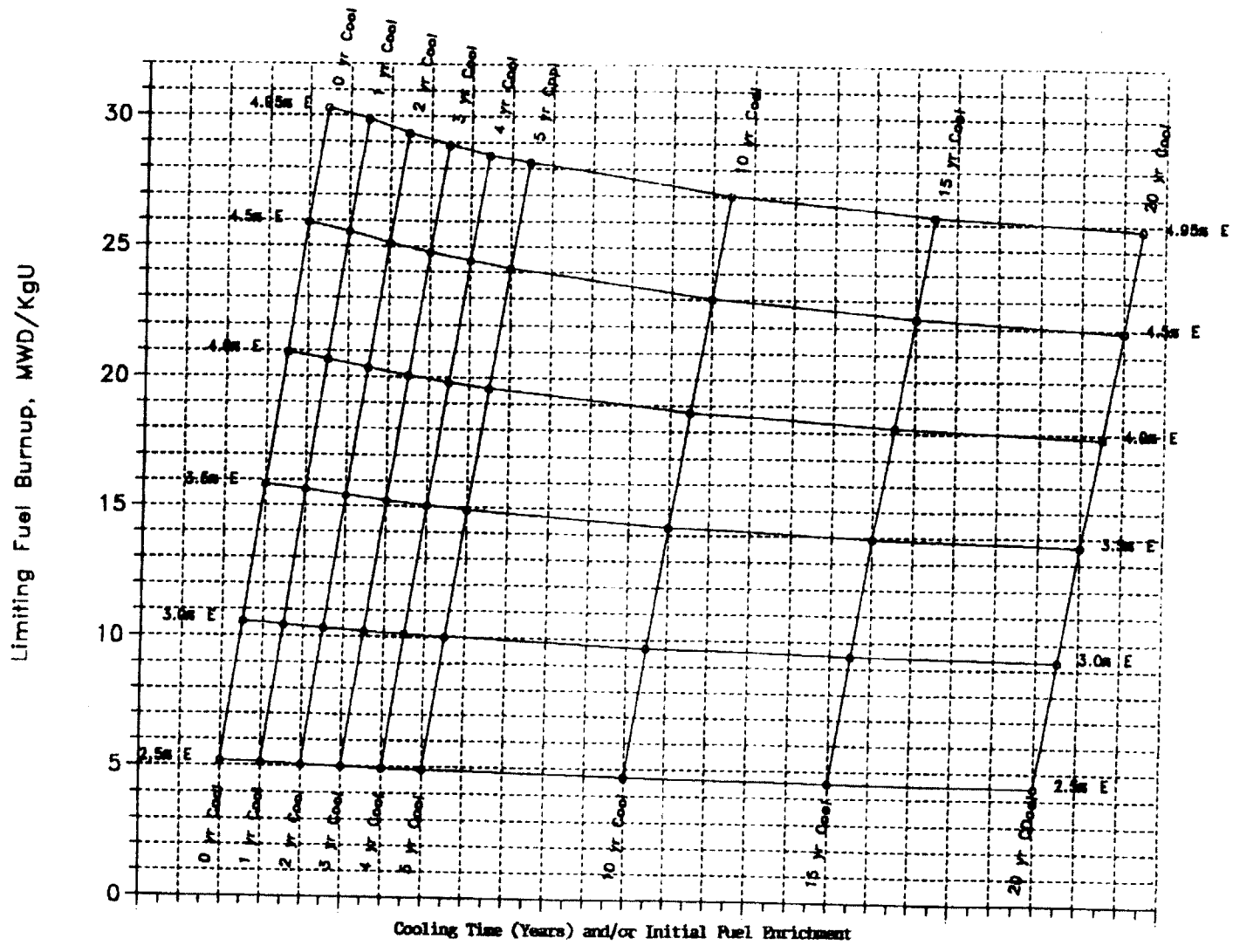
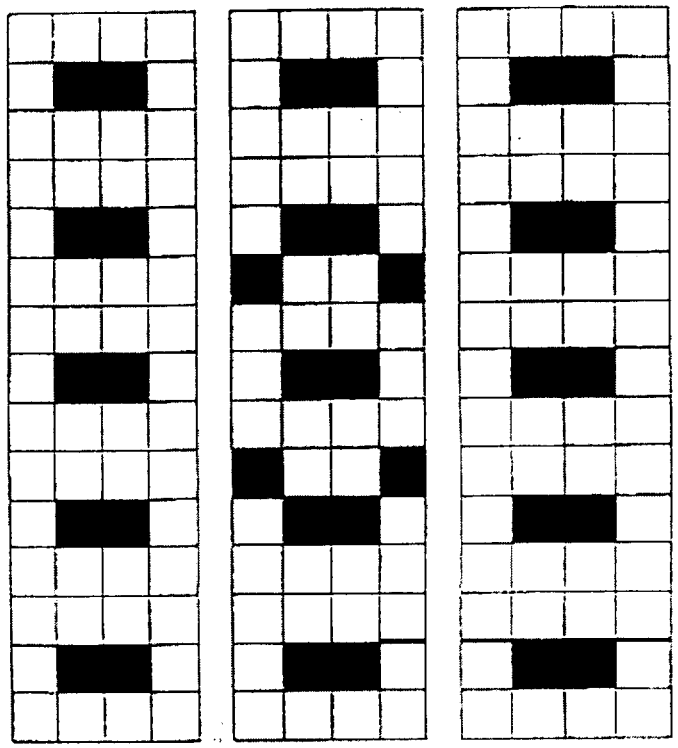


Fig. 5.6-3 3- Dimensional Plot of Minimum Fuel Burnups in Region 2 for Enrichments and Cooling Times



Basic Cell 21 inch X 21 inch

Empty Cell

9 - 4 X 5 Cell Racks

146 / 180 Loading Pattern

Figure 5.6-4
New Fuel Pit Storage Rack Loading Pattern

Table 5.6-1
Region 1 Storage Burnup Restrictions: Checkerboard of 1
Fresh Fuel Assembly and 3 Spent Fuel Assemblies (Without Gadolinium or IFBA Rods)

For Zero Year Cooling Time Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
For One Year Cooling Time Bu (limit) = - 27.3317 + 22.5087 x E – 2.40586 x E^2 + 0.164207 x E^3
For Two Years Cooling Time Bu (limit) = -26.4693 + 21.8404 x E – 2.31873 x E^2 + 0.158218 x E^3
For Three Years Cooling Time Bu (limit) = -25.7404 + 21.2659 x E – 2.24287 x E^2 + 0.153018 x E^3
For Four Years Cooling Time Bu (limit) = - 25.1367 + 20.7910 x E –2.18484 x E^2 + 0.1499363 x E^3
For Five Years Cooling Time Bu (limit) = - 24.5981 + 20.3568 x E – 2.12719 x E^2 + 0.145431 x E^3
For Ten Years Cooling Time Bu (limit) = - 23.2050 + 19.2969 x E – 2.06993 x E^2 + 0.145875 x E^3
For Fifteen Years Cooling Time Bu (limit) = -22.6098 + 18.8544 x E – 2.08617 x E^2 + 0.150473 x E^3
For Twenty Years Cooling Time Bu (limit) = - 22.3017 + 18.622 x E – 2.11206 x E^2 + 0.15467 x E^3

Table 5.6-2

Region 1 Storage Burnup Restrictions with Gadolinium or IFBA

With Gadolinium Credit: Checkerboard of 1 Fresh Fuel Assembly with 3 Spent Fuel Assemblies

Zero Year Cooling Time, 0 Gadolinia Rods Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
Zero Year Cooling Time, 4 Gadolinia Rods Bu (limit) = - 28.4012 + 22.0062 x E – 2.19268 x E^2 + 0.143601 x E^3
Zero Year Cooling Time, 8 Gadolinia Rods Bu (limit) = - 31.4262 + 22.0768 x E – 2.38845 x E^2 + 0.164888 x E^3

Note: If more that 8 Gadolinium rods per assembly, use the 8 rod correlation

With IFBA Credit: Checkerboard of 1 Fresh Fuel Assembly with 3 Spent Fuel Assemblies

Zero Year Cooling Time, 0 IFBA Rods Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
Zero Year Cooling Time, 16 IFBA Rods Bu (limit) = - 28.5048 + 21.6411 x E – 2.15262 x E^2 + 0.140904 x E^3
Zero Year Cooling Time, 32 IFBA Rods Bu (limit) = - 31.0949 + 22.0435 x E – 2.36088 x E^2 + 0.162229 x E^3
Zero Year Cooling Time, 48 IFBA Rods Bu (limit) = - 33.1342 + 22.3999 x E – 2.55367 x E^2 + 0.18082 x E^3
Zero Year Cooling Time, 64 IFBA Rods Bu (limit) = - 36.0468 + 24.1492 x E – 3.11807 x E^2 + 0.233987 x E^3

Note: If more that 64 IFBA rods per assembly, use the correlation for 64 IFBA rods

Table 5.6-3

Region 2 Storage Burnup Restrictions

Zero Cooling Time Bu (limit) = - 23.8702 + 12.3026 x E - 0.275672 x E^2
1 Year Cooling Time Bu (limit) = - 23.6854 + 12.2384 x E - 0.287498 x E^2
2 Years Cooling Time Bu (limit) = - 23.499 + 12.1873 x E - 0.305988 x E^2
3 Years Cooling Time Bu (limit) = - 23.3124 + 12.1249 x E - 0.319566 x E^2
4 Years Cooling Time Bu (limit) = - 23.1589 + 12.0748 x E - 0.332212 x E^2
5 Years Cooling Time Bu (limit) = - 22.6375 + 11.7906 x E - 0.307623 x E^2
10 Years Cooling Time Bu (limit) = - 21.7256 + 11.3660 x E – 0.31029 x E^2
15 Years Cooling Time Bu (limit) = - 21.1160 + 11.0663 x E - 0.306231 x E^2
20 Years Cooling Time Bu (limit) = - 20.6055 + 10.7906 x E - 0.29291 x E^2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-328

SEQUOYAH NUCLEAR PLANT, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 256
License No. DPR-79

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Tennessee Valley Authority (the licensee) dated August 31, 2000, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Facility Operating License No. DPR-79 is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendices A and B, as revised through Amendment No. 256 , are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance and shall be implemented within 45 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Richard P. Correia, Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: December 19, 2000

ATTACHMENT TO LICENSE AMENDMENT NO. 256

FACILITY OPERATING LICENSE NO. DPR-79

DOCKET NO. 50-328

Replace the following pages of the Appendix A Technical Specifications with the attached pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
Index Page IX	Index Page IX
Index Page XIV	Index Page XIV
--	3/4 7-53 (new page)
--	3/4 7-54 (new page)
3/4 9-2	3/4 9-2
--	B 3/4 7-9 (new page)
--	B 3/4 7-10 (new page)
--	B 3/4 7-11 (new page)
--	B 3/4 7-12 (new page)
--	B 3/4 7-13 (new page)
--	B 3/4 7-14 (new page)
--	B 3/4 7-15 (new page)
5-5	5-5
5-5a	5-5a
5-5b	5-5b
5-5c	5-5c (Figure 5.6-1)
5-5d	5-5d (Figure 5.6-1a)
5-5e	5-5e (Figure 5.6-2)
5-5f	5-5f (Figure 5.6-3)
--	5-5g (Figure 5.6-4)
--	5-5h (new Table 5.6-1)
--	5-5i (new Table 5.6-2)
--	5-5j (new Table 5.6-3)

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SURVEILLANCE REQUIREMENTS (Continued)

4.9.1.2 The boron concentration of the reactor coolant system and the refueling canal shall be determined by chemical analysis at least once per 72 hours.

4.9.1.3 One of the following valve combinations shall be verified closed under administrative control at least once per 72 hours:

Combination A	Combination B	Combination C	Combination D
a. 2-81-536	a. 2-81-536	a. 2-81-536	a. 2-81-536
b. 2-62-922	b. 2-62-922	b. 2-62-907	b. 2-62-907
c. 2-62-916	c. 2-62-916	c. 2-62-914	c. 2-62-914
d. 2-62-933	d. 2-62-940	d. 2-62-921	d. 2-62-921
	e. 2-62-696	e. 2-62-933	e. 2-62-940
	f. 2-62-929		f. 2-62-929
	g. 2-62-932		g. 2-62-932
	h. 2-FCV-62-128		h. 2-62-696
			i. 2-FCV-62-128

3/4.7.13 SPENT FUEL POOL MINIMUM BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.7.13 The spent fuel pool boron concentration shall be ≥ 2000 ppm.

APPLICABILITY: Whenever fuel assemblies are stored in the spent fuel storage racks.

ACTION:

With the requirements of the specification not satisfied, suspend all movement of fuel assemblies and initiate action to restore spent fuel storage pool boron concentration to within limit. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.7.13.1 Verify at least once per 7 days the spent fuel pool boron concentration is within limit.

4.7.13.2 Verify at least once per 72 hours during fuel movement the spent fuel pool boron concentration is within limit and until the configuration of the assemblies in the storage rack is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.c.

3/4.7.14 CASK PIT POOL MINIMUM BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.7.14 The cask pit pool boron concentration shall be ≥ 2000 ppm.

APPLICABILITY: Whenever fuel assemblies are stored in the cask pit rack.

ACTION:

With the requirements of the specification not satisfied, suspend all movement of fuel assemblies and initiate action to restore cask pit pool boron concentration to within limit. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS

4.7.14.1 Verify at least once per 7 days the cask pit pool boron concentration is within limit.

4.7.14.2 Verify at least once per 72 hours during fuel movement the cask pit pool boron concentration is within limit and until the configuration of the assemblies in the storage rack is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.d.

PLANT SYSTEMS

BASES

3/4.7.13 SPENT FUEL POOL MINIMUM BORON CONCENTRATION

BACKGROUND

The spent fuel racks have been analyzed in accordance with the Holtec International methodology contained in Holtec Report HI - 992349 (Ref. 1). This methodology ensures that the spent fuel rack multiplication factor, k_{eff} is less than or equal to 0.95, as recommended by the NRC guidance contained in NRC Letter to All Power Reactor Licensees from B.K. Grimes, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", April 14, 1978 and USNRC Internal Memorandum from L. Kopp, "Guidance On The Regulatory Requirements For Criticality Analysis Of Fuel Storage At Light-Water Reactor Power Plants", August 19, 1998 (Refs. 2 & 3). The codes, methods, and techniques contained in the methodology are used to satisfy the k_{eff} criterion. The spent fuel storage racks were analyzed using Westinghouse 17x17 V5H fuel assemblies, with enrichments up to 4.95 ±0.05 w/o U-235 and configurations which take credit for checkerboarding, burnup, soluble boron, integral fuel burnable absorbers (such as IFBA or gadolinia), and cooling time to ensure that k_{eff} is maintained ≤ 0.95, including uncertainties, tolerances, and accident conditions. In addition, the SFP k_{eff} is maintained < 1.0, including uncertainties, tolerances on a 95/95 basis without any soluble boron. Calculations were performed to evaluate the reactivity of fuel types used at SQN. The results show that the Westinghouse 17x17 V5H fuel assembly exhibits the highest reactivity, thereby bounding all fuel types utilized and stored at SQN.

In the high density Spent Fuel Storage Rack design (Refs. 1 and 4), the spent fuel storage pool is divided into three separate and distinct regions which, for the purpose of criticality considerations, are considered as separate pools. Region 1 is designed to accommodate new fuel with a maximum enrichment of 4.95 ± 0.05 wt% U-235, or spent fuel regardless of the discharge fuel burnup in a 1-in-4 checkerboard arrangement of 1 fresh assembly with 3 spent fuel assemblies with enrichment, burnup and cooling times in accordance with Design Features 5.6.1.1.c.1. Region 2 is designed to accommodate fuel which have 4.95 ± 0.05 wt% U-235 initial enrichment burned to at least 30.27 MWD/KgU (assembly average), or fuel of other enrichment with a burnup yielding an equivalent reactivity in the fuel racks in accordance with Design Features 5.6.1.1.c.2. Region 3 is designed to accommodate fuel of 4.95 ± 0.05 wt% U-235 initial enrichment or fuel assemblies of any lower reactivity in a 2-out-of-4 checkerboard arrangement with water-filled cells and in accordance with Design Features 5.6.1.1.c.3.

The water in the spent fuel storage pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of < 1.0 be evaluated in the absence of soluble boron. Hence, the design of all regions is based on the use of unborated water, which maintains each region in a subcritical condition during normal operation with the regions fully loaded. The double

(continued)

PLANT SYSTEMS

BASES

BACKGROUND (continued)

contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 5) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the accidental mishandling of a fresh fuel assembly face adjacent to a fresh fuel assembly of Region 3. This could potentially increase the criticality of Region 3. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. The soluble boron concentration required to maintain $k_{eff} \leq 0.95$ under normal conditions is 300 ppm and 700 ppm under the most severe postulated fuel mis-location accident. Safe operation of the spent fuel storage racks may therefore be achieved by controlling the location of each assembly in accordance with Design Features 5.6 FUEL STORAGE. During fuel movement, it is necessary to perform Surveillance Requirement 4.7.13.2.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of any one of the three regions. Examples of these accident conditions are the loss of cooling and the dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble boron in the storage pool prevents criticality in all regions. The most limiting postulated accident with respect to the storage configurations assumed in the spent fuel rack criticality analysis is the misplacement of a nominal 4.95 ± 0.05 w/o U-235 fuel assembly into an empty storage cell location in the Region 3 checkerboard storage arrangement. The amount of soluble boron required to maintain k_{eff} less than or equal to 0.95 due to this fuel misload accident is 700 ppm (Ref. 1).

A spent fuel boron dilution analysis was performed to ensure that sufficient time is available to detect and mitigate dilution of the spent fuel pool prior to exceeding the k_{eff} design basis limit of 0.95 (Ref. 6). The spent fuel pool boron dilution analysis concluded that an inadvertent or unplanned event that would result in a dilution of the spent fuel pool boron concentration from 2000 ppm to 700 ppm is not a credible event.

The concentration of dissolved boron in the spent fuel storage pool satisfies Criterion 2 of the NRC Policy Statement.

LCO

The spent fuel storage pool boron concentration is required to be $\geq$ 2000 ppm. The specified concentration of dissolved boron in the spent fuel storage pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 7. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel storage pool.

(continued)

PLANT SYSTEMS

BASES (continued)

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel storage pool.

ACTIONS

Action a:

When the concentration of boron in the spent fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored along with suspending movement of fuel assemblies.

Action a is modified by a provision indicating that LCO 3.0.3 does not apply. If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. Moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4 is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

Surveillance 4.7.13.1

This Surveillance Requirement verifies that the concentration of boron in the spent fuel storage pool is within the required limit. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no significant replenishment of pool water is expected to take place over such a short period of time. (Ref. 6)

Surveillance 4.7.13.2

This Surveillance Requirement verifies that the concentration of boron in the spent fuel storage pool is within the required limit during fuel movement until the final configuration of the assemblies in the storage racks is verified to be correct. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 72 hour Frequency provides additional assurance that the maximum k_{eff} remains below the 0.95 limit under the postulated accident condition. (Ref. 8)

(continued)

PLANT SYSTEMS

BASES (continued)

REFERENCES

1. Stanley E. Turner (Holtec International), "Criticality Safety Analyses of Sequoyah Spent Fuel Racks with Alternative Arrangements," HI-992349

2. B. K. Grimes (NRC GL78011), "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", April 14, 1978

3. L. Kopp, "Guidance On The Regulatory Requirements For Criticality Analysis Of Fuel Storage At Light-Water Reactor Power Plants", August 19, 1998

4. UFSAR, Section 4.3.2.7, "Critically of Fuel Assemblies"

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

6. K. K. Niyogi (Holtec International), "Boron Dilution Analysis," HI-992302

7. FSAR, Section 15.4.5

8. NRC letter to TVA dated August 1, 1990, " Increase Fuel Enrichment to 5.0 Weight Percent (TAC Nos. 76074, 76075, 76774, 76775) (TS 90-12) - Sequoyah Nuclear Plant, Units 1 and 2"

PLANT SYSTEMS

BASES

3/4.7.14 CASK PIT POOL MINIMUM BORON CONCENTRATION

BACKGROUND

The Sequoyah cask pit pool consists of a deep pool with adjacent shelf area. The cask pit pool is connected to the spent fuel pool through a weir gate. The cask pit is intended to be used for spent fuel shipment activities.

High density spent fuel storage racks have been approved for addition and use in the cask loading area of the cask pit (Ref. 1) but presently are not installed. The 15 x 15 module could store 225 fuel assemblies and is designed to maintain stored fuel having an initial enrichment of up to 5 wt % U-235, in a safe, coolable, and sub-critical configuration during normal discharge, full core offload storages and postulated accident conditions. Fuel assemblies shall be stored in accordance with paragraph 5.6.1.1.d in Design Features 5.6, Fuel Storage.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of the cask pit. Examples of accident conditions are the loss of cooling and the dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble boron in the cask pit pool prevents criticality. The most limiting postulated accident bounding the cask pit pool has been determined to occur in the spent fuel pool. The postulated accident with respect to the storage configurations assumed in the spent fuel rack criticality analysis is the misplacement of a nominal 4.95 ± 0.05 w/o U-235 fuel assembly into an storage cell location in the Region 2 checkerboard storage arrangement for an irradiated fuel assembly. The amount of soluble boron required to maintain k_{eff} less than or equal to 0.95 due to this fuel misload accident is 700 ppm (Ref. 2).

The concentration of dissolved boron in the fuel storage pool satisfies Criterion 2 of the NRC Policy Statement.

LCO

The cask pit pool boron concentration is required to be ≥ 2000 ppm. The specified concentration of dissolved boron in the cask pit pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 3. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the cask pit pool.

(continued)

PLANT SYSTEMS

BASES (continued)

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the cask pit pool.

ACTIONS

Action a:

When the concentration of boron in the cask pit pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored along with suspending movement of fuel assemblies.

Action a is modified by a provision indicating that LCO 3.0.3 does not apply. If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. Moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4 is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

Surveillance 4.7.14.1

This Surveillance Requirement verifies that the concentration of boron in the cask pit pool is within the required limit. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no significant replenishment of pool water is expected to take place over such a short period of time. (Ref. 4)

Surveillance 4.7.14.2

This Surveillance Requirement verifies that the concentration of boron in the cask pit pool is within the required limit during fuel movement until the final configuration of the assemblies in the storage racks is verified to be correct. As long as this Surveillance Requirement is met, the analyzed accidents are fully addressed. The 72 hour Frequency provides additional assurance that the maximum k_{eff} remains below the 0.95 limit under the postulated accident condition. (Ref. 1)

(continued)

PLANT SYSTEMS

BASES (continued)

REFERENCES

NRC letter to TVA dated April 28, 1993, "Issuance of Amendments (TAC Nos. M83068 and M83069)"

Stanley E. Turner (Holtec International), "Criticality Safety Analyses of Sequoyah Spent Fuel Racks with Alternative Arrangements," HI-992349

FSAR, Section 15.4.5

K. K. Niyogi (Holtec International), "Boron Dilution Analysis," HI-992302

5.6 FUEL STORAGE

CRITICALITY - SPENT FUEL

5.6.1.1 The spent fuel storage racks are designed for fuel enriched to 5 weight percent U-235 and shall be maintained with:

a. A k_{eff} less than critical when flooded with unborated water and a k_{eff} less than or equal to 0.95 when flooded with water containing 300 ppm soluble boron.*

b. A nominal 8.972 inch center-to-center distance between fuel assemblies placed in the storage racks.

c. Arrangements of one or more of three different arrays (Regions) or sub-arrays as illustrated in Figures 5.6-1 and 5.6-1a. These arrangements in the spent fuel storage pool have the following definitions:

1. Region 1 is designed to accommodate new fuel with a maximum enrichment of 4.95 ± 0.05 wt% U-235, (or spent fuel regardless of the fuel burnup), in a 1-in-4 checkerboard arrangement of 1 fresh assembly with 3 spent fuel assemblies with enrichment-burnup and cooling times illustrated in Figure 5.6-2 and defined by the equations in Table 5.6-1. Cooling time is defined as the period since reactor shutdown at the end of the last operating cycle for the discharged spent fuel assembly. The presence of a removable, non-fissile insert such as a burnable poison rod assembly (BPRA) or either gadolinia or integral fuel burnable absorber (IFBA) in a fresh fuel assembly does not affect the applicability of Figure 5.6-2 or Table 5.6-1.

   Two alternative storage arrays (or sub-arrays) are acceptable in Region 1 if the fresh fuel assemblies contain rods with either gadolinia or integral fuel burnable absorber (IFBA). For these types of assemblies, the minimum burnup of the spent fuel in the 1-of-4 sub-array are defined by the equations in Table 5.6-2.

   Restrictions in Region 1

   Any of the three sub-arrays illustrated in Figure 5.6-1a may be used in any combination provided that:

   1) Each sub-array of 4 fuel assemblies includes, in addition to the fresh fuel assembly, 3 assemblies with enrichment and minimum burnup requirements defined by the equations in Tables 5.6-1 and 5.6-2, as appropriate.

   2) The arrangement of Region 1 sub-arrays must not allow a configuration with fresh assemblies adjacent to each other.

   3) If Region 1 arrays are used in conjunction with Region 2 or Region 3 arrangements (see below), the arrangements shall not allow fresh fuel assemblies to be adjacent to each other (see also Figure 5.6-1).

*For some accident conditions, the presence of dissolved boron in the pool water may be taken into account by applying the double contingency principle which requires two unlikely, independent, concurrent events to produce a criticality accident.

5.6 FUEL STORAGE

2. Region 2 is designed to accommodate fuel of 4.95±0.05 wt% U-235 initial enrichment burned to at least 30.27 MWD/KgU (assembly average), or fuel of other enrichments with a burnup yielding an equivalent reactivity in the fuel racks. The minimum required assembly average burnup in MWD/KgU and cooling time is given by the equations in Table 5.6-3 in terms of E, where E is the initial enrichment in the axial zone of highest enrichment (wt% U-235). The minimum required burnups are illustrated in Figure 5.6-3 in terms of the initial enrichment and cooling time.

Restrictions in Region 2

The following restrictions apply to the storage of spent fuel in the Region 2 cells:

1) The spent fuel shall conform to the minimum burnup requirements defined by the equations in Table 5.6-3. Linear interpolation between cooling times may be made if desired.

2) For the interface with Region 1 storage cells, fresh fuel in Region 1 shall not be stored adjacent to spent fuel assemblies in the Region 2 storage cells.

3. Region 3 is designed to accommodate fuel of 4.95±0.05 wt% U-235 initial enrichment (or fuel assemblies of any lower reactivity) in a 2-out-of-4 checkerboard arrangement with water-filled cells. The water-filled cells shall not contain any components bearing any fissile material, but may accommodate miscellaneous items or equipment.

Restrictions in Region 3

1) For the interface between Region 1 and Region 3 storage regions, fresh fuel assemblies shall not be stored adjacent to each other.

2) If miscellaneous items or equipment are stored in the water cells of Region 3, the total volume of the miscellaneous items shall be no more than 75% of the storage cell volume.

3) No fuel rods, assemblies, or items containing fissile material shall be stored in the water cells of Region 3.

An empty cell is less reactive than any cell containing fuel and therefore may be used as a Region 1, Region 2, or Region 3 cell in any arrangement.

d. Region 2 array described above may be used in the 15 x 15 storage rack module in the cask loading area of the cask pit.

e. A nominal concentration of 2000 ppm boron in the pool water. This concentration of soluble boron provides a margin sufficient to allow timely detection of a boron dilution accident and corrective action before the minimum concentration (700 ppm) required to protect against the most severe postulated fuel handling accident or before the minimum concentration (300 ppm) required to maintain the storage configuration design basis (k_{eff} less than 0.95) is reached.

5.6 FUEL STORAGE

CRITICALITY - NEW FUEL

5.6.1.2 The new fuel pit storage racks are designed for fuel enriched to 5.0 weight percent U-235 and shall be maintained with the arrangement of 146 storage locations shown in Figure 5.6-4. The cells shown as empty cells in Figure 5.6-4 shall have physical barriers installed to ensure that inadvertant loading of fuel assemblies into these locations does not occur. This configuration ensures k_{eff} will remain less than or equal to 0.95 when flooded with unborated water and less than or equal to 0.98 under optimum moderation conditions.

DRAINAGE

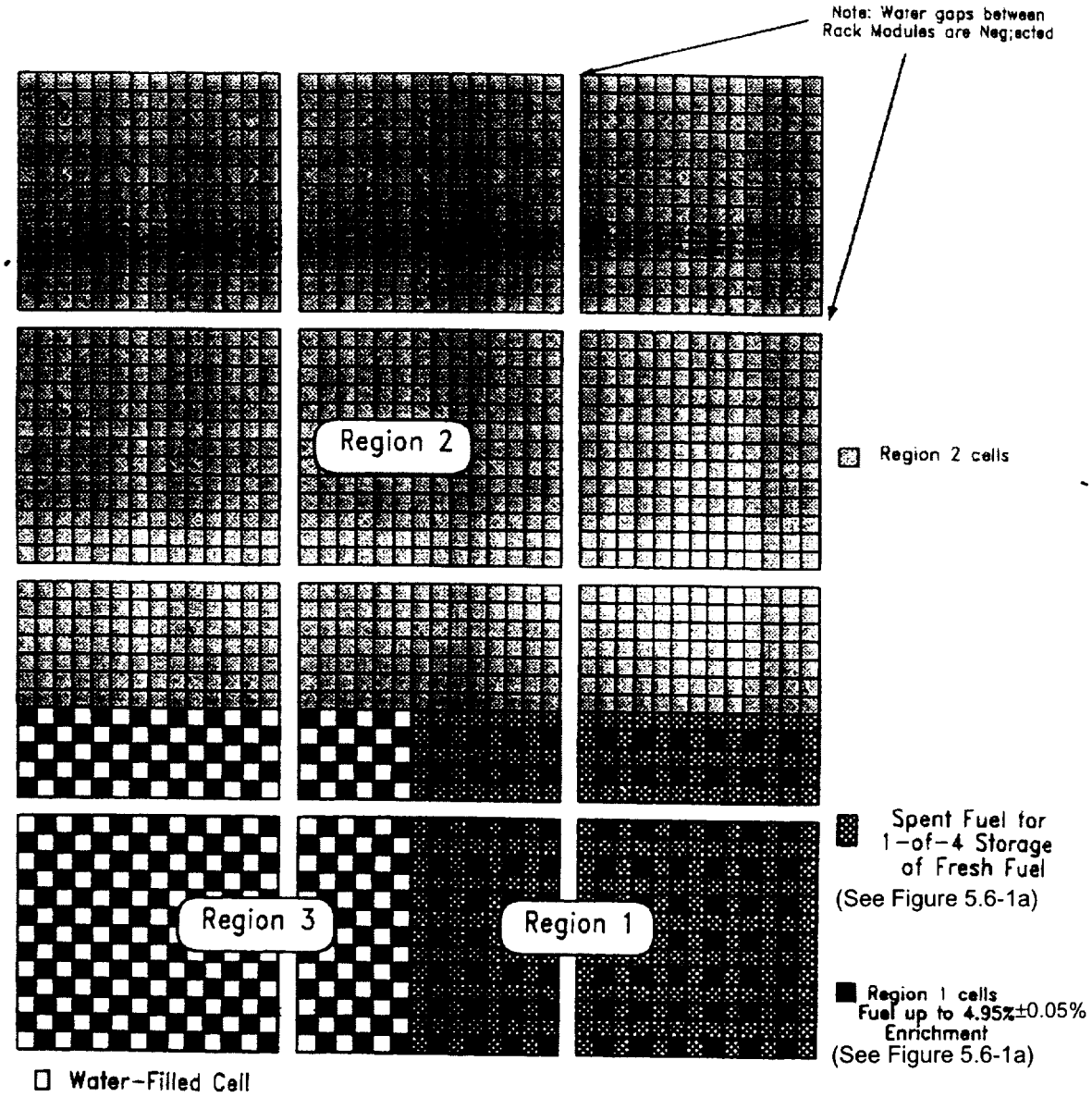
5.6.2 The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 722 ft.

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 2091 fuel assemblies. In addition, no more than 225 fuel assemblies will be stored in a rack module in the cask loading area of the cask pit.

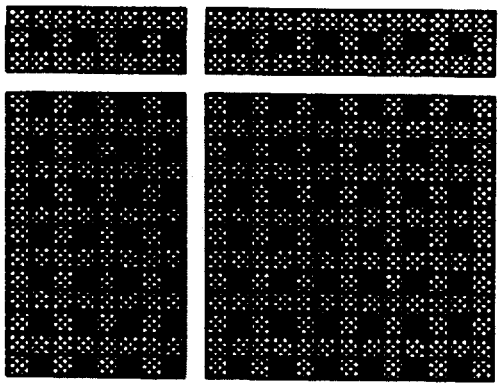
5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.



Note: The edges of the sketch above are not necessarily the edges of the pool. The Regions may appear anywhere in the pool and in any orientation, subject to the restriction in Design Feature 5.6.1.1.c.

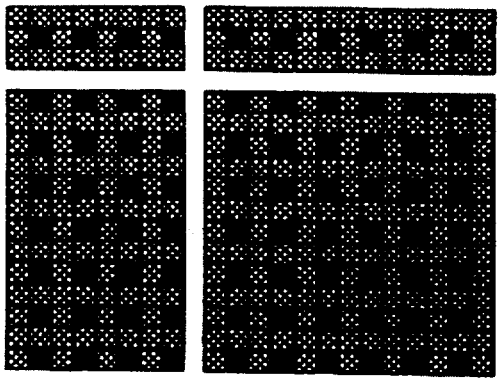
Figure. 5.6-1
Arrangements of Fuel Storage Regions in the Sequoyah Spent Fuel Storage Pool



Spent Fuel for Region 1 Storage 1-of-4 Pattern

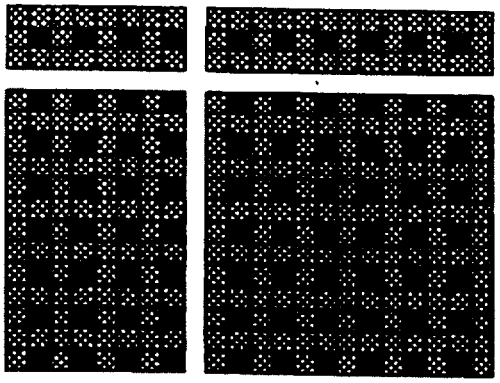
Fresh Fuel for Region 1 cells No Gd or IFBA

NOTE: WHEN CREDIT IS TAKEN FOR GADOLINIA OR IFBA RODS IN FRESH ASSEMBLIES THE SPENT FUEL ASSEMBLIES NEED NOT HAVE CONTAINED GADOLINIA OR IFBA RODS..



Spent Fuel for Region 1 Storage 1-of-4 Pattern

Fresh Fuel for Region 1 cells With Gadolinia



Spent Fuel for Region 1 Storage 1-of-4 Pattern

Fresh Fuel for Region 1 cells with IFBA Rods

Figure 5.6-1a

Acceptable Spent Fuel Pool Loading Patterns for Checkerboard Storage of Fresh and Spent Fuel Assemblies - Example

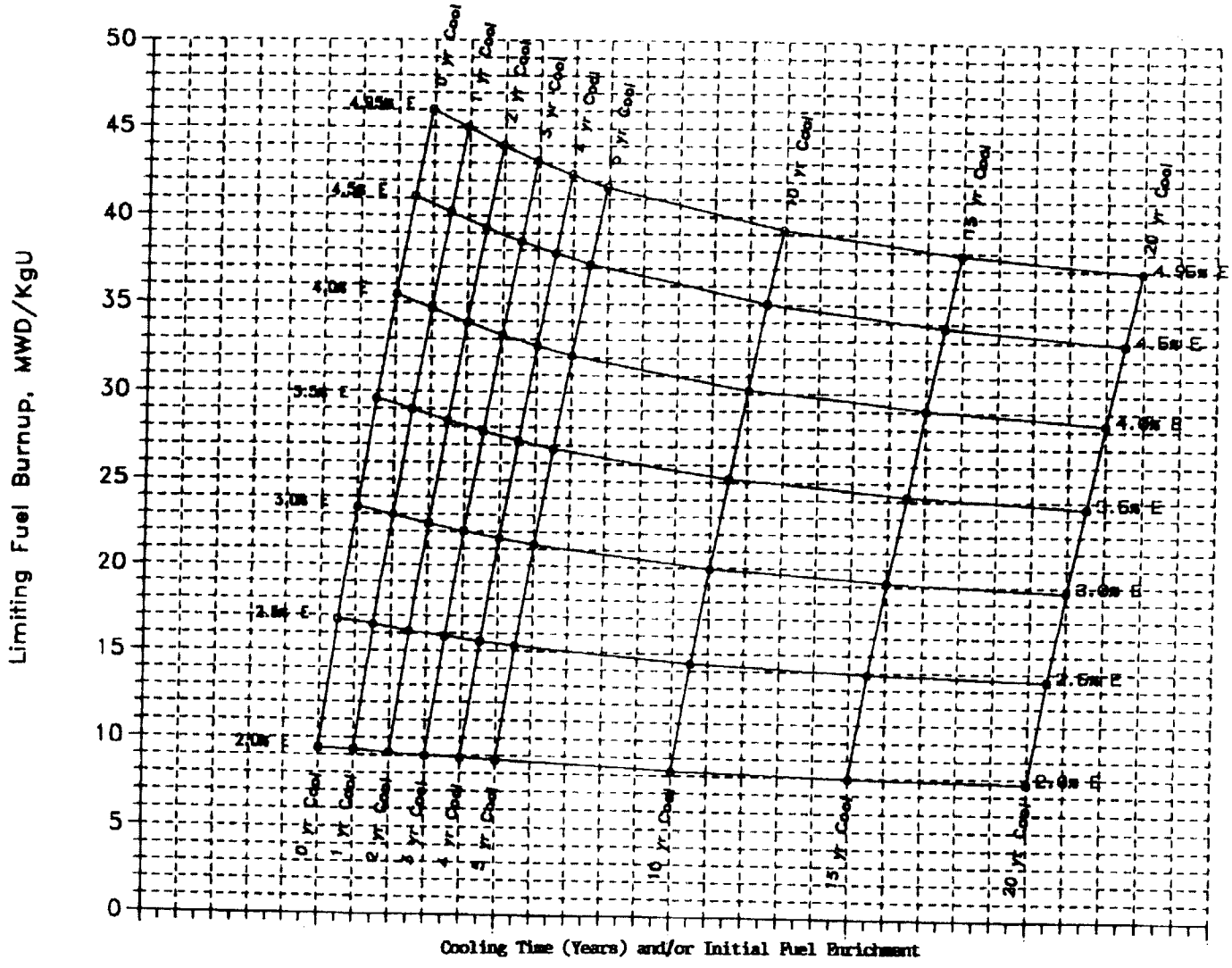


Fig. 5.6-2 3-Dimensional Plot of Minimum Fuel Burnups in Region 1 for Enrichments and/or Cooling Times

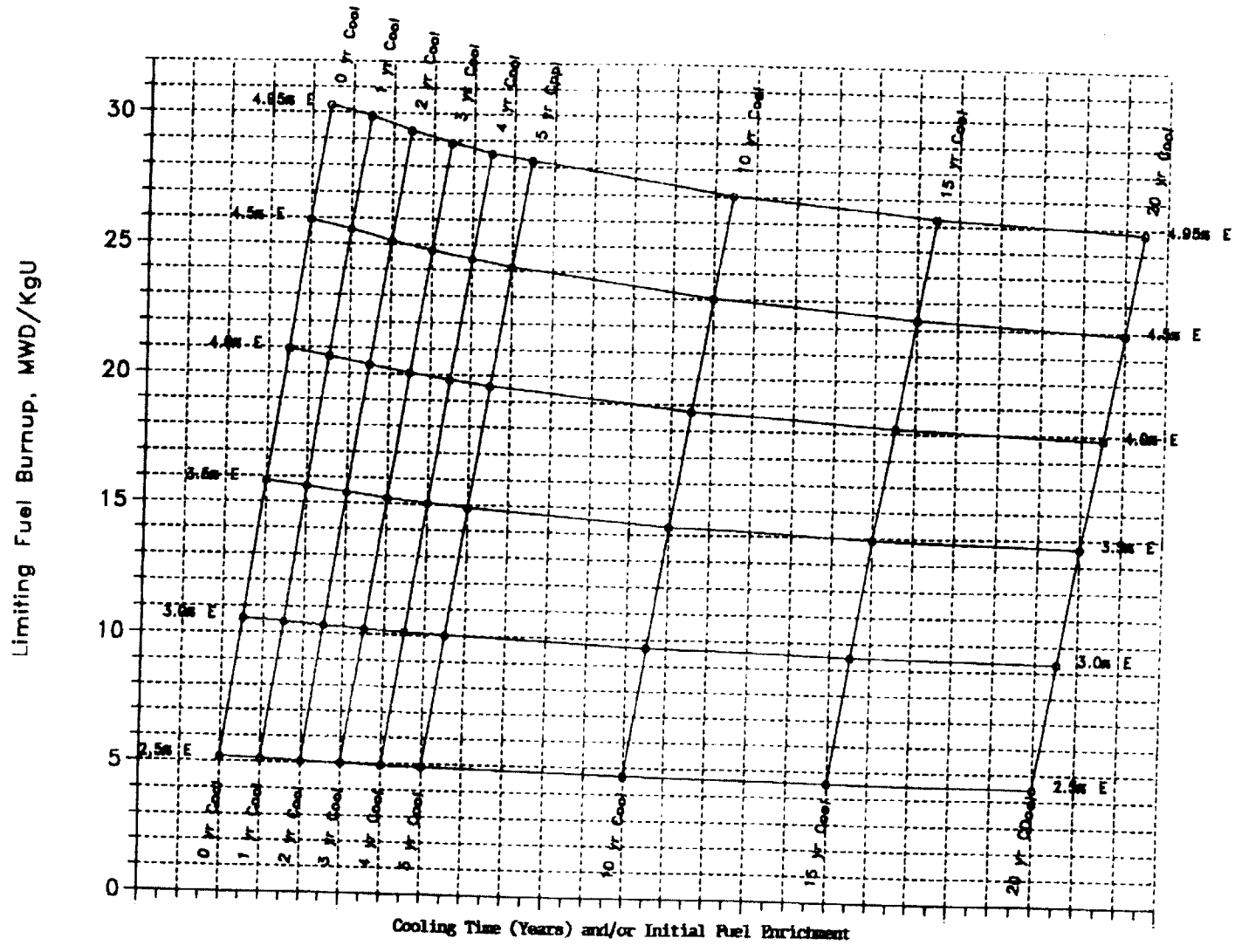


Fig. 5.6-3 3- Dimensional Plot of Minimum Fuel Burnups in Region 2 for Enrichments and Cooling Times

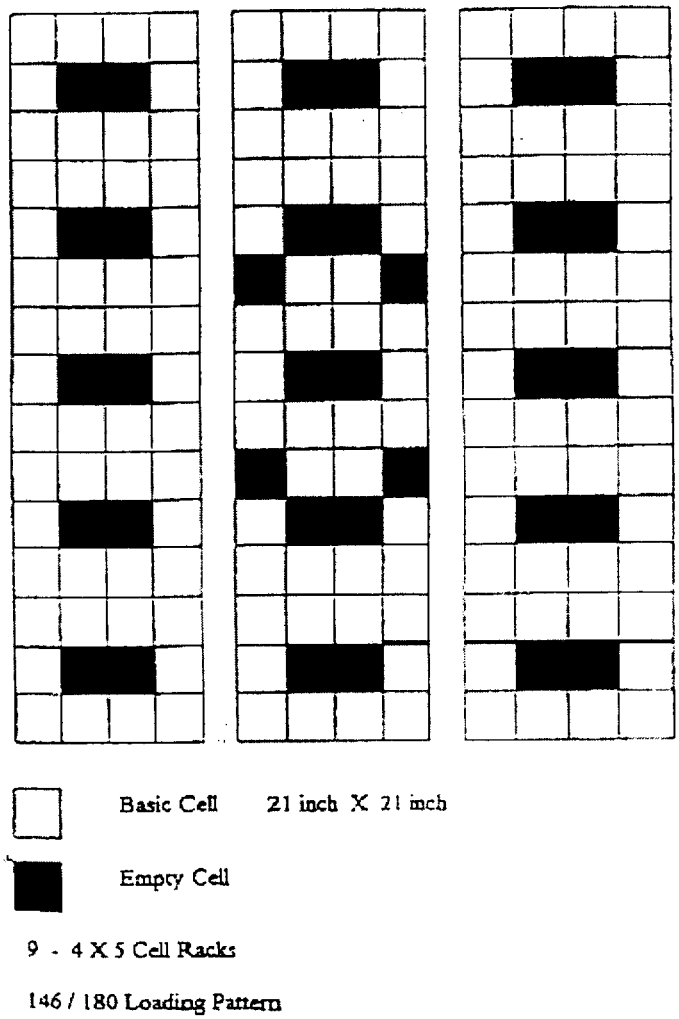


Figure 5.6-4
New Fuel Pit Storage Rack Loading Pattern

Table 5.6-1
Region 1 Storage Burnup Restrictions: Checkerboard of 1 Fresh
Fuel Assembly and 3 Spent Fuel Assemblies (Without Gadolinium or IFBA Rods)

For Zero Year Cooling Time Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
For One Year Cooling Time Bu (limit) = - 27.3317 + 22.5087 x E – 2.40586 x E^2 + 0.164207 x E^3
For Two Years Cooling Time Bu (limit) = -26.4693 + 21.8404 x E – 2.31873 x E^2 + 0.158218 x E^3
For Three Years Cooling Time Bu (limit) = -25.7404 + 21.2659 x E – 2.24287 x E^2 + 0.153018 x E^3
For Four Years Cooling Time Bu (limit) = - 25.1367 + 20.7910 x E –2.18484 x E^2 + 0.1499363 x E^3
For Five Years Cooling Time Bu (limit) = - 24.5981 + 20.3568 x E – 2.12719 x E^2 + 0.145431 x E^3
For Ten Years Cooling Time Bu (limit) = - 23.2050 + 19.2969 x E – 2.06993 x E^2 + 0.145875 x E^3
For Fifteen Years Cooling Time Bu (limit) = -22.6098 + 18.8544 x E – 2.08617 x E^2 + 0.150473 x E^3
For Twenty Years Cooling Time Bu (limit) = - 22.3017 + 18.622 x E – 2.11206 x E^2 + 0.15467 x E^3

Table 5.6-2
Region 1 Storage Burnup Restrictions with Gadolinium or IFBA

With Gadolinium Credit: Checkerboard of 1 Fresh Fuel Assembly with 3 Spent Fuel Assemblies

Zero Year Cooling Time, 0 Gadolinia Rods Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
Zero Year Cooling Time, 4 Gadolinia Rods Bu (limit) = - 28.4012 + 22.0062 x E – 2.19268 x E^2 + 0.143601 x E^3
Zero Year Cooling Time, 8 Gadolinia Rods Bu (limit) = - 31.4262 + 22.0768 x E – 2.38845 x E^2 + 0.164888 x E^3

Note: If more that 8 Gadolinium rods per assembly, use the 8 rod correlation

With IFBA Credit: Checkerboard of 1 Fresh Fuel Assembly with 3 Spent Fuel Assemblies

Zero Year Cooling Time, 0 IFBA Rods Bu (limit) = - 28.1868 + 23.0765 x E – 2.46264 x E^2 + 0.167868 x E^3
Zero Year Cooling Time, 16 IFBA Rods Bu (limit) = - 28.5048 + 21.6411 x E – 2.15262 x E^2 + 0.140904 x E^3
Zero Year Cooling Time, 32 IFBA Rods Bu (limit) = - 31.0949 + 22.0435 x E – 2.36088 x E^2 + 0.162229 x E^3
Zero Year Cooling Time, 48 IFBA Rods Bu (limit) = - 33.1342 + 22.3999 x E – 2.55367 x E^2 + 0.18082 x E^3
Zero Year Cooling Time, 64 IFBA Rods Bu (limit) = - 36.0468 + 24.1492 x E – 3.11807 x E^2 + 0.233987 x E^3

Note: If more that 64 IFBA rods per assembly, use the correlation for 64 IFBA rods

Table 5.6-3
Region 2 Storage Burnup Restrictions

Zero Cooling Time Bu (limit) = - 23.8702 + 12.3026 x E - 0.275672 x E^2
1 Year Cooling Time Bu (limit) = - 23.6854 + 12.2384 x E - 0.287498 x E^2
2 Years Cooling Time Bu (limit) = - 23.499 + 12.1873 x E - 0.305988 x E^2
3 Years Cooling Time Bu (limit) = - 23.3124 + 12.1249 x E - 0.319566 x E^2
4 Years Cooling Time Bu (limit) = - 23.1589 + 12.0748 x E - 0.332212 x E^2
5 Years Cooling Time Bu (limit) = - 22.6375 + 11.7906 x E - 0.307623 x E^2
10 Years Cooling Time Bu (limit) = - 21.7256 + 11.3660 x E – 0.31029 x E^2
15 Years Cooling Time Bu (limit) = - 21.1160 + 11.0663 x E - 0.306231 x E^2
20 Years Cooling Time Bu (limit) = - 20.6055 + 10.7906 x E - 0.29291 x E^2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 265 TO FACILITY OPERATING LICENSE NO. DPR-77

AND AMENDMENT NO. 256 TO FACILITY OPERATING LICENSE NO. DPR-79

TENNESSEE VALLEY AUTHORITY

SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2

DOCKET NOS. 50-327 AND 50-328

1.0 INTRODUCTION

In a letter dated August 31, 2000 (Ref. 1), Tennessee Valley Authority (TVA) requested changes to the Sequoyah Nuclear Plant (SQN), Units 1 and 2, Technical Specifications (TS) to allow the use of credit for soluble boron in the spent fuel pool criticality safety analyses. The request is based on analyses presented in two Holtec International topical reports, which were reviewed and approved by the U.S. Nuclear Regulatory Commission (NRC) staff in a letter to TVA dated November 3, 2000. The first report (HI-992349) provides the criticality safety analysis (Ref. 2) and the second report (HI-992302) provides the boron dilution analysis (Ref. 3). The criticality safety analysis was performed using the methodology developed by the Westinghouse Owners Group and described in Westinghouse Topical Report (WCAP) 14416-NP-A, Rev. 1, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology" (Ref. 4). A boron dilution evaluation was performed (Ref. 3) to confirm that design features, instrumentation, administrative procedures, and sufficient time are available to detect and mitigate boron dilution in the spent fuel pool before the boron concentration is reduced below the value assumed in the criticality safety analysis.

TVA proposes a revision to TS 5.6.1.1, "Criticality - Spent Fuel," to provide for revised storage location patterns. Specifically, the proposed change would revise the currently approved loading patterns to accommodate fresh (unirradiated) fuel assemblies enriched to 4.95 ± 0.05 weight percent (w/o) U-235 in checkerboard loading patterns with spent fuel of specified minimum fuel burnups. The proposed revised patterns would also accommodate fresh assemblies that may include fuel rods containing gadolinia or integral fuel burnable absorbers.

In addition, TVA proposes the following TS changes to accommodate the revised storage location patterns:

1. Implement a new specification, TS 3/4.7.13, "Spent Fuel Pool Minimum Boron Concentration."

2. Implement a new specification, TS 3/4.7.14, "Cask Pit Pool Minimum Boron Concentration."

3. Relocate Surveillance Requirement (SR) 4.9.1.4 to proposed TS 3/4.7.13.

4. Revise SR 4.9.1.4 by deleting "and 5.6.1.1.d."

5. Relocate SR 4.9.1.5 to proposed TS 3/4.7.14.

6. Revise SR 4.9.1.5 by modifying "5.6.1.1.e" to reference the correct Design Features section, "5.6.1.1.d."

The staff's evaluation of the requested TS changes follows.

2.0 EVALUATION

TS 5.6.1.1

Section 5.6.1.1.a would be revised to require the spent fuel storage racks be maintained with k_{eff} less than 1.0 when flooded with unborated water and less than 0.95 when flooded with water containing 300 ppm of soluble boron.

NRC General Design Criterion (GDC) 62 of Appendix A to *Title 10 of the Code of Federal Regulations,* Part 50 (10 CFR 50) requires prevention of criticality in fuel handling and storage areas outside the reactor. The SQN spent fuel storage racks were analyzed by Holtec International (Refs. 2 and 3) using the Westinghouse methodology, which has been reviewed and approved by the NRC (Ref. 4). This methodology takes partial credit for soluble boron in the fuel storage pool criticality analyses and conforms with the following NRC acceptance criteria to meet GDC 62 requirements for preventing criticality outside the reactor:

1. k_{eff} shall be less than 1.0 if fully flooded with unborated water, which includes an allowance for uncertainties at a 95 percent probability, 95 percent confidence (95/95) level as described in WCAP-14416-NP-A, Rev 1; and

2. k_{eff} shall be less than or equal to 0.95 if fully flooded with borated water, which includes an allowance for uncertainties at a 95/95 level as described in WCAP-14416-NP-A, Rev. 1.

Soluble boron credit is used to provide safety margin by maintaining k_{eff} less than or equal to 0.95 including 95/95 uncertainties. The minimum soluble boron required to maintain k_{eff} less than or equal to 0.95 including 95/95 uncertainties was determined to be 300 ppm for the Region 1 and Region 2 storage configurations. The required amount of soluble boron is well below the minimum spent fuel pool boron concentration value of 2000 ppm required by the proposed plant TS 3.7.13 and is, therefore, acceptable.

The proposed changes to TS 5.6.1.1.a conform with the approved safety analysis (Ref. 2) and are, therefore, acceptable.

Sections 5.6.1.1.c and 5.6.1.1.d would be combined under Section 5.6.1.1.c and re-labeled to indicate the appropriate loading patterns, including restrictions for each of the three spent fuel pool regions. Loading pattern and cooling time figures, as well as burnup restriction tables, are provided for each region.

The SQN spent fuel pools are each divided into three regions and each region was analyzed in Holtec International Topical Report HI-992349. Region 1 was analyzed to store high-reactivity (fresh or low burnup) fuel with a maximum enrichment of 4.95 (nominal) + 0.05 w/o U-235 in a checkerboard pattern alternating with burned fuel (one fresh assembly out of four burned assemblies). Region 2 was analyzed to store lower reactivity (lower enrichment or higher burnup) fuel. Region 3 was analyzed to store fresh fuel alternating with water-filled cells. Both Westinghouse 17x17 fuel and Framatome Mark-BW17 fuel were evaluated.

These region configurations are described in proposed TS 5.6.1.1.c and illustrated in proposed TS Figures 5.6-1and 5.6-1a. The burnup and cooling time restrictions are given in proposed TS Tables 5.6-1, 5.6-2, and 5.6-3 and are illustrated in proposed TS Figures 5.6-2 and 5.6-3.

The proposed configurations and burnup and cooling time restrictions are in conformance with the approved analysis presented in Ref. 2. This analysis confirmed that safe operation of the spent fuel storage racks may be achieved by adhering to these configurations and burnup and cooling time restrictions. The proposed revisions are, therefore, acceptable.

Section 5.6.1.1.d would be modified to allow the Region 2 array to be used in the 15x15 storage rack module in the cask loading area of the cask pit.

The cask pit loading area is separated by a wall from the spent fuel storage area and has been approved by the NRC for the addition of spent fuel assembly storage racks, although racks are not currently installed. The criticality analysis (Ref. 2) has revised the storage capability of future cask loading racks to the Region 2 storage arrangement. Therefore, the proposed revision is acceptable.

Section 5.6.1.1.e would be modified to state that the spent fuel storage racks will be maintained with a nominal concentration of 2000 ppm boron in the pool water. The modified section also explains that this concentration of soluble boron provides a margin sufficient to allow timely detection of a boron dilution event and corrective action before the minimum concentration (300 ppm) required to maintain the storage configuration design basis (k_{eff} less than 0.95) is reached. The spent fuel pool is maintained with water borated to at least 2000 ppm of boron. This section merely reiterates the requirements of the dilution analysis to maintain a minimum boron limit of 2000 ppm in the pool and is consistent with proposed TS 3/4.7.13 described below. Therefore, the proposed modification is acceptable.

<u>TS 3/4.7.13</u>

Specification 3.7.13, "Spent Fuel Pool Minimum Boron Concentration," would be added requiring a minimum boron concentration of 2000 ppm whenever fuel assemblies are stored in the spent fuel pool. This Limiting Condition for Operation is mandated by the NRC's safety evaluation report of the Westinghouse methodology for crediting soluble boron (Ref. 4) since it is the initial concentration assumed in the boron dilution analysis. Surveillance Requirement (SR) 4.9.1.4 would be relocated to this specification from TS 3/4.9.1. Since this SR defines boron concentration requirements during fuel movement for the spent fuel pool, it better represents the plant system for which it is intended and its relocation will not change or modify the intent of this SR. Therefore, the proposed TS and relocated SR are acceptable.

TS 3/4.7.14

Specification 3.7.14, "Cask Pit Pool Minimum Boron Concentration," would be added, requiring a minimum boron concentration of 2000 ppm whenever fuel assemblies are stored in the cask pit rack. The separation wall between the cask pit loading area and the spent fuel storage area contains a gated access with the ability to insert a weir gate. TVA has proposed this new specification as a conservative measure to ensure the minimum soluble boron concentration limit exists in the cask pit pool and to address future criticality concerns during fuel assembly movement and storage in the cask pit pool. SR 4.9.1.5 would be relocated to this specification from TS 3/4.9.1. Since this SR defines boron concentration requirements during fuel movement in the cask pit pool, it better represents the plant system for which it is intended and its relocation will not change or modify the intent of this SR. Therefore, the proposed TS and relocated SR are acceptable. The staff considers this proposed specification acceptable as it provides actions and surveillance requirements for water volume adjacent to the spent fuel pool.

Conclusion

The staff has reviewed the proposed TS changes for SQN to allow partial credit for soluble boron in the spent fuel storage pool. The proposed changes are in conformance with the criticality safety analysis presented in Holtec report HI-992349 and the boron dilution event analysis presented in HI-992302, both of which have been reviewed and approved by the NRC. Therefore, we conclude that the spent fuel storage racks in SQN can safely accommodate fuel with initial nominal enrichments up to 4.95 ±0.05 w/o U-235, with assurance that under normal and accident conditions the maximum reactivity, including calculational and manufacturing uncertainties and credit taken for soluble boron, will be less than 0.95, with 95 percent probability at the 95 percent confidence level, provided the fuel conforms to the enrichment, burnup limits, cooling time and loading patterns given in the proposed TS. This meets the staff's subcriticality margin guidelines as well as the subcriticality requirements of GDC 62 and, therefore, the proposed TS changes are acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Tennessee State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration (65 FR 62392), and there has been no public comment on such finding. Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact

statement or environmental assessment need be prepared in connection with the issuance of the amendment.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (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 amendment will not be inimical to the common defense and security or to the health and safety of the public.

8.0 REFERENCES

1. P. Salas, TVA, letter to NRC, "Sequoyah Nuclear Plant (SQN) - Units 1 and 2 - Technical Specification (TS) Change No. 99-17, "Soluble Boron Credit," August 31, 2000.

2. "Criticality Safety Analyses of Sequoyah Spent Fuel Racks with Alternative Arrangements," HI-992349, Holtec International, April 20, 2000.

3. "Boron Dilution Analysis Sequoyah Nuclear Plant Units 1 & 2," HI-992302, Holtec International, April 20, 2000.

4. W. D. Newmyer, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology," Westinghouse Electric Corporation, WCAP-14416-NP-A, Rev. 1, November 1996.

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