APPLICABILITY OF WCAP-14181 PRA RESULTS TO VOGTLE

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1.0 INTRODUCTION

In an analysis documented in WCAP-14181, "Evaluation of the Potential for Diluting PWR Spent Fuel Pools" (Reference 1), a generic methodology was applied to identify potential events which could dilute the soluble boron contained in a representative PWR spent fuel pool. The methodology utilized a Probabilistic Risk Assessment (PRA) of a "composite plant" to calculate the frequencies of these dilution events. The results of that PRA supported the conclusion that the event frequencies are less than the NRC Safety Goal Policy Statement target risk objective of 1.0E-06/ry for the assumed composite plant.

In order to form a valid judgment regarding the applicability of the conclusions of WCAP-14181 to Vogtle, a comparison of the Vogtle-specific spent fuel pool features to those of the "composite plant" was made. The specific items compared are discussed in Section 2.0 of this report. In addition, Vogtle-specific boron dilution events were examined to determine the time available for the operators to respond to a range of dilution events. These representative events considered nominal conditions at Vogtle and were compared to the best estimate case of Reference 1. Deterministic calculations were then performed to define the critical dilution times and volumes for Vogtle. This data was compared to the analogous data for the composite plant. Finally, the dilution sources present at Vogtle were compared to the critical dilution volume to determine the feasibility of a spent fuel pool dilution event. The specific dilution events evaluated for Vogtle are discussed in Section 2.3.

2.0 PLANT COMPARISON

To assess the applicability of the generic PRA results to Vogtle, the following plant-specific features and characteristics were evaluated:

- Spent Fuel Pool and Related Systems
  - Dilution Sources
  - Dilution Flow Rates
  - Boration Sources
  - Instrumentation
  - Administrative Procedures
  - Piping
  - Loss of Offsite Power Impact
- Boron Dilution Initiating Events
- Boron Dilution Times and Volumes

2.1 SPENT FUEL POOL CHARACTERISTICS

Table 2-1 provides a comparison of relevant spent fuel pool data for the composite plant and Vogtle.

TABLE 2-1

SPENT FUEL POOL COMPARISON - VOGTLE vs COMPOSITE PLANT

Plant Feature	WCAP-14181 Composite Plant	Vogtle Pool (each pool - 2 total)
Pool Water Volume (gal)	232,000	447,030 (without racks or fuel assemblies) 357,500 w/racks and assemblies When both pools are connected total water volume is 715,000
Typical Pool Boron Concentration (ppm)	2200	2400
Location	Fuel Building, Top Floor, Seismic I	Fuel Building, Grade elevation, Seismic I
Unborated Water Sources	CCW. Demineralized Water, Reactor Makeup Water, Fire Protection, SW	CCW, Demineralized Water, Reactor Makeup Water, Fire Protection, Utility Water
Borated Water Sources	CVCS, RWST	RWST, RHT
Piping near Spent Fuel Pool	Reactor Makeup, Fire Protection Demineralized Water, CCW, SW	Fire Protection, Demineralized Water, Utility Water, Normal Chilled Water
Dilution Flow Rates	100 gpm for Demin Water, Reactor Makeup, Fire Protection 500 gpm for CCW, SW	2400 gpm for Fire Protection, 375 gpm for Demin Water 600 gpm for Normal Chilled Water, 45 gpm for Utility Water
Instrumentation	1 Train Level Alarm, No Safety Related Power	1 Train Level Alarm, No Safety Related Power 2 alarms total for the two pools 1 sump alarm, No Safety Related Power
Loss of Offsite Power	Cannct Use RWST	Can use RMWST OR RWST (gravity feed)
Leaks in SFP Heat Exch.	To SFP from CCW	To SFP from CCW
Administrative Controls	In effect	In effect except 1) Currently sample boron 1/month. 2) Potential dilution path valves are not tagged as such.

2.2 BORON DILUTION INITIATION EVENT

Based on a review of Vogtle data (i.e., Licensee Event Reports pertaining to spent fuel pool events), one spent fuel pool boron dilution initiating event, previously undetermined in the generic study, was identified. This event was the diversion of letdown flow to the SFP transfer canal due to an improper valve lineup following SFP makeup from the Recycle Holdup Tanks (RHTs). The justification for disregarding some potential initiating events as discussed in Reference 1 is likewise valid for Vogtle.

Note that for Vogtle, the typical spent fuel pool boron concentration is 2400 ppm. This was assumed to be the starting point in this analysis for a dilution event. Per Reference 2, the minimum soluble boron concentration necessary to preclude loss of an acceptable margin to criticality is 1250 ppm. Thus, 1250 ppm was assumed as the endpoint for the analysis of Vogtle dilution events.

Further note that the SFPs are normally connected and contain a combined volume of approximately 715,000 gallons. This value for SFP volume conservatively disregards the Cask Loading Pit which is located between the pools and is part of the total water volume when the pools are connected. When the pools are separated, the volume of each individual pool is approximately 357,500 gallons. The pools are typically connected approximately 51 weeks out of the year.

External flood water is not expected to enter the SFP. While the SFP is at approximately grade level (220'), the probable maximum flood is at elevation 165' msl.

Finally, the Vogtle analysis assumed that, for the Seismic and Tornado cases where offsite power is lost , the SFP alarms would be available since their battery back-up power supplies are rated for two hours and the dilution flowrate into the SFP would cause the high level alarm setpoint to be reached in as little as 5 minutes.

The following sections (2.2.1 - 2.2.7) further discuss the differences between the composite plant and Vogtle in the treatment of the initiating events for SFP dilution.

2.2.1 REACTOR CAVITY PNEUMATIC SEAL FAILURE

This WCAP-14181 initiating event is not applicable to Vogtle. Vogtle has a permanent cavity seal ring that is inspected for damage which could affect cavity sealing prior to flooding the refueling cavity.

2.2.2 CCW LEAK

The initiating event frequency, event tree, and top event descriptions discussed in Reference 1 for the composite plant are applicable to Vogtle. In addition, the WCAP-14181 assumption of a 100 gpm leak rate is valid for Vogtle. However, calculated allowed operator action times are different for Vogtle. Specifically, the detection (DETECT LATER) and response (OPERATOR RESPONSE) times are much longer for Vogtle due to its larger pool volume. Based on the calculated dilution time for a 100 gpm dilution flowrate for the Vogtle pool volume, over 77 hours are available for detection and response. This is over four times as long as the detection/response time calculated for the best estimate case of the composite plant. With the assumption of 6 hour operator rounds, the probability of detection is greater than that for the composite plant. Thus, for this initiating event, Vogtle is bounded by the analysis of the composite plant.

The dilution event frequency for the Vogtle large pool due to a CCW leak is calculated to be 4.61E-10/ry. The dilution event frequency for the Vogtle small pool due to a CCW leak is calculated to be 9.60E-10/ry. Thus, the overall dilution event frequency due to a CCW leak is (4.61E-10/ry) (51/52)+(9.60E-10/ry)(1/52) = 4.71E-10/ry which is less than the 1.5E-08 /ry frequency calculated for the composite plant.

2.2.3 SEISMIC EVENT

For a Vogtle seismic event, the safe shutdown earthquake is 0.2g (Reference 3). From NUREG-1488 (Reference 4), the mean frequency of exceedance for a .2g earthquake is approximately 2.95E-04/ry. Thus, the seismic initiating event frequency for Vogtle is greater than the 2.0E-04/ry seismic initiating event frequency assumed for the composite plant.

The maximum flow rate from postulated pipe ruptures in the nonsafety-related systems located in the vicinity of the SFP is assumed to be 3520 gpm for this analysis: 2500 gpm for Fire Water, 375 gpm for Demineralized Water, 45 gpm for Utility Water, and 600 gpm for Normal Chilled Water (a closed system -- during the first 15 minutes of the event, a total of 9000 gallons of water could be added by Normal Chilled Water before the system is effectively drained). If offsite power is available, a 3520 gpm flow rate for the first 15 minutes and 2920 gpm for the remainder of the event are assumed. These flowrates would take approximately 2.6 hours to dilute the large pool to the assumed endpoint dilution of 1250 ppm. If offsite power is not available, the dilution sources are assumed to be: 2500 gpm from the Fire Water system, 120 gpm from gravity drain of the Demineralized Water, 300 gpm for Normal Chilled Water by gravity drain (total water admitted is 9000 gallons in 30 minutes), and 40 gpm for Utility Water by gravity drain. A total flowrate of 2960 gpm would exist for the first 30 minutes, then 2660 gpm for the remainder of the event. Under these conditions, the dilution endpoint for the large pool would be reached in approximately 2.9 hours.

The dilution event frequency for the Vogtle large pool due to a seismic event is calculated to be 1.26E-07/ry. The dilution event frequency for the Vogtle small pool due to a seismic event is calculated to be 1.33E-07/ry. Thus the overall dilution event frequency due to a seismic event is (1.26E-07/ry) (51/52) + (1.33E-07/ry) (1/52) = 1.26E-07/ry.

2.2.4 TORNADO EVENT

The Vogtle initiating event frequency for a tornado of sufficient magnitude to be of interest is 1.0E-07/ry. The tornado is assumed to cause a loss of offsite power and the rupture of the piping in the vicinity of the SFP. The pumps for the demineralized water system, normal chilled water system, and the utility water system would not operate following the loss of offsite power. Therefore, if these pipes were ruptured, these systems would deliver unborated water to the spent fuel pool via gravity drain. The piping that could rupture in the vicinity of the Vogtle spent fuel pool as a result of a tornado which is of the greatest significance is the 2500 gpm fire protection piping. The total flow from these sources to the SFP due to a tornado with a loss of offsite power would be 2960 gpm for 30 minutes, then 2660 gpm for the remainder of the event. The dilution endpoint of 1250 ppm would be reached in approximately 2.9 hours, a shorter period of time than the calculated 3.6 hours for the composite plant.

The dilution event frequency for the Vogtle large pool due to a tornado event is calculated to be 8.52E-11/ry. The dilution event frequency for the Vogtle small pool due to a tornado event is calculated to be 8.99E-11/ry. Thus, the overall dilution event frequency due to a tornado event is (8.52E-11/ry) (51/52) + (8.99E-11/ry) (1/52) = 8.53E-11/ry.

2.2.5 RANDOM PIPE BREAKS

The following differences from the event considered in the Reference 1 analysis are noted.

For Vogtle, there are 165 pipe sections (10' to a pipe section) in the vicinity of the spent fuel pool. The composite plant considered 50 pipe sections. Using a fault tree methodology, the random pipe break frequency for Vogtle is calculated to be 4.39E-04/ry. This value is approximately three times the 1.3E-04/ry frequency calculated for the composite plant.

The accident sequence modeled for the composite plant includes a split fraction for the probability of a break of safety related piping. Thus, the composite plant model assumed a 500 gpm dilution flow rate from a safety related piping break and a 100 gpm dilution flow rate for a non-safety related piping break. For Vogtle however, there is no safety related piping in the vicinity of the spent fuel pool. As noted in Table 2-1, the dilution flow rates for the fire protection, demineralized water system, normal chilled water, and utility water are 2500, 375, 600, and 45 gpm, respectively, which results in a total flow significantly greater than that assumed for the composite plant. As a result, with respect to operator detection and response time, calculations performed in Section 2.3 indicate that, considering of the larger pool volume, 3.1 hours are available at Vogtle for the largest single random pipe break compared to 3.6 hours for the composite plant.

The remaining top events for the random pipe break event of the composite plant are applicable to Vogtle. Based on the above, the Vogtle random pipe break is bounded by the seismic event considered for the composite plant.

The dilution event frequency for the Vogtle large pool due to a random pipe break event is calculated to be 1.21E-07/ry. The dilution event frequency for the Vogtle small pool due to a random pipe break event is calculated to be 5.61E-07/ry. Thus the overall dilution event frequency due to a random pipe break event is (1.21E-07/ry) (51/52) + (5.61E-07/ry) (1/52) = 1.29E-07/ry.

2.2.6 DEMINERALIZER VALVES / MAKEUP VALVES / LETDOWN VALVES OPEN

A discussion of spent fuel pool dilution events due to the mispositioning of the subject valves at Vogtle is provided below along with the determination of the associated initiating event frequencies.

Demineralizer Valves Open

This event is modeled by failure to close and verify closed one valve (8.29E-04), followed by failure to close two other valves (failure to close the first valve [5.0E-03] and a conditional failure to close the second valve [0.5] from WCAP-14181). The frequency of this event is 2.07E-06/ry.

The dilution event frequency for the Vogtle large pool due to a demineralizer valves event is calculated to be 6.85E-13/ry. The dilution event frequency for the Vogtle small pool due to a demineralizer valves event is calculated to be 1.03E-11/ry. Thus, the overall dilution event frequency due to a demineralizer valves event is (6.85E-13/ry) (51/52) + (1.03E-11/ry) (1/52) = 8.70E-13/ry.

Misalignment of Valves Interfacing with the Spent Fuel Pool

Normal makeup of the SFP is via the Reactor Makeup Water Storage Tank (RMWST). This source is non-borated water. Once the valve is opened for makeup to the SFP, continuous monitoring and verification of closure of the valve are required by procedure. This dilution event is modeled by the operator failing to close the makeup valve and a verifier failing to verify the valve closed, or error of omission with verification (8.29E-04) multiplied by the average annual frequency of valve opening (50) which equals 4.15E-02/ry. Thus, the frequency of this event is 4.15E-02/ry. The subsequent Vogtle top events are the same as those for the composite plant.

The dilution event frequency for the Vogtle large pool due to a misaligned makeup valves event is calculated to be 6.36E-09/ry. The dilution event frequency for the Vogtle small pool due to a misaligned makeup valves event is calculated to be 4.36E-08/ry. Thus, the overall dilution event frequency due to a misaligned makeup valves event is (6.36E-09/ry) (51/52) + (4.36E-08/ry) (1/52) = 7.08E-09/ry.

An additional potential dilution event considered was a valve interfacing with the spent fuel pool transfer canal and the CVCS letdow stem being left open after makeup has been provided from the RHTs to the SFP for evaporative losses. Vogtle SFP makeup from the RHTs is performed by closing the inlet to the RHT that is to be transferred to the SFP. The flowpath is such that if the CVCS letdown divert valve were to divert after the procedure for transfer was complete (with the errors of not opening the RHT inlet and not closing two valves to the SFP inlet from the Recycle Evaporator feed demineralizers). This could result in a flowrate of up to 120 gpm to the Spent Fuel Pool Transfer Canal. The transfer canal would fill and spill into the SFP.

The dilution event frequency for the Vogtle large pool due to a misaligned makeup valves event is calculated to be 5.49E-10/ry. The dilution event frequency for the Vogtle small pool due to a misaligned makeup valves event is calculated to be 7.54E-10/ry. Thus, the overall dilution event frequency due to a misaligned makeup valves event is (5.49E-10/ry) (51/52) + (7.54E-10/ry) (1/52) = 5.53E-10/ry.

2.2.7 INITIATING EVENT RESULTS

Based on Sections 2.2.1 - 2.2.6, it can be concluded that the total Vogtle spent fuel pool boron dilution event frequency (approximately 2.6E-07) is of the same magnitude as the frequency calculated for the composite plant (3.8E-7) using the generic methodology presented in Reference 1.

TABLE 2-2

Comparison of Dilution Event Frequencies

EVENT	WCAP-14181	VOGTLE
CCW LEAK	**1.5E-8**	4.7E-10
SEISMIC	7.3E-9	**1.3E-7**
TORNADO	**4.1E-9**	8.5E-11
RANDOM PIPE BREAK	**2.9E-7**	1.3E-7
DEMIN VALVE OPEN	**5.6E-8**	8.7E-13
MAKEUP VALVE OPEN	**1.0E-8**	7.1E-9
LETDOWN DIVERT		5.5E-10
REACTOR CAVITY SEAL	**3.3E-12**	N/A
TOTAL	**3.8E-7**	**2.6E-7**

2.3 BORON DILUTION TIMES AND VOLUMES

For Vogtle, the normal boron concentration maintained in the spent fuel pool is in the range of 2400 ppm. Based on the Vogtle criticality analysis, the soluble boron concentration necessary to meet criticality requirements (i.e., a $k_{eff} \leq 0.95$) is 1250 ppm. These were the endpoints considered for the deterministic evaluation of dilution volumes and times and a boron dilution event of 1150 ppm (2400 ppm - 1250 ppm) was evaluated. This amount of dilution is greater than that which results in the 820 ppm considered as the best estimate case for the composite plant analysis. The dilution volumes and times for the Vogtle scenarios are calculated based on the following equation:

$$t_{end} = \ln (C_0 \; / \; C_{end})V/Q \qquad \text{(Equation 1)}$$

Where:

t_{end} = time to dilute

C_0 = the boron concentration of the pool volume at the beginning of the event

C_{end} = the boron endpoint concentration

Q = dilution rate (gallons of water/minute)

V = volume (gallons) of spent fuel pool.

The time to dilute depends on the initial volume of the pool and the postulated rate of dilution. At Vogtle there are two 447,030 gallon spent-fuel pools which are normally opened to each other. The volume of the combined pools (referred to herein as the "large pool") was derived by assuming that 20% of each pool's gross volume is taken up by spent fuel racks and spent fuel. Therefore, the large pool volume is (447,030) (.80) (2) = 715,248 or approximately 715,000 gallons. This is a conservative value since the volume of the shared cask loading area would be filled with borated water and an integral part of the combined pools, but was not included in this analysis. When the pools are separated, a single (small) pool volume is assumed. This volume is half of the large pool volume, or 357,500 gallons (again allowing for the spent fuel and racks).

Equation 1, above, was used to calculate the dilution times for a range of dilution rates from 3520 gpm to 45 gpm for the spent fuel volumes cited above. Tables 2-3 and 2-4 list the Vogtle dilution times and volume data for a dilution event from 2400 ppm to 1250 ppm boron for both the combined (large) pool and single (small) pool cases for the range of dilution flow rates considered. Table 2-5 lists the calculated dilution times and volume data for the composite plant dilution event from 2200 ppm to 1380 ppm.

TABLE 2-3

Vogtle Dilution Time & Volume Data for Combined (Large) Pools

Dilution Event : 2400 ppm to 1250 ppm

Initial Boron Concentration - 2400 ppm

Final Boron Concentration - 1250 ppm

SFP Volume - 715,000 gallons

Dilution Volume - 466,413 gallons

Dilution Rate (gpm)	**Time to Dilute** (minutes)	(hours)
3520	132.5	2.2
2960	157.6	2.6
2660	175.3	2.9
2500	186.6	3.1
600	777	13.0
300	1554	25.9
200	2332	38.8
120	3887	64.8
100	4664	77.7
45	10365	172.7

TABLE 2-4

Vogtle Dilution Time & Volume Data for Single (Small) Pool

Dilution Event : 2400 ppm to 1250 ppm

Initial Boron Concentration - 2400 ppm

Final Boron Concentration - 1250 ppm

SFP Volume - 357, 500 gallons

Dilution Volume - 233,206 gallons

Dilution Rate (gpm)	**Time to Dilute** (minutes)	(hours)
3520	66.3	1.1
2960	78.8	1.3
2660	87.7	1.5
2500	93.3	1.6
600	388.7	6.5
300	777.4	12.9
200	1166	19.4
120	1943	32.4
100	2332	38.9
45	5182	86.4

TABLE 2-5

Composite Plant Dilution Time & Volume Data

Dilution Event: 2200 ppm to 1380 ppm

Initial Boron Concentration - 2200 ppm

Final Boron Concentration - 1380 ppm

SFP Volume - 400,000 gallons

Dilution Rate (gpm)	Time to Dilute (minutes)	(hours)
1500	124	2.1
1000	187	3.1
500	373	6.2
300	622	10.5
250	746	12.4
200	933	15.6
150	1244	20.7
100	1866	31.1
50	3731	62.2

2.3.1 CONSIDERATION OF DILUTION VOLUMES

As can be seen in Tables 2-3 and 2-4, a large volume of diluting water, compared to the composite plant, is necessary at Vogtle for a spent fuel pool boron dilution event to occur. For a dilution event from the nominal spent fuel pool boron concentration of 2400 ppm to a boron endpoint concentration of 1250 ppm, a dilution volume of nearly 466,000 gallons (approximately 65% of the normal pool water inventory) is required for the large pool. When the pools are separated, the volume required for the subject dilution becomes approximately 233,000 gallons (again approximately 65% of the normal pool water inventory).

To assess the potential of a spent fuel pool boron dilution event at Vogtle, the water available to dilute the spent fuel pool was determined and can be compared to the volumes required for dilution. The Vogtle dilution sources are summarized in Table 2-6 below.

TABLE 2-6

Vogtle Dilution Sources

Dilution Source	Quantity	Available Water (gal)	Total Water (gal)
Fire Protection Tank	2 (Shared)	300,000	600,000
Demin Water Tank	1 (Shared)	250,000	250,000
Reactor Makeup Tank	2 (1 each unit)	165,000	330,000
Component Cooling Surge Tank	4 (2 each unit)	2,200	8,800
Water Utility Water Tank	1 (Shared)	300,000	300,000

Although the CCW system and the other tanks have makeup capability from other systems, detection of a dilution event via level alarms and/or visual inspections would be expected long before a dilution to 1250 ppm would occur.

3.0 CONCLUSIONS

Based on the above analysis, the spent fuel pool boron dilution event frequency for Vogtle is approximately 2.6E-07, which is the same order of magnitude as the composite plant analyzed in WCAP 14181 and less than the NRC Safety Goal Policy Statement target frequency risk level objective of 1.0E-6/ry. Furthermore, evaluations show that a large volume of water (466,000 gallons for the large pool and 233,000 gallons for the small pool) would be necessary to dilute the spent fuel pool to the minimum soluble boron concentration required to preclude loss of an acceptable margin to criticality at Vogtle (1250 ppm). Since such a large water volume addition is required, the dilution event would be readily detected and terminated by plant personnel.

4.0 REFERENCES

1. WCAP-14181, " Evaluation of the Potential for Diluting PWR Spent Fuel Pools, July 1995.

2. Vogtle Units 1 and 2 Spent Fuel Rack Criticality Analysis with Credit for Soluble Boron, June, 1996

3. Vogtle Updated Final Safety Analysis Report.

4. NUREG-1488, "Revised Livermore Seismic Hazard Estimates for Sixty-Nine Nuclear Power Plant Sites East of the Rocky Mountains," US Nuclear Regulatory Commission, Final Report, April 1994.

5. NUREG/CR-1278, "Handbook of Human Reliability Analysis with Emphasis of Nuclear Power Plant Application - Final Report," US Nuclear Regulatory Commission, August 1983.

ENCLOSURE 7

VOGTLE ELECTRIC GENERATING PLANT
REQUEST TO REVISE TECHNICAL SPECIFICATIONS
CREDIT FOR BORON AND ENRICHMENT INCREASE FOR FUEL STORAGE

COLR SECTIONS

The following sections would be inserted into the COLRs for VEGP Units 1 and 2. The COLR section numbers for the current COLR would be new section numbers 2.9 and 2.10. The COLR section numbers for the COLR associated with the ITS may be different but the wording would be the same. A marked up version of the current COLRs for Units 1 and 2 are included for information. When the COLR for the ITS is issued, the sections for the fuel storage pool will be added as independent sections. Therefore, the page numbers and section numbers may differ.

Proposed new sections for the Unit 1 COLR

2.9 Fuel Storage Pool Boron Concentration (Specification 3.7.17)

2.9.1 The boron concentration shall be greater than or equal to 1100 ppm.

2.10 Fuel Assembly Storage (Specification 3.7.18)

2.10.1 All Cell Storage

Storage of 17x17 fuel assemblies in any cell location. Fuel assemblies must have an initial nominal enrichment no greater than 2.0 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10.

2.10.2 3-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 3-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial nominal enrichment no greater than 2.70 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10. A 3-out-of-4 checkerboard with empty cells means that no more than 3 fuel assemblies can occupy any 2x2 matrix of storage cells. Figure 11 shows two examples of acceptable 3-out-of-4 checkerboard patterns.

COLR SECTIONS (continued)

2.10.3 2-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 2-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial maximum enrichment no greater than 5.0 weight percent U-235. A 2-out-of-4 checkerboard with empty cells means that no 2 fuel assemblies may be stored face adjacent. Fuel assemblies may be stored corner adjacent. Figure 11 shows the 2-out-of-4 checkerboard pattern.

2.10.4 Checkerboard Storage Interface

More than one storage pattern may be utilized in the fuel storage pool at the same time. At the interfaces between all cell, 3-out-of-4, and/or 2-out-of-4 storage patterns, every 2x2 array of assemblies must meet the storage requirements for the assembly in that 2x2 array with the most restrictive storage requirements. Alternately, a row of empty storage cells may be used to interface between storage patterns.

Proposed new sections for the Unit 2 COLR

2.9 Fuel Storage Pool Boron Concentration (Specification 3.7.17)

2.9.1 The boron concentration shall be greater than or equal to 1250 ppm.

2.10 Fuel Assembly Storage (Specification 3.7.18)

2.10.1 All Cell Storage

Storage of 17x17 fuel assemblies in any cell location. Fuel assemblies must have an initial nominal enrichment no greater than 1.82 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10.

2.10.2 3-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 3-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial nominal enrichment no greater than 2.54 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10. A 3-out-of-4 checkerboard with empty cells means that no more than 3 fuel assemblies can occupy any 2x2 matrix of storage cells. Figure 12 shows two examples of acceptable 3-out-of-4 checkerboard patterns.

2.10.3 2-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 2-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial maximum enrichment no greater than 5.0 weight percent U-235. A 2-out-of-4 checkerboard with empty cells means that no 2 fuel assemblies may be stored face adjacent. Fuel assemblies may be stored corner adjacent. Figure 13 shows the 2-out-of-4 checkerboard pattern.

2.10.4 3x3 Checkerboard Storage

Storage of Westinghouse 17x17 fuel assemblies with nominal enrichments no greater than 4.0 weight percent U-235 (equivalent enrichment with IFBA credit, shown in table 3 and figure 11) in the center of a 3x3 checkerboard shown in figure 13. The surrounding fuel assemblies must have an initial nominal enrichment no greater than 1.48 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10.

2.10.5 Checkerboard Storage Interface

More than one storage pattern may be utilized in the fuel storage pool at the same time.

2.10.5.1 Interfaces Between All Cell, 3-out-of-4, and/or 2-out-of-4 Storage Patterns

At the interfaces between all cell, 3-out-of-4, and/or 2-out-of-4 storage patterns, every 2x2 array of assemblies must meet the storage requirements for the assembly in that 2x2 array with the most restrictive storage requirements. Alternately, a row of empty storage cells may be used to interface between storage patterns.

2.10.5.2 Interfaces Between the 3x3 Storage Patterns and All Other Storage Patterns

The interface between the 3x3 storage pattern and all other storage patterns shall consist of a row of empty storage cells.

VOGTLE ELECTRIC GENERATING PLANT (VEGP) UNIT 1 CYCLE 7

CORE OPERATING LIMITS REPORT

MARCH 1996

9604170009 19pp

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for VEGP UNIT 1 CYCLE 7 has been prepared in accordance with the requirements of Technical Specification 6.8.1.6.

The Technical Specifications affected by this report are listed below:

3/4.1.1.1	SHUTDOWN MARGIN - MODES 1 and 2
3/4.1.1.2	SHUTDOWN MARGIN - MODES 3, 4 and 5
3/4.1.1.3	Moderator Temperature Coefficient
3/4.1.3.5	Shutdown Rod Insertion Limit
3/4.1.3.6	Control Rod Insertion Limits
3/4.2.1	Axial Flux Difference
3/4.2.2	Heat Flux Hot Channel Factor - $F_Q(Z)$
3/4.2.3	Nuclear Enthalpy Rise Hot Channel Factor - $F^N_{\Delta H}$
3/4.7.17	Fuel Storage Pool Boron Concentration
3/4.7.18	Fuel Assembly Storage.

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in section 1.0 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 6.8.1.6

2.1 SHUTDOWN MARGIN - MODES 1 AND 2 (Specification 3/4.1.1.1)

2.1.1 The SHUTDOWN MARGIN shall be greater than or equal to 1.3 percent $\Delta k/k$.

2.2 SHUTDOWN MARGIN - MODES 3, 4 AND 5 (Specification 3/4.1.1.2)

2.2.1 The SHUTDOWN MARGIN shall be greater than or equal to the limits shown in figures 1 and 2.

2.3 Moderator Temperature Coefficient (Specification 3/4.1.1.3)

2.3.1 The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO/HZP - MTC shall be less positive than $+0.7 \times 10^{-4}$ $\Delta k/k/°F$ for power levels up to 70 percent RTP with a linear ramp to 0 $\Delta k/k/°F$ at 100 percent RTP.

The EOL/ARO/RTP-MTC shall be less negative than -5.50×10^{-4} $\Delta k/k/°F$.*

2.3.2 The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to -4.75×10^{-4} $\Delta k/k/°F$.*

where: BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
HZP stands for Hot Zero THERMAL POWER
EOL stands for End of Cycle Life
RTP stands for RATED THERMAL POWER

2.4 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

2.4.1 The shutdown rods shall be withdrawn to a position greater than or equal to 225 steps.

2.5 Control Rod Insertion Limits (Specification 3/4.1.3.6)

2.5.1 The control rod banks shall be limited in physical insertion as shown in figure 3.

*Based on full-power T-average of 586.4.

2.6 Axial Flux Difference (Specification 3/4.2.1)
{relaxed axial offset control (RAOC) methodology}

2.6.1 The Axial Flux Difference (AFD) acceptable operation limits are provided in figure 4.

2.7 Heat Flux Hot Channel Factor - $F_Q(Z)$ (Specification 3/4.2.2)
{F_Q methodology}

2.7.1 $$F_Q(Z) \le \frac{F_Q^{RTP}}{P} * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \le \frac{F_Q^{RTP}}{0.5} * K(Z) \quad \text{for } P \le 0.5$$

where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

2.7.2 $F_Q^{RTP} = 2.50$

2.7.3 K(Z) is provided in figure 5.

2.7.4 $$F_Q^{C}(Z) \le \frac{F_Q^{RTP} * K(Z)}{P * W(Z)} \quad \text{for } P > 0.5$$

$$F_Q^{C}(Z) \le \frac{F_Q^{RTP} * K(Z)}{0.5 * W(Z)} \quad \text{for } P \le 0.5$$

2.7.5 W(Z) values are provided in figures 6 through 9.

2.7.6 The $F_Q^C(Z)$ penalty factors are provided in table 1.

2.8 Nuclear Enthalpy Rise Hot Channel Factor - $F_{\Delta H}^N$ (Specification 3/4.2.3)

2.8.1 $F_{\Delta H}^N \le F_{\Delta H}^{RTP} * (1 + PF_{\Delta H} * (1-P))$

where: $P = \dfrac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

2.8.2a $F_{\Delta H}^{RTP}$ = 1.53 for LOPAR fuel and

2.8.2b $F_{\Delta H}^{RTP}$ = 1.65 for VANTAGE 5 fuel

2.8.3 $PF_{\Delta H}$ = 0.3 for LOPAR and VANTAGE 5 fuel

TABLE 1

$F_Q^c(Z)$ PENALTY FACTOR

Cycle Burnup (MWD/MTU)	$F_Q^c(Z)$ Penalty Factor
360	1.021
1408	1.021
3085	1.024
3295	1.030
3924	1.033
4344	1.031
4973	1.026
5392	1.024
6021	1.023
6650	1.022
7069	1.021

Notes:

1. The Penalty Factor, to be applied to $F_Q^c(Z)$ in accordance with surveillance requirement 4.2.2.2.f, is the maximum factor by which $F_Q^c(Z)$ is expected to increase over a 39 EFPD interval (surveillance interval of 31 EFPD plus the maximum allowable extension not to exceed 25% of the surveillance interval per Technical Specification 4.0.2) starting from the burnup at which the $F_Q^c(Z)$ was determined.
2. Linear interpolation is adequate for intermediate cycle burnups.
3. For <u>all</u> cycle burnups outside the range of the table, a penalty factor of 1.0200 shall be used.

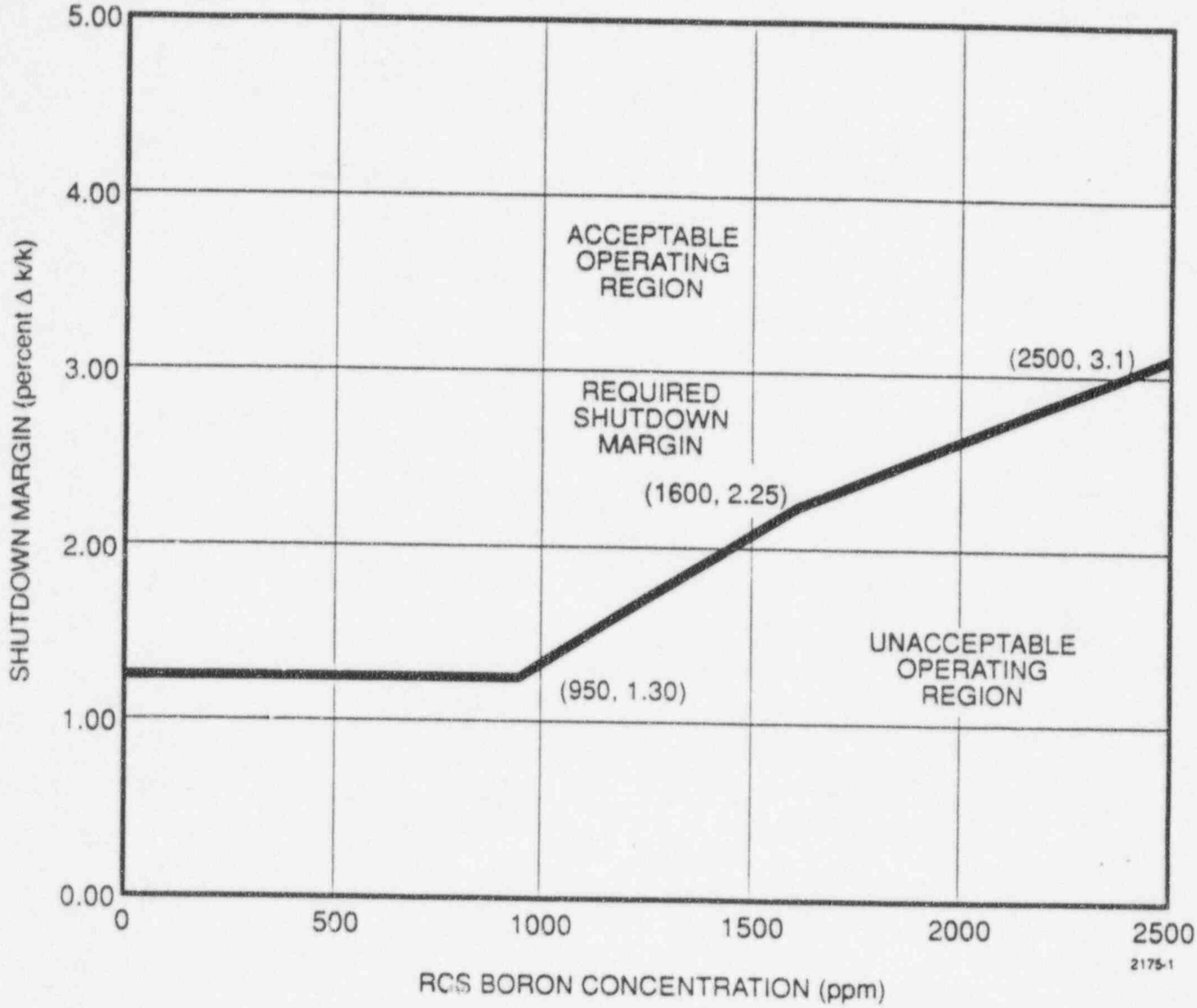


FIGURE 1

REQUIRED SHUTDOWN MARGIN FOR MODES 3 AND 4 (MODE 4 WITH AT LEAST ONE REACTOR COOLANT PUMP RUNNING)

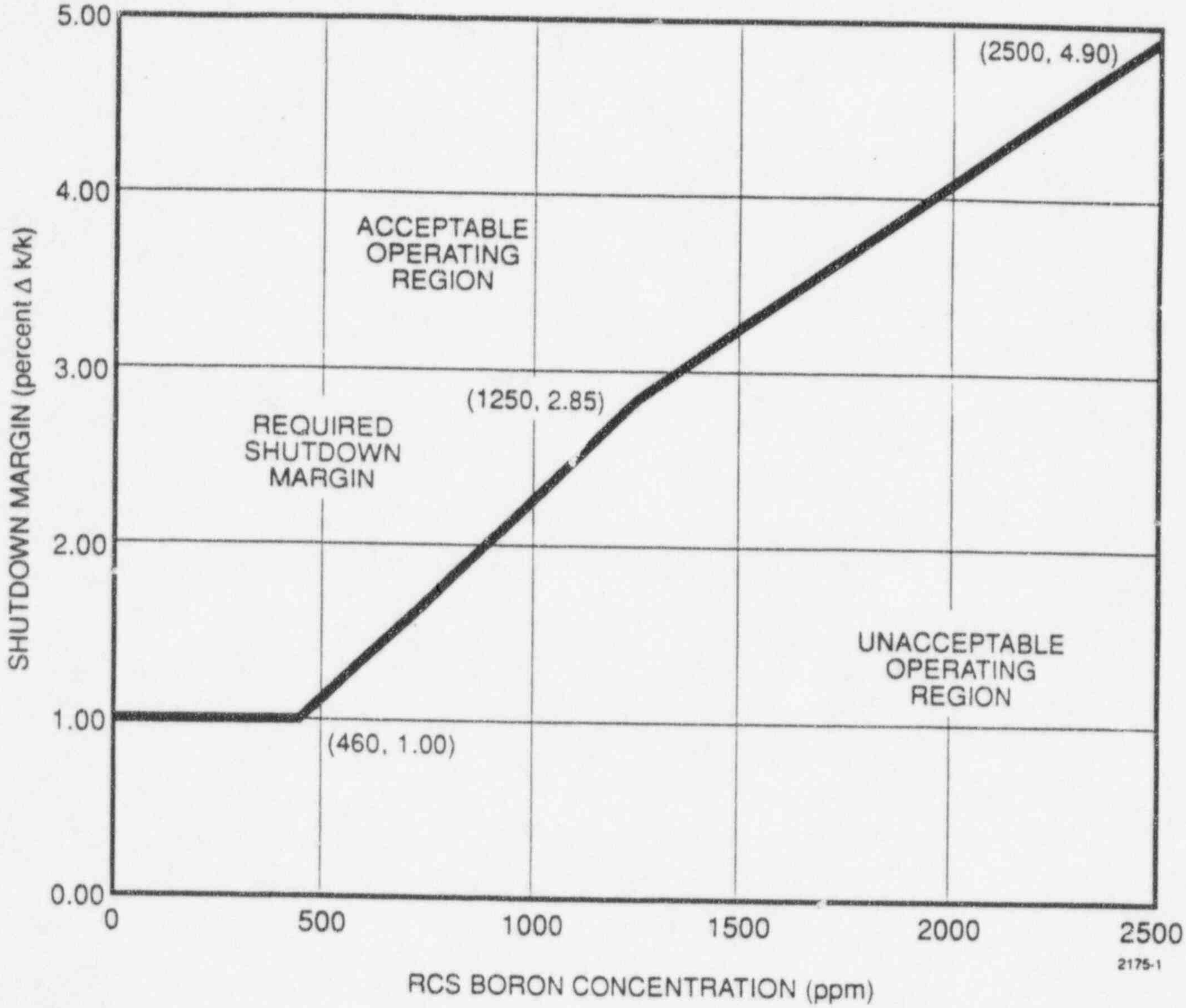
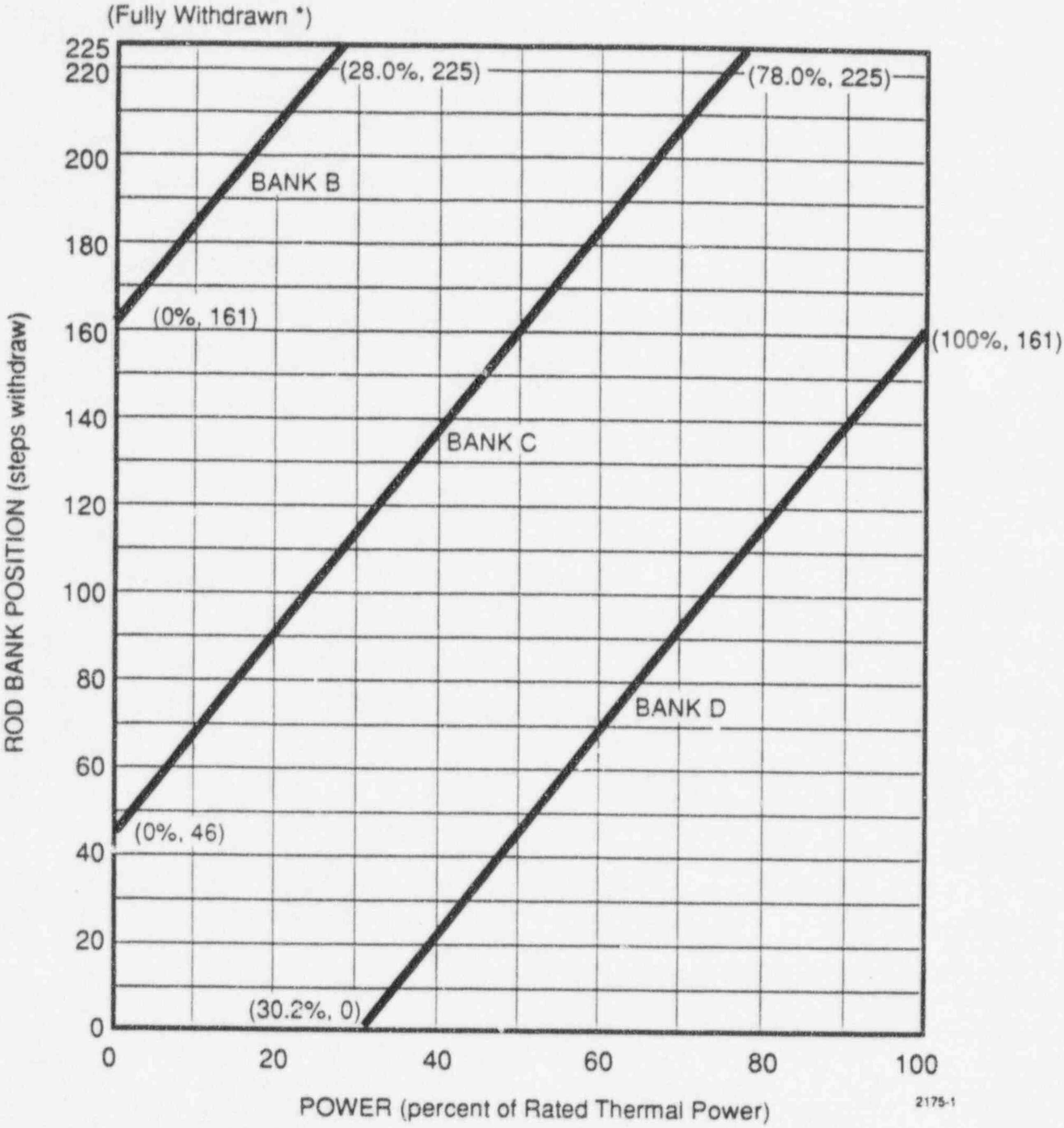


FIGURE 2

REQUIRED SHUTDOWN MARGIN FOR MODES 4 AND 5 (MODE 4 WITH NO REACTOR COOLANT PUMPS RUNNING)



* Fully withdrawn shall be the condition where control rods are at a position within the interval ≥225 and ≤231 steps withdrawn.

NOTE: The Rod Bank Insertion Limits are based on the control bank withdrawal sequence A, B, C, D and a control bank tip-to-tip distance of 115 steps.

FIGURE 3

ROD BANK INSERTION LIMITS VERSUS RATED THERMAL POWER

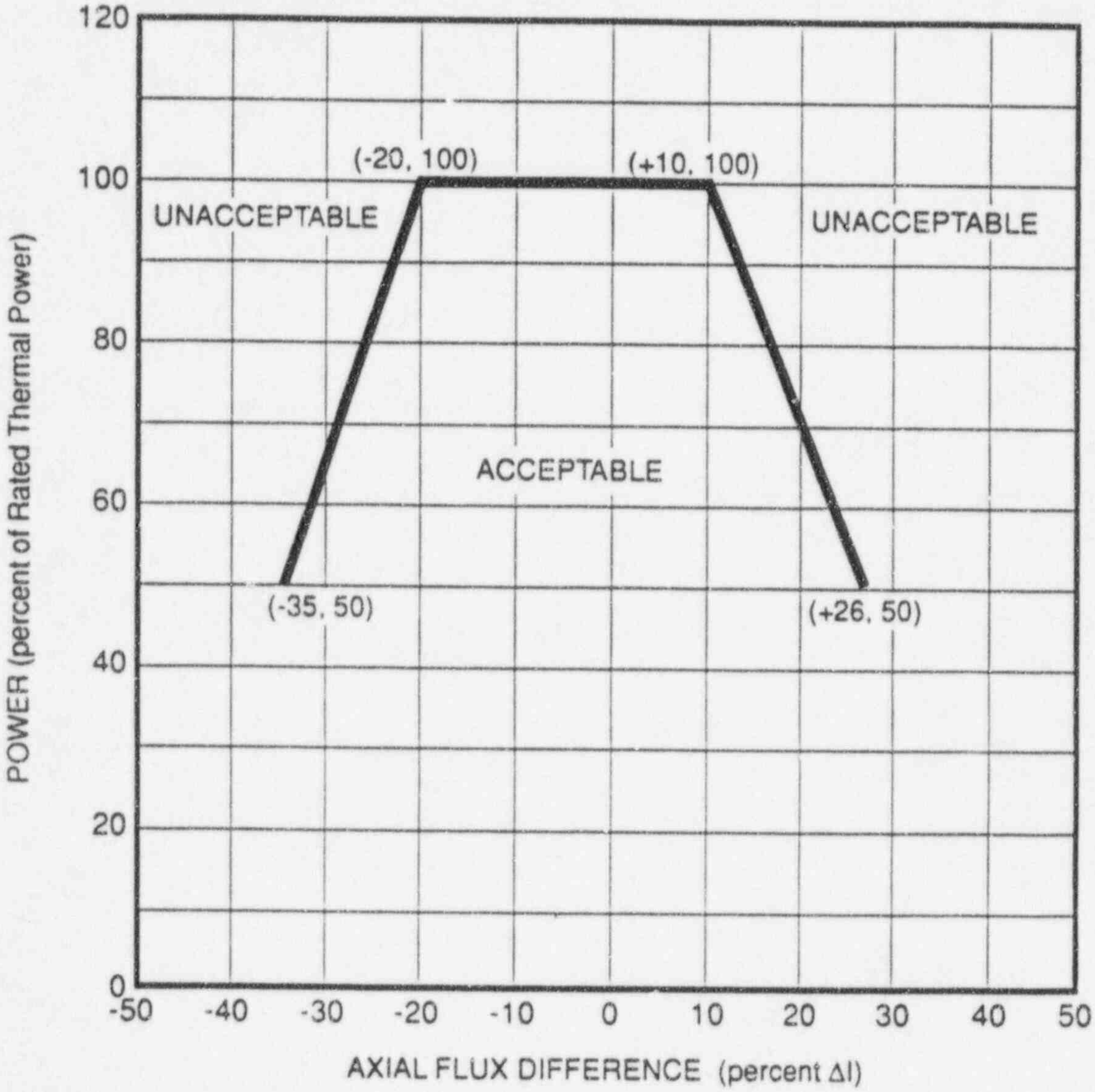


FIGURE 4

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER FOR RAOC

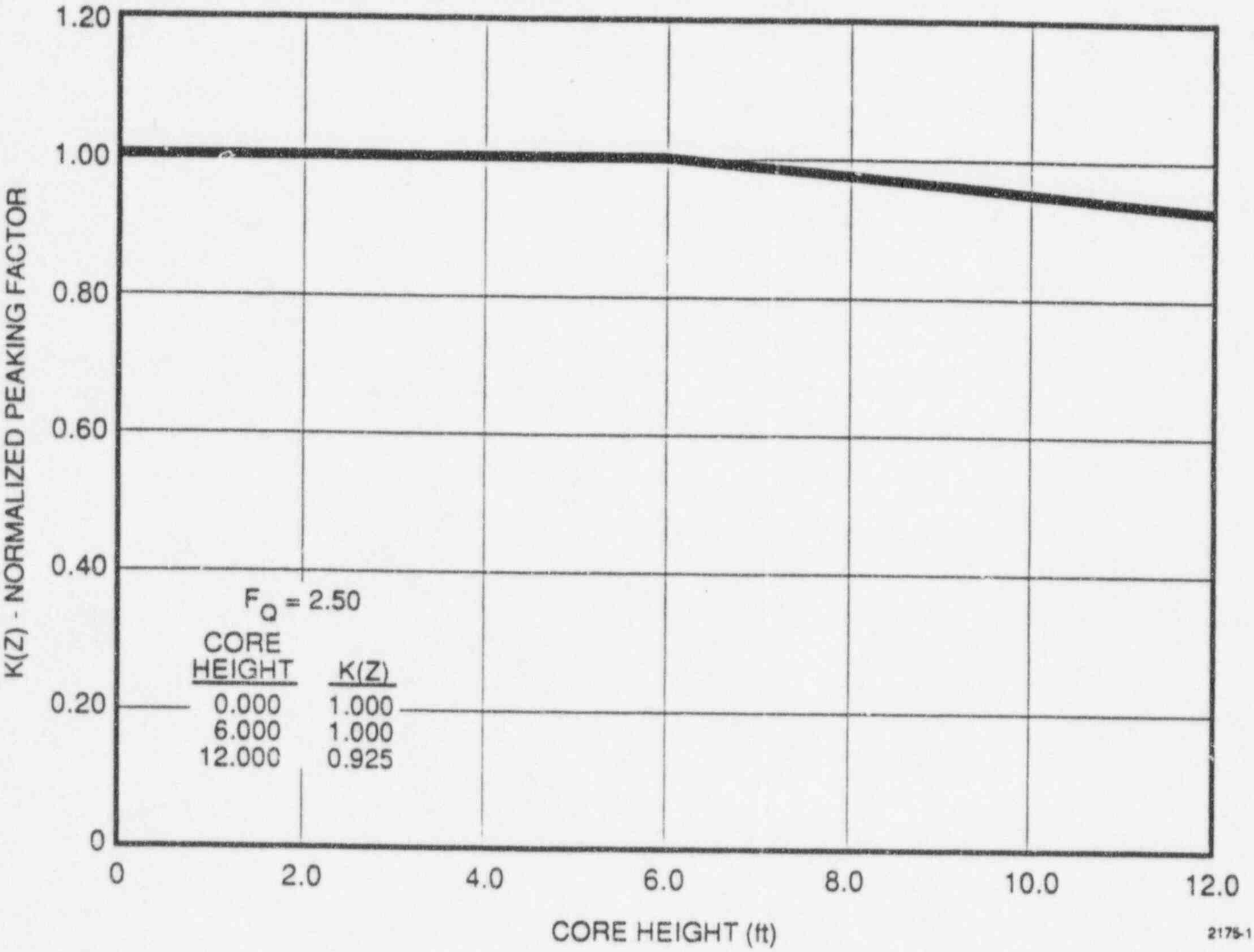
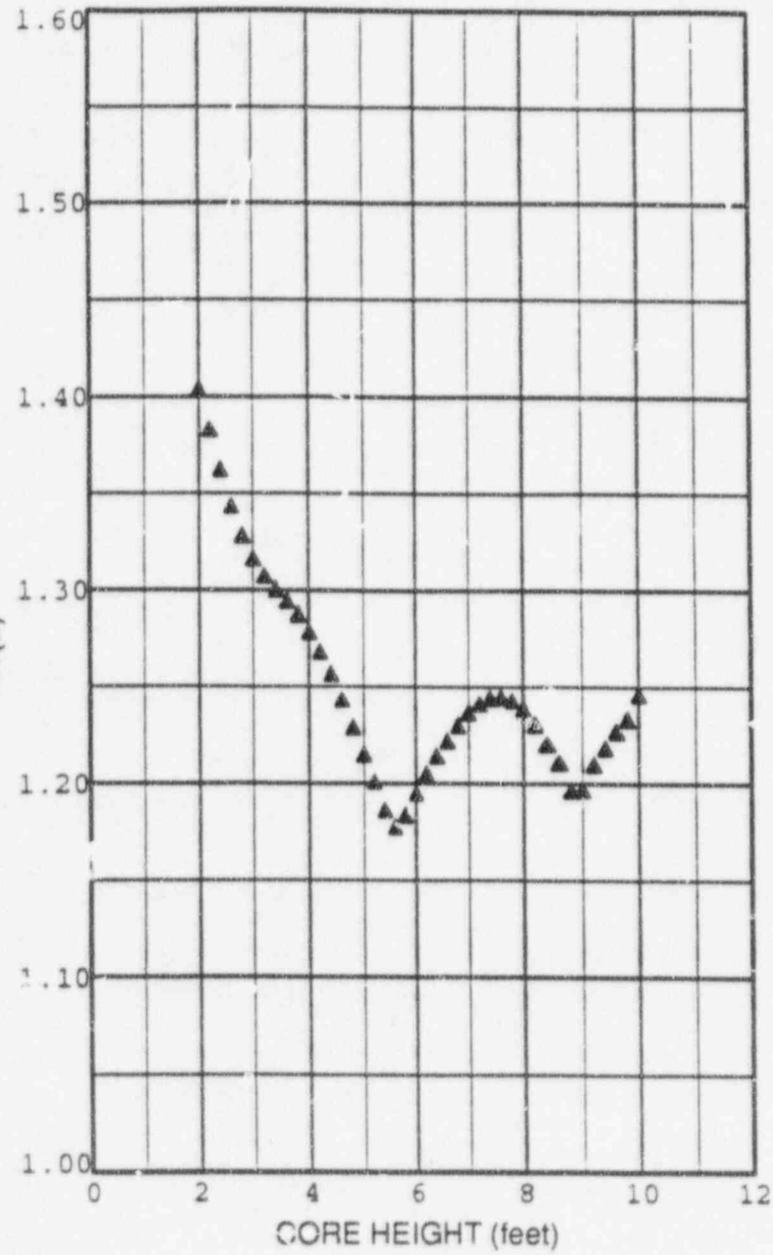


FIGURE 5

K(Z) - NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

COLR FOR VEGP UNIT 1 CYCLE 7



	Axial Point	Elevation (feet)	BOL W(z)
*	1	12.00	1.0000
*	2	11.80	1.0000
*	3	11.60	1.0000
*	4	11.40	1.0000
*	5	11.20	1.0000
*	6	11.00	1.0000
*	7	10.80	1.0000
*	8	10.60	1.0000
*	9	10.40	1.0000
*	10	10.20	1.0000
	11	10.00	1.2462
	12	9.80	1.2334
	13	9.60	1.2269
	14	9.40	1.2183
	15	9.20	1.2096
	16	9.00	1.1967
	17	8.80	1.1963
	18	8.60	1.2108
	19	8.40	1.2202
	20	8.20	1.2303
	21	8.00	1.2383
	22	7.80	1.2427
	23	7.60	1.2448
	24	7.40	1.2442
	25	7.20	1.2414
	26	7.00	1.2366
	27	6.80	1.2298
	28	6.60	1.2219
	29	6.40	1.2141
	30	6.20	1.2050
	31	6.00	1.1950
	32	5.80	1.1835
	33	5.60	1.1774
	34	5.40	1.1861
	35	5.20	1.2007
	36	5.00	1.2148
	37	4.80	1.2289
	38	4.60	1.2433
	39	4.40	1.2564
	40	4.20	1.2680
	41	4.00	1.2783
	42	3.80	1.2872
	43	3.60	1.2944
	44	3.40	1.3001
	45	3.20	1.3072
	46	3.00	1.3163
	47	2.80	1.3280
	48	2.60	1.3432
	49	2.40	1.3620
	50	2.20	1.3829
	51	2.00	1.4038
*	52	1.80	1.0000
*	53	1.60	1.0000
*	54	1.40	1.0000
*	55	1.20	1.0000
*	56	1.00	1.0000
*	57	0.80	1.0000
*	58	0.60	1.0000
*	59	0.40	1.0000
*	60	0.20	1.0000
*	61	0.00	1.0000

* Top and Bottom 15% Excluded per Technical Specification 4.2.2.2

FIGURE 6

RAOC W(Z) AT 150 MWD/MTU

This figure is referred to by Technical Specifications 4.2.2.2d, B3/4.2.2

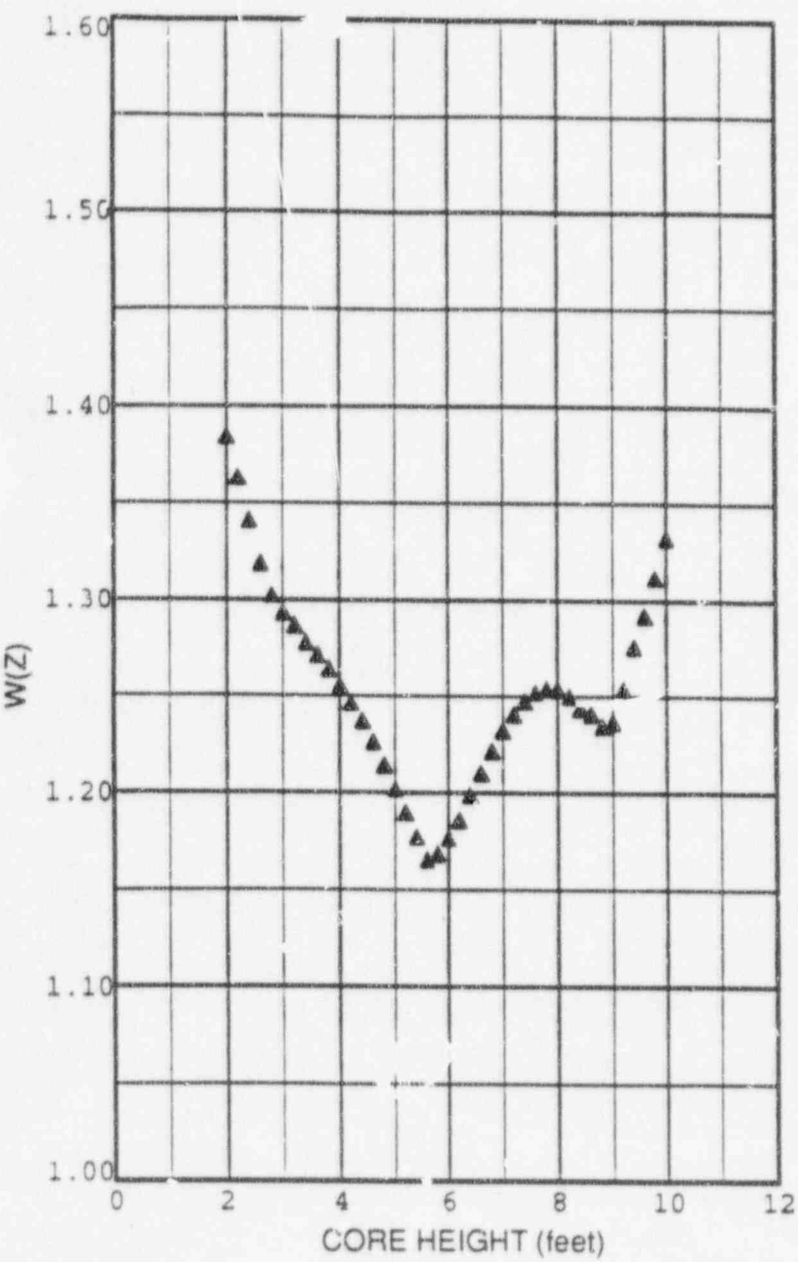


FIGURE 7

RAOC W(Z) AT 4000 MWD/MTU

Axial Point	Elevation (feet)	MOL-1 W(z)
* 1	12.00	1.0000
* 2	11.80	1.0000
* 3	11.60	1.0000
* 4	11.40	1.0000
* 5	11.20	1.0000
* 6	11.00	1.0000
* 7	10.80	1.0000
* 8	10.60	1.0000
* 9	10.40	1.0000
* 10	10.20	1.0000
11	10.00	1.3323
12	9.80	1.3115
13	9.60	1.2919
14	9.40	1.2756
15	9.20	1.2534
16	9.00	1.2[illegible]64
17	8.80	1.2341
18	8.60	1.2404
19	8.40	1.2434
20	8.20	1.2494
21	8.00	1.2534
22	7.80	1.2538
23	7.60	1.2518
24	7.40	1.2472
25	7.20	1.2404
26	7.00	1.2318
27	6.80	1.2213
28	6.60	1.2097
29	6.40	1.1985
30	6.20	1.1856
31	6.00	1.1763
32	5.80	1.1681
33	5.60	1.1652
34	5.40	1.1769
35	5.20	1.1894
36	5.00	1.2014
37	4.80	1.2139
38	4.60	1.2258
39	4.40	1.2366
40	4.20	1.2460
41	4.00	1.2552
42	3.80	1.2637
43	3.60	1.2708
44	3.40	1.2773
45	3.20	1.2861
46	3.00	1.2930
47	2.80	1.3020
48	2.60	1.3185
49	2.40	1.3409
50	2.20	1.3627
51	2.00	1.3839
* 52	1.80	1.0000
* 53	1.60	1.0000
* 54	1.40	1.0000
* 55	1.20	1.0000
* 56	1.00	1.0000
* 57	0.80	1.0000
* 58	0.60	1.0000
* 59	0.40	1.0000
* 60	0.20	1.0000
* 61	0.00	1.0000

* Top and Bottom 15% Excluded per Technical Specification 4.2.2.2

This figure is referred to b[illegible] al Specifications 4.2.2.2d, B3/4 2.2

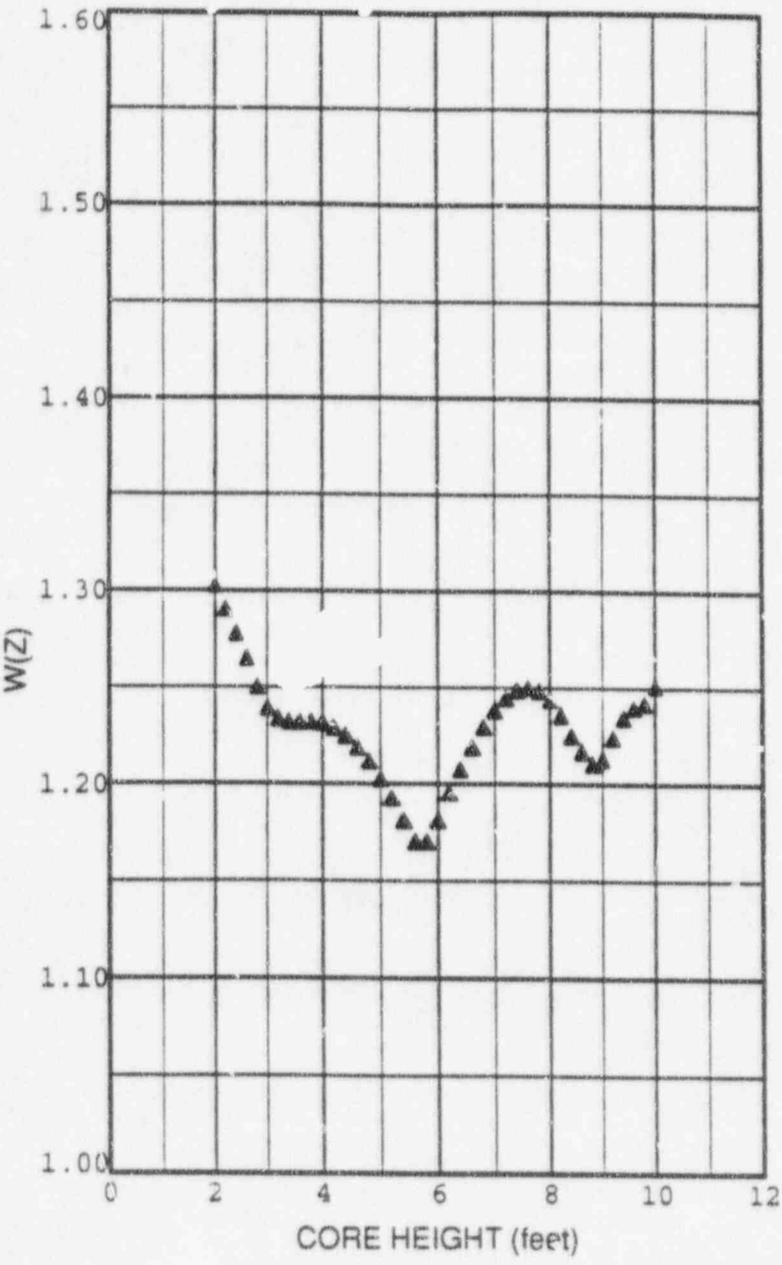


FIGURE 8

RAOC W(Z) AT 11000 MWD/MTU

	Axial Point	Elevation (feet)	MOL-2 W(z)
*	1	12.00	1.0000
*	2	11.80	1.0000
*	3	11.60	1.0000
*	4	11.40	1.0000
*	5	11.20	1.0000
*	6	11.00	1.0000
*	7	10.80	1.0000
*	8	10.60	1.0000
*	9	10.40	1.0000
*	10	10.20	1.0000
	11	10.00	1.2506
	12	9.80	1.2416
	13	9.60	1.2393
	14	9.40	1.2343
	15	9.20	1.2239
	16	9.00	1.2129
	17	8.80	1.2103
	18	8.60	1.2166
	19	8.40	1.2249
	20	8.20	1.2354
	21	8.00	1.2435
	22	7.80	1.2480
	23	7.60	1.2496
	24	7.40	1.2483
	25	7.20	1.2443
	26	7.00	1.2379
	27	6.80	1.2292
	28	6.60	1.2187
	29	6.40	1.2071
	30	6.20	1.1952
	31	6.00	1.1810
	32	5.80	1.1699
	33	5.60	1.1699
	34	5.40	1.1808
	35	5.20	1.1923
	36	5.00	1.2024
	37	4.80	1.2113
	38	4.60	1.2186
	39	4.40	1.2245
	40	4.20	1.2286
	41	4.00	1.2312
	42	3.80	1.2318
	43	3.60	1.2316
	44	3.40	1.2316
	45	3.20	1.2333
	46	3.00	1.2389
	47	2.80	1.2499
	48	2.60	1.2644
	49	2.40	1.2775
	50	2.20	1.2902
	51	2.00	1.3025
*	52	1.80	1.0000
*	53	1.60	1.0000
*	54	1.40	1.0000
*	55	1.20	1.0000
*	56	1.00	1.0000
*	57	0.80	1.0000
*	58	0.60	1.0000
*	59	0.40	1.0000
*	60	0.20	1.0000
*	61	0.00	1.0000

* Top and Bottom 15% Excluded per Technical Specification 4.2.2.2

This figure is referred to by Technical Specifications 4.2.2.2d, B3/4.2.2

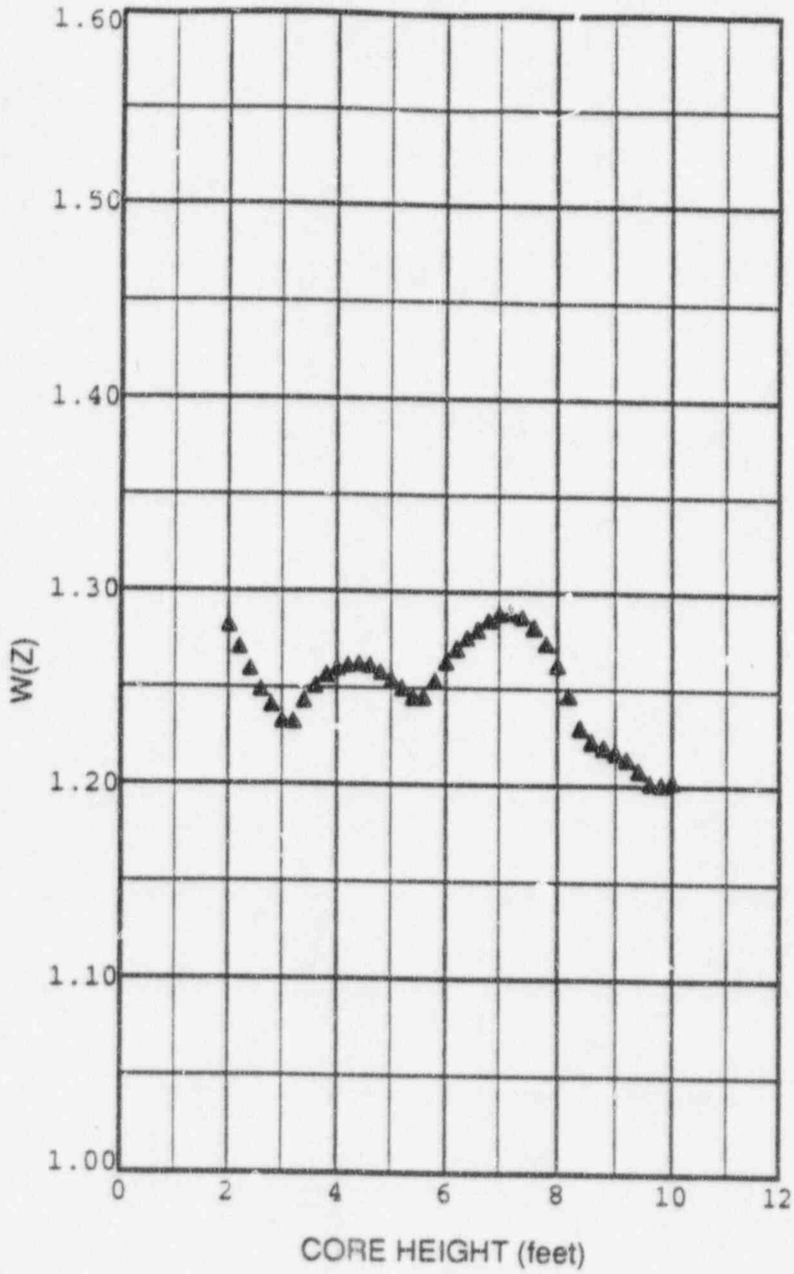


FIGURE 9

RAOC W(Z) AT 19000 MWD/MTU

	Axial Point	Elevation (feet)	EOL W(z)
*	1	12.00	1.0000
*	2	11.80	1.0000
*	3	11.60	1.0000
*	4	11.40	1.0000
*	5	11.20	1.0000
*	6	11.00	1.0000
*	7	10.80	1.0000
*	8	10.60	1.0000
*	9	10.40	1.0000
*	10	10.20	1.0000
	11	10.00	1.2023
	12	9.80	1.2005
	13	9.60	1.2013
	14	9.40	1.2077
	15	9.20	1.2133
	16	9.00	1.2167
	17	8.80	1.2193
	18	8.60	1.2226
	19	8.40	1.2297
	20	8.20	1.2464
	21	8.00	1.2620
	22	7.80	1.2732
	23	7.60	1.2816
	24	7.40	1.2869
	25	7.20	1.2891
	26	7.00	1.2886
	27	6.80	1.2851
	28	6.60	1.2802
	29	6.40	1.2759
	30	6.20	1.2703
	31	6.00	1.2635
	32	5.80	1.2534
	33	5.60	1.2450
	34	5.40	1.2450
	35	5.20	1.2497
	36	5.00	1.2541
	37	4.80	1.2579
	38	4.60	1.2614
	39	4.40	1.2623
	40	4.20	1.2616
	41	4.00	1.2600
	42	3.80	1.2565
	43	3.60	1.2509
	44	3.40	1.2433
	45	3.20	1.2322
	46	3.00	1.2325
	47	2.80	1.2408
	48	2.60	1.2487
	49	2.40	1.2595
	50	2.20	1.2708
	51	2.00	1.2821
*	52	1.80	1.0000
*	53	1.60	1.0000
*	54	1.40	1.0000
*	55	1.20	1.0000
*	56	1.00	1.0000
*	57	0.80	1.0000
*	58	0.60	1.0000
*	59	0.40	1.0000
*	60	0.20	1.0000
*	61	0.00	1.0000

* **Top and Bottom 15% Excluded per Technical Specification 4.2.2.2**

This figure is referred to by Technical Specifications 4.2.2.2d, B3/4.2.2

FUEL STORAGE

2.9 Fuel Storage Pool Boron Concentration (Specification 3.7.17)

2.9.1 The boron concentration shall be greater than or equal to 1100 ppm.

2.10 Fuel Assembly Storage (Specification 3.7.18)

2.10.1 All Cell Storage

Storage of 17x17 fuel assemblies in any cell location. Fuel assemblies must have an initial nominal enrichment no greater than 2.0 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10.

2.10.2 3-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 3-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial nominal enrichment no greater than 2.70 weight percent U-235 or satisfy a minimum burnup requirement shown in table 2 and figure 10. A 3-out-of-4 checkerboard with empty cells means that no more than 3 fuel assemblies can occupy any 2x2 matrix of storage cells. Figure 11 shows two examples of acceptable 3-out-of-4 checkerboard patterns.

2.10.3 2-out-of-4 Checkerboard Storage

Storage of 17x17 fuel assemblies in a 2-out-of-4 checkerboard arrangement with empty cells. Fuel assemblies must have an initial maximum enrichment no greater than 5.0 weight percent U-235. A 2-out-of-4 checkerboard with empty cells means that no 2 fuel assemblies may be stored face adjacent. Fuel assemblies may be stored corner adjacent. Figure 11 shows the 2-out-of-4 checkerboard pattern.

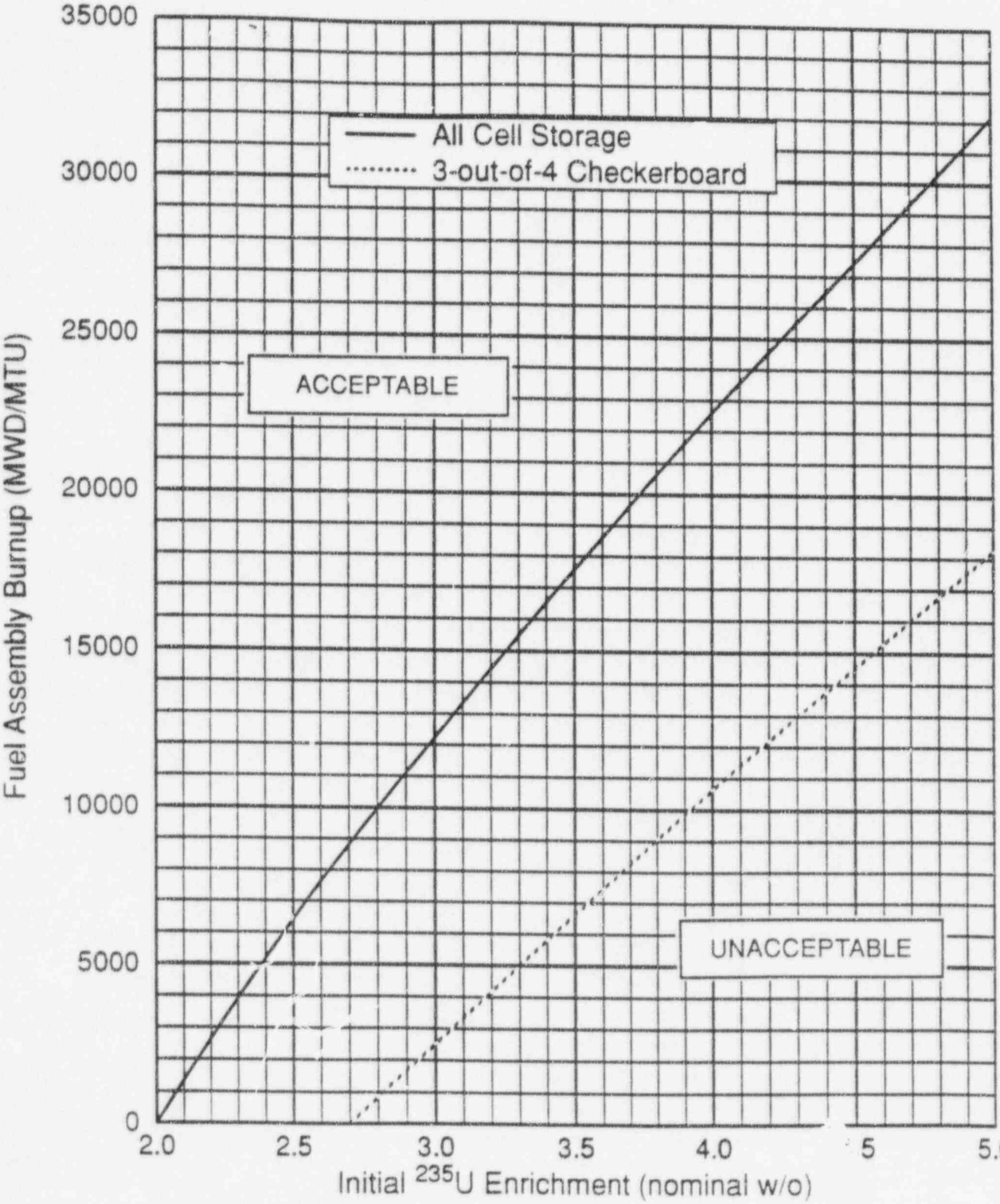
2.10 Checkerboard Storage Interface

More than one storage pattern may be utilized in the fuel storage pool at the same time. At the interfaces between all cell, 3-out-of-4, and/or 2-out-of-4 storage patterns, every 2x2 array of assemblies must meet the storage requirements for the assembly in that 2x2 array with the most restrictive storage requirements. Alternately, a row of empty storage cells may be used to interface between storage patterns.

TABLE 2. MINIMUM BURNUP REQUIREMENTS FOR VOGTLE UNIT 1

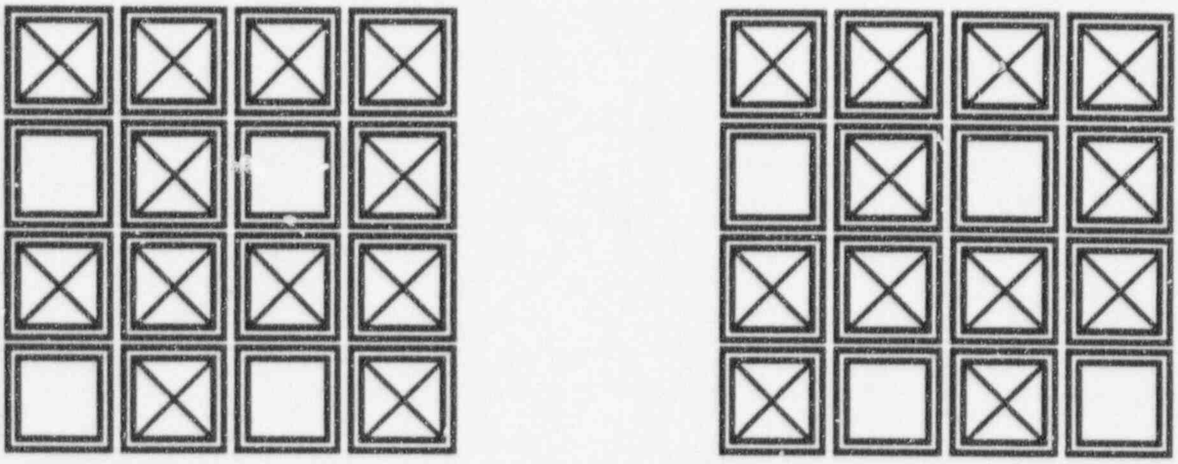
Nominal Enrichment (w/o ^{235}U)	All Cell Burnup (MWD/MTU)	3-out-of-4 .erboard Burnup (MWD/MTU)	2-out-of-4 Checkerboard Burnup (MWD/MTU)
2.00	0	0	0
2.20	2647	0	0
2.40	5185	0	0
2.60	7622	0	0
2.70	8806	0	0
2.80	9967	846	0
3.00	12229	2524	0
3.20	14416	4183	0
3.40	16537	5824	0
3.60	18600	7445	0
3.80	20614	9048	0
4.00	22589	10632	0
4.20	24532	12197	0
4.40	26453	13744	0
4.60	28359	15271	0
4.80	30260	16780	0
5.00	32165	18270	0

NOTE: There is no minimum burnup requirement for the 2-out-of-4 Checkerbo.rd Storage Configuration for enrichments up to and including 5.0 weight percent U-235 (COLR Section 2.10.3).



NOTE: There is no minimum burnup requirement for the 2-out-of-4 Checkerboard Storage Configuration for enrichments up to and including 5.0 weight percent U-235 (COLR Section 2.10.3).

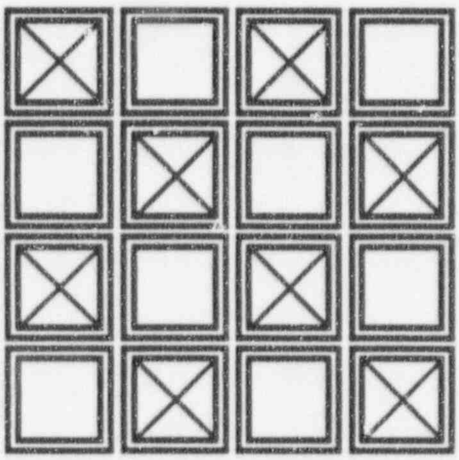
FIGURE 10 VOGTLE UNIT 1 BURNUP CREDIT REQUIREMENTS



Empty Storage Cell

Fuel Assembly in Storage Cell

Typical Acceptable Patterns for 3-out-of-4
Checkerboard Storage



Empty Storage Cell

Fuel Assembly in Storage Cell

2-out-of-4 Checkerboard Storage

FIGURE 11 VOGTLE UNIT 1 CHECKERBOARD STORAGE CONFIGURATIONS