TVA

WATTS BAR UNIT 1
CYCLE 2
RELOAD SAFETY EVALUATION

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1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

This Reload Safety Evaluation (RSE) report presents an evaluation for Watts Bar Unit 1 Cycle 2, which demonstrates that the core reload and the associated Core Operating Limits Report (COLR) will not adversely affect the safe operation of the plant. This evaluation was accomplished utilizing the methodology described in WCAP-9273-NP-A, "Westinghouse Reload Safety Evaluation Methodology"(1).

The Watts Bar Nuclear Power Plant Unit 1 is completing its first cycle of operation. The unit is expected to be refueled and ready for Cycle 2 startup during October 1997. Watts Bar Unit 1 operated Cycle 1 with 193 Westinghouse 17X17 VANTAGE 5H (V5H) fuel assemblies with the Standard fuel rods. The V5H features have been addressed previously in a Final Safety Analysis Report (FSAR) update(2) for Cycle 1.

For Cycle 2, the Watts Bar Unit 1 fresh reload fuel will consist of Westinghouse 17X17 VANTAGE+ fuel assemblies with PERFORMANCE+ features as described in Section 2.1. Non-LOCA and small break LOCA analyses have been performed to justify use of this fuel in combination with increased peaking factors(F_Q=2.50, $F_{\Delta H}$=1.65), 10% steam generator tube plugging (SGTP) level, revised OTΔT margin enhancement, reduced reactor coolant system (RCS) flow and boron concentration increase for the Refueling Water Storage Tank (RWST) and cold leg accumulators. These analyses are documented in Reference 3. Large break LOCA was also analyzed in Reference 3, but with values of $F_{\Delta H}$ =1.60 and 5% SGTP level. A Best Estimate (BE) large break LOCA analysis was also performed(5,6). The BE LOCA analysis utilizes values of $F_{\Delta H}$=1.65 and 10% SGTP level based on the NRC-approved methodology(7), but requires changes to the Technical Specifications before implementation. The BE LOCA analysis will be implemented at a future date, possibly prior to the end of Cycle 2. Cycle 2 operation will be limited to $F_{\Delta H}$ of 1.60 and 5% SGTP until the BE LOCA analysis is implemented.

A safety assessment(8) for ZIRLO™ cladding of the VANTAGE+ fuel provides the justification to support ZIRLO™ usage as allowed by the Technical Specifications. An administrative Technical Specification change(9) was submitted to the NRC to identify the NRC-approved methodology used for the rod heat-up calculation in the LOCA evaluation model with consideration for ZIRLO™ clad fuel properties. This supports the analysis for the Heat Flux Hot Channel Factor which is a parameter specified in the Core Operating Limits Report (COLR).

The Cycle 2 core will also contain four tritium-producing burnable absorber rod (TPBAR) lead test assemblies (LTAs). The TPBAR design has been reviewed by the NRC in the safety evaluation report(10). The proposed licensing submittal(11)(12) to the NRC describes the application of TPBAR LTAs in the Cycle 2 core.

The RSE is consistent with the evaluation/analyses given in the technical reports and the licensing submittals(3)(4)(5)(6)(9)(11)(12). The RSE addresses mechanical, nuclear and thermal/hydraulic aspects of the fuel and reload design. In addition, this RSE incorporates the results of the non-LOCA transient analyses and LOCA analyses. The Cycle 2 reload evaluation also considers the presence of limited TPBAR LTAs(11)(12) in the reactor core. The Cycle 2 reload evaluation reflects the limits that bound the assumptions used in the safety analyses to support the VANTAGE+ fuel. The Cycle 2 safety analysis results are also valid without the implementation of the BE LOCA analysis(5)(6).

1.2 GENERAL DESCRIPTION

The Watts Bar Unit 1 Cycle 2 reactor core is comprised of 193 fuel assemblies arranged in the core loading pattern configuration shown in Figure 1. During the cycle 1/2 refueling, 84 assemblies will be replaced with fresh Region 4 fuel assemblies. A summary of the Cycle 2 fuel inventory is given in Table 1. The core design parameters utilized for Cycle 2 are as follows:

Core Power (MWt)	3411 (100% RTP)
System Pressure (psia)	2250
Core Inlet Temperature (^{o}F)	557.7*
Thermal Design Flow (gpm)	372400
Average Linear Power Density (kw/ft)	5.45**

* Consistent with a vessel average temperature of 588.2 °F and a core average temperature of 592.8 °F.
** Based on best estimate hot, densified core average stack height of 143.7 inches.

1.3 CONCLUSIONS AND ASSESSMENT

From the evaluation presented in this report, the Watts Bar Unit 1 Cycle 2 reload design does not result in the previously acceptable safety limits for any incident being exceeded and does not result in any unreviewed safety questions as defined in 10 CFR 50.59. The basis for this determination is as follows:

1. Will the probability of an accident previously evaluated in the SAR be increased?

   This RSE documents that the probability of an accident previously evaluated in Watts Bar Unit 1 FSAR(13) **is not increased**. The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. Though fuel and core design are not directly related to the probability of any previously evaluated accident, the demonstrated adherence to applicable standards and acceptance criteria precludes new challenges to components and systems that could increase the probability of any previously evaluated accident. Specifically, the mechanical changes as specified in Section 2.1 will not increase the probability of occurrence of an accident previously evaluated in the Watts Bar Unit 1 FSAR(13). The clad integrity is maintained and the structural integrity of the fuel rods, fuel assemblies, and core is not affected. The ZIRLO™ material improves corrosion performance and dimensional stability. The other mechanical features, noted in Section 2.1, have no adverse effect on fuel rod performance or dimensional stability as documented in the RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. Therefore, the probability of occurrence of an accident previously evaluated in the FSAR(13) **has not increased.**

2. Will the consequences of an accident previously evaluated in the SAR be increased?

   This RSE documents that the consequences of an accident previously evaluated in Watts Bar Unit 1 FSAR(13) **are not increased**. The Cycle 2 reload core design does not have a direct role in mitigating the consequences of any accident, and does not affect any of the bases (assumptions, actions, etc.) for the current analyses as described in the Watts Bar Unit 1 FSAR(13) and the proposed licensing submittals(3)(4)(5)(6)(9). The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE.

The demonstrated adherence to these standards and criteria precludes new challenges to components and systems that could: a) adversely affect the ability of existing components and systems to mitigate the consequences of any accident and/or; b) adversely affect the integrity of the fuel rod cladding as a fission product barrier. Furthermore, adherence to applicable standards and criteria ensures that these fission product barriers maintain design margin to safety. Specifically, the mechanical changes as specified in Section 2.1 will not increase the consequences of an accident previously evaluated in the Watts Bar Unit 1 FSAR(13). The ZIRLO™ material is similar in chemical composition and has similar physical and mechanical properties as that of Zircaloy-4. The other mechanical features, noted in Section 2.1, have no effect on chemical, physical or mechanical properties as documented in this RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. Thus, clad integrity is maintained. Since the safety limits presented in the FSAR(13) are met with the fuel mechanical changes specified in this report, the consequences of accidents previously evaluated in the Watts Bar Unit 1 FSAR(13) **have not increased.**

3. <u>Will the possibility of an accident which is different from any already in the SAR be created?</u>

This RSE documents that the possibility of an accident which is different from any already in the Watts Bar Unit 1 FSAR(13) **is not created.** The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. The demonstrated adherence to these standards and criteria precludes new challenges to components and systems that could introduce a new type of accident. Specifically, the mechanical changes as specified in Section 2.1 will not create the possibility of an accident of a different type than any previously evaluated in the Watts Bar Unit 1 FSAR(13) and the proposed licensing submittals(3)(4)(5)(6)(9). The fuel assemblies containing the mechanical features noted in Section 2.1 will satisfy the same design bases(14)(15) as that used for fuel assemblies in the other fuel regions. All design and performance criteria will continue to be met and no new single failure mechanisms have been created as documented in this RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. Therefore, the possibility of an accident of a different type than any previously evaluated in the FSAR(13) **has not been created.**

4. Will the probability of a malfunction of equipment important to safety previously evaluated in the SAR be increased?

This RSE documents that the probability of a malfunction of equipment important to safety previously evaluated in the Watts Bar Unit 1 FSAR(13) **is not increased**. The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. Demonstrated adherence to applicable standards and acceptance criteria precludes new challenges to components and systems that could increase the probability of any previously evaluated malfunction of equipment important to safety. Specifically, the mechanical changes as specified in Section 2.1, in compliance with the methodology established in References 14 and 15, will not increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the Watts Bar Unit 1 FSAR(13). No new performance requirements are being imposed on any system or component such that any design criteria will be exceeded as documented in this RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. No new modes or limiting single failures have been created with the mechanical features noted above. Therefore, the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the FSAR(13) **has not increased**.

5. Will the consequences of a malfunction of equipment important to safety previously evaluated in the SAR be increased?

This RSE documents that the consequences of a malfunction of equipment important to safety previously evaluated in the Watts Bar Unit 1 FSAR(13) **are not increased**. The Cycle 2 reload core design does not have a direct role in mitigating the consequences of any malfunction of equipment important to safety, and does not affect any of the bases (assumptions, actions, etc.) for the current analyses as described in the Watts Bar Unit 1 FSAR(13) and the proposed licensing submittals(3)(4)(5)(6)(9). The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. The demonstrated adherence to these standards and criteria precludes new challenges to components and systems that could: a) adversely affect the ability of existing components and systems to mitigate the consequences of any accident and/or; b) adversely affect the integrity of the fuel rod cladding as a fission product barrier. Furthermore, adherence to applicable standards and criteria ensures that these fission product barriers maintain design margin of safety. Specifically, the mechanical changes as specified in Section 2.1 will not increase the consequences of a malfunction of equipment important to safety previously evaluated in the Watts Bar Unit 1 FSAR(13). The predictions presented in the FSAR(13) are not sensitive to the fuel rod cladding material or other mechanical changes that do not alter the metallurgical composition of the core. The use of ZIRLO™ material, or the other mechanical features mentioned in Section 2.1, do not change the performance requirements on any system or component such that any design criteria will be exceeded as documented in this RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. No new modes or limiting single failures have been created with any of the mechanical features mentioned above. Therefore, the consequences of a malfunction of equipment important to safety previously evaluated in the Watts Bar Unit 1 FSAR(13) **have not increased.**

6. Will the possibility of a malfunction of equipment important to safety different from any already evaluated in the SAR be created?

This RSE documents that the possibility of a malfunction of equipment important to safety different from any already evaluated in the Watts Bar Unit 1 FSAR(13) **is not created**. The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. The demonstrated adherence to these standards and criteria precludes new challenges to components and systems that could introduce a new type of a malfunction of equipment important to safety. Specifically, the mechanical changes as specified in Section 2.1 will not create the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the Watts Bar Unit 1 FSAR(13). All original design and performance criteria continue to be met, and no new failure modes have been created for any system, component, or piece of equipment. No new single failure mechanisms have been introduced as documented in this RSE nor will they cause the core to operate in excess of pertinent design basis operating limits. Therefore, the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the FSAR(13) **has not been created.**

7. Will the margin of safety as defined in the BASES to any technical specifications be reduced?

This RSE documents that the margin of safety as defined in the Bases to any Watts Bar Unit 1 Technical Specifications(16) **is not reduced**. The Cycle 2 reload core design meets all applicable design and performance standards, and ensures that all pertinent licensing basis acceptance criteria are met. These standards and criteria are referenced throughout the body of this RSE. The Watts Bar Unit 1 reload design and safety analyses are supported by the Watts Bar Unit 1 Technical Specifications(16) for Cycle 2 (refer to Section 4.0). Specifically, the mechanical changes as specified in Section 2.1 will not reduce the margin of safety as defined in the basis for any Technical Specification(16). The use of these fuel assemblies will take into consideration the normal core operating conditions allowed in the Technical Specifications(16). For each cycle reload core, these fuel assemblies will be specifically evaluated using standard reload design methods(1) and approved fuel rod design models and methods(14)(17)(18)(19). This will include considerations of the core physics analysis peaking factors and core average linear heat rate effects. Therefore, the margin of safety as defined in the Bases to the Watts Bar Unit 1 Technical Specifications(16) **has not been reduced.**

Based upon the preceding information and the following:

1. the End-Of-Cycle 1 core average burnup is bounded by 16,244 and 17,398 MWD/MTU;
2. the Cycle 2 core average burnup will not exceed 19,000 MWD/MTU including power coastdown operation; and
3. there is adherence to plant operating limitations as given in the Technical Specifications(16), Cycle 2 Core Operating Limits Report (COLR) and the Technical Specification changes as defined in Section 4.0 of this report. The Cycle 2 COLR is presented in Appendix A.

There are no unreviewed safety questions identified as a result of the Watts Bar Unit 1 Cycle 2 core design. Therefore, the Cycle 2 design does not require prior NRC approval under 10 CFR 50.59 guidelines, except for approval of the aforementioned licensing submittals(4)(9)(11)(12) related to revised OTΔT/OPΔT margin enhancement, reduced RCS flow, boron concentration increase for RWST and cold leg accumulators, ZIRLO™ cladding, and TPBAR LTAs, and except for optional approval of the proposed licensing submittals(5)(6) related to BE LOCA analysis.

2.0 REACTOR DESIGN

2.1 MECHANICAL DESIGN

The mechanical design of the new Region 4 fuel assemblies is the same as the previous Regions 1, 2, and 3 fuel assemblies, except for the following changes:

1. ZIRLO™ fuel rod cladding.
2. ZIRLO™ mid-structural grids.
3. ZIRLO™ thimble/instrument tubes.
4. Slightly increased rod length and plenum length.
5. Slightly reduced fuel pellet length and dish diameter and depth (pellet chamfered).
6. Solid axial blanket pellets (slightly enriched).
7. Protective bottom grid and elongated end plug.
8. Integral Fuel Burnable Absorber (IFBA) fuel rods.
9. Cast bottom nozzle.

The above changes do not affect the core safety considerations and do not cause any transition core effects adverse to safety. More detailed descriptions of the Region 4 fuel features are provided in the proposed FSAR update[20] and the mechanical design/licensing assessment report[21].

Limited fresh fuel rods for Cycle 2 will contain IFBA coated UO_2 fuel pellets, which are identical to other fresh fuel pellets except for the addition of a thin boride coating on the pellet cylindrical surface along the central portion of the fuel stack length. In addition, fresh Wet Annular Burnable Absorber (WABA) rodlets will be utilized in core locations requiring discrete absorbers instead of the glass Pyrex absorbers used in Cycle 1. The location and number of absorber rods are defined in Section 2.2, Table 1 and Figure 2. The new burnable absorber design used in Cycle 2 has the absorber centerline aligned with the fuel pellet stack centerline at beginning of life and at hot full power. The full length WABA was set to 132 inches for Cycle 2. Furthermore, several design enhancements have been made and implemented for the holddown assemblies and crimp nuts so that manufacturing standardization could be achieved. The design enhancements again do not affect the core safety considerations.

Table 1 presents a comparison of pertinent design parameters of the various fuel regions. Fuel rod design evaluations for the Watts Bar Unit 1 Cycle 2 fuel were performed using NRC approved models(14)(17) and the NRC approved design methods(18)(19) to demonstrate that all of the fuel rod design bases are satisfied.

Westinghouse has had considerable experience with fuel assemblies composed of either Zircaloy or ZIRLO™ material, which includes VANTAGE 5H and VANTAGE+ fuel assemblies with PERFORMANCE+ features. This experience is summarized in WCAP-8183, "Operational Experience with Westinghouse Cores"(22).

2.2 NUCLEAR DESIGN

The nuclear design models for the Cycle 2 core are based on the modified PHOENIX-P(23)(24)(25) and Advanced Nodal Code (ANC)(25)(26) computer codes. PHOENIX-P is a two-dimensional transport theory based code which calculates lattice physics constants. ANC is an advanced nodal analysis theory code capable of two-dimensional and three-dimensional calculations. The modified PHOENIX-P and ANC are capable of explicit modeling of the TPBAR LTAs. These supplement the standard "Westinghouse Reload Safety Evaluation Methodology"(1).

The Cycle 2 core loading satisfies the F_Q^T x P ECCS limit of $\leq$ 2.50 x K(Z). K(Z) is shown in Figure 2 of Appendix A. The flux difference (ΔI) bandwidth during normal operation will be changed from the Cycle 1 bands. The Cycle 2 ΔI RAOC bands are shown in Figures 3 and 4 of Appendix A. The RAOC methodology(27) has been approved by the NRC. The control rod insertion limits will be unchanged from Cycle 1, as shown in Figure 1 of Appendix A.

Table 2 provides a comparison of the Cycle 2 kinetics characteristics with the current analysis limits based on previous accident analysis(2)(13) and the proposed licensing submittals(3)(4)(5)(9). It can be seen from Table 2 that all Cycle 2 kinetics parameter values fall within the ranges of the current evaluation values. The available shutdown margin exceeds the minimum required.

Eighty of the Region 4 fuel assemblies will contain fresh IFBAs. Twenty-four of the Region 4 fuel assemblies will also contain WABAs. The IFBAs and WABAs are used for peaking factor and MTC control. In addition, TPBAR LTAs will be used in four Region 4 fuel assemblies. Two Region 4 fuel assemblies contain previously activated secondary source rod assemblies. The location of burnable absorber and source rods is shown in Figure 2.

The Cycle 2 core loading plan was developed to account for the presence of TPBAR LTAs. The Cycle 2 core loading satisfies the design and safety limits(3)(4)(5)(6)(9)(11)(12)(13).

Cycle 2 has been analyzed with the current Westinghouse boron requirements methodology (BORDER) and may operate unrestricted for the entire cycle length. The revised BORDER methodology described in Reference 28 was also performed for Cycle 2 and will allow TVA to operate Cycle 2 with a reduced boric acid tank concentration. The reload values for the following parameters were shown to be bounded by the information transmitted by TVA in References 29 and 30:

1. HFP equilibrium xenon boron concentrations at BOL and EOL.

2. Change in boron concentration from HFP to HZP, K = .99 with all rods out at BOL and EOL.

3. Change in boron concentration from equilibrium xenon to no xenon conditions at BOL and EOL.

4. Boron concentrations for the maintenance of shutdown margin for the conservative cooldown scenario (all modes).

In addition, analyses have shown that a boration rate of 10 gpm of 20,000 ppm boric acid is sufficient to compensate for xenon decay.

2.3 THERMAL AND HYDRAULIC DESIGN

The Cycle 2 thermal-hydraulic (T/H) design and safety analyses are based on the NRC-approved T/H methodology Revised Thermal Design Procedure (RTDP)(31) and the WRB-1 DNB correlation(32). For events where conditions fall outside the range of applicability of RTDP and the WRB-1 correlation, the W-3 correlation is used with the Standard Thermal Design Procedure (STDP).

The Cycle 2 core containing the VANTAGE+ fuel assemblies with PERFORMANCE+ features meets the design and safety limits(3)(4)(9)(13). Sufficient DNBR margin exists for all DNB related events, including the hot zero power steamline break transient, to meet the criteria(13)(33) for the Cycle 2 reload core. Some available DNBR margin has been allocated to address DNBR penalties due to rod bow and potential RCS flow anomaly. Additional DNBR margin has been conservatively assessed for Cycle 2 in the Steamline Break Coincident with RCCA Withdrawal at Power (SLB w/RWAP) analysis.

The TPBAR LTAs in the Cycle 2 core do not have any adverse effect on the core T/H design. The TPBAR T/H design and the evaluation of the LTAs are described in the LTA evaluation report(34) and the safety evaluation report(10).

3.0 POWER CAPABILITY AND ACCIDENT EVALUATION

3.1 POWER CAPABILITY

The plant power capability has been evaluated considering the consequences of those incidents examined in the FSAR(13) and the proposed licensing submittals(3)(4)(5)(6)(9)(11)(12) using the previously accepted design basis. It is concluded that the core reload will not adversely affect the ability to safely operate at 100% of rated thermal power during Cycle 2. For overpower transients, the fuel centerline temperature limit of 4700°F can be accommodated with margin during Cycle 2. The NRC approved models(14)(17) were used for fuel temperature evaluations. The LOCA limit is satisfied for the power control maneuvers allowed by the technical specifications, which assures that the 10 CFR 50.46 acceptance criteria are met for a spectrum of Small and Large Break LOCAs.

3.2 ACCIDENT EVALUATION

The effects of the Cycle 2 reload, including the introduction of the mechanical design changes discussed in section 2.1, on the design basis and postulated incidents analyzed in the FSAR(13) and the proposed licensing submittals(3)(4)(5)(6)(9)(11)(12) have been examined. The results of the examinations determined that all of the applicable acceptance criteria continue to be met for all events. Note that for Cycle 2, DNB margin was conservatively assessed in the Steamline Break Coincident with RCCA Withdrawal at Power (SLB w/RWAP) analysis in order to demonstrate the the DNB design basis was met.

The IFBA fuel design has been used in the Westinghouse Pressurized Water Reactors since 1987. NRC approval of the design and Safety Evaluation Report for IFBA fuel with natural boron is included in WCAP-10444-P-A, Addendum 2(35). A safety evaluation(36) justifies the application of IFBA fuel with enriched boron which will be used in the Watts Bar Unit 1 Cycle 2 core.

The presence of the TPBAR LTAs has no adverse effect on the existing accident evaluations. The LTA evaluation report(34) and the safety evaluation report(10) justify the application of the TPBAR LTAs for Cycle 2.

A core reload can typically affect accident analysis input parameters in the following areas: core kinetics characteristics, control rod worths, and core peaking factors. Cycle 2 parameters in each of these three areas were examined to ascertain whether new accident analyses were required. The Cycle 2 reload parameters were found to be acceptable with respect to the applicable safety analyses.

3.2.1 KINETICS PARAMETERS

A comparison of Cycle 2 core physics parameters with the previous analysis values is presented in Table 2. All the kinetics values remain within the bounds of the current evaluation limits.

3.2.2 CONTROL ROD WORTHS

Changes in control rod worths may affect differential rod worths, shutdown margin, ejected rod worths, and trip reactivity. Table 2 shows that the maximum differential rod worth of two RCCA control banks moving together in their highest worth region for Cycle 2 meets the analysis limits. The Cycle 2 shutdown margin requirements are satisfied. Ejected rod worths for Cycle 2 are within the bounds of the analysis limits.

3.2.3 CORE PEAKING FACTORS

Evaluation of peaking factors for the rod out of position and dropped RCCA incident show that the DNBR limit value is not violated. Peaking factors following control rod ejection are within the bounds of the analysis limits. The peaking factors for steamline break have been evaluated and the minimum DNBR is above the analysis limits.

3.2.4 LOCA EVALUATION

New LOCA analyses are being applied for the first time for Cycle 2 operation. The new Small Break and Large Break LOCA analyses will be part of the plant licensing basis with the approval of a plant licensing amendment change prior to the start-up of Cycle 2(4)(9). The Best Estimate Large Break LOCA analysis(5)(6) will be implemented at a future date, but an approval prior to the start-up of Cycle 2 is not required.

A new Small Break LOCA analysis was recently performed to support increased Steam Generator Tube Plugging (SGTP) (10%), an additional 2% reduced thermal design flow and increased peaking factors ($F_{\Delta H}$=1.65, F_Q=2.5) (3)(4). This new analysis calculated a Peak Clad Temperature (PCT) of

1126°F, and established a 1°F PCT assessment to cover a ±6°F Tavg uncertainty. As this is a new analysis, no additional evaluation model or PCT assessments apply. Note that while Cycle 2 is limited to an $F_{\Delta H}$=1.60 under the Large Break LOCA BASH analysis described below, this new Small Break LOCA analysis supports an $F_{\Delta H}$ of 1.65, consistent with the Best Estimate Large Break LOCA analysis for implementation during Cycle 2 operation. The Cycle 2 fuel parameters and reload redesign were specifically included or evaluated, relative to the Small Break LOCA analysis referenced herein, to have no adverse impact on the reported analysis results.

A new Large Break LOCA analysis was recently performed to support increased SGTP (5%), an additional 2% reduced thermal design flow (RTDF) and increased peaking factors ($F_{\Delta H}$=1.60, F_Q=2.5)(3)(4). This new analysis calculated a Peak Clad Temperature (PCT) of 2111°F which included the effects of a ±6°F Tavg uncertainty. As this is a new analysis, no evaluation model or PCT assessments apply. Note that while Cycle 2 is limited to an $F_{\Delta H}$=1.60 under this Large Break LOCA BASH analysis, implementation of the Best Estimate Large Break LOCA analysis described below will support an $F_{\Delta H}$ of 1.65. The Cycle 2 fuel parameters and reload redesign were specifically included or evaluated, relative to the Large Break LOCA BASH analysis referenced herein, to have no adverse impact on the reported analysis results.

A Best Estimate Large Break LOCA analysis has been performed so as to support Cycle 2(5)(6). This analysis supports increased SGTP (10%), an additional 2% reduced thermal design flow (RTDF) and increased peaking factors ($F_{\Delta H}$=1.65, F_Q=2.5). This new analysis resulted in a Peak Clad Temperature (PCT) at the 95% probability level of 1900°F which included the effects of a ±6°F Tavg uncertainty. As this is a new analysis, no evaluation model or PCT assessments apply. Note that while Cycle 2 is limited to an $F_{\Delta H}$=1.60 under the Large Break LOCA BASH analysis, implementation of the Best Estimate Large Break LOCA analysis will support a peaking factor $F_{\Delta H}$ of 1.65. The Cycle 2 fuel parameters and reload redesign were specifically included or evaluated, relative to the Best Estimate LOCA analysis referenced herein, to have no adverse impact on the reported analysis results.

The Small Break, Large Break BASH, and Best Estimate Large Break LOCA analyses described above have specifically considered the VANTAGE+ fuel containing IFBA. In the Large Break BASH analysis, credit was taken for peaking factor margin associated with the IFBA loaded fuel assemblies in order to demonstrate that the IFBA fuel assemblies are non-limiting. The IFBA fuel is supported by all other LOCA analyses described herein. Therefore no additional PCT penalties are applied to any of the Watts Bar Unit 1 LOCA analyses to support the IFBA fuel product.

The Small Break and Large Break BASH LOCA analyses examined ZIRLO™ fuel cladding as reported in the Safety Assessment for the Watts Bar Unit 1 Fuel Assemblies with ZIRLO™ Cladding(8) and the licensing submittals(9). The Best Estimate Large Break LOCA analysis also considered ZIRLO™ fuel cladding such that the reported Best Estimate Large Break LOCA PCT bounds ZIRLO™ clad fuel. Therefore no additional PCT penalties are applied to any of the Watts Bar Unit 1 LOCA analyses to support ZIRLO™ fuel cladding.

As discussed earlier, Cycle 2 will see the introduction of four TPBAR LTAs which have been evaluated for Cycle 2(34). Since the presence of TPBAR LTAs has no effect on the existing LOCA analyses, the LTA evaluation report(34) justifies the application of the TPBARs for Cycle 2.

New Hot Leg Switchover (HLSO) and Long Term Core Cooling (LTCC) calculations were performed to support Cycle 2 operation(3)(4). The Cycle 2 fuel parameters and reload design were explicitly considered, or evaluated to have no adverse impact on the HLSO and LTCC calculations.

In summary, the results of the LOCA analyses applicable to Watts Bar Unit 1 Cycle 2 meet the acceptance criteria of 10 CFR 50.46. Further, Cycle 2 is supported by both the Large Break LOCA BASH analysis(3)(4) or the Best Estimate Large Break LOCA Analysis(5)(6) as the licensing basis.

4.0 TECHNICAL SPECIFICATION CHANGES

The Watts Bar Unit 1 Technical Specifications(16) ensure that the plant operates in a manner that provides acceptable levels of protection for the health and safety of the public. Technical Specifications(16) are based upon assumptions made in the safety and accident analysis, including those relating to the core design. Since it has been concluded that the core design parameters and assumptions utilized in the accident analyses remain appropriate, the conclusions in the Watts Bar Unit 1 FSAR(13) remain valid. Therefore, the regulated margin of safety as defined in the Bases of the Technical Specifications(16) is not affected by the Cycle 2 reload design.

In support of Cycle 2 operation, Westinghouse has prepared separate licensing amendment requests for submittal to the NRC seeking approval for certain Watts Bar Unit 1 Technical Specification changes(4)(5)(6)(9) that are related to reduced RCS flow, the OTΔT/OPΔT margin enhancement, boron concentration increase in RWST and cold leg accumulators, the BE LOCA analyses and ZIRLO™ cladding. These related technical specification changes were supported by Westinghouse via written safety evaluations establishing a 10 CFR 50.92 No Significant Hazards determination for each. In addition, the licensing submittals(11)(12) describe the Technical Specification changes associated with the TPBAR LTAs. Technical Specification 5.9.5.b specifies the NRC-approved methodologies used to support the parameters specified in the COLR.

A review of the Watts Bar Unit 1 Cycle 2 Reload Safety Evaluation (RSE) has been performed relative to the effects of the Cycle 2 core design on the Watts Bar Unit 1 Technical Specifications(16) (with the changes identified above, and inclusive of Amendment 5) and the Core Operating Limits Report (COLR). As a result of this review, it has been determined that the Cycle 2 core design will not require changes to the Watts Bar Unit 1 Technical Specifications(16) in addition to those identified(4)(9)(11)(12). The Cycle 2 RSE also accounts for the proposed Technical Specification changes described in the proposed licensing submittals(5)(6) related to the BE LOCA analysis, although they are optional for Cycle 2 operation.

The Cycle 2 core will not meet the current FSAR Section 9.3.4.3.1 requirements concerning boration rate to compensate for xenon decay. This section states that "the rate of boration, with a single boric acid transfer pump operating, is sufficient to take the reactor from full power operation to 1% shutdown in the hot condition, with no rods inserted, in less than 90 minutes. In less than 100 additional minutes, enough boric acid can be injected via the normal boron charging path to compensate for xenon decay." At the Technical Specification minimum boration rate (35 gpm), 170 minutes are required to fully borate to compensate for xenon decay. The FSAR requirement of 100 minutes should be revised to 200 minutes. 200 minutes will provide sufficient margin for future cycles. The change of the value to 200 minutes is acceptable because xenon decay below the initial equilibrium level will not begin until approximately 25 hours after shutdown, as stated in the FSAR.

5.0 REFERENCES

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2. Letter from L. Tomasic (Westinghouse) to J. Robert (TVA), "Watts Bar Recaging FSAR Chapter 4 Markups", February 3, 1993.

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TABLE 1

FUEL ASSEMBLY DESIGN PARAMETERS

WATTS BAR UNIT 1 - CYCLE 2

Region	1	2	3	4
Enrichment (wt% of U235)*	2.110	2.619	3.100	3.709
Density (% theoretical)*	94.608	94.536	94.432	95.629
Number of Assemblies	1	44	64	84
Burnup at Beginning of Cycle 2 (MWD/MTU)**	16,840	18,562	13,322	0
Number of IFBA rods: Fresh	-----	-----	-----	7648***
Number of WABA rods:	-----	-----	-----	160****
Number of TPBARs	-----	-----	-----	32

* All fuel region enrichments and densities are as-built values. Region 4 has enriched uranium (2.613 wt%) top and bottom solid axial blankets 6 inches in length

** Based on Cycle 1 burnup of 16,900 MWD/MTU.

*** IFBA lengths are 120 inches and 132 inches centered axially.

**** WABA lengths are 132 inches centered axially.

TABLE 2

KINETICS CHARACTERISTICS

WATTS BAR UNIT 1 - CYCLE 2

	Analysis Limit	Cycle 2
Least Positive Moderator Density Coefficient (MDC), (Δk/gm/cc) ++	0.08	0.12
Least Negative Doppler - Only Power Coefficient Zero to Full Power (pcm/% power) * (except for Hot Full Power SLB Analysis)	-9.55 + 0.035Q **	<-9.55 + 0.035Q ** +
Most Negative Doppler - Only Power Coefficient Zero to Full Power (pcm/% power) *	-19.4 + 0.068Q **	> -19.4 + 0.068Q **
Delayed Neutron Fraction β_{eff} (percent)	0.44 to 0.75	0.44 to 0.75
β_{eff} (percent) minimum (BOL rod ejection only)	0.48	> 0.48
Maximum Reactivity Insertion Rate for Two Banks Moving Together at HZP (pcm/sec) *	75	≤75
Doppler Temperature Coefficient (pcm/°F) *	-2.90 to -1.00	-2.90 to -1.00

* pcm = 10^{-5} Δρ.
++ These values apply to the SLB w/RWAP analysis and correspond to a negative Moderator Temperature Coefficient (MTC). At all other core conditions, the MTC has been confirmed to be less than or equal to 0.0 pcm/°F.
** Q = Core Power in MWt
+ Note that the least negative limit value of -11.75 + 0.035Q is assumed in the SLB w/RWAP analysis.

FIGURE 1

CORE LOADING PATTERN

WATTS BAR UNIT 1 - CYCLE 2

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1					2	2	2	3	2	2	2				
2			2	3	4	4	4	3	4	4	4	3	2		
3		2	4	4	4	3	4	2	4	3	4	4	4	2	
4		3	4	3	3	4	3	4	3	4	3	3	4	3	
5	2	4	4	3	4	2	4	3	4	2	4	3	4	4	2
6	2	4	3	4	2	3	3	4	3	3	2	4	3	4	2
7	2	4	4	3	4	3	4	3	4	3	4	3	4	4	2
8 (90°)	3	3	2	4	3	4	3	1	3	4	3	4	2	3	3
9	2	4	4	3	4	3	4	3	4	3	4	3	4	4	2
10	2	4	3	4	2	3	3	4	3	3	2	4	3	4	2
11	2	4	4	3	4	2	4	3	4	2	4	3	4	4	2
12		3	4	3	3	4	3	4	3	4	3	3	4	3	
13		2	4	4	4	3	4	2	4	3	4	4	4	2	
14			2	3	4	4	4	3	4	4	4	3	2		
15					2	2	2	3	2	2	2				

0°

LEGEND

#	Region Identifier

FIGURE 2

BURNABLE ABSORBER AND SOURCE ROD LOCATIONS

WATTS BAR UNIT 1 - CYCLE 2

	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1															
2					48I	48I	48I		48I	48I	48I				
3				4W 104I	128I		128I	6SSA	128I		128I	4W 104I			
4			4W 104I			8W 104I		128I		8W 104I			4W 104I		
5		48I	128I		128I		8W 104I		8W 104I		128I		128I	48I	
6		48I		8W 104I				128I				8W 104I		48I	
7		48I	128I		8W 104I		8T 104I		8T 104I		8W 104I		128I	48I	
8 (90°)				128I		128I				128I		128I			
9		48I	128I		8W 104I		8T 104I		8T 104I		8W 104I		128I	48I	
10		48I		8W 104I				128I				8W 104I		48I	
11		48I	128I		128I		8W 104I		8W 104I		128I		128I	48I	
12			4W 104I			8W 104I		128I		8W 104I			4W 104I		
13				4W 104I	128I		128I	6SSA	128I		128I	4W 104I			
14					48I	48I	48I		48I	48I	48I				
15															

0°

LEGEND

- ##T Number of TPBARs
- ##W Number of WABA Rodlets
- ##I Number of Fresh IFBA Rods
- #SSA Number of Secondary Source Rodlets

APPENDIX A

CYCLE 2 CORE OPERATING LIMITS REPORT

WATTS BAR UNIT 1 - NUCLEAR PLANT

August 1997

CORE OPERATING LIMITS REPORT

WATTS BAR UNIT 1, CYCLE 2

REVISION 0

AUGUST 1997

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 1 Cycle 2 has been prepared in accordance with the requirements of the Technical Specifications 5.9.5 .

The Technical Specifications affected by this report are listed below:

3.1.4 Moderator Temperature Coefficient (MTC)
3.1.6 Shutdown Bank Insertion Limits
3.1.7 Control Bank Insertion Limits
3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)
3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)
3.2.3 Axial Flux Difference (AFD)
3.9.1 Boron Concentration

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 the Technical Specifications Section 5.9.5 .

The following abbreviations are used in this section:

BOL -- Beginning of Cycle Life
ARO -- All Rods Out
HZP -- Hot Zero Thermal Power
EOL -- End of Cycle Life
RTP -- Rated Thermal Power

2.1 MODERATOR TEMPERATURE COEFFICIENT - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

The BOL/ARO/HZP - MTC shall be less positive than or equal to 0 $\Delta k/k/^\circ F$ (upper limit). With the measured BOL/ARO/HZP - MTC more positive than -2.3 $\Delta k/k/^\circ F$ (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to 0 $\Delta k/k/^\circ F$ (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to -4.0×10^{-4} $\Delta k/k/^\circ F$ (lower limit).

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm /ARO/RTP-MTC should be less negative than or equal to -3.1×10^{-4} $\Delta k/k/^\circ F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm /ARO/RTP-MTC should be less negative than or equal to -3.75×10^{-4} $\Delta k/k/^\circ F$.

2.2 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.6)

2.2.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.3 CONTROL BANK INSERTION LIMITS (LCO 3.1.7)

2.3.1 The control banks shall be limited in physical insertion as shown in Figure 1.

2.3.2 Table 4 shows the control rod overlap positions.

2.4 HEAT FLUX HOT CHANNEL FACTOR - $F_Q(Z)$ (LCO 3.2.1)

$F_Q(Z) \leq CFQ/P * K(Z)$ for $P > 0.5$

$F_Q(Z) \leq CFQ/0.5 * K(Z)$ for $P \leq 0.5$

Where P = Thermal Power / Rated Thermal Power

2.4.1 CFQ = 2.50

2.4.2 K(Z) is provided in Figure 2

2.4.3 $F_Q^C(Z) = F_Q^M(Z) * 1.0815$

where: $F_Q^M(Z)$ is the measured value of $F_Q(Z)$ obtained from incore flux map results and 1.0815 is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

2.4.4 $F_Q^W(Z) = F_Q^C(Z) * W(Z)$

where: W(Z) values are provided in Figures 5 through 13. The figures provide sufficient information to determine W(Z) versus core height for all cycle burnups.

2.5 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR - $F_{\Delta H}^N$ (LCO 3.2.2)

$F_{\Delta H}^N \leq F_{\Delta H}^{RTP} * (1 + PF * (1-P))$

where P = Thermal Power / Rated Thermal Power

$F_{\Delta H}^{RTP} = 1.60$

PF = 0.3

2.6 AXIAL FLUX DIFFERENCE - AFD (LCO 3.2.3)

2.6.1 The AFD limits for cycle burnup between 0 and 3500 MWD/MTU is provided in Figure 3.

2.6.2 The AFD limits for cycle burnup between 3000 and 19000 MWD/MTU is provided in Figure 4.

2.7 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.7.1 The refueling boron concentration shall be $\geq$ 2000 ppm

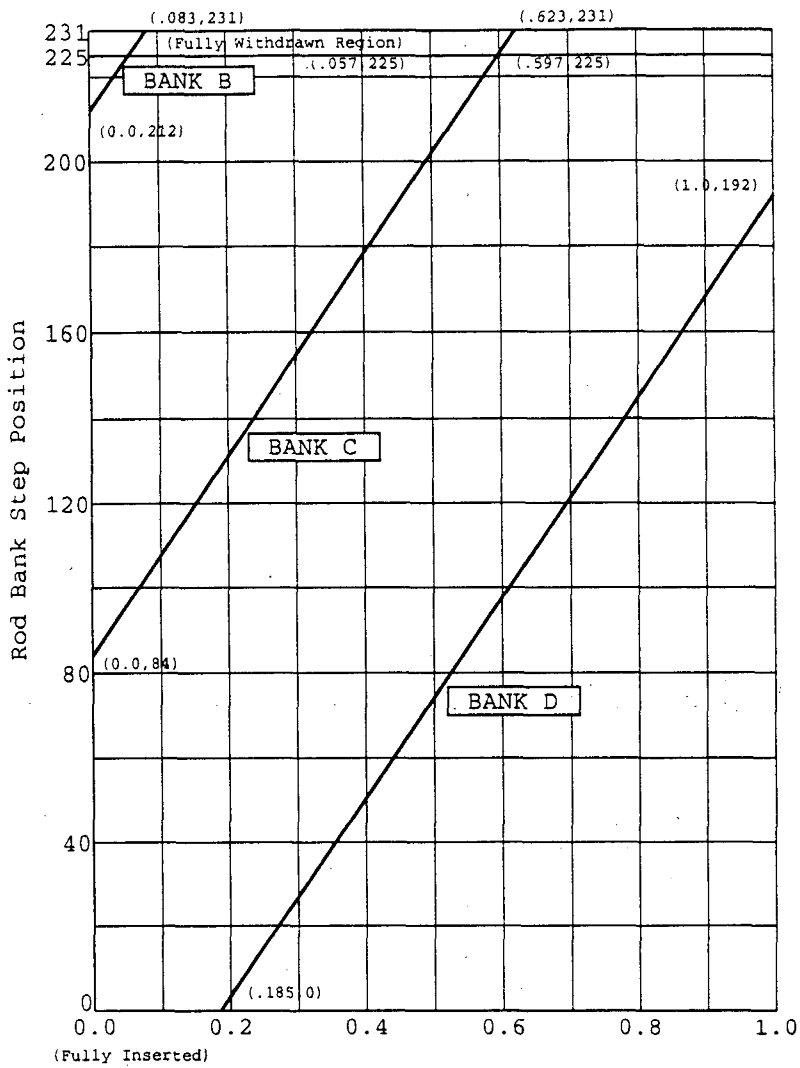


Figure 1
Control Bank Insertion Limits Versus Thermal Power Four Loop Operation

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

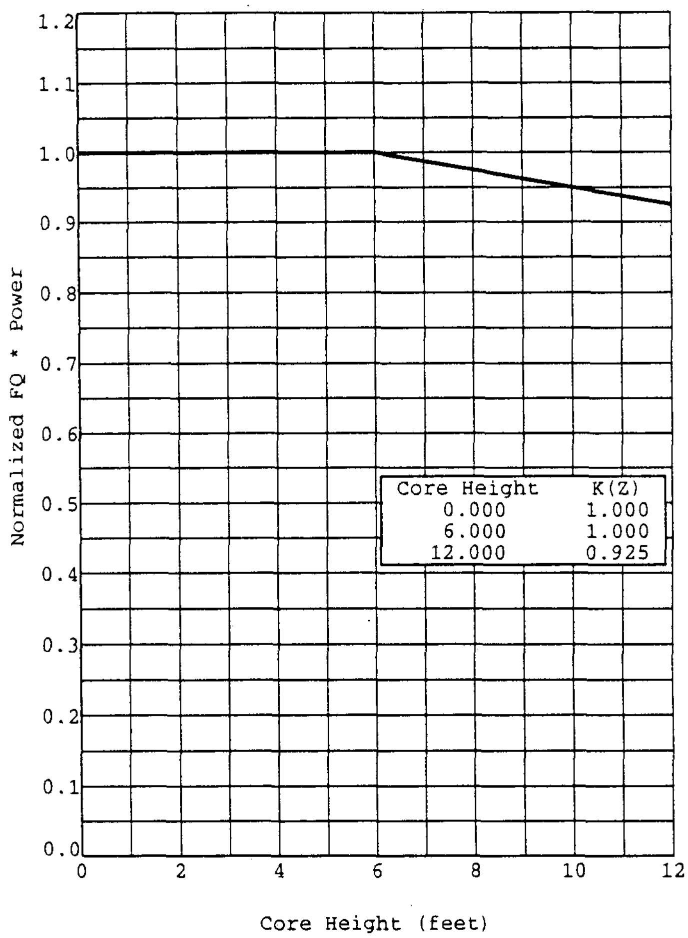


Figure 2
K(Z) - Normalized Fq(Z) as a Function of Core Height

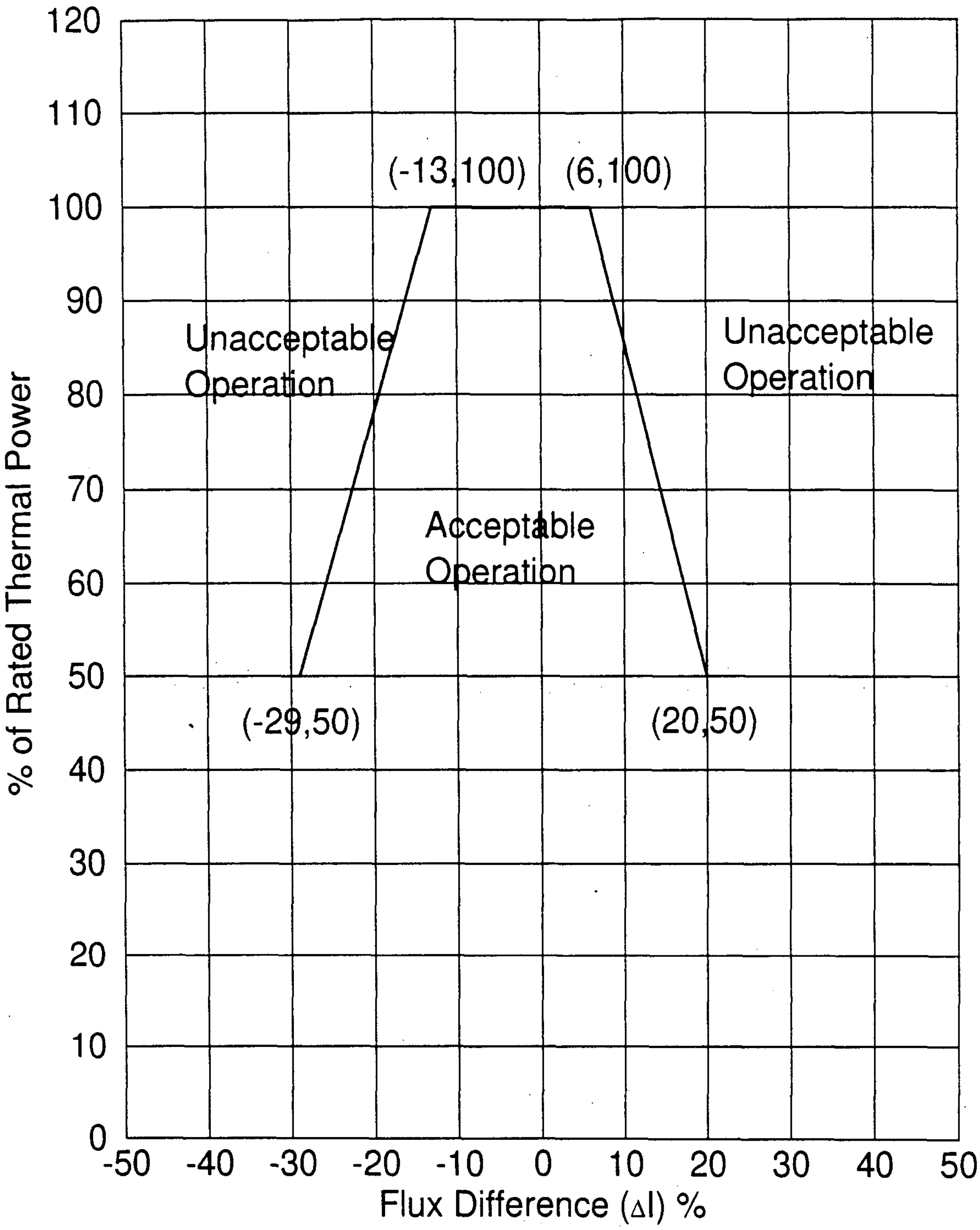


Figure 3
Axial Flux Difference Acceptable Operation Limits as a Function of Rated Thermal Power (RAOC)
For Cycle Burnup 0 to 3500 MWD/MTU

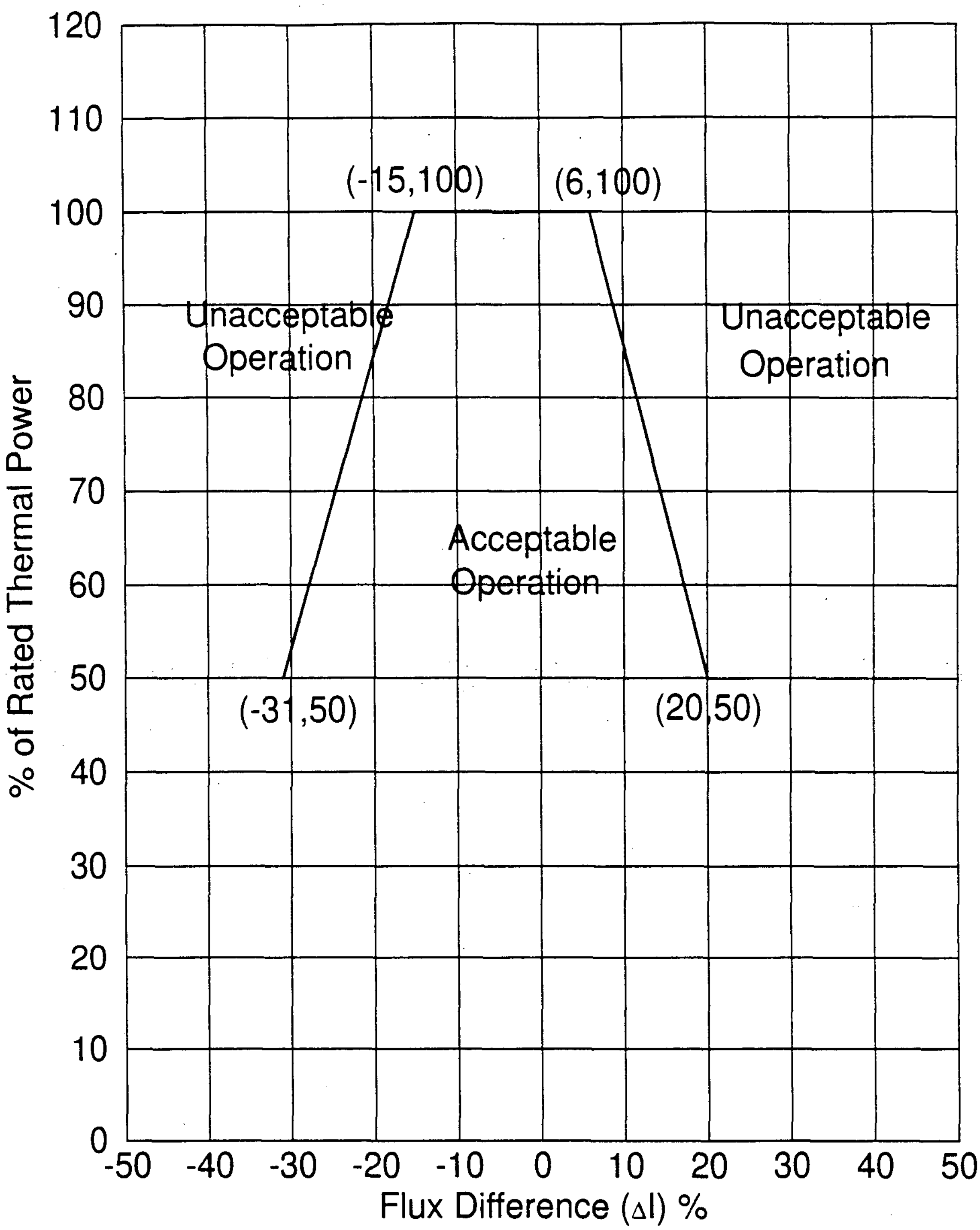
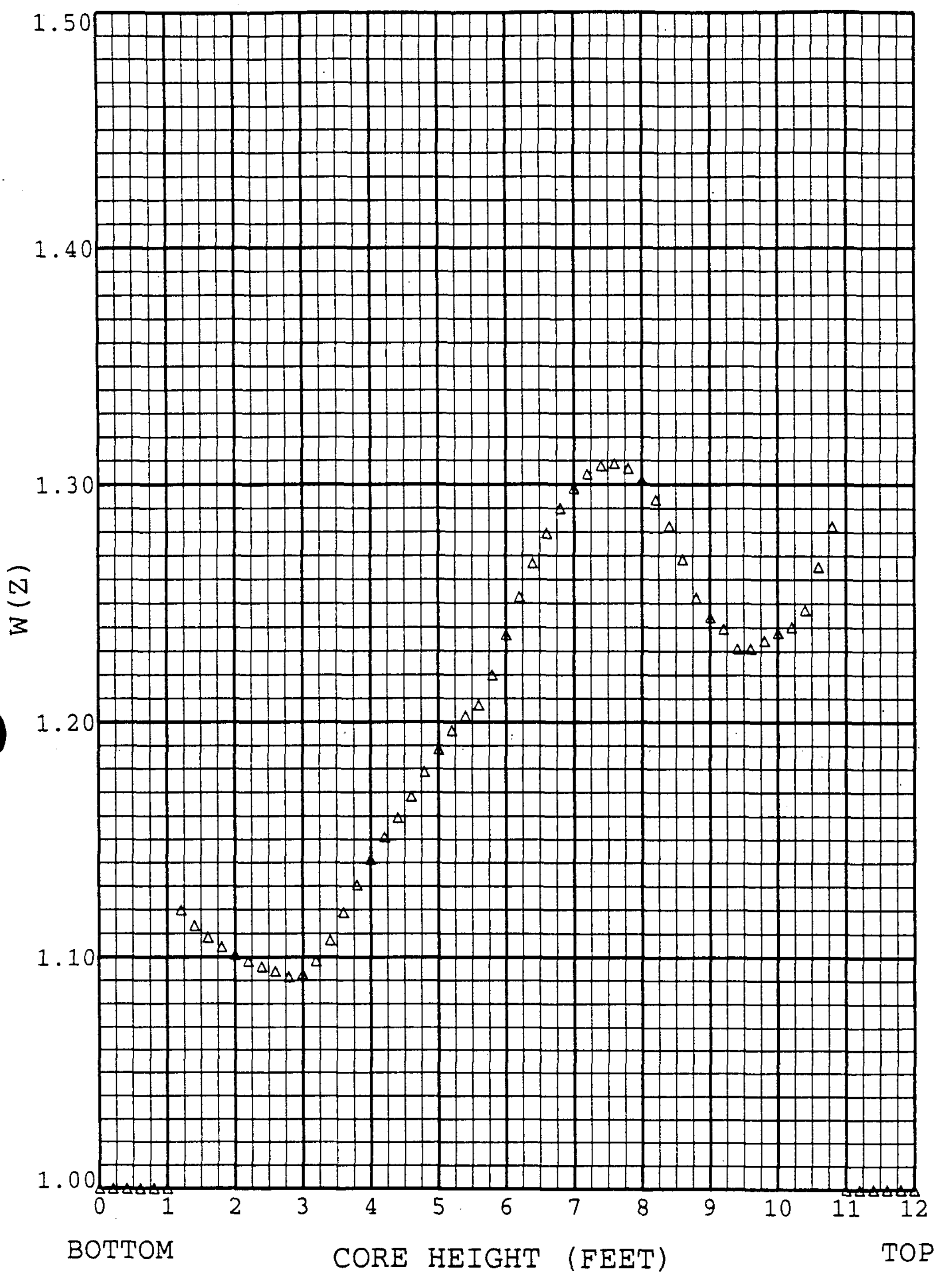
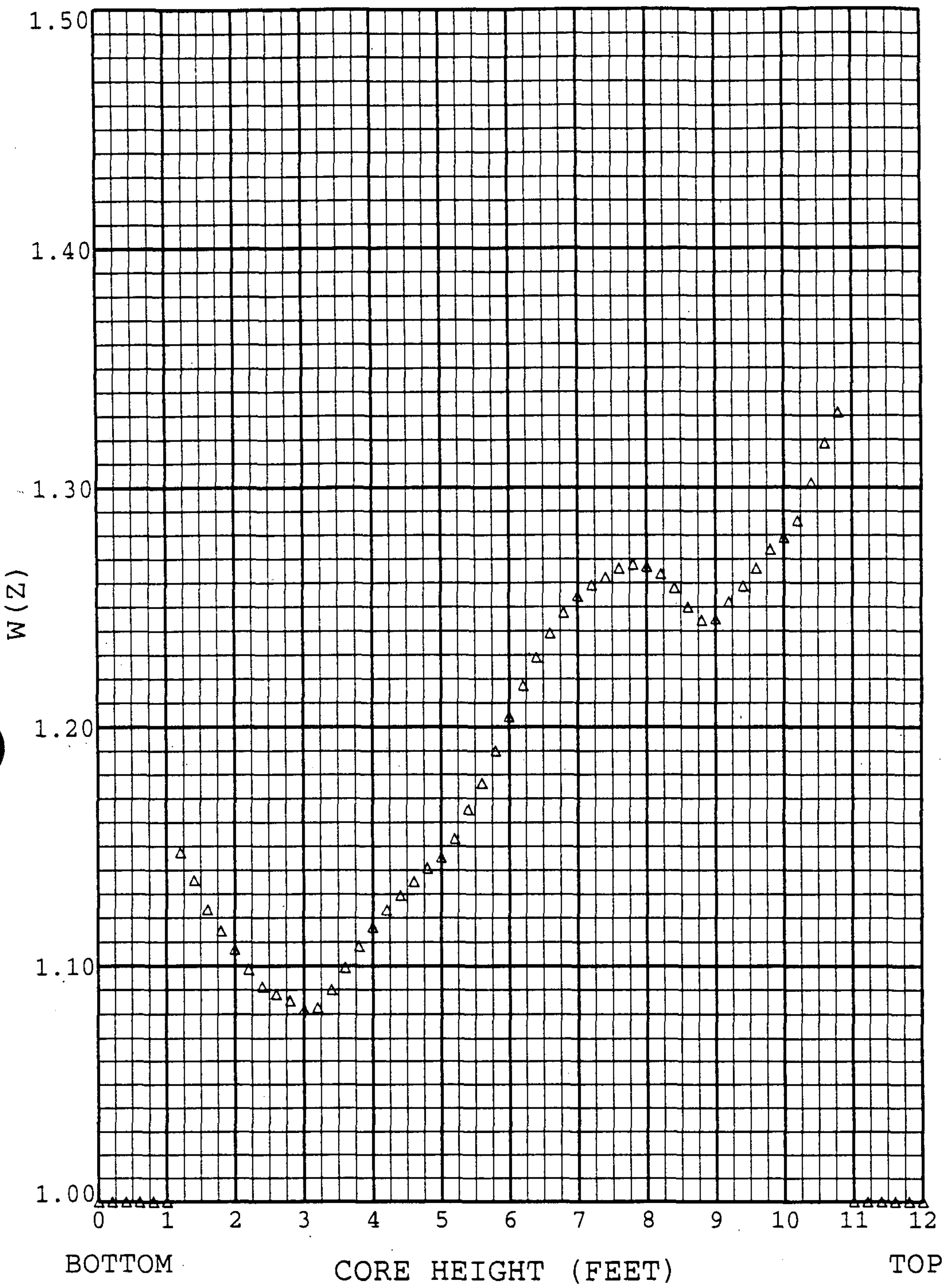


Figure 4
Axial Flux Difference Acceptable Operation Limits as a Function of Rated Thermal Power (RAOC)
For Cycle Burnup 3000 to 19000 MWD/MTU



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.1198
1.40	1.1133
1.60	1.1083
1.80	1.1043
2.00	1.1011
2.20	1.0982
2.40	1.0959
2.60	1.0939
2.80	1.0916
3.00	1.0927
3.20	1.0984
3.40	1.1072
3.60	1.1189
3.80	1.1306
4.00	1.1415
4.20	1.1510
4.40	1.1594
4.60	1.1684
4.80	1.1788
5.00	1.1884
5.20	1.1964
5.40	1.2027
5.60	1.2072
5.80	1.2200
6.00	1.2369
6.20	1.2528
6.40	1.2669
6.60	1.2794
6.80	1.2899
7.00	1.2983
7.20	1.3044
7.40	1.3079
7.60	1.3088
7.80	1.3067
8.00	1.3017
8.20	1.2936
8.40	1.2826
8.60	1.2685
8.80	1.2524
9.00	1.2442
9.20	1.2395
9.40	1.2312
9.60	1.2311
9.80	1.2344
10.00	1.2378
10.20	1.2402
10.40	1.2473
10.60	1.2654
10.80	1.2825
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 5
RAOC Summary of Max W(z) at 150 MWD/MTU With HFP AFD Band of -13/+6 %
(Top and Bottom 10% Excluded)

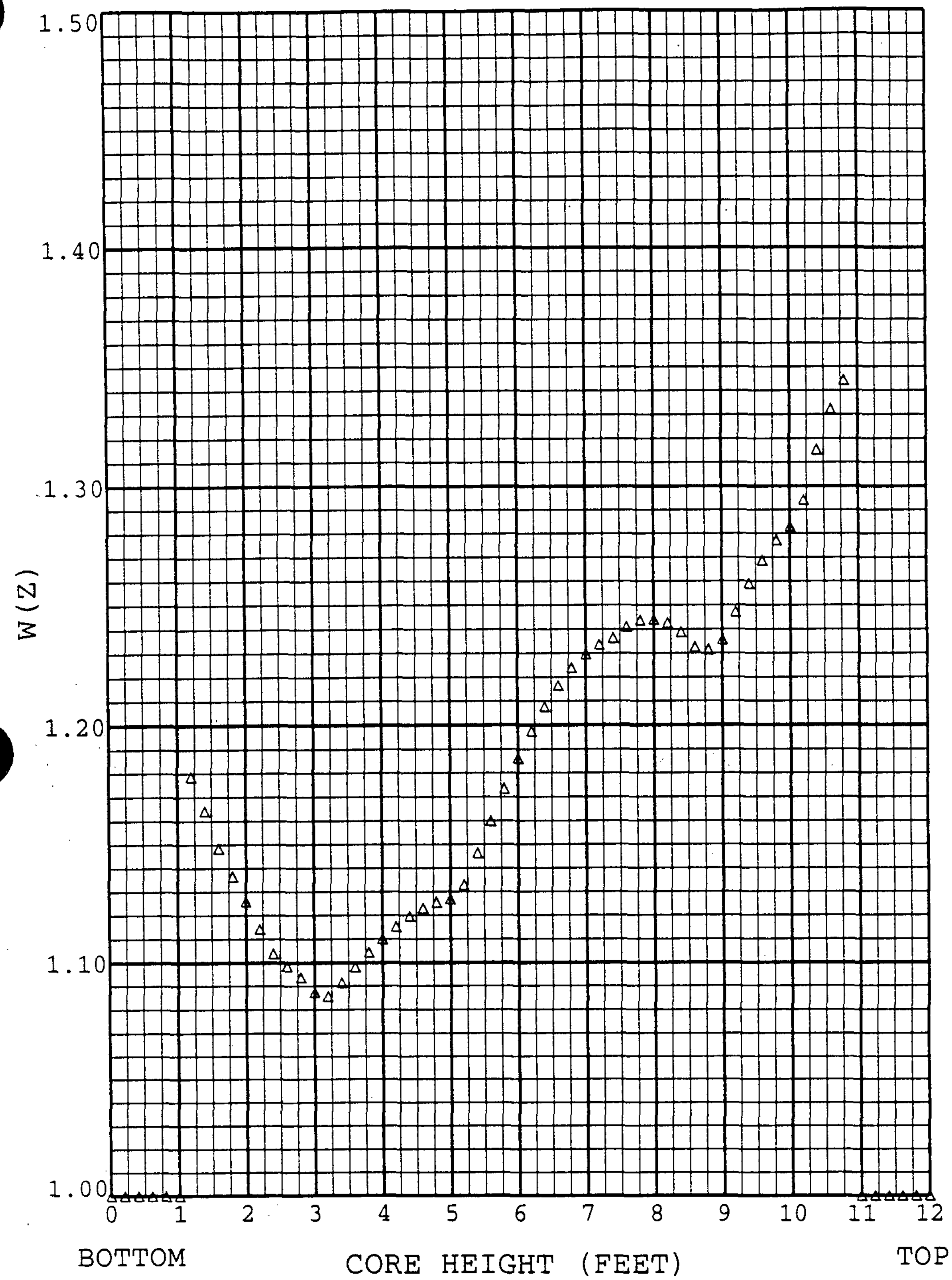


Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.1475
1.40	1.1357
1.60	1.1234
1.80	1.1146
2.00	1.1070
2.20	1.0986
2.40	1.0914
2.60	1.0883
2.80	1.0855
3.00	1.0819
3.20	1.0826
3.40	1.0901
3.60	1.0993
3.80	1.1082
4.00	1.1162
4.20	1.1233
4.40	1.1295
4.60	1.1352
4.80	1.1409
5.00	1.1454
5.20	1.1531
5.40	1.1655
5.60	1.1765
5.80	1.1900
6.00	1.2043
6.20	1.2172
6.40	1.2289
6.60	1.2391
6.80	1.2476
7.00	1.2545
7.20	1.2591
7.40	1.2624
7.60	1.2662
7.80	1.2678
8.00	1.2669
8.20	1.2638
8.40	1.2580
8.60	1.2498
8.80	1.2444
9.00	1.2449
9.20	1.2522
9.40	1.2587
9.60	1.2662
9.80	1.2739
10.00	1.2789
10.20	1.2861
10.40	1.3019
10.60	1.3185
10.80	1.3315
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 6

RAOC Summary of Max W(z) at 2000 MWD/MTU With HFP AFD Band of -13/+6 %

(Top and Bottom 10% Excluded)

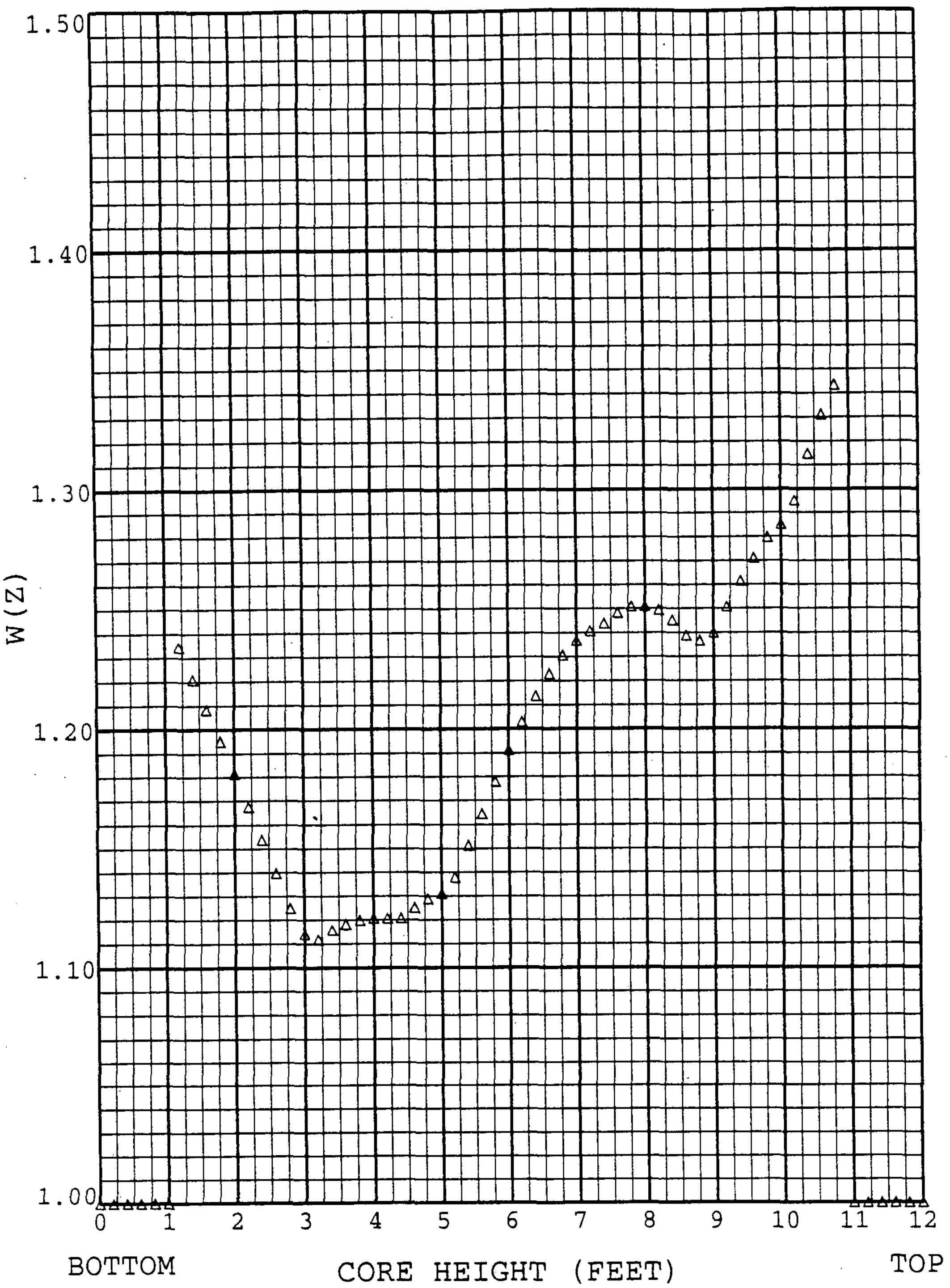


Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.1787
1.40	1.1642
1.60	1.1484
1.80	1.1367
2.00	1.1261
2.20	1.1142
2.40	1.1038
2.60	1.0985
2.80	1.0937
3.00	1.0875
3.20	1.0857
3.40	1.0915
3.60	1.0982
3.80	1.1043
4.00	1.1100
4.20	1.1152
4.40	1.1196
4.60	1.1230
4.80	1.1256
5.00	1.1270
5.20	1.1330
5.40	1.1463
5.60	1.1599
5.80	1.1735
6.00	1.1862
6.20	1.1975
6.40	1.2076
6.60	1.2165
6.80	1.2239
7.00	1.2297
7.20	1.2336
7.40	1.2364
7.60	1.2410
7.80	1.2437
8.00	1.2441
8.20	1.2426
8.40	1.2388
8.60	1.2326
8.80	1.2316
9.00	1.2358
9.20	1.2473
9.40	1.2590
9.60	1.2687
9.80	1.2773
10.00	1.2830
10.20	1.2942
10.40	1.3154
10.60	1.3323
10.80	1.3444
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 7

RAOC Summary of Max W(z) at 3500 MWD/MTU With HFP AFD Band of -13/+6 %

(Top and Bottom 10% Excluded)

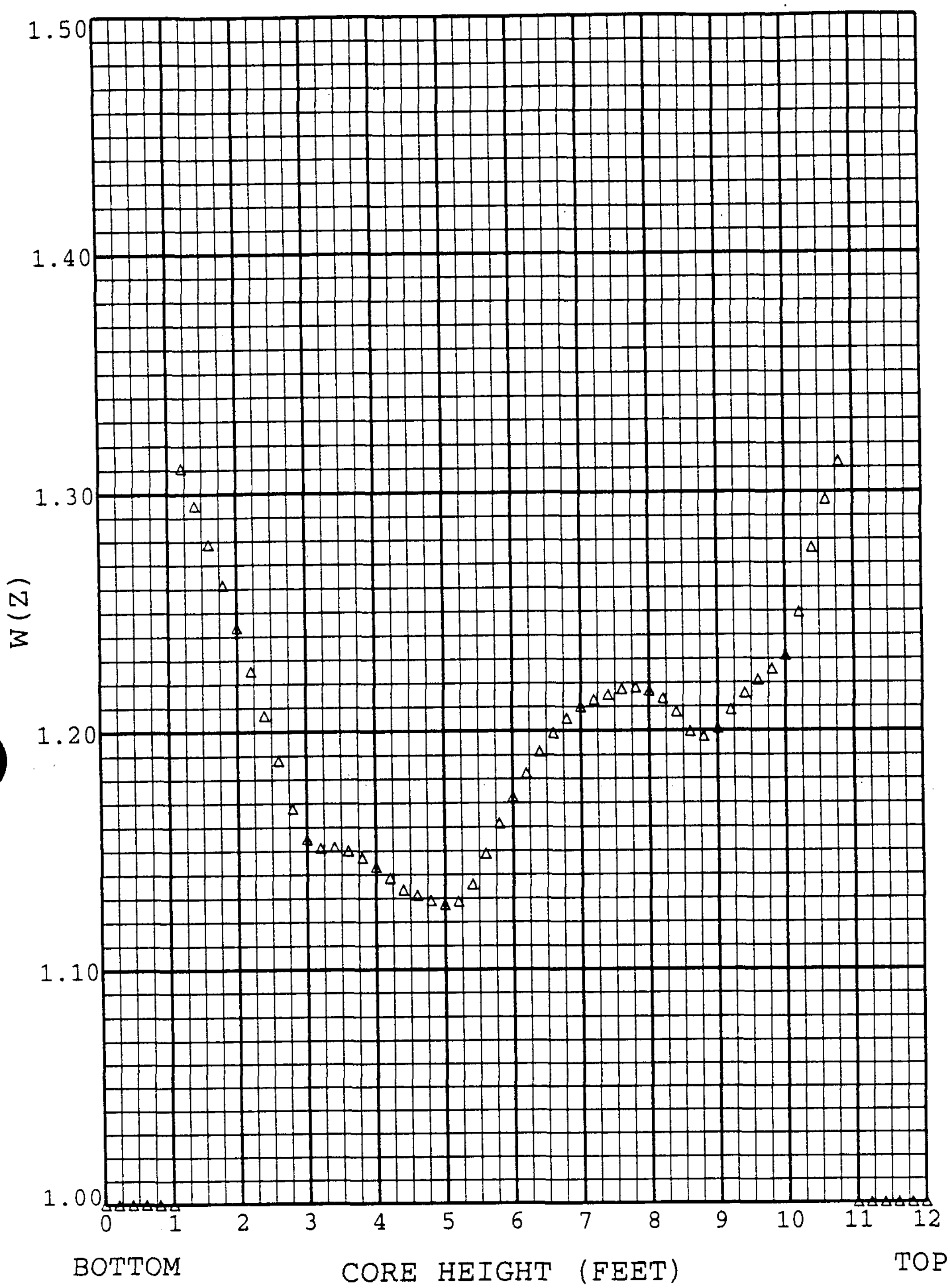


Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.2344
1.40	1.2210
1.60	1.2083
1.80	1.1951
2.00	1.1815
2.20	1.1676
2.40	1.1537
2.60	1.1397
2.80	1.1250
3.00	1.1141
3.20	1.1117
3.40	1.1158
3.60	1.1182
3.80	1.1198
4.00	1.1207
4.20	1.1207
4.40	1.1209
4.60	1.1252
4.80	1.1289
5.00	1.1311
5.20	1.1379
5.40	1.1514
5.60	1.1645
5.80	1.1781
6.00	1.1913
6.20	1.2030
6.40	1.2137
6.60	1.2229
6.80	1.2306
7.00	1.2368
7.20	1.2408
7.40	1.2439
7.60	1.2483
7.80	1.2510
8.00	1.2511
8.20	1.2494
8.40	1.2452
8.60	1.2387
8.80	1.2367
9.00	1.2401
9.20	1.2509
9.40	1.2617
9.60	1.2712
9.80	1.2798
10.00	1.2853
10.20	1.2952
10.40	1.3148
10.60	1.3313
10.80	1.3435
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 8

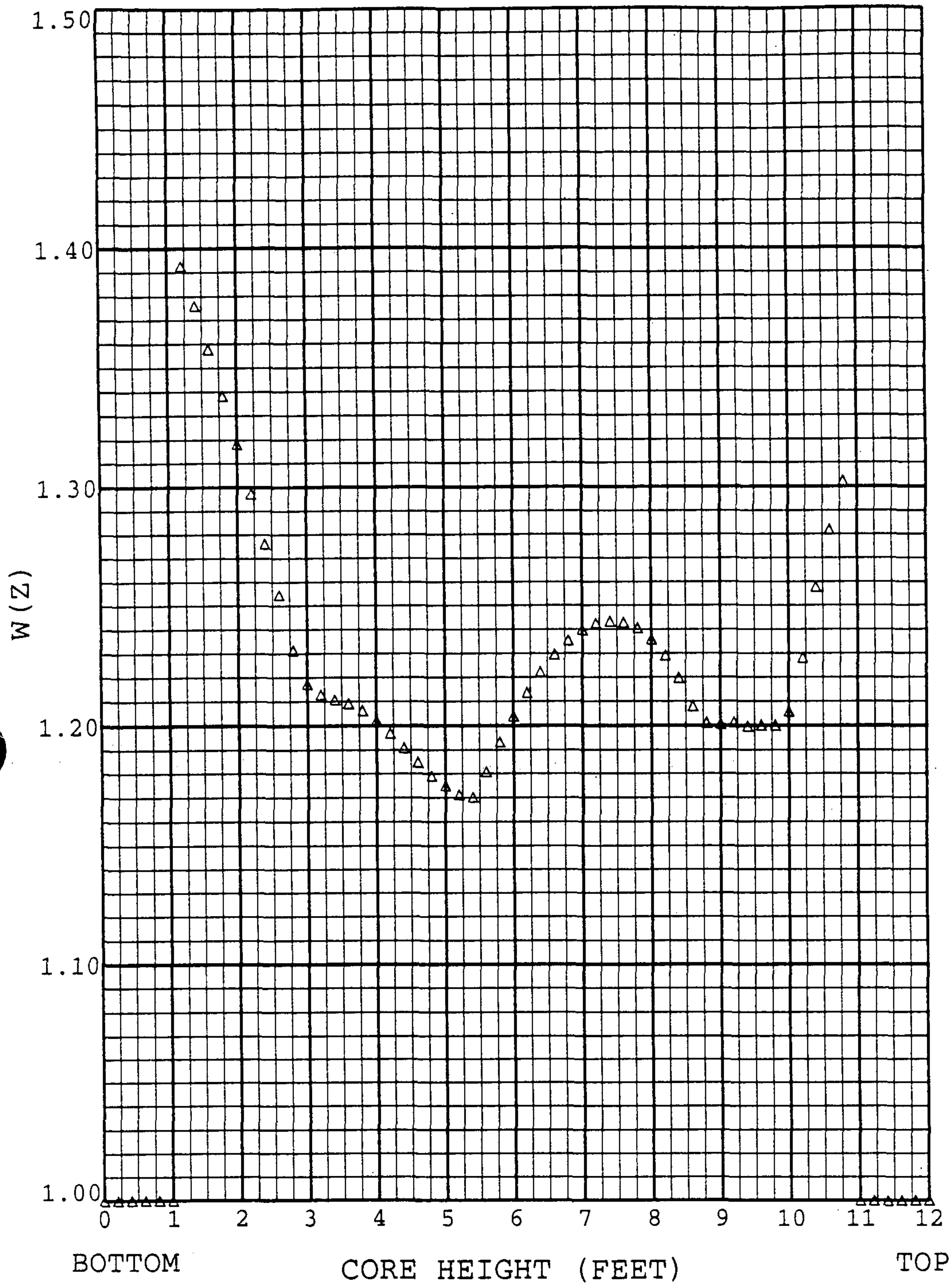
RAOC Summary of Max W(z) at 3000 MWD/MTU With HFP AFD Band of -15/+6 %

(Top and Bottom 10% Excluded)



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.3108
1.40	1.2951
1.60	1.2788
1.80	1.2616
2.00	1.2438
2.20	1.2254
2.40	1.2068
2.60	1.1880
2.80	1.1679
3.00	1.1549
3.20	1.1512
3.40	1.1518
3.60	1.1501
3.80	1.1472
4.00	1.1433
4.20	1.1385
4.40	1.1336
4.60	1.1313
4.80	1.1291
5.00	1.1274
5.20	1.1288
5.40	1.1359
5.60	1.1488
5.80	1.1615
6.00	1.1726
6.20	1.1825
6.40	1.1914
6.60	1.1990
6.80	1.2052
7.00	1.2100
7.20	1.2130
7.40	1.2149
7.60	1.2174
7.80	1.2181
8.00	1.2166
8.20	1.2134
8.40	1.2078
8.60	1.1996
8.80	1.1975
9.00	1.2010
9.20	1.2087
9.40	1.2155
9.60	1.2212
9.80	1.2256
10.00	1.2314
10.20	1.2494
10.40	1.2765
10.60	1.2968
10.80	1.3125
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

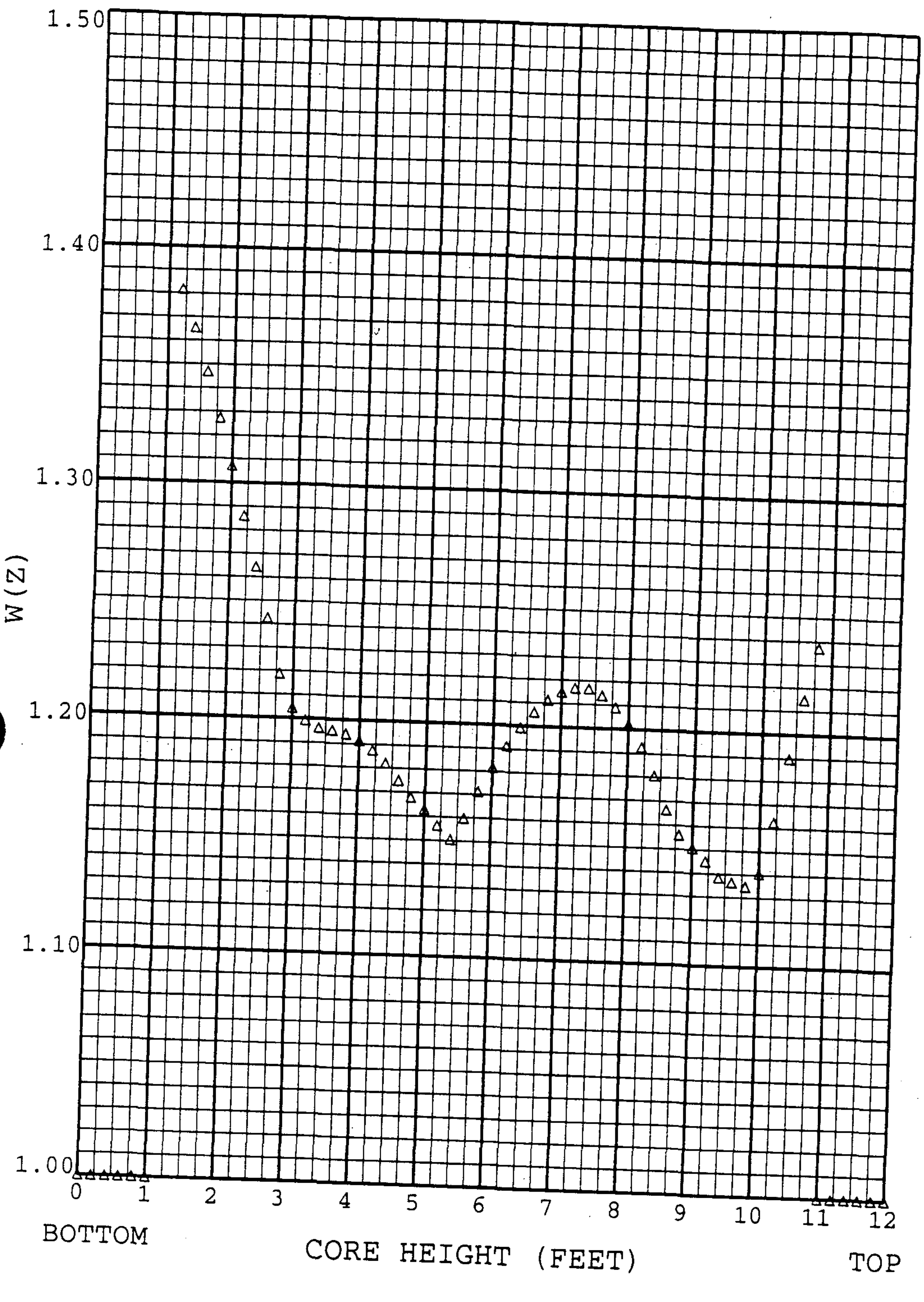
Figure 9
RAOC Summary of Max W(z) at 6000 MWD/MTU With HFP AFD Band of -15/+6 %
(Top and Bottom 10% Excluded)



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.3927
1.40	1.3761
1.60	1.3578
1.80	1.3384
2.00	1.3183
2.20	1.2974
2.40	1.2762
2.60	1.2547
2.80	1.2314
3.00	1.2174
3.20	1.2129
3.40	1.2108
3.60	1.2092
3.80	1.2063
4.00	1.2022
4.20	1.1970
4.40	1.1909
4.60	1.1848
4.80	1.1790
5.00	1.1751
5.20	1.1713
5.40	1.1703
5.60	1.1808
5.80	1.1931
6.00	1.2039
6.20	1.2137
6.40	1.2223
6.60	1.2296
6.80	1.2355
7.00	1.2398
7.20	1.2424
7.40	1.2433
7.60	1.2429
7.80	1.2405
8.00	1.2359
8.20	1.2292
8.40	1.2199
8.60	1.2080
8.80	1.2013
9.00	1.2008
9.20	1.2014
9.40	1.1997
9.60	1.2002
9.80	1.2001
10.00	1.2059
10.20	1.2282
10.40	1.2578
10.60	1.2820
10.80	1.3023
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 10

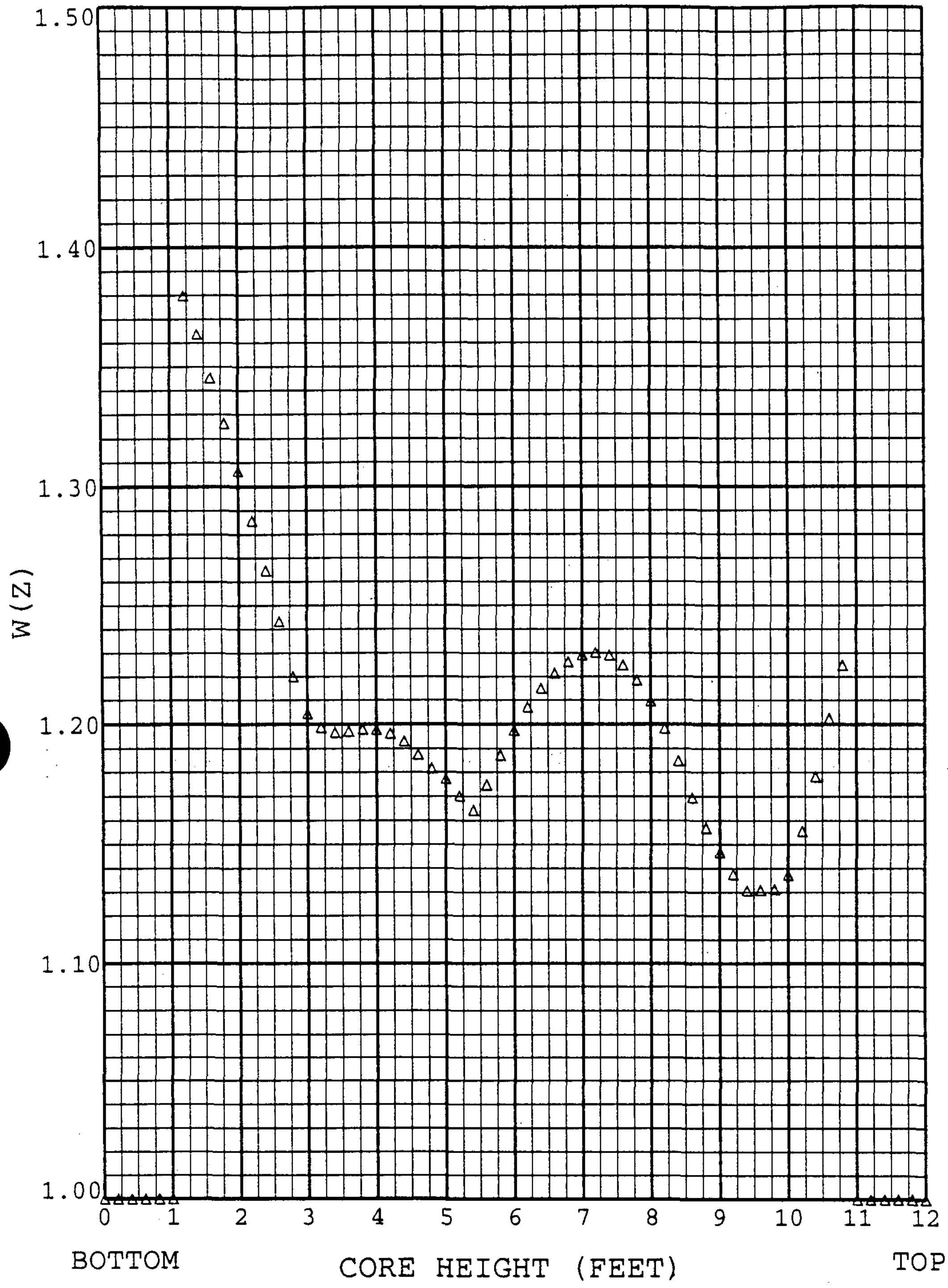
RAOC Summary of Max W(z) at 8000 MWD/MTU With HFP AFD Band of -15/+6 %
(Top and Bottom 10% Excluded)



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.3816
1.40	1.3654
1.60	1.3469
1.80	1.3273
2.00	1.3070
2.20	1.2859
2.40	1.2644
2.60	1.2425
2.80	1.2187
3.00	1.2042
3.20	1.1992
3.40	1.1961
3.60	1.1954
3.80	1.1940
4.00	1.1913
4.20	1.1874
4.40	1.1821
4.60	1.1749
4.80	1.1679
5.00	1.1631
5.20	1.1564
5.40	1.1505
5.60	1.1597
5.80	1.1713
6.00	1.1817
6.20	1.1911
6.40	1.1992
6.60	1.2060
6.80	1.2112
7.00	1.2149
7.20	1.2168
7.40	1.2166
7.60	1.2139
7.80	1.2090
8.00	1.2019
8.20	1.1925
8.40	1.1806
8.60	1.1664
8.80	1.1560
9.00	1.1507
9.20	1.1452
9.40	1.1383
9.60	1.1366
9.80	1.1348
10.00	1.1405
10.20	1.1625
10.40	1.1898
10.60	1.2149
10.80	1.2372
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 11

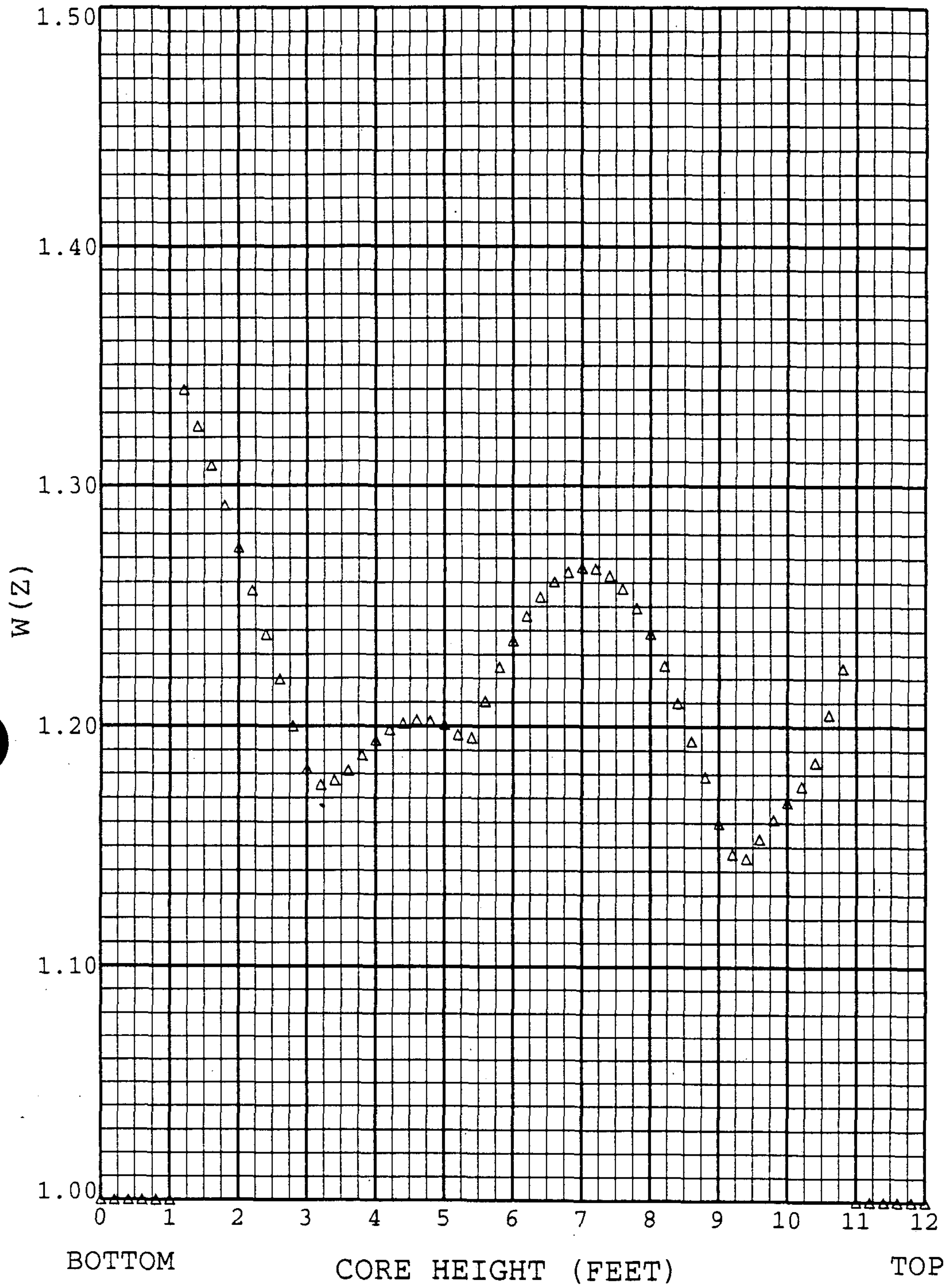
RAOC Summary of Max W(z) at 10000 MWD/MTU With HFP AFD Band of -15/+6 %
(Top and Bottom 10% Excluded)



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.3798
1.40	1.3637
1.60	1.3455
1.80	1.3263
2.00	1.3065
2.20	1.2858
2.40	1.2648
2.60	1.2433
2.80	1.2201
3.00	1.2044
3.20	1.1987
3.40	1.1966
3.60	1.1972
3.80	1.1980
4.00	1.1979
4.20	1.1962
4.40	1.1930
4.60	1.1875
4.80	1.1817
5.00	1.1774
5.20	1.1703
5.40	1.1643
5.60	1.1749
5.80	1.1872
6.00	1.1976
6.20	1.2071
6.40	1.2150
6.60	1.2214
6.80	1.2262
7.00	1.2291
7.20	1.2302
7.40	1.2290
7.60	1.2249
7.80	1.2184
8.00	1.2096
8.20	1.1984
8.40	1.1848
8.60	1.1695
8.80	1.1569
9.00	1.1467
9.20	1.1376
9.40	1.1308
9.60	1.1310
9.80	1.1313
10.00	1.1374
10.20	1.1557
10.40	1.1783
10.60	1.2025
10.80	1.2248
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 12

RAOC Summary of Max W(z) at 12000 MWD/MTU With HFP AFD Band of -15/+6 %
(Top and Bottom 10% Excluded)



Height (feet)	Max. W(z)
.00	1.0000
.20	1.0000
.40	1.0000
.60	1.0000
.80	1.0000
1.00	1.0000
1.20	1.3397
1.40	1.3245
1.60	1.3083
1.80	1.2916
2.00	1.2743
2.20	1.2565
2.40	1.2382
2.60	1.2195
2.80	1.2000
3.00	1.1821
3.20	1.1756
3.40	1.1774
3.60	1.1814
3.80	1.1879
4.00	1.1942
4.20	1.1985
4.40	1.2014
4.60	1.2027
4.80	1.2022
5.00	1.2008
5.20	1.1964
5.40	1.1952
5.60	1.2104
5.80	1.2247
6.00	1.2359
6.20	1.2460
6.40	1.2541
6.60	1.2603
6.80	1.2643
7.00	1.2662
7.20	1.2658
7.40	1.2629
7.60	1.2575
7.80	1.2494
8.00	1.2388
8.20	1.2254
8.40	1.2098
8.60	1.1941
8.80	1.1790
9.00	1.1598
9.20	1.1471
9.40	1.1454
9.60	1.1534
9.80	1.1614
10.00	1.1686
10.20	1.1754
10.40	1.1852
10.60	1.2052
10.80	1.2245
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Figure 13

RAOC Summary of Max W(z) at 15000 MWD/MTU With HFP AFD Band of -15/+6 %

(Top and Bottom 10% Excluded)

Table 4: Control Rod Overlap Determination

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
0	0			
2	2			
4	4			
6	6			
8	8			
10	10			
12	12			
14	14			
16	16			
18	18			
20	20			
22	22			
24	24			
26	26			
28	28			
30	30			
32	32			
34	34			
36	36			
38	38			
40	40			
42	42			
44	44			
46	46			
48	48			
50	50			
52	52			
54	54			
56	56			
58	58			
60	60			
62	62			
64	64			
66	66			
68	68			
70	70			

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
72	72			
74	74			
76	76			
78	78			
80	80			
82	82			
84	84			
86	86			
88	88			
90	90			
92	92			
94	94			
96	96			
98	98			
100	100			
102	102			
104	104			
106	106			
108	108			
110	110			
112	112			
114	114			
116	116			
118	118			
120	120			
122	122			
124	124			
126	126			
128	128	0		
130	130	2		
132	132	4		
134	134	6		
136	136	8		
138	138	10		
140	140	12		
142	142	14		

Table 4: Control Rod Overlap Determination

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
144	144	16		
146	146	18		
148	148	20		
150	150	22		
152	152	24		
154	154	26		
156	156	28		
158	158	30		
160	160	32		
162	162	34		
164	164	36		
166	166	38		
168	168	40		
170	170	42		
172	172	44		
174	174	46		
176	176	48		
178	178	50		
180	180	52		
182	182	54		
184	184	56		
186	186	58		
188	188	60		
190	190	62		
192	192	64		
194	194	66		
196	196	68		
198	198	70		
200	200	72		
202	202	74		
204	204	76		
206	206	78		
208	208	80		
210	210	82		
212	212	84		
214	214	86		
216	216	88		
218	218	90		

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
220	220	92		
222	222	94		
224	224	96		
226	226	98		
228	228	100		
230	230	102		
232	232	104		
234		106		
236		108		
238		110		
240		112		
242		114		
244		116		
246		118		
248		120		
250		122		
252		124		
254		126		
256		128	0	
258		130	2	
260		132	4	
262		134	6	
264		136	8	
266		138	10	
268		140	12	
270		142	14	
272		144	16	
274		146	18	
276		148	20	
278		150	22	
280		152	24	
282		154	26	
284		156	28	
286		158	30	
288		160	32	
290		162	34	
292		164	36	
294		166	38	

Table 4: Control Rod Overlap Determination

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
296		168	40	
298		170	42	
300		172	44	
302		174	46	
304		176	48	
306		178	50	
308		180	52	
310		182	54	
312		184	56	
314		186	58	
316		188	60	
318		190	62	
320		192	64	
322		194	66	
324		196	68	
326		198	70	
328		200	72	
330		202	74	
332		204	76	
334		206	78	
336		208	80	
338		210	82	
340		212	84	
342		214	86	
344		216	88	
346		218	90	
348		220	92	
350		222	94	
352		224	96	
354		226	98	
356		228	100	
358		230	102	
360		232	104	
362			106	
364			108	
366			110	
368			112	

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
370			114	
372			116	
374			118	
376			120	
378			122	
380			124	
382			126	
384			128	0
386			130	2
388			132	4
390			134	6
392			136	8
394			138	10
396			140	12
398			142	14
400			144	16
402			146	18
404			148	20
406			150	22
408			152	24
410			154	26
412			156	28
414			158	30
416			160	32
418			162	34
420			164	36
422			166	38
424			168	40
426			170	42
428			172	44
430			174	46
432			176	48
434			178	50
436			180	52
438			182	54
440			184	56
442			186	58

Table 4: Control Rod Overlap Determination

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
444			188	60
446			190	62
448			192	64
450			194	66
452			196	68
454			198	70
456			200	72
458			202	74
460			204	76
462			206	78
464			208	80
466			210	82
468			212	84
470			214	86
472			216	88
474			218	90
476			220	92
478			222	94
480			224	96
482			226	98
484			228	100
486			230	102
488			232	104
490				106
492				108
494				110
496				112
498				114
500				116
502				118
504				120
506				122
508				124
510				126
512				128
514				130
516				132

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
518				134
520				136
522				138
524				140
526				142
528				144
530				146
532				148
534				150
536				152
538				154
540				156
542				158
544				160
546				162
548				164
550				166
552				168
554				170
556				172
558				174
560				176
562				178
564				180
566				182
568				184
570				186
572				188
574				190
576				192
578				194
580				196
582				198
584				200
586				202
588				204
590				206

Table 4: Control Rod Overlap Determination

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
592				208
594				210
596				212
598				214
600				216
602				218
604				220
606				222
608				224
610				226
612				228
614				230
616				232

This information is provided in 2 step increments. One step increments can be derived by interpolation. Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥225 and ≤231 steps withdrawn. The Table indicates a maximum step of 232 to be consistent with 2 step increments.