Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37379

August 31, 2000

TVA-SQN-TS-99-17 10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2 - TECHNICAL SPECIFICATION (TS) CHANGE NO. 99-17, "SOLUBLE BORON CREDIT"

Reference: TVA letter to NRC dated April 21, 2000, "Sequoyah Nuclear Plant (SQN) - Holtec International Topical Reports"

In accordance with the provisions of 10 CFR 50.4 and 50.90, TVA is submitting a request for an amendment to SQN's Licenses DPR-77 and 79 to change the TSs for Units 1 and 2. The proposed change provides for modification to the current TS requirements for fuel storage.

The above referenced topical reports, concerning the criticality safety analysis and the boron dilution analysis, provide the design bases for the proposed revision. Subsequently, TVA proposes revisions to Design Features 5.6, "Fuel Storage" to provide for fuel storage management by taking credit for soluble boron. This proposed revision provides for greater flexibility and simplicity in acceptable fuel storage locations and was developed in compliance with 10 CFR 50.68. Additionally, TVA proposes two new specifications and associated Bases; TS 3.7.13, "Spent Fuel Pool Minimum Boron Concentration," as mandated by

D030

the Boron Dilution Analysis; and TS 3.7.14, "Cask Pit Pool Minimum Boron Concentration," as a conservative measure during fuel movement and storage in the cask pit. With the addition of the new specifications and modification to Design Features 5.6, TVA also proposes revisions and relocation of Surveillance Requirements (SRs) 4.9.1.4 and 4.9.1.5 regarding soluble boron concentration during fuel movement to these new specifications, respectively.

TVA has determined that there are no significant hazards considerations associated with the proposed change and that the change is exempt from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9). The SQN Plant Operations Review Committee and the SQN Nuclear Safety Review Board have reviewed this proposed change and determined that operation of SQN Units 1 and 2, in accordance with the proposed change, will not endanger the health and safety of the public. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Tennessee State Department of Public Health.

Enclosure 1 to this letter provides the description and evaluation of the proposed change. This includes TVA's determination that the proposed change does not involve a significant hazards consideration, and is exempt from environmental review. Enclosure 2 contains copies of the appropriate TS pages from Units 1 and 2 marked up to show the proposed change. Enclosure 3 contains a copy of the appropriate Updated Final Safety Analysis Report pages marked up to show the proposed change.

As discussed with NRC during a June 29, 1999 presentation, the proposed TS change is a part of our overall strategy to ensure adequate future spent fuel storage capacity at SQN. Accordingly, we request NRC approval of the proposed TS change by March 2001. TVA requests that the revised TS be made effective within 45 days of NRC approval.

The request for soluble boron credit in the SQN spent fuel storage pool is consistent with those previously approved by NRC for other stations such as the South Texas Project, Units 1 and 2 (approved on March 3, 1999) and the Byron and Braidwood Stations (approved on December 4, 1997).

If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Pedro Salas
Licensing and Industry Affairs Manager

Subscribed and sworn to before me
on this 31st day of August

Peggy M. Billingsley
Notary Public

My Commission Expires October 9, 2002

Enclosures
cc: See page 4

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2
DOCKET NOS. 327 AND 328

PROPOSED TECHNICAL SPECIFICATION (TS) CHANGE 99-17
DESCRIPTION AND EVALUATION OF THE PROPOSED CHANGE

I. DESCRIPTION OF THE PROPOSED CHANGE

TVA proposes a revision to SQN TS 5.6.1.1, "Criticality - Spent Fuel" to provide for revised storage location patterns (storage management). The proposed change in TS 5.6.1.1 revises the approved loading patterns to accommodate fresh fuel assemblies of 4.95% ± 0.05% U-235 enrichment in checkerboard loading patterns with spent fuel of specified minimum fuel burnups. The revised patterns are also designed to safely accommodate fresh fuel assemblies which may include fuel rods containing gadolinia or integral fuel burnable absorber (IFBA). Specific proposed provisions for management of fuel assemblies stored in the racks of Sequoyah spent fuel pool (SFP) are described in detail in Enclosure 2.

In addition to the revision of TS 5.6.1.1, TVA proposes the following 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 Specification 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 Specification 3/4.7.14.

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

TVA will revise the index and add the applicable TS Bases discussions to support the addition of these new specifications.

II. REASON FOR THE PROPOSED CHANGE

Since TS 5.6.1.1 was originally developed and approved, 10 CFR 50.68 has been created which permits partial credit for dissolved boron under specified conditions. The purpose of the proposed change is: (1) to incorporate provisions of 10 CFR 50.68, and (2) to provide for greater flexibility and simplification in storing fuel in the spent fuel storage racks thereby extending the time period before loss of full core storage capability. This increased flexibility will extend the time before dry cask storage is needed.

III. SAFETY ANALYSIS

Detailed evaluations supporting and documenting the criticality safety to the approved loading patterns and for the proposed revision of TS 5.6.1.1 are contained in the following topicals previously submitted to NRC:

1. Holtec International Report, "Criticality Safety Analyses For Sequoyah Spent Fuel Racks With Alternative Arrangements," HI-992349, Revision 1

2. Holtec International Report, "Boron Dilution Analysis - Sequoyah Nuclear Plant," HI-992302, Revision 1

The criticality safety analysis shows that, for the postulated fuel misplacement accident with the most severe reactivity effect, a soluble boron concentration of 700 part per million (ppm)* is adequate to assure criticality safety of the fuel storage system. The Sequoyah SFP normally contains a minimum 2000 ppm soluble boron which is more than adequate to assure the continued criticality safety of the storage pool. With 2000 ppm boron, even the incredible condition of completely filling the pool with fresh fuel of the maximum reactivity would not result in criticality.

The boron dilution evaluation confirms that any significant boron dilution accident (despite the double contingency principle, very conservatively assumed to occur concurrently with the most severe independent fuel misplacement accident) would be detected and corrective action taken with more than ample time to prevent the soluble boron concentration from being diluted below 800 ppm. This boron dilution evaluation was performed on an extremely conservative basis. The level of conservatism in the evaluation and the numerous alarms and early-detection capability gives assurance that a boron dilution of any significance would be quickly detected and

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* For additional conservatism, an administrative limit of 800 ppm soluble boron concentration was used for the boron dilution accident analysis.

readily corrected. Furthermore, if the second major accident (i.e., fuel misplacement) was not assumed to occur simultaneously, total boron dilution would not have a significant safety impact. The plant design features, instrumentation, and administrative procedures are sufficiently robust to give confidence that a significant boron dilution accident will not occur.

Specific revision details of TS 5.6.1.1 are presented in Enclosure 2. Section 5.6.1.1.a is revised to require the spent fuel storage racks be maintained with k_{eff} of less than 1.0 when flooded with unborated water and less than 0.95 when flooded with water containing 300 ppm of soluble boron. In order to dilute the SFP to the design k_{eff} with boron credit, a large amount of unborated water (547,000 gallons) would be required. This volume of water is only available through the postulation of leaving manual isolation valves open for an extended period of time following a normal dilution or makeup operation. Since a large volume of water (517,000 gallons) would spill over during the event, it would be readily detected by plant personnel due to the level alarms, flooding in the Auxiliary Building, and by usual operator rounds in the Auxiliary Building. The event could then be terminated prior to exceeding the design k_{eff} of 0.95. Moreover, the criticality evaluation for the SFP confirms that k_{eff} remains less than 1.0 at a 95/95 probability/confidence level even if the pool was completely filled with unborated water.

Sections 5.6.1.1.c and 5.6.1.1.d are combined and revised, as the proposed Section 5.6.1.1.c, to indicate the appropriate loading patterns including restrictions for each of the three regions of the SFP. Loading pattern and cooling time figures, as well as burnup restriction tables for each region, are provided for explanation and determination of appropriate burnup limits. Specific revisions to these sections are found in Enclosure 2. Subsequently, the spent fuel racks have been analyzed in accordance with the Holtec International methodology contained in the criticality analysis, Reference 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 NRC 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. 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 higher reactivity, thereby bounding all fuel types utilized and stored at SQN. The criticality analysis determined the soluble boron concentration required to maintain k_{eff} is maintained ≤ 0.95 under normal conditions is 300 ppm and 700 ppm under the most severe postulated fuel mislocation accident.

The cask pit has been approved for storage of fuel assemblies under Amendment Nos. 167 and 157 of the SQN operating license, although fuel assemblies storage racks have not been installed. The referenced criticality analysis has revised the storage capability of future cask loading racks to Region 2 storage arrangement. This revision is reflected as the proposed 5.6.1.1.d section which states, "Region 2 array described above may be used in the 15x15 storage rack module in the cask loading area of the cask pit." As a conservative measure TVA will implement a new TS, discussed below, to address criticality concern in the cask pit pool and insure uniform boron concentration with the SFP.

The proposed Section 5.6.1.1.e ensures that the spent fuel storage rack will be maintained with a nominal concentration of 2000 ppm boron in the pool water. Currently the pool is filled with borated water of a least 2000 ppm. 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 or equal to 0.95) is reached. This proposal is added insurance and a conservative measure which reiterates the requirement of the dilution analysis to maintain a minimum boron limit of 2000 ppm in the SFP.

In support of the revised fuel assembly storage pattern, a new specification, TS 3/4.7.13, "Spent Fuel Pool Minimum Boron Concentration," is proposed. The minimum soluble boron concentration requirement determined from the criticality analysis during normal operation is 300 ppm and 700 ppm if the most severe postulated accident is considered. This limiting condition for operation (LCO) addition, consistent with NUREG-1431, is mandated by the boron dilution analysis (Reference 2) to assure requirements

with credit taken for soluble boron. For additional conservatism, the minimum boron concentration limit of 700 ppm for the postulated accident is increased to 2000 ppm.

The cask pit loading area is separated by a wall from the spent fuel storage area and is NRC approved for the addition of spent fuel assembly storage racks, although a rack is not currently installed. The separation wall contains a gated access with the ability to insert a weir gate. As a conservative measure to ensure the minimum soluble boron concentration limit exist in the cask pit pool and to address future criticality concerns during fuel assembly movement and storage in the cask pit pool, TVA proposes the addition of new specification, TS 3/4.7.14, " Cask Pit Pool Minimum Boron Concentration." This specification is commensurate to the proposed SFP minimum boron concentration specification above and is considered conservative as it provides LCO actions and SRs for water volume adjacent to the SFP.

TVA proposes relocating SR 4.9.1.4 to the proposed specification for minimum boron concentration in the SFP. The SR existence was coordinated with a previous fuel storage revision and remains valid for the current proposed fuel storage management. However, currently this SR is located in specification 3/4.9.1, "Boron Concentration" of Refueling Operations. This particular LCO defines specific requirements of boron concentration for water volumes with direct access to the reactor vessel (i.e., the reactor cooling system and refueling canal). The proposed SR for relocation defines boron concentration requirements during fuel movement for the SFP. Relocation will not change or modify the intent of this SR, but better represent the plant system it is intended to address, the SFP.

Surveillance Requirement 4.9.1.4 references two Design Features sections, which have proposed revisions to support long-term storage of fuel assemblies in the SFP. The revisions of the Design Features dictate the need to modify the SR by deleting "and 5.6.1.1.d." This deletion does not change the intent of the SR.

TVA proposes relocating SR 4.9.1.5 to the proposed specification for minimum boron concentration in the cask pit pool. The SR existence was coordinated with a previous amendment for fuel storage within the cask pit area and remains valid for the current proposed fuel storage management. Currently, this SR is located in TS 3/4.9.1, "Boron Concentration" of Refueling Operations. This particular LCO defines specific requirements of boron concentration for water volumes with direct access to the

reactor vessel (i.e., the reactor cooling system and refueling canal). The proposed SR for relocation defines minimum boron concentration for the cask pit. Relocation will not change or modify the intent of this SR, but better represent the plant system it is intended to address, the cask pit.

Surveillance Requirement 4.9.1.5 references Design Features, which has proposed revisions to support long-term storage of fuel assemblies in the SFP. The revisions of the Design Features sections dictate the need to modify the SR by revising "5.6.1.1.e" to read "5.6.1.1.d." This revision is appropriate because is does not change intent of the SR.

IV. NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

TVA has concluded that operation of SQN Units 1 and 2, in accordance with the proposed change to the technical specifications (TSs) [or operating license(s)], does not involve a significant hazards consideration. TVA's conclusion is based on its evaluation, in accordance with 10 CFR 50.91(a)(1), of the three standards set forth in 10 CFR 50.92(c).

In compliance with 10 CFR 50.91, this analysis provides a determination that the proposed change to the TS described previously does not involve any significant hazard consideration as defined in 10 CFR 50.92, as described below:

A. <u>The proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.</u>

The presence of soluble boron in the spent fuel pool (SFP) water for criticality control does not increase the probability of a fuel assembly misplacement accident in the SFP. The handling of the fuel assemblies in the SFP has always been performed in borated water. The proposed change does allow greater flexibility for fuel storage configurations in the SFP. The increased flexibility does not introduce any greater complexity than the 3-zone configuration now in use. Fuel assembly placement will continue to be controlled pursuant to approved fuel handling procedures and will be in accordance with the TS limitations. There is no increase in the probability of a fuel placement accident.

The criticality analysis shows the consequences of the most serious fuel assembly misplacement accident in the

SFP are not affected when considering the presence of soluble boron. Under normal conditions, the rack k_{eff} remains subcritical as required by 10 CFR 50.68, and is less than 0.95 with only 300 ppm soluble boron concentration. In the event of a postulated fuel assembly misplacement, the presence of sufficient soluble boron in the SFP precludes criticality as a result of the misplacement. The criticality analysis demonstrates that the pool k_{eff} will remain less than 0.95 following an accidental misplacement due to 2000 parts per million (ppm) boron concentration of the pool. In fact, concentration of only 700 ppm soluble boron is sufficient to maintain k_{eff} less than 0.95 with 95% probability at 95% confidence level for the most serious fuel assembly misplacement. The proposed TS will ensure that an adequate SFP boron concentration is maintained. There is no significant increase in the consequences of the accidental misplacement of spent fuel assemblies in the SFP.

There is no increase in the probability of the loss of normal cooling to the SFP water when considering the presence of soluble boron in the pool water for subcriticality control since a high concentration of soluble boron has always been maintained in the SFP water.

Reactivity changes due to SFP temperature changes have been evaluated. The base case criticality analysis used a SFP temperature of 20°C. The SFP reactivity uncertainty due to temperature changes was considered for SFP temperatures ranging from 4°C to 120°C. The reactivity increment between 4°C and 20°C is taken into account as additional uncertainty in the analysis. In all spent fuel temperature cases, the temperature (and void) coefficients of reactivity are negative. Therefore there is no requirement for additional soluble boron above the base case level. Because the coefficients of reactivity are negative, the consequences of the loss of normal cooling to the SFP will not be increased.

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

B. <u>The proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.</u>

Spent fuel handling accidents are not new or different types of accidents and have been evaluated in the criticality analysis, Reference 1.

The boron concentration in the SFP water is maintained at a minimum of 2000 ppm. The proposed changes to the TS do not change boron concentration requirements for the SFP water. A dilution of the SFP soluble boron has always been a possibility; however, it was shown in the SFP dilution evaluation (Reference 2) that there are no credible dilution events for which the SFP k_{eff} could reach criticality. Therefore, the implementation of proposed changes to the TS will not result in the possibility of a new kind of accident.

The proposed changes for re-rack storage management continue to specify requirements for the spent fuel rack configurations. Since the proposed SFP storage configuration limitations are comparable to those used in the past, the new limitations will not have any significant effect on normal SFP operations and maintenance and will not create any possibility of a new or different kind of accident. Verifications will continue to be performed to ensure that the SFP loading configuration meets specified requirements.

The misplacement of a fuel assembly in the revised storage configurations has been evaluated. In all cases, the rack k_{eff} remains subcritical and less than 0.95 with 700 ppm boron in the water.

As discussed above, the proposed changes will not create the possibility of a new or different kind of accident. There is no significant change in plant configuration, equipment design, or equipment.

Under the proposed amendment, no changes are being made to the racks themselves, any other systems, or to the physical fuel handling structures in the Auxiliary Building itself. Therefore, the proposed change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

C. **<u>The proposed change does not involve a significant reduction in a margin of safety.</u>**

The TS changes proposed by this License Amendment Request and the resulting spent fuel storage configuration limitations will provide adequate safety margin to ensure that the storage fuel assembly array will always remain subcritical. Those limits are based on a plant specific criticality analysis (Reference 1) performed in accordance with accepted spent fuel rack criticality analysis methodology.

While the criticality analysis utilized partial credit for soluble boron, storage configurations have been defined to ensure that the spent fuel rack k_{eff} will be less than 1.0 with no soluble boron. Soluble boron credit is used to provide subcritical margin such that the SFP k_{eff} is maintained less than 0.95 under all credible conditions.

The loss of substantial amounts of soluble boron from the SFP, which could lead to k_{eff} exceeding 0.95, has been evaluated (Reference 2) and shown to be not credible. This evaluation also shows that dilution of the SFP boron concentration from 2000 ppm to 800 ppm is not credible. Also, the spent fuel storage pool k_{eff} remains less than 1.0 at a 95/95 probability/confidence level with the pool filled with unborated water. Therefore, the proposed change does not involve a significant reduction in the margin of safety.

Based on the above evaluation, TVA concludes that the proposed changes to the TSs does not result in a significant reduction in a margin of safety.

V. ENVIRONMENTAL IMPACT CONSIDERATION

The proposed change does not involve a significant hazards consideration, a significant change in the types of or significant increase in the amounts of any effluents that may be released offsite, or a significant increase in individual or cumulative occupational radiation exposure. Therefore, the proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), an environmental assessment of the proposed change is not required.

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT (SQN)
UNITS 1 AND 2

PROPOSED TECHNICAL SPECIFICATION (TS) CHANGE 99-17
MARKED PAGES

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3/4 7.14, "CASK PIT POOL MINIMUM BORON CONCENTRATION"

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THIS PAGE IS INSERTED TO ASSIST IN THE REVIEW OF THE PROPOSED TS MODIFICATIONS AND CONTAINS NO CHANGES.

3/4.9 REFUELING OPERATIONS

3/4.9.1 BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.9.1 With the reactor vessel head closure bolts less than fully tensioned or with the head removed, the boron concentration of all filled portions of the Reactor Coolant System and the refueling canal shall be maintained uniform and sufficient to ensure that the more restrictive of the following reactivity conditions is met: R176

a. Either a K_{eff} of 0.95 or less, which includes a 1% delta k/k conservative allowance for uncertainties, or R176
b. A boron concentration of greater than or equal to 2000 ppm, which includes a 50 ppm conservative allowance for uncertainties.

APPLICABILITY: MODE 6*

ACTION:

With the requirements of the above specification not satisfied, immediately suspend all operations involving CORE ALTERATIONS or positive reactivity changes and initiate and continue boration at greater than or equal to 35 gpm of a solution containing greater than or equal to 6120 ppm boron or its equivalent until Keff is reduced to less than or equal to 0.95 or the boron concentration is restored to greater than or equal to 2000 ppm, whichever is the more restrictive. The provisions of Specification 3.0.3 are not applicable. R176

SURVEILLANCE REQUIREMENTS

4.9.1.1 The more restrictive of the above two reactivity conditions shall be determined prior to:

a. Removing or unbolting the reactor vessel head, and
b. Withdrawal of any full length control rod in excess of 3 feet from its fully inserted position within the reactor pressure vessel.

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. R16

*The reactor shall be maintained in MODE 6 whenever fuel is in the reactor vessel with the vessel head closure bolts less than fully tensioned or with the head removed.

SURVEILLANCE REQUIREMENTS (Continued) R16

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		q. 1-62-932
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			i. 1-FCV-62-128

R148

~~4.9.1.4 The boron concentration in the spent fuel pool shall be determined by chemical analysis to be greater than or equal to 2,000 parts per million (ppm) at least once per 72 hours during fuel movement and until the configuration of the assemblies in the storage racks is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.c and 5.6.1.1.d.~~ R171

~~4.9.1.5 The boron concentration in the cask loading area of the cask pit shall be determined by chemical analysis to be greater than or equal to 2000 parts per million (ppm) at least once per 72 hours during fuel movement in that area and until the assemblies in that storage rack are verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.e.~~

THIS PAGE REPRESENTS THE NEW TS REQUIRMENTS FOR BORON CONCENTRATION IN THE SPENT FUEL POOL.

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:

a. 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.

THIS PAGE REPRESENTS THE NEW TS REQUIRMENTS FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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:

a. 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.

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 5.6.1.1c.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 5.6.1.1c.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 5.6.1.1c.3.

The water in the spent fuel storage pool normally contains

(continued)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE SPENT FUEL POOL.

BACKGROUND (continued)

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 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 maintained $k_{eff} \leq 0.95$ 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

(continued)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE SPENT FUEL POOL.

APPLICABLE SAFETY ANALYSES (continued)	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 ≥ 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.
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.

(continued)

SURVEILLANCE REQUIREMENTS

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)

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)

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"

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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

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)

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)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

REFERENCES

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

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

3. FSAR, Section 15.4.5

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

5.6 FUEL STORAGE

CRITICALITY - SPENT FUEL

R171

5.6.1.1 The spent fuel storage racks are designed for fuel enriched to 5.0 weight percent U-235 and shall be maintained with:

a. A k_{eff} ~~equivalent to~~ less than ~~0.95~~ critical when flooded with unborated water.*

Insert 1

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

c. ~~A three region arrangement~~ in the spent fuel storage pool ~~with~~ have the following definitions :

Insert 2

1. Region 1 is designed to accommodate new fuel with a maximum enrichment of 4.95 ± 0.05 wt% U-235, ±0.05 wt% U-235 or spent fuel regardless of the fuel burnup~~.~~), 30.27 (

Insert 3

2. Region 2 is designed to accommodate fuel of 4.95~~%~~ initial enrichment burned to at least ~~50~~ 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 ~~Y; when Y = -23.761 + 22.075E - 2.0165E^2 + 0.1152E^3~~, where E is the initial enrichment in the axial zone of highest enrichment.

Insert 4

Insert 5

3. Region 3 is designed to accommodate new fuel of 4.95~~%~~ ±0.05 wt% U-235 initial enrichment ~~burned to at least 41 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 is given by Y(MWD/KgU) where Y = -25.7425 + 18.76E - 1.3933E^2 + 0.0666E^3, where E is the initial enrichment in the axial zone of highest enrichme nt.~~

Insert 6

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.

Insert 7

~~d. The following arrangement of regions apply in the spent fuel storage pool:~~

~~1. Region 1 fuel assemblies located along with periphery of the storage modules adjacent to the pool walls must be isolated from~~

R171

*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 R171

~~each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU burnup or equivalent).~~

~~2. Region 1 fuel assemblies located along the wide water-gaps** between storage modules must be isolated from each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU assembly average burnup or equivalent).~~

~~3. Region 1 fuel assemblies located along the narrow water-gaps** between storage modules must be isolated from each other by at least two (2) Region 2 spent fuel assemblies and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU assembly average burnup or equivalent).~~

~~4. A checkerboard pattern of fresh fuel and empty cells may be used throughout any storage module, or internal to any storage module in lieu of Region 3 fuel as shown in Figure 5.6-2.~~

~~Figure 5.6-1 shows a typical arrangement of regions. Figure 5.6-2 illustrates internal module checkerboarding of fresh fuel with empty cells in a portion of the fuel pool. Figure 5.6-3 illustrates the two burnup-enrichment equations (5.6.1.1.c.2 and 5.6.1.1.c.3) in graphical form.~~

~~e. Only spent fuel meeting the Region 3 burnup requirements shall be stored in any module in the cask loading area of the cask pit.~~

~~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. R229

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.

~~**The nominal gap (2-1/8 inches) running in the E-W direction between the adjacent modules is referred to as the "wide gap." The N-S direction gap (1.5 inch) is referred to as the "narrow gap."~~

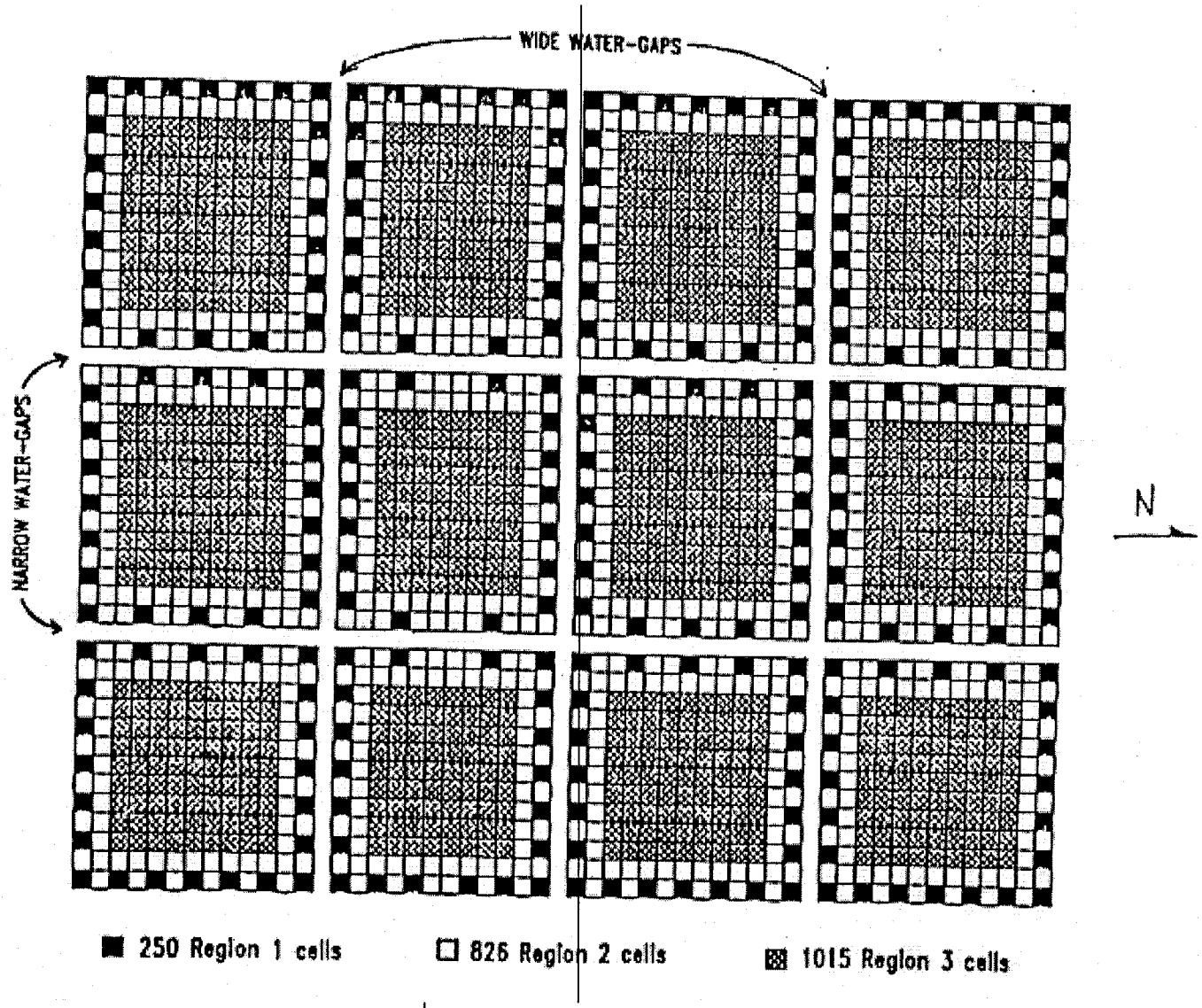


FIGURE 5.6-1 REFERENCE SPENT FUEL POOL LAYOUT

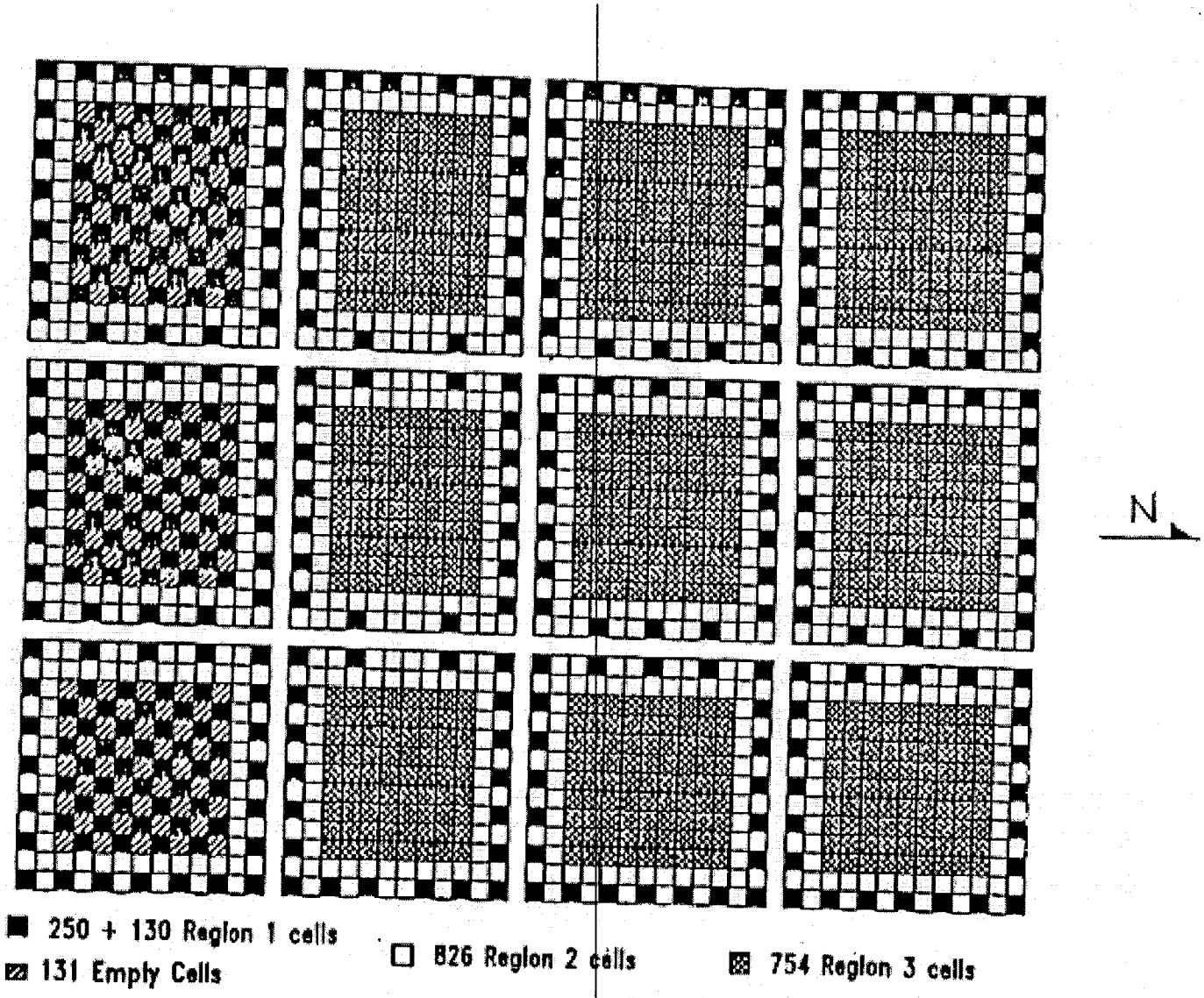


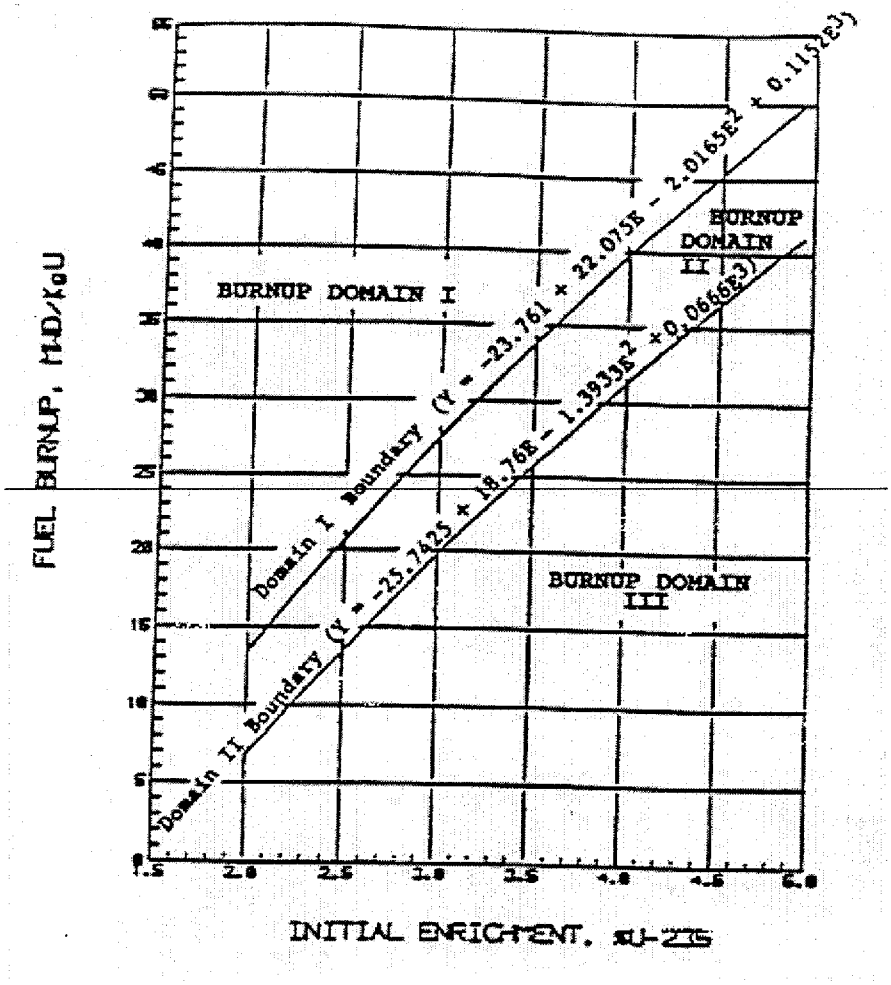
FIGURE 5.6-2 EXAMPLE OF CHECKERBOARD SPENT FUEL POOL STORAGE ARRAY

FIGURE DELETED AND REPLACED BY APPROPRIATE FIGURE OF INSERT 8

R171

FIGURE DELETED AND REPLACED BY APPROPRIATE FIGURE OF INSERT 8

RI71



~~Domain I: Fuel assemblies with initial enrichment-burnup combinations in Domain I may be placed in either Region 1, 2, or 3 storage cells.~~

~~Domain II: Fuel assemblies with initial enrichment-burnup combinations in Domain II may be placed only in Region 1 or 3 storage cells.~~

~~Domain III: Fuel assemblies with initial enrichment-burnup combinations in Domain III may be placed only in Region 1 storage cells.~~

~~FIGURE 5.6-3~~

DESIGN FEATURES ATTACHMENT

Tech Spec Change Inserts

INSERT 1. Change as marked and add the following sentence:

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

INSERT 2. Delete marked phrase and substitute the following:

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...

INSERT 3. Add the following

... 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).

INSERT 4. Delete marked phrases and substitute the following:

... by the equations in Table 5.6-3 in terms of E,...

INSERT 5. Add the following:

... (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.

INSERT 6. Delete the marked lines and add the following:

...(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.

INSERT 7. Delete the indicated lines and add the following:

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.

INSERT 8. Delete the old Figures 5.6-1, 5.6-2, and 5.6-3.

Replace with Figures 5.6-1, 5.6-1 a, 5.6-2, and 5.6-3.

Add Tables 5.6-1, 5.6-2, and 5.6-3.

Insert 8

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

Insert 8

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 Gadolinium Rods $Bu\ (limit) = -28.1868 + 23.0765 \times E - 2.46264 \times E^2 + 0.167868 \times E^3$
Zero Year Cooling Time, 4 Gadolinium Rods $Bu\ (limit) = -28.4012 + 22.0062 \times E - 2.19268 \times E^2 + 0.143601 \times E^3$
Zero Year Cooling Time, 8 Gadolinium Rods $Bu\ (limit) = -31.4262 + 22.0768 \times E - 2.38845 \times E^2 + 0.164888 \times E^3$

Note. If more than 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 $Bu\ (limit) = -28.1868 + 23.0765 \times E - 2.46264 \times E^2 + 0.167868 \times E^3$
Zero Year Cooling Time, 16 IFBA Rods $Bu\ (limit) = -28.5048 + 21.6411 \times E - 2.15262 \times E^2 + 0.140904 \times E^3$
Zero Year Cooling Time, 32 IFBA Rods $Bu\ (limit) = -31.0949 + 22.0435 \times E - 2.36088 \times E^2 + 0.162229 \times E^3$
Zero Year Cooling Time, 48 IFBA Rods $Bu\ (limit) = -33.1342 + 22.3999 \times E - 2.55367 \times E^2 + 0.18082 \times E^3$
Zero Year Cooling Time, 64 IFBA Rods $Bu\ (limit) = -36.0468 + 24.1492 \times E - 3.11807 \times E^2 + 0.233987 \times E^3$

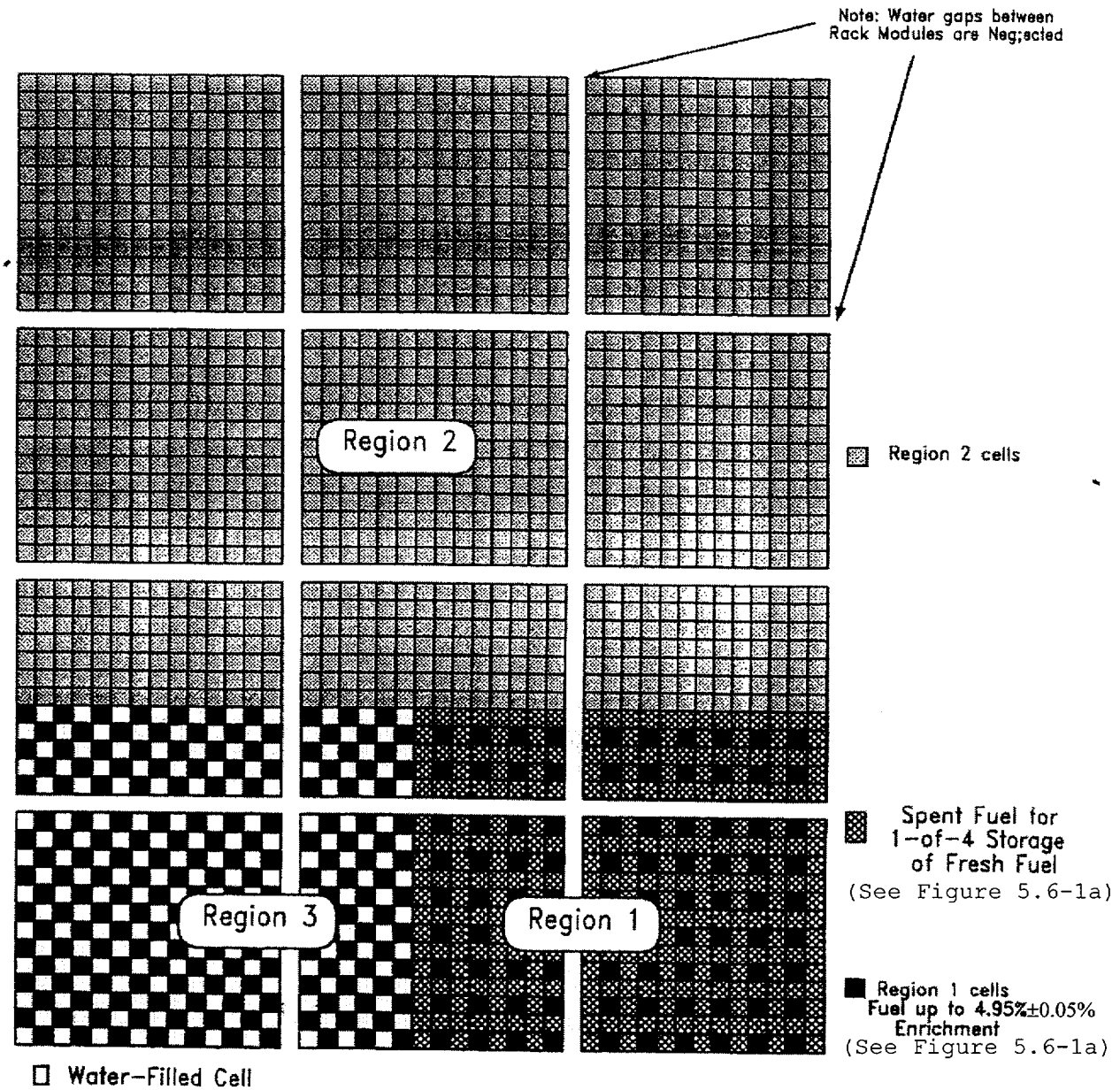
Note. If more than 64 IFBA rods per assembly, use the correlation for 64 IFBA rods.

Insert 8

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

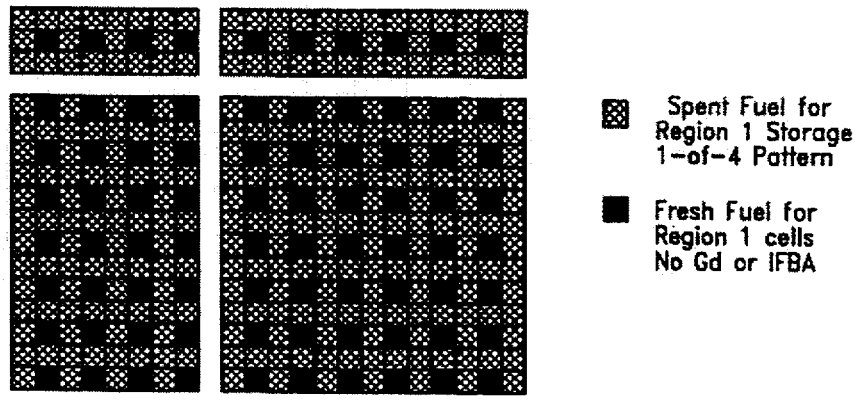
Insert 8



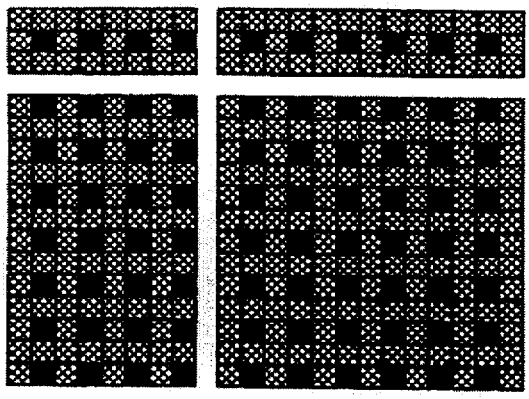
Note: The edges of the sketch above are not necessarily the edges of the pool. The Regions may appear anywhere in the pool and in any orientation, subject to the restriction in Design Feature 5.6.1.1.c.

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

Insert 8

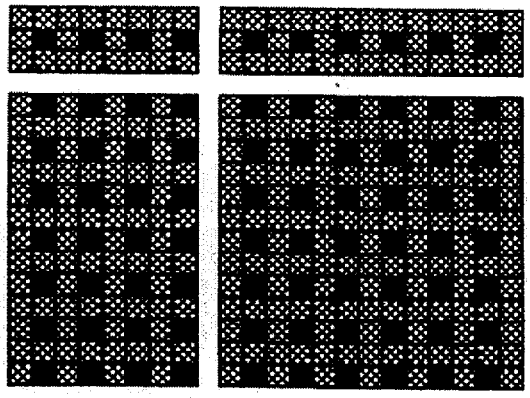


NOTE: WHEN CREDIT IS TAKEN FOR GADOLINIA OR IFBA RODS IN FRESH ASSEMBLIES THE SPENT FUEL ASSEMBLIES NEED NOT HAVE CONTAINED GADOLINIA OR IFBA RODS..



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

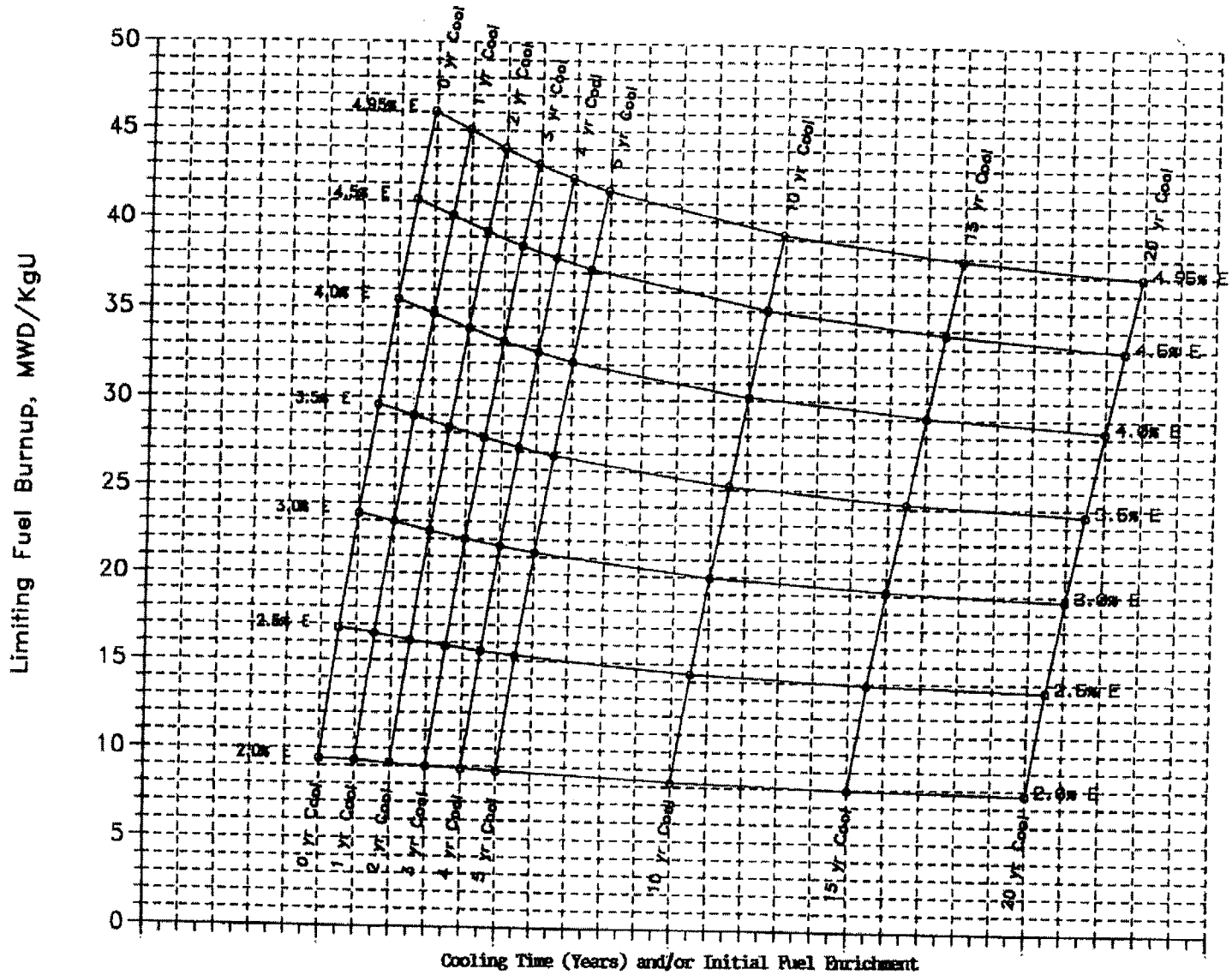


Fig. 5.6-2 3-Dimensional Plot of Minimum Fuel Burnups in Region 1 for Enrichments and/or Cooling Times

Insert 8

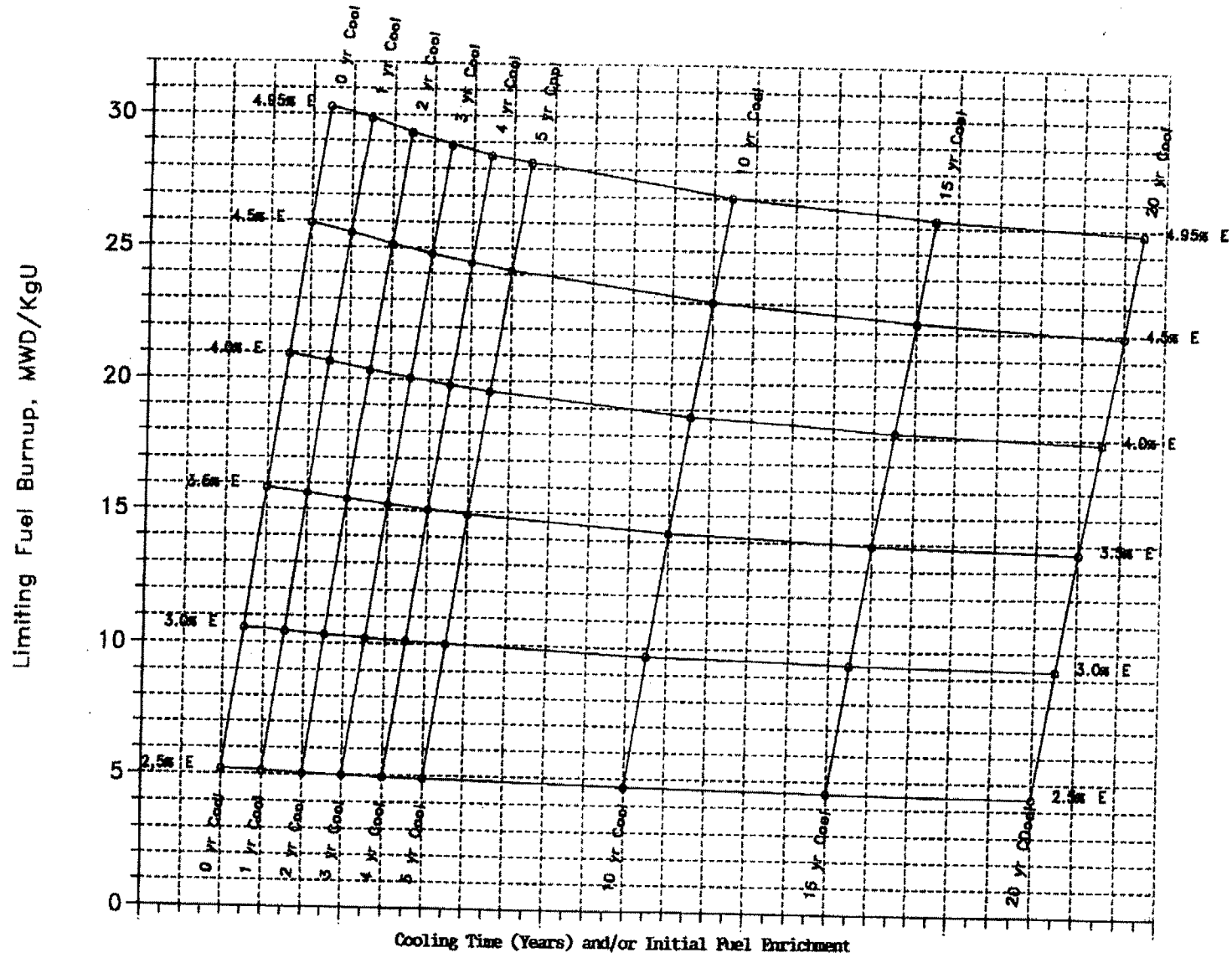


Fig. 5.6-3 3- Dimensional Plot of Minimum Fuel Burnups in Region 2 for Enrichments and Cooling Times

Insert 8

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THIS PAGE IS INSERTED TO ASSIST IN THE REVIEW OF THE PROPOSED TS MODIFICATIONS AND CONTAINS NO CHANGES.

3/4.9 REFUELING OPERATIONS

3/4.9.1 BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

3.9.1 With the reactor vessel head closure bolts less than fully tensioned or with the head removed, the boron concentration of all filled portions of the Reactor Coolant System and the refueling canal shall be maintained uniform and sufficient to ensure that the more restrictive of the following reactivity conditions is met:

a. Either a K_{eff} of 0.95 or less, which includes a 1% delta k/k conservative allowance for uncertainties, or

b. A boron concentration of greater than or equal to 2000 ppm, which includes a 50 ppm conservative allowance for uncertainties.

APPLICABILITY: MODE 6*

ACTION:

With the requirements of the above specification not satisfied, immediately suspend all operations involving CORE ALTERATIONS or positive reactivity changes and initiate and continue boration at greater than or equal to 35 gpm of a solution containing greater than or equal to 6120 ppm boron or its equivalent until Keff is reduced to less than or equal to 0.95 or the boron concentration is restored to greater than or equal to 2000 ppm, whichever is the more restrictive. The provisions of Specification 3.0.3 are not applicable. R163

SURVEILLANCE REQUIREMENTS

4.9.1.1 The more restrictive of the above two reactivity conditions shall be determined prior to:

a. Removing or unbolting the reactor vessel head, and

b. Withdrawal of any full length control rod in excess of 3 feet from its fully inserted position within the reactor pressure vessel.

* The reactor shall be maintained in MODE 6 whenever fuel is in the reactor vessel with the vessel head closure bolts less than fully tensioned or with the head removed. R104

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

R125

~~4.9.1.4 The boron concentration in the spent fuel pool shall be determined by chemical analysis to be greater than or equal to 2000 ppm at least once per 72 hours during fuel movement and until the configuration of the assemblies in the storage racks is verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.c and 5.6.1.1.d.~~

R157

~~4.9.1.5 The boron concentration in the cask loading area of the cask pit shall be determined by chemical analysis to be greater than or equal to 2000 parts per million (ppm) at least once per 72 hours during fuel movement in that area and until the assemblies in that storage rack are verified to comply with the criticality loading criteria specified in Design Feature 5.6.1.1.e.~~

THIS PAGE REPRESENTS THE NEW TS REQUIRMENTS FOR BORON CONCENTRATION IN THE SPENT FUEL POOL.

REFUELING OPERATIONS

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 irradiated fuel assemblies are stored in the spent fuel storage racks.

ACTION:

a. 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.

THIS PAGE REPRESENTS THE NEW TS REQUIRMENTS FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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:

a. 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.

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 5.6.1.1c.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 5.6.1.1c.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 5.6.1.1c.3.

The water in the spent fuel storage pool normally contains

(continued)

BACKGROUND (continued)

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 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 maintained $k_{eff} \leq 0.95$ 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

(continued)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE SPENT FUEL POOL.

APPLICABLE SAFETY ANALYSES (continued)	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 ≥ 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.
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.

(continued)

SURVEILLANCE REQUIREMENTS

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)

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)

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"

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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 empty 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)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

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

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)

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)

THIS PAGE REPRESENTS THE NEW TS BASES FOR BORON CONCENTRATION IN THE CASK PIT POOL.

REFERENCES

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

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

3. FSAR, Section 15.4.5

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

5.6 FUEL STORAGE

R157

CRITICALITY - SPENT FUEL

5.6.1.1 The spent fuel storage racks are designed for fuel enriched to 5.0 weight percent U-235 and shall be maintained with:

a. A k_{eff} ~~equivalent to~~ less than ~~0.95~~ critical when flooded with unborated water.*

Insert 1

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

c. ~~A three region arrangement~~ in the spent fuel storage pool ~~with~~ have the following definitions :

Insert 2

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~~.~~), 30.27 (±0.05 wt% U-235

Insert 3

2. Region 2 is designed to accommodate fuel of 4.95~~%~~ initial enrichment burned to at least ~~50~~ 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 ~~Y; when Y = -23.761 + 22.075E - 2.0165E^2 + 0.1152E^3~~, where E is the initial enrichment in the axial zone of highest enrichment.

Insert 4

Insert 5

3. Region 3 is designed to accommodate new fuel of 4.95~~%~~ initial enrichment ~~burned to at least 41 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 is given by Y(MWD/KgU) where Y = -25.7425 + 18.76E - 1.3933E^2 + 0.0666E^3, where E is the initial enrichment in the axial zone of highest enrichment.~~ ±0.05 wt% U-235

Insert 6

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.

Insert 7

~~d. The following arrangement of regions apply in the spent fuel storage pool:~~

~~1. Region 1 fuel assemblies located along with periphery of the storage modules adjacent to the pool walls must be isolated from~~

R4

*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 R157

~~each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU burnup or equivalent).~~

~~2. Region 1 fuel assemblies located along the wide water-gaps** between storage modules must be isolated from each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU assembly average burnup or equivalent).~~

~~3. Region 1 fuel assemblies located along the narrow water-gaps** between storage modules must be isolated from each other by at least two (2) Region 2 spent fuel assemblies and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU assembly average burnup or equivalent).~~

~~4. A checkerboard pattern of fresh fuel and empty cells may be used throughout any storage module, or internal to any storage module in lieu of Region 3 fuel as shown in Figure 5.6-2.~~

~~Figure 5.6-1 shows a typical arrangement of regions. Figure 5.6-2 illustrates internal module checkerboarding of fresh fuel with empty cells in a portion of the fuel pool. Figure 5.6-3 illustrates the two burnup-enrichment equations (5.6.1.1.c.2 and 5.6.1.1.c.3) in graphical form.~~

~~e. Only spent fuel meeting the Region 3 burnup requirements shall be stored in any module in the cask loading area of the cask pit.~~

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. R216

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.

~~**The nominal gap (2-1/8 inches) running in the E-W direction between the adjacent modules is referred to as the "wide gap." The N-S direction gap (1.5 inch) is referred to as the "narrow gap."~~

FIGURE DELETED AND REPLACED BY APPROPRIATE FIGURE OF INSERT 8

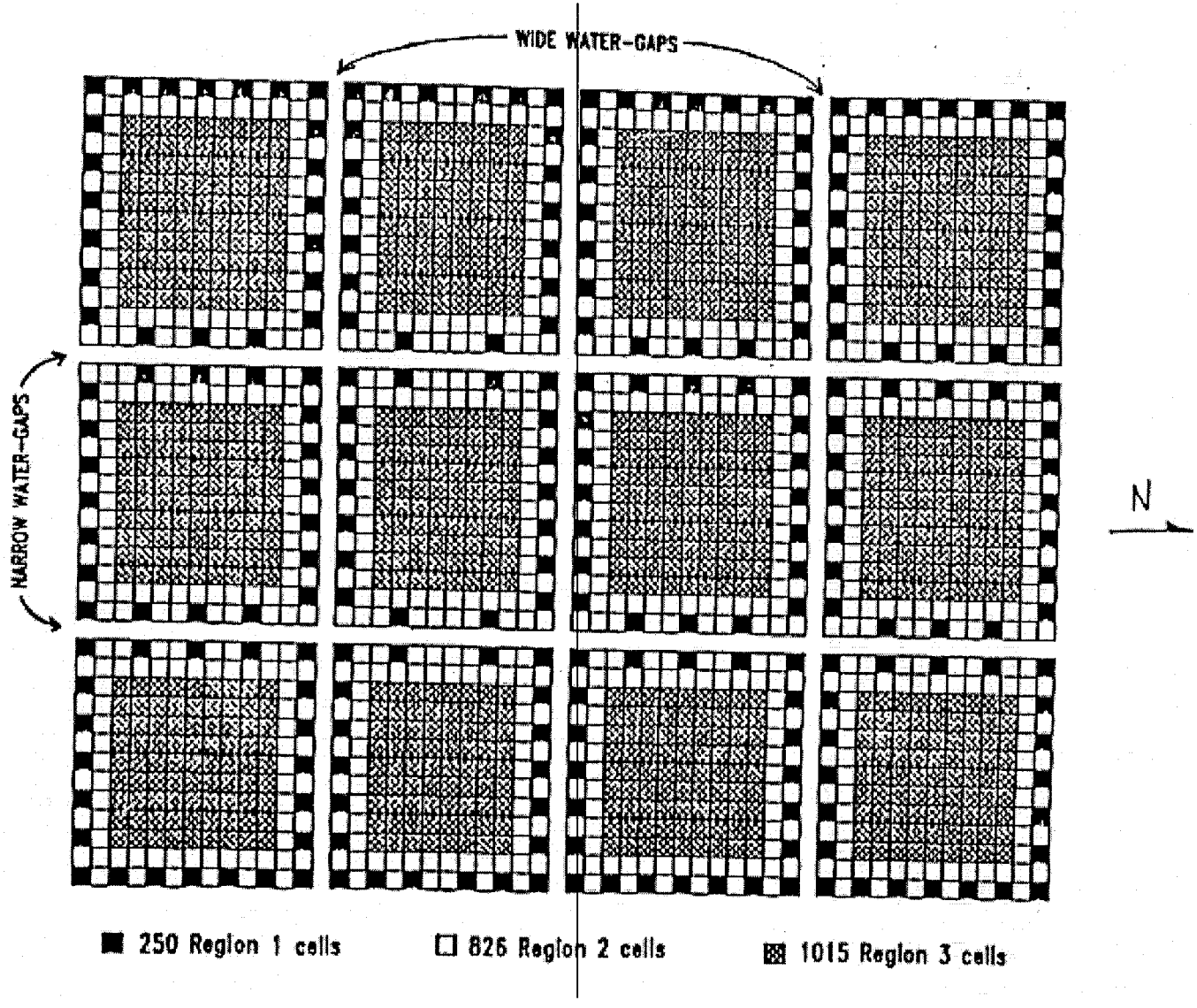


FIGURE 5.6-1 REFERENCE SPENT FUEL POOL LAYOUT

R157

FIGURE DELETED AND REPLACED BY APPROPRIATE FIGURE OF INSERT 8

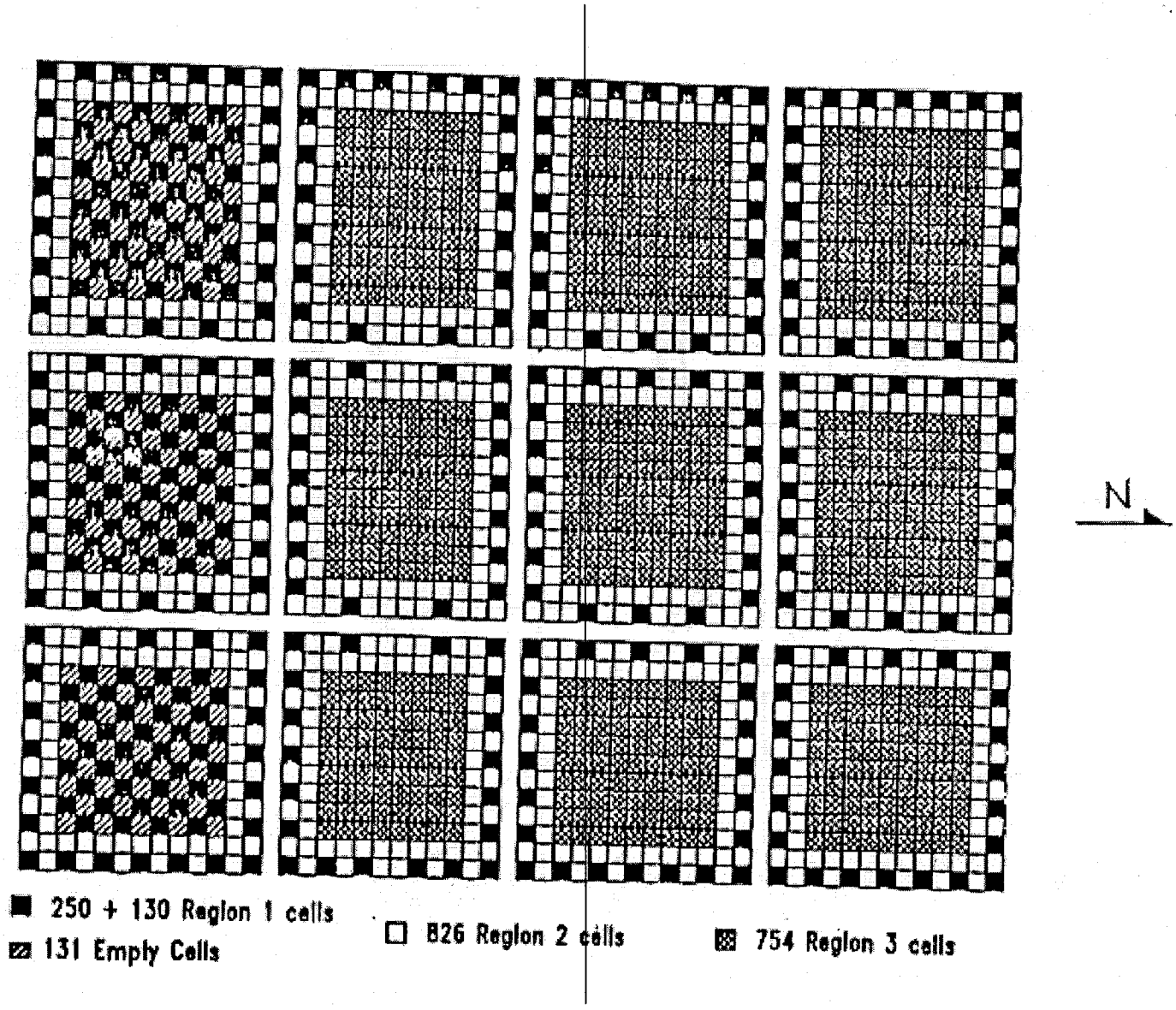
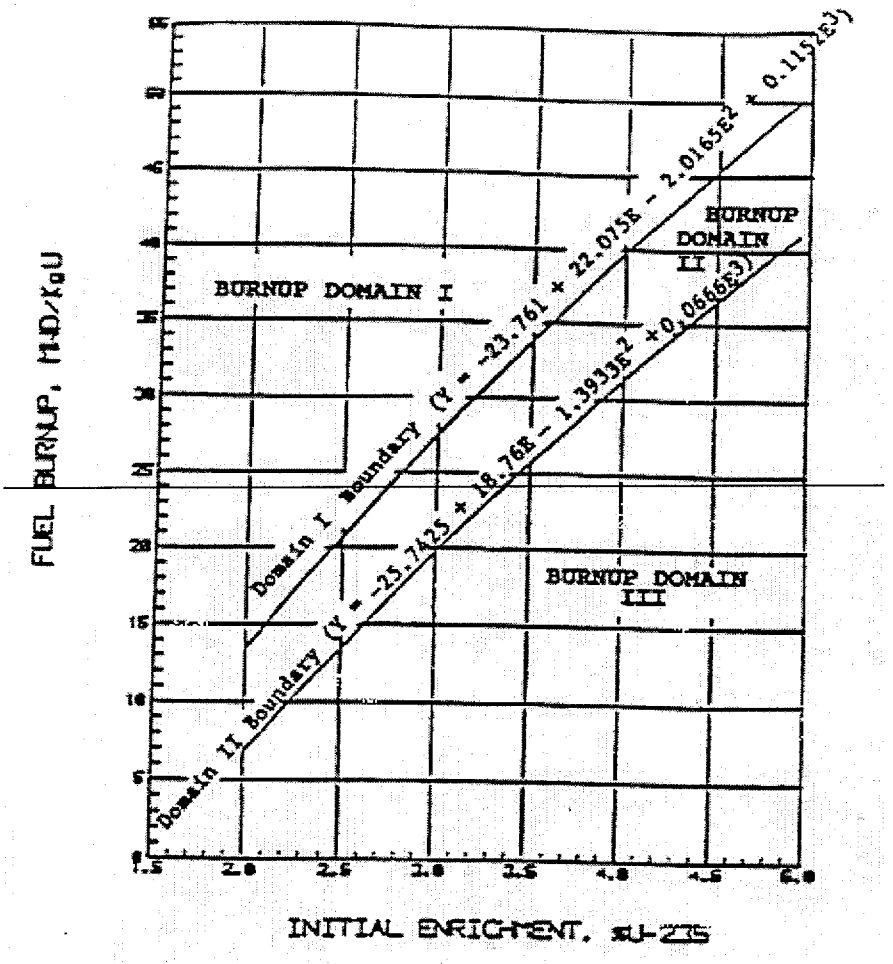


FIGURE 5.6-2 EXAMPLE OF CHECKERBOARD SPENT FUEL POOL STORAGE ARRAY

R157

FIGURE DELETED AND REPLACED BY APPROPRIATE FIGURE OF INSERT 8

RI57



~~Domain I: Fuel assemblies with initial enrichment-burnup combinations in Domain I may be placed in either Region 1, 2, or 3 storage cells.~~

~~Domain II: Fuel assemblies with initial enrichment-burnup combinations in Domain II may be placed only in Region 1 or 3 storage cells.~~

~~Domain III: Fuel assemblies with initial enrichment-burnup combinations in Domain III may be placed only in Region 1 storage cells.~~

~~FIGURE 5.6-3~~

DESIGN FEATURE ATTACHMENT

Tech Spec Change Inserts

INSERT 1. Change as marked and add the following sentence:

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

INSERT 2. Delete marked phrase and substitute the following:

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...

INSERT 3. Add the following

... 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 as the end of the last operating cycle for the discharged spent fuel assemble. 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).

INSERT 4. Delete marked phrases and substitute the following:

... by the equations in Table 5.6-3 in terms of E,...

INSERT 5. Add the following:

... (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.

INSERT 6. Delete the marked lines and add the following:

...(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.

INSERT 7. Delete the indicated lines and add the following:

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.

INSERT 8. Delete the old Figures 5.6-1, 5.6-2, and 5.6-3.

Replace with Figures 5.6-1, 5.6-1 a, 5.6-2, and 5.6-3.

Add Tables 5.6-1, 5.6-2, and 5.6-3.

Insert 8

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

Insert 8

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 Gadolinium Rods $Bu\ (limit) = -28.1868 + 23.0765 \times E - 2.46264 \times E^2 + 0.167868 \times E^3$
Zero Year Cooling Time, 4 Gadolinium Rods $Bu\ (limit) = -28.4012 + 22.0062 \times E - 2.19268 \times E^2 + 0.143601 \times E^3$
Zero Year Cooling Time, 8 Gadolinium Rods $Bu\ (limit) = -31.4262 + 22.0768 \times E - 2.38845 \times E^2 + 0.164888 \times E^3$

Note. If more than 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 $Bu\ (limit) = -28.1868 + 23.0765 \times E - 2.46264 \times E^2 + 0.167868 \times E^3$
Zero Year Cooling Time, 16 IFBA Rods $Bu\ (limit) = -28.5048 + 21.6411 \times E - 2.15262 \times E^2 + 0.140904 \times E^3$
Zero Year Cooling Time, 32 IFBA Rods $Bu\ (limit) = -31.0949 + 22.0435 \times E - 2.36088 \times E^2 + 0.162229 \times E^3$
Zero Year Cooling Time, 48 IFBA Rods $Bu\ (limit) = -33.1342 + 22.3999 \times E - 2.55367 \times E^2 + 0.18082 \times E^3$
Zero Year Cooling Time, 64 IFBA Rods $Bu\ (limit) = -36.0468 + 24.1492 \times E - 3.11807 \times E^2 + 0.233987 \times E^3$

Note. If more than 64 IFBA rods per assembly, use the correlation for 64 IFBA rods.

Insert 8

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

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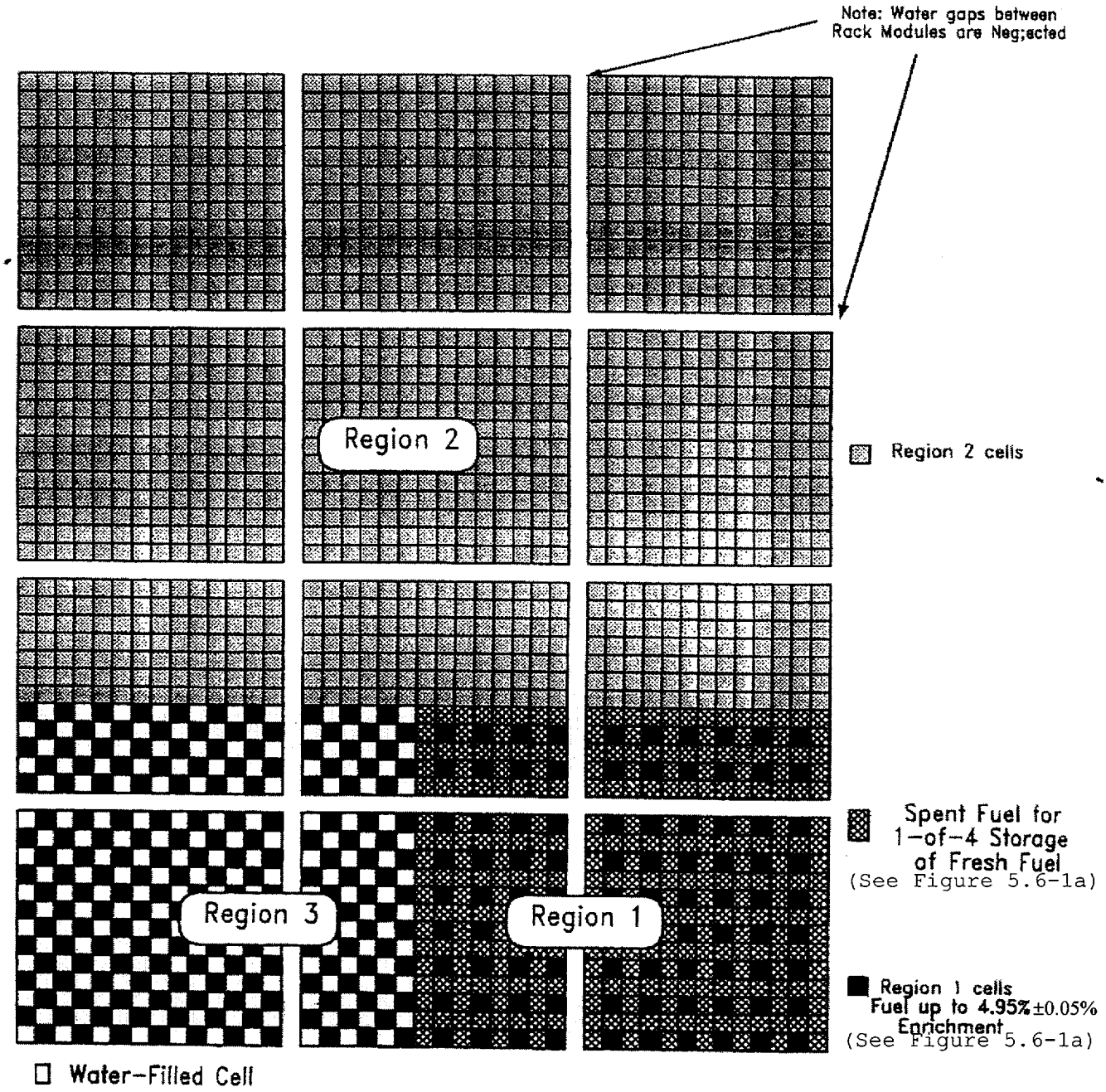

Note: The edges of the sketch above are not necessarily the edges of the pool. The Regions may appear anywhere in the pool and in any orientation, subject to the restriction in Design Feature 5.6.1.1.c.

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

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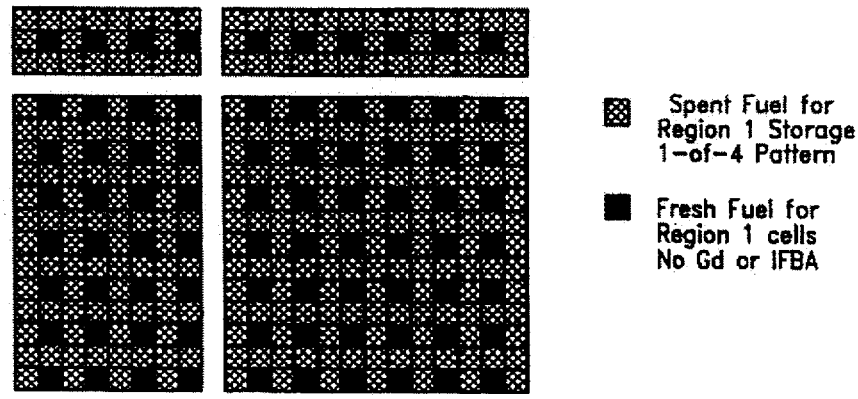

NOTE: WHEN CREDIT IS TAKEN FOR GADOLINIA OR IFBA RODS IN FRESH ASSEMBLIES THE SPENT FUEL ASSEMBLIES NEED NOT HAVE CONTAINED GADOLINIA OR IFBA RODS..

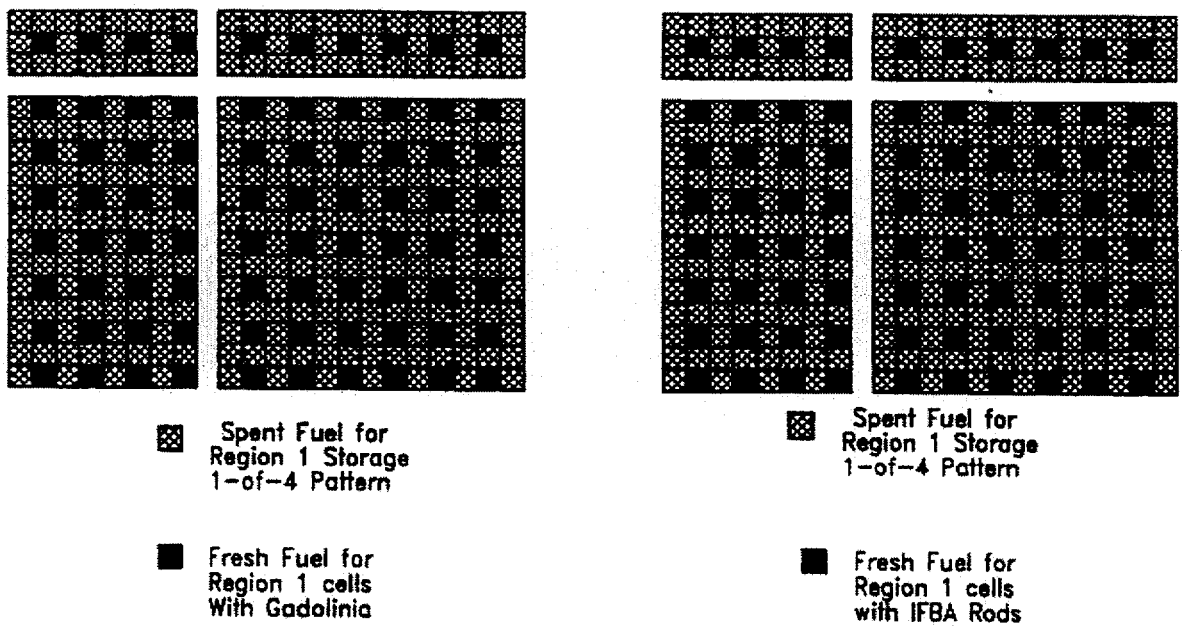

Figure 5.6-1a Acceptable Spent Fuel Pool Loading Patterns for Checkerboard Storage of Fresh and Spent Fuel Assemblies - Example

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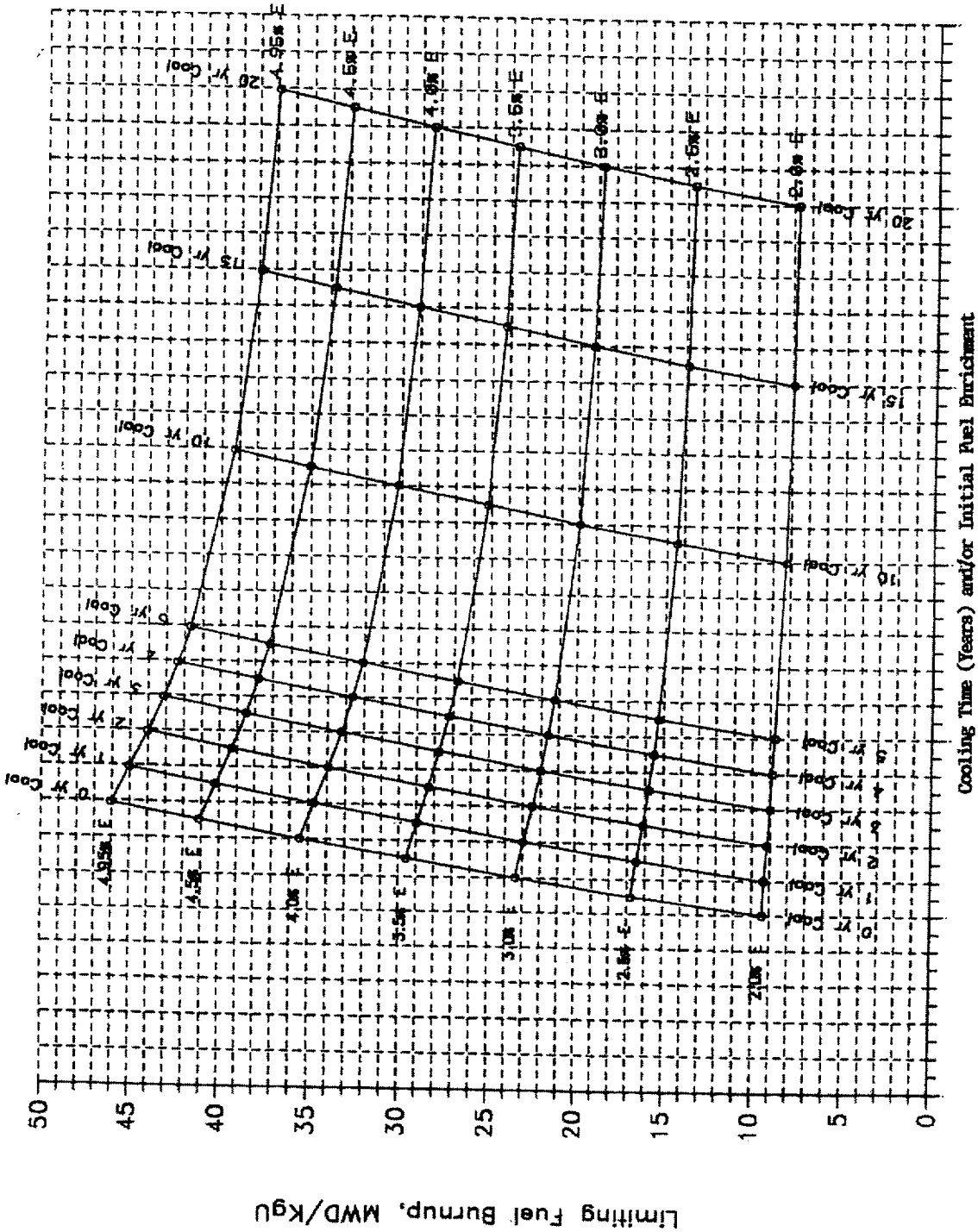

Fig. 5.6-2 3-Dimensional Plot of Minimum Fuel Burnups in Region 1 for Enrichments and/or Cooling Times

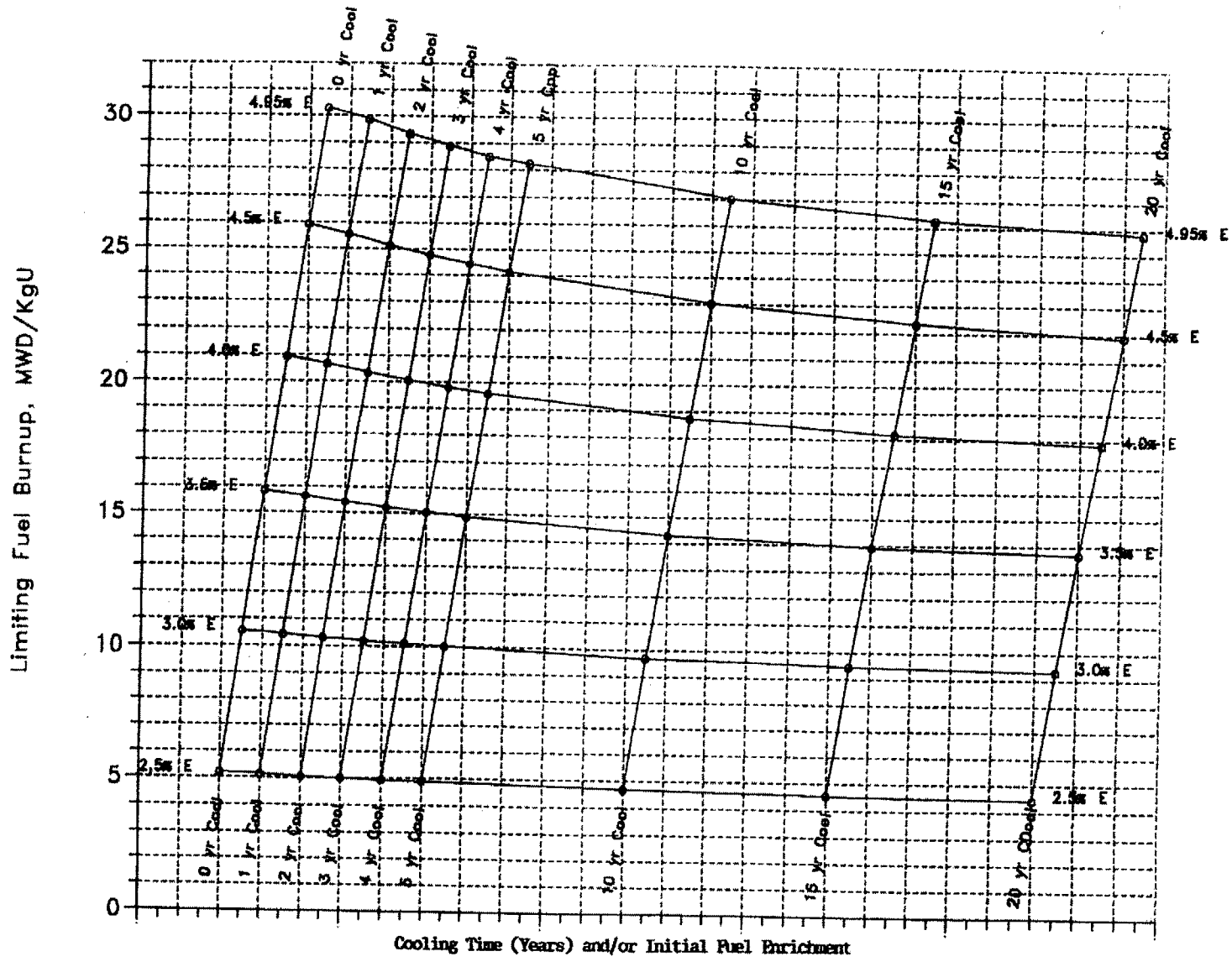

Fig. 5.6-3 3- Dimensional Plot of Minimum Fuel Burnups in Region 2 for Enrichments and Cooling Times

Insert 8

ENCLOSURE 3

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2

PROPOSED FINAL SAFETY ANALYSIS REPORT
MARKED PAGES

I. AFFECTED PAGE LIST

4.3-28
4.3-29
4.3-30
4.3-40

9.1-2
9.1-4

II. MARKED PAGES

See attached.

The results of these experiments yielded a method bias of 0.0083 Δk. The most conservative k_{eff} under normal conditions was calculated using full density water as 0.9416, meeting the criticality criteria to maintain k_{eff} at or below 0.95. This k_{eff} included the method bias and 95/95 uncertainties in the method bias and the maximum k_{eff}. In addition, this most conservative case combined the effects of worst-case mechanical tolerances, material thickness tolerances, and conservatively accounting for enrichment variability (with enrichment assumed to be 5.05 wt%).

A low density, optimum moderation case has been determined to be the worst-case accident scenario for these new fuel storage racks. The model used in the full density case was used to model the low density case. A water density of 0.060 gm/cm3 was also used in this analysis. The result was a k_{eff} of 0.9660, including all biases and uncertainties, meeting the criticality criteria for accident conditions to maintain k_{eff} at or below 0.98.

For other accident conditions, the double contingency principle of ANSI N16.1-1975 is applied. In applying this principle, one is not required to assume two independent, unlikely, concurrent events to preclude criticality. For all other accident conditions, the absence of a moderator in the new fuel storage racks is a realistic initial condition.

Thus, for normal operations, using the method described above including all the biases and uncertainties mentioned, the k_{eff} of the new fuel storage racks is determined to be <0.95. This meets the criteria stated in Section 4.3.1.5 .

Spent Fuel Storage - Wet

~~The high density spent fuel storage racks for the Sequoyah Nuclear Plant are designed (Reference 32) to assure that the effective neutron multiplication factor (k_{eff}) is equal to or less than 0.95 reactivity, and flooded with unborated water at the temperature within the operating range corresponding to the highest reactivity. The maximum calculated reactivity includes a margin for uncertainty in reactivity calculations including mechanical tolerances. All uncertainties are statistically combined, such that the final k_{eff} will be equal to or less than 0.95 with a 95% probability at a 95% confidence level.~~

Each storage cell has an internal envelope dimension of 8.75-inches square with 0.060-inch thick stainless steel walls. A single Boral absorber panel is positioned between the walls of adjacent cells within the modules.

Peripheral cells with a 0.0235-inch stainless steel sheathing on the outside supporting the Boral panel. The fuel storage cells are located on a nominal lattice spacing of 8.97 ± 0.04 inches. The Boral absorber has a thickness of 0.102 ± 0.005 inch and a nominal B-10 areal density of 0.0324 g/cm^2 (0.030 g B-10/cm^2 minimum). The design basis fuel assembly is a 17 x 17 Westinghouse Vantage-5H assembly containing UO_2 at a maximum initial enrichment of 4.95 ± 0.05 wt% U-235 by weight. (If fuel assemblies with natural UO_2 blankets are used, the design basis enrichment is that of the central enriched zone.)

~~In the fuel rack analyses, the primary criticality analyses of the high density spent fuel storage racks were performed with the KENO-5a computer code, using the 27-group SCALE cross-section library and the NITAWL subroutine for U-238 resonance shielding effects (Nordheim integral treatment). Depletion analyses and determination of equivalent enrichments were made with the two-dimensional transport theory code, CASMO-3. Three separate storage regions are~~

~~provided in the spent fuel storage pool, with independent criteria defining the highest potential reactivity in each of the three regions as follows:~~

- ~~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.~~

- ~~Region 2 is designed to accommodate fuel of 4.95% initial enrichment burned to at least 50 MWD/KgU (assembly average), or fuel of other enrichments with a burnup yielding an equivalent reactivity.~~

- ~~Region 3 is designed to accommodate fuel of 4.95% initial enrichment burned to at least 41 MWD/KgU (assembly average), or fuel of other enrichments with a burnup yielding an equivalent reactivity.~~

~~The principles involved in the design and specification of an acceptable loading arrangement for fuel or different burnups are as follows:~~

- ~~Fresh fuel assemblies located along the periphery of the storage modules adjacent to the pool walls must be isolated from each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU burnup or equivalent),~~

- ~~Fresh fuel assemblies located along the wide water-gap between storage modules must be isolated from each other and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU burnup or equivalent),~~

- ~~Fresh fuel assemblies located along the narrow water-gap between storage modules must be isolated from each other by at least two (2) Region 2 spent fuel assemblies and from the inner Region 3 cells by at least one (1) Region 2 spent fuel assembly (i.e., fuel of 50 MWD/KgU burnup or equivalent),~~

- ~~A checkerboard loading pattern of fresh fuel intermixed with empty cells may be used throughout any storage module or internal to any storage module.~~

~~In these criteria, the term "fresh fuel" includes any fuel of lesser reactivity, such as may be encountered with partially-burned fuel in a full core off-load.~~

~~The Technical Specifications include figures showing typical arrangements of regions and a curve defining the limiting burnup for fuel of various initial enrichments for Region 2 and Region 3, both of which assume that the fresh fuel (Region 1) is enriched to 4.95% U-235. The calculated maximum reactivity is 0.943 which is within the regulatory limit of a k_{eff} of 0.95. This maximum reactivity includes calculational uncertainties and manufacturing tolerances (95% probability at the 95% confidence level), an allowance for uncertainty in depletion calculations and the evaluated effect of the axial distribution in burnup. Fresh fuel of less than 4.95% enrichment would result in lower reactivities.~~

~~Although credit for the soluble poison normally present in the spent fuel pool water is permitted under abnormal or accident conditions (double contingency principle), most abnormal or accident conditions will not result in exceeding the limiting reactivity (k_{eff} of 0.95) even in the absence of~~

~~soluble poison. However, the inadvertent misplacement of a fresh fuel assembly in a Region 2 location with the remainder of the rack fully loaded with fuel of the highest permissible reactivity, has the potential for exceeding the limiting reactivity, should there be a concurrent loss of all soluble poison. Under this accident condition, calculations show that approximately 685 ppm would be sufficient to assure that the limiting k_{eff} of 0.95 is not exceeded. Assuring the presence of soluble poison during fuel handling operations will preclude the possibility of the simultaneous occurrence of the two independent accident conditions. Administrative controls require that the spent fuel pool boron concentration be monitored (to ensure at least 2000 ppm) during operations requiring fuel moves in the pool until verification is made of assembly locations.~~

Insert 1

4.3.2.8 Stability

4.3.2.8.1 Introduction

The stability of the PWR cores against xenon-induced spatial oscillations and the control of such transients are discussed extensively in References 6, 12, 13 and 14. A summary of these reports is given in the following discussion, and the design bases are given in Paragraph 4.3.1.6.

In a large reactor core, xenon-induced oscillations can take place with no corresponding change in the total power of the core. The oscillation may be caused by a power shift in the core which rapidly occurs by comparison with the xenon-iodine time constants. Such a power shift occurs in the axial direction when a plant load change is made by control rod motion and results in a change in the moderator density and fuel temperature distributions. Such a power shift could occur in the diametral plane of the core as a result of abnormal control action.

Due to the negative power coefficient of reactivity, PWR cores are inherently stable to oscillations in total power. Protection against total power instabilities is provided by the Control and Protection System as described in Section 7.7. Hence, the discussion on the core stability is limited here to xenon-induced spatial oscillations.

4.3.2.8.2 Stability Index

Power distributions, either in the axial direction or in the X-Y plane, can undergo oscillations due to perturbations introduced in the equilibrium distributions without changing the total core power. The xenon-induced oscillations are essentially limited to the first flux overtones in the current PWR's, and the stability of the core against xenon-induced oscillations can be determined in terms of the eigenvalues of the first flux overtones. Writing the eigenvalue ζ of the first flux harmonic as

$$\zeta = b + ic, \qquad (4.3\text{-}1)$$

then b is defined as the stability index and $T = 2\pi/c$ as the oscillation period of the first harmonic. The time-dependence of the first harmonic $\delta\Phi$ in the power distribution can now be represented as

$$\delta\Phi(t) = A\, e^{\zeta t} = a e^{bt} \cos ct. \qquad (4.3\text{-}2)$$

32. Stanley E. Turner (Holtec International), "Criticality Safety Analysis - Spent Fuel Storage Racks - Sequoyah Nuclear Plant," PFE - J54 (TVA Nuclear Fuel Division).

33. Letter, N. R. Metcalf (Westinghouse) to T. A. Keys (TVA), July 17, 1990, 90TV*-G-077, "Tennessee Valley Authority Sequoyah and Watts Bar Nuclear Plants - Sequoyah/Watts Bar Fuel Rack Criticality Analysis". RIMS L38 900718 809.

34. Henderson, W.B., " Results of the Control Rod Worth Program; " WCAP- 9217 (Proprietary) and WCAP-9218 (Non-Proprietary), October 1977.

35. Harris, A. J., Mayhue, L. T., and Mildrum, C. M., "A Description of the Nuclear Design Analysis Programs for Boiling Water Reactors," WCAP-10106-P-A (Proprietary), June 1982.

36. Ford, W. E., et al., "CSRL-V: Processed ENDF/B-V 227-Neutron-Group and Point-wise Cross Section Libraries for Criticality Safety, Reactor and Shielding Studies," NUREG/CR-2306, ORNL/CSD/TM-160 (1982).

Insert 2

37. Nguyen, T. Q., et al., "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," WCAP-11596, November 19 87.

The details of the seismic design and testing procedures are presented in Section 3.7.

9.1.2 Spent Fuel Storage

9.1.2.1 Design Bases

1. Spent fuel storage space will be provided for a total of 10 cores (193 per core) plus 161 extra storage positions. However, only 159 of the 161 extra storage spaces may be utilized due to physical obstructions. Therefore, 2089 total spaces are available for fuel assembly storage.

2. Spent fuel storage racks are ~~designed~~ 1.0 for new fuel enriched to a maximum of 5.0% by weight U-235 with K_{eff} less than ~~0.95~~ 1.0 when flooded with ~~unborated water~~. Insert 3

3. Administrative controls over fuel loading, discussed in Section 4.3.2.7, assures that the fuel will be stored in an array such that K_{eff} will be less than ~~0.95~~ 1.0 even if the water in the storage pit contains no boron. However, for some accident conditions, the presence of dissolved boron in the pool water is taken into account as a realistic initial condition. This assumption can be made by applying the double contingency principle of ANSI N16.1-1975 which requires two unlikely, independent, concurrent events to produce a criticality accident. Insert 4

4. The depth of shielding water over the spent fuel will be sufficient to limit the radiation dose to acceptable levels.

5. The spent fuel storage facility will be capable of withstanding loads imposed by the dead load of the fuel assemblies, loads resulting from the impact and handling of fuel assemblies, the maximum uplift force from the spent fuel bridge hoist and loads from 1/2 SSE and SSE's. Damage to spent fuel pit and storage racks will neither be sufficient to cause a loss of water below the top of the racks nor increase K_{eff} ~~above 0.95~~ to 1.0.

6. Electrical and mechanical interlocks are provided to prevent the movement of loads over stored spent fuel.

7. The spent fuel shipping cask loading area will not be separated from the spent fuel storage area. A cask drop is not a credible event provided that heavy loads and safe load paths are in place in accordance with NUREG-0612 (SRP-9.1.2, NUREG-0800).

8. Adequate cooling water will be available for cooling the pool water (Section 9.1.3).

9. Consideration of criticality safety analysis is discussed in Section 4.3.2.

9.1.2.2 Description

The location of the spent fuel pit is shown in Figure 9.1.1-1 and in Figures 1.2.3-5 and 1.2.3-8. Figure 9.1.2-1 shows the design of the spent fuel storage racks. Figure 9.1.2-2 shows the spent fuel storage rack layout in the spent fuel pool and cask pit.

9.1.2.2.1 Storage Rack Structure

The high density Spent Fuel Storage Racks consists of 12 modular racks containing a total of 2091 storage cells with a 8.972" nominal pitch. All rack modules are of the so-called "free-

Separate pedestal bearing pads are not used in the cask pit area, in that the adjustable pedestal has weight distribution pads integrated into the pedestal design to account for this weight bearing function.

9.1.2.3 Safety Evaluation

The spent fuel pit is a reinforced concrete structure which rests on the rock formation which underlies the Sequoyah site. The pit is designed to withstand 1/2 SSE and SSE forces and the maximum uplift force of the spent fuel bridge hoist without deformation, as is the Auxiliary Building in which the pit is located. The pit is lined with stainless steel plates to ensure water tightness. Radiological aspects of the facility are discussed in Chapter 12.

The spent fuel pit structure includes a fuel storage area, a spent fuel cask loading area, and a transfer canal which communicates with the refueling canal in the containment building. The following discussion shows how the facilities comply with the design bases given in Section 9.1.2.1:

1. The fuel storage area contains six 13 X 14 spent fuel storage rack arrays, two 12 X 14 spent fuel storage rack arrays, three 13 X 13 spent fuel storage rack arrays, and one 12 X 13 spent fuel storage rack array, for a total of 2091 storage locations. This provides storage space for 10 cores plus 161 additional storage spaces. Some storage spaces are "shadowed" by overhead obstructions. All but two of the "shadowed" spaces were pre-loaded prior to final rack positioning, therefore only 2089 cells can be utilized. The two inaccessible cells are located beneath the gate opening between the spent fuel pool and the transfer canal and are shadowed by a support plate for the transfer canal gate.

1.0

2. The spent fuel storage racks provide a nominal spacing of 8.972 inches between fuel assemblies. The nominal gap between rack arrays ~~is~~ 2 1/8 inch north-south and 1.5 inch east-west. The spacing is such that K_{eff} is below ~~0.95~~ if the racks are filled with fuel assemblies having the highest anticipated enrichment ~~even~~ when flooded with ~~unborated~~ water and including all mechanical tolerances. The design of the racks precludes criticality even with a misplaced fuel assembly on top of ~~to~~ the rack. The design of the racks precludes placement of a fuel assembly adjacent to the rack.

2000 ppm borated

Insert 5

3. The normal depth of water in the spent fuel storage area is about 39 feet 10 inches. The SFPCS maintains adequate water depth for shielding in the spent fuel pit, for spent fuel storage and for handling spent fuel over the storage racks. A low level alarm is annunciated in the control room when the water level drops to approximately two inches below normal pool level. The hoist on the spent fuel pit bridge is physically prevented from lifting the active fuel region of a spent fuel assembly higher than a level which is approximately 10 feet below the low level alarm setpoint due to the length of the long handle tool. Thus, the requirement of a water shield of 10 feet above the fuel assembly active fuel region is met.

4. The spent fuel storage racks shown in Figure 9.1.2-1 are designed to comply with the stress limits of ASME boiler and pressure vessel code, Section III, Subsection NF (1986).

   The racks have been shown by dynamic analysis to withstand SSE and 1/2 SSE loads as well as the dead load of the fuel assemblies. The racks are also capable of withstanding accidental drops of a fuel assembly or the gates which cover the slots between the pool and transfer canal and cask loading pit.

Final Safety Analysis Report Inserts

INSERT 1.

The spent fuel racks have been analyzed in accordance with the Holtec International methodology contained in Holtec Report HI - 992349 (Ref. 38). 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. 39 & 40). The codes, methods, and techniques contained in the methodology are used to satisfy the k_{eff} criterion. The spent fuel storage racks are analyzed to allow storage of Westinghouse 17 X 17 V5H fuel assemblies and other fuel assemblies, with enrichments up to 4.95%±0.05% w/o U-235 utilizing credit for checkerboard configurations, burnup, integral fuel burnable absorbers, gadolinia absorbers, cooling time, and soluble boron, to ensure that k_{eff} is maintained ≤ 0.95, including uncertainties, tolerances, and accident conditions. In addition, the spent fuel pool k_{eff} is maintained < 1.0 including uncertainties and tolerances on a 95/95 basis without any soluble boron. Calculations have been performed to evaluate the reactivity of fuel used at SQN. The results show that Westinghouse 17 X 17 exhibits higher reactivity, thereby bounding all fuel utilized and stored in the spent fuel pool at SQN.

In the high density Spent Fuel Storage Rack design (Refs. 38 and 41), 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 specified enrichment, burnup and cooling times. Region 2 is designed to accommodate fuel which have 4.95 ± 0.05 wt% 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. Region 3 is designed to accommodate fuel of 4.95 ± 0.05 wt% initial enrichment or fuel assemblies of any lower reactivity in a 2-out-of-4 checkerboard arrangement with water-filled cells.

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 contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 42) 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 maintained $k_{eff} \leq 0.95$ 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 Technical Specifications. During fuel movement boron concentration is verified to be within limit.

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 wt% 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. 38).

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. 43). 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.

The spent fuel storage pool boron concentration is required to be ≥ 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 44. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel storage pool.

INSERT 2.

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

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

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

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

42 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).

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

44 FSAR, Section 15.4.5

INSERT 3.

...2000 ppm borated water and considering uncertainties. With partial credit for dissolved boron in the pool, k_{eff} is less than 0.95 with 300 ppm boron for normal conditions.

The racks are regionalized into three arrangements as to what limitations exist on fuel assemblies stored in each region.

INSERT 4.

Maintaining 700 ppm dissolved boron in the pool shall meet the criteria for k_{eff} to be less than 0.95 with consideration of uncertainties.

INSERT 5.

Partial credit for dissolved boron in the pool water ensures the k_{eff} shall remain less than 0.95 with consideration of uncertainties and fuel mis-placement. The spent fuel pool boron concentration is nominally above 2000 ppm though only 700 ppm is required.

The spent fuel racks are regionalized into three arrangements as the what limitations exist on fuel assemblies stored in each region.