

Harris Unit 1 Cycle 6
Core Operating Limits Report - Rev. 2
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1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Shearon Harris Unit 1 Cycle 6 has been prepared in accordance with the requirements of Technical Specification 6.9.1.6.

The Technical Specifications affected by this report are listed below:

- 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 - $F_{\Delta H}$
- 3/4.9.1.a Boron Concentration During Refueling Operations

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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 NRC-approved methodologies specified in Technical Specification 6.9.1.6 and given in Section 3.0.

2.1 Moderator Temperature Coefficient (Specification 3/4.1.1.3)

1. The Moderator Temperature Coefficient (MTC) limits are:

The Positive MTC Limit (ARO/HZP) shall be less positive than +5.0 pcm/°F for power levels up to 70% RTP with a linear ramp to 0 pcm/°F at 100% RTP.

The Negative MTC Limit (ARO/RTP) shall be less negative than -45 pcm/°F.

2. The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to -37.4 pcm/°F.

where: ARO stands for All Rods Out
 HZP stands for Hot Zero THERMAL POWER
 RTP stands for RATED THERMAL POWER

2.2 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

Fully withdrawn for all shutdown rods shall be 231 steps.

2.3 Control Rod Insertion Limit (Specification 3/4.1.3.6)

The control rod banks shall be limited in physical insertion as specified in Figure 1. Fully withdrawn for all control rods shall be 231 steps.

2.4 Axial Flux Difference (Specification 3/4.2.1)

The AXIAL FLUX DIFFERENCE (AFD) target band is specified in Figure 2.

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2.5 Heat Flux Hot Channel Factor - $F_Q(Z)$ (Specification 3/4.2.2)

$$F_Q(Z) \leq F_Q^{RTP} * K(Z)/P \text{ for } P > 0.5$$

$$F_Q(Z) \leq F_Q^{RTP} * K(Z)/0.5 \text{ for } P \leq 0.5$$

where: P = THERMAL POWER/RATED THERMAL POWER

- a. F_Q^{RTP} = 2.45 for LOPAR and VANTAGE 5 fuel
- b. F_Q^{RTP} = 2.52 for SPC fuel
- c. $K(Z)$ is specified in Figure 3.
- d. $V(Z)$ Curve for PDC-3 Operation is specified in Figure 4. The $V(z)$ curve is sufficient to determine the PDC-3 $V(z)$ versus core height for Cycle 6 burnups through the end of full power reactivity plus a coastdown for a maximum cycle energy of 461 EFPDs.

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

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

where: P = THERMAL POWER/RATED THERMAL POWER

- a. $F_{\Delta H}^{RTP}$ = 1.62 for LOPAR fuel
- b. $F_{\Delta H}^{RTP}$ = 1.65 for VANTAGE 5 fuel
- c. $F_{\Delta H}^{RTP}$ = 1.73 for SPC fuel
- d. $PF_{\Delta H}$ = 0.3 for LOPAR fuel
- e. $PF_{\Delta H}$ = 0.35 for VANTAGE 5 and SPC fuel

2.7 Boron Concentration for Refueling Operations (Specification 3/4.9.1.a)

Through the end of Cycle 6, the boron concentration required to maintain K_{off} less than or equal to .95 is less restrictive than the 2000 ppm boron requirement. Boron concentration must be maintained greater than or equal to 2000 ppm during refueling operations.

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3.0 METHODOLOGY REFERENCES

1. XN-75-27(A), and Supplements 1, 2, 3, 4, and 5, "Exxon Nuclear Neutronics Design Methods for Pressurized Water Reactors," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient, 3.1.3.5 - Shutdown Bank Insertion Limits, 3.1.3.6 - Control Bank Insertion Limits, 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor, and 3.9.1 - Boron Concentration).

2. ANF-89-151(A), and Correspondence, "ANF-RELAP Methodology for Pressurized Water Reactors: Analysis of Non-LOCA Chapter 15 Events," Advanced Nuclear Fuels Corporation, Richland, WA 99352.

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient, 3.1.3.5 - Shutdown Bank Insertion Limits, 3.1.3.6 - Control Bank Insertion Limits, 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

3. XN-NF-82-21(A), Revision 1, "Application of Exxon Nuclear Company PWR Thermal Margin Methodology to Mixed Core Configurations," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

4. XN-75-32(A), Supplements 1, 2, 3, and 4, "Computational Procedure for Evaluating Fuel Rod Bowing," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

5. XN-NF-84-93(A), and Supplement 1, "Steamline Break Methodology for PWRs," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient, 3.1.3.5 - Shutdown Bank Insertion Limits, 3.1.3.6 - Control Bank Insertion Limits, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

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3.0 METHODOLOGY REFERENCES (continued)

6. EXEM PWR Large Break LOCA Evaluation Model as defined by:

XN-NF-82-20(A), Revision 1 and Supplements 1, 2, 3, and 4, "Exxon Nuclear Company Evaluation Model EXEM/PWR ECCS Model Updates," Exxon Nuclear Company, Richland, WA 99352.

XN-NF-82-07(A), Revision 1, "Exxon Nuclear Company ECCS Cladding Swelling and Rupture Model," Exxon Nuclear Company, Richland, WA 99352.

XN-NF-81-58(A), Revision 2 and Supplements 1, 2, 3, and 4, "RODEX2 Fuel Rod Thermal Response Evaluation Model," Exxon Nuclear Company, Richland, WA 99352.

XN-NF-85-16(A), Volume 1 and Supplements 1, 2, and 3, Volume 2, Revision 1 and Supplement 1, "PWR 17x17 Fuel Cooling Test Program," Exxon Nuclear Company, Richland, WA 99352.

XN-NF-85-105(A), and Supplement 1, "Scaling of FCTF Based Reflood Heat Transfer Correlation for Other Bundle Designs," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

7. XN-NF-78-44(A), "A Generic Analysis of the Control Rod Ejection Transient for Pressurized Water Reactors," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.1.3.5 - Shutdown Bank Insertion Limits, 3.1.3.6 - Control Bank Insertion Limits, and 3.2.2 - Heat Flux Hot Channel Factor).

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3.0 METHODOLOGY REFERENCES (continued)

8. ANF-88-054(A), "PDC-3: Advanced Nuclear Fuels Corporation Power Distribution Control for Pressurized Water Reactors and Application of PDC-3 to H. B. Robinson Unit 2," Advanced Nuclear Fuels Corporation, Richland, WA 99352.

(Methodology for Specification 3.2.1 - Axial Flux Difference, and 3.2.2 - Heat Flux Hot Channel Factor).
9. WCAP-9272-P-A, "WESTINGHOUSE RELOAD SAFETY EVALUATION METHODOLOGY", July 1985 (W Proprietary).

(Methodology for Specification 3.2.2 - Heat Flux Hot Channel Factor and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).
10. WCAP-10266-P-A, Rev. 2, "The 1981 Version of the WESTINGHOUSE ECCS EVALUATION MODEL USING THE BASH CODE", March 1987 (W Proprietary).

(Methodology for Specification 3.2.2 - Heat Flux Hot Channel Factor).
11. WCAP-11837-P-A, "EXTENSION OF METHODOLOGY FOR CALCULATING TRANSITION CORE DNBR PENALTIES", January 1990 (W Proprietary).

(Methodology for Specification 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).
12. EMF-92-081(A), and Supplement 1, "Statistical Setpoint/Transient Methodology for Westinghouse Type Reactors," Siemens Power Corporation, Richland, WA 99352.

(Methodology for Specification 3.1.1.3 - Moderator Temperature Coefficient, 3.1.3.5 - Shutdown Bank Insertion Limits, 3.1.3.6 - Control Bank Insertion Limits, 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).
13. EMF-92-153(A), and Supplement 1, "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel," Siemens Nuclear Power Corporation, Richland, WA 99352.

(Methodology for Specification 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

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3.0 METHODOLOGY REFERENCES (Continued)

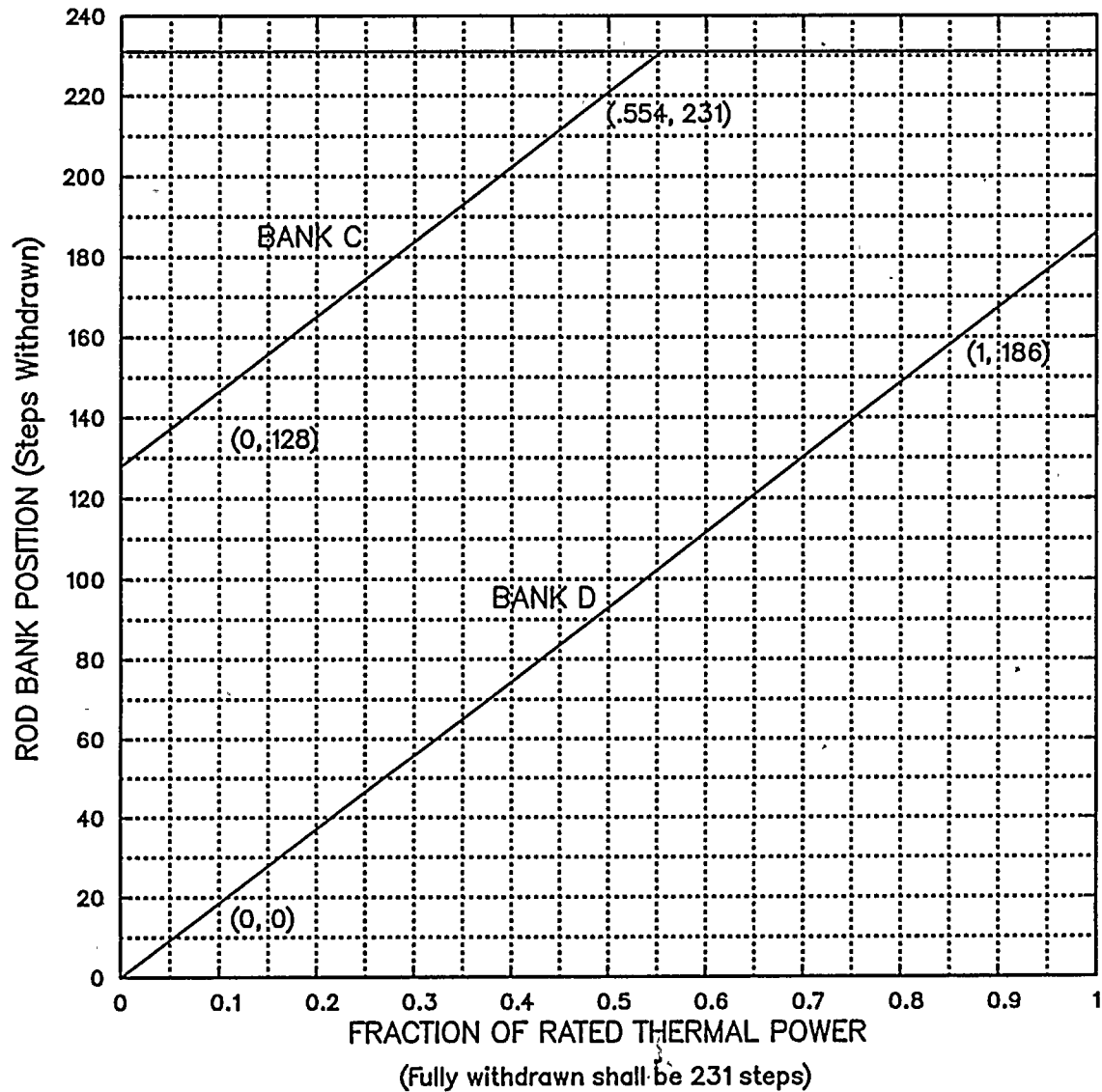
14. XN-NF-82-49(A), Revision 1, and XN-NF-82-49(P), Revision 1, Supplement 1, "Exxon Nuclear Company Evaluation Model EXEM PWR Small Break Model," Exxon Nuclear Company, Richland, WA 99352.

(Methodology for Specification 3.2.1 - Axial Flux Difference, 3.2.2 - Heat Flux Hot Channel Factor, and 3.2.3 - Nuclear Enthalpy Rise Hot Channel Factor).

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FIGURE 1
 ROD GROUP INSERTION LIMITS VERSUS THERMAL POWER
 (THREE-LOOP OPERATION)

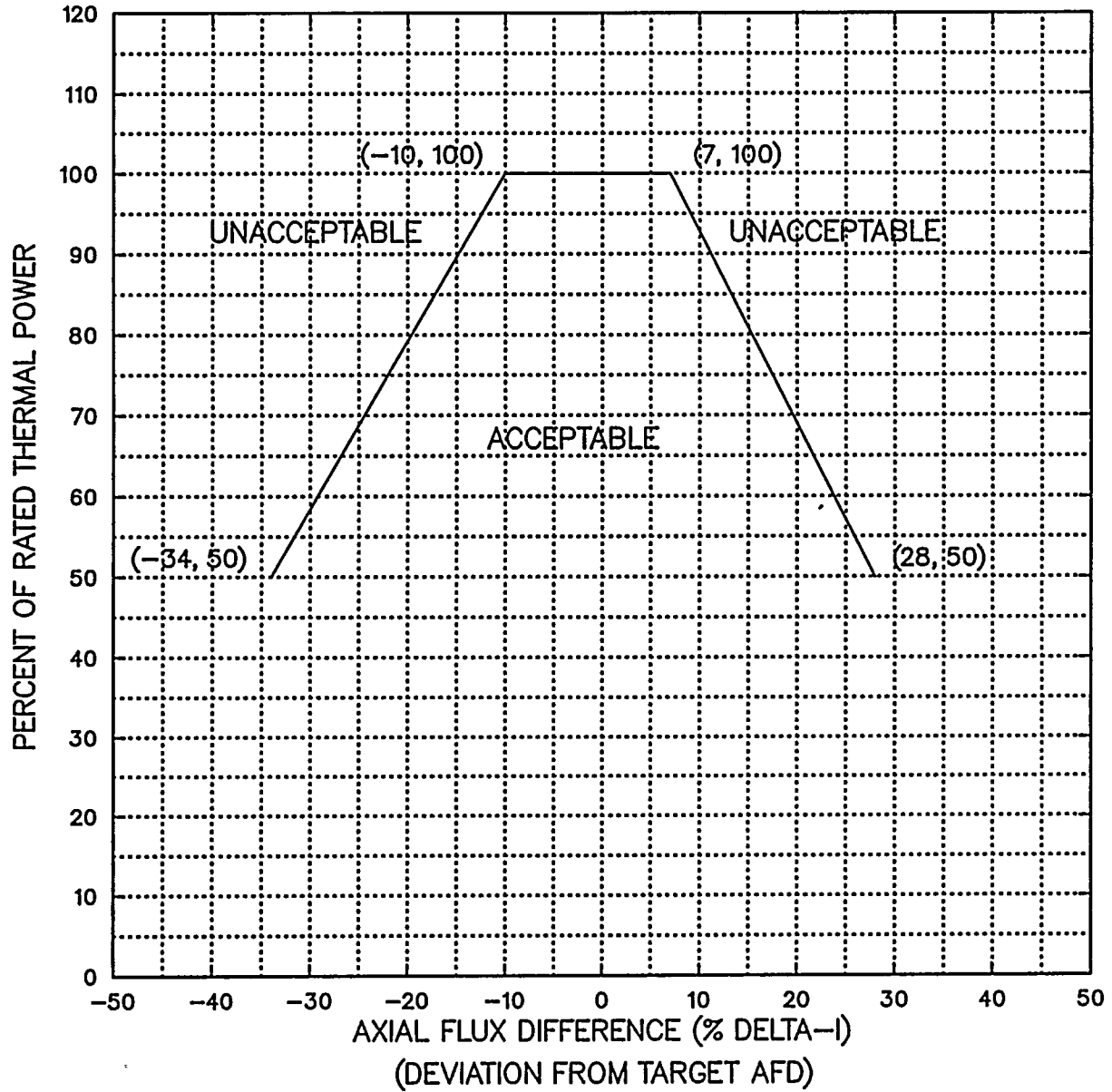


Note: Control Banks A and B Must be Withdrawn From
 The Core Prior to Power Operation

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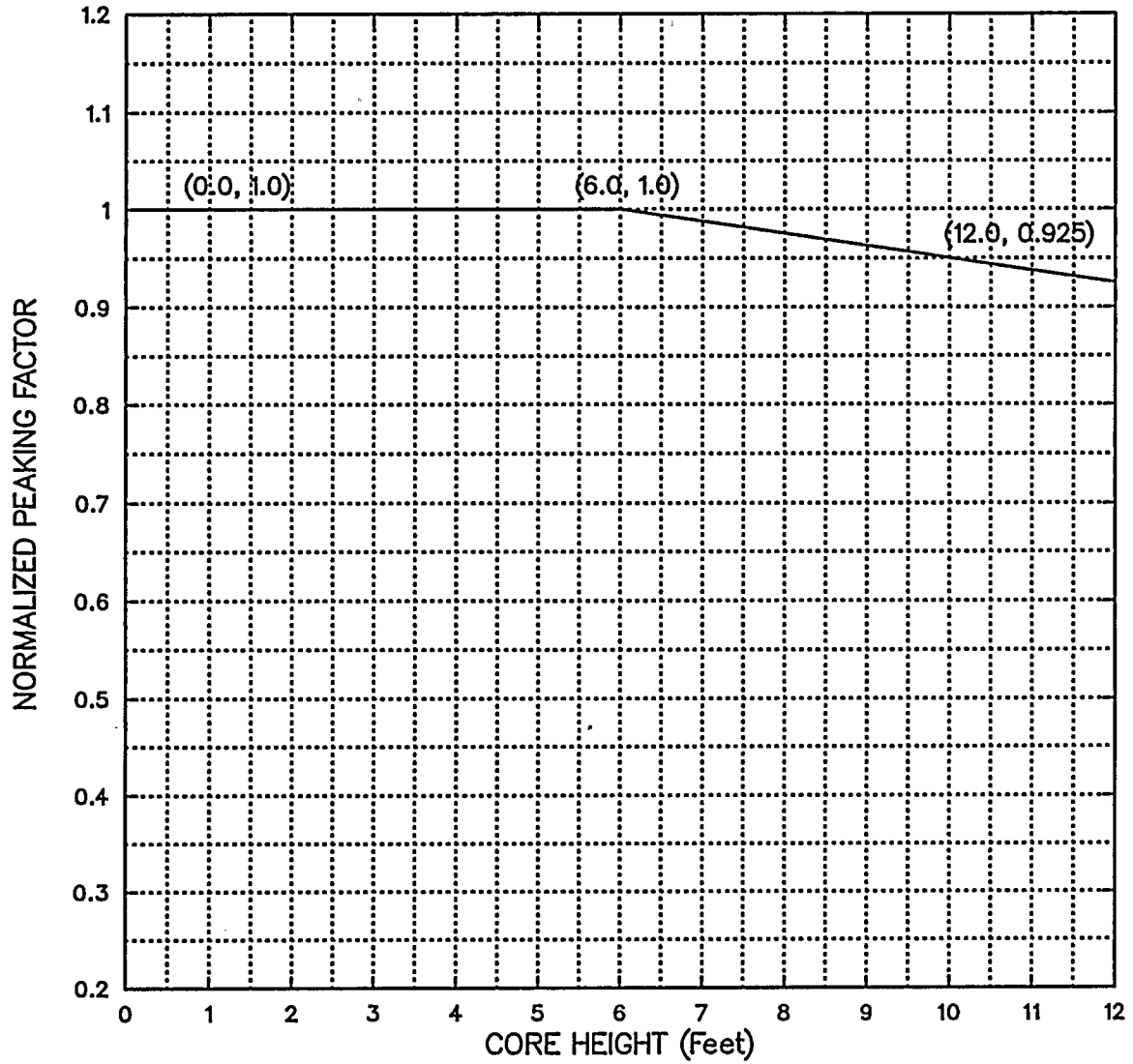
FIGURE 2
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF
RATED THERMAL POWER



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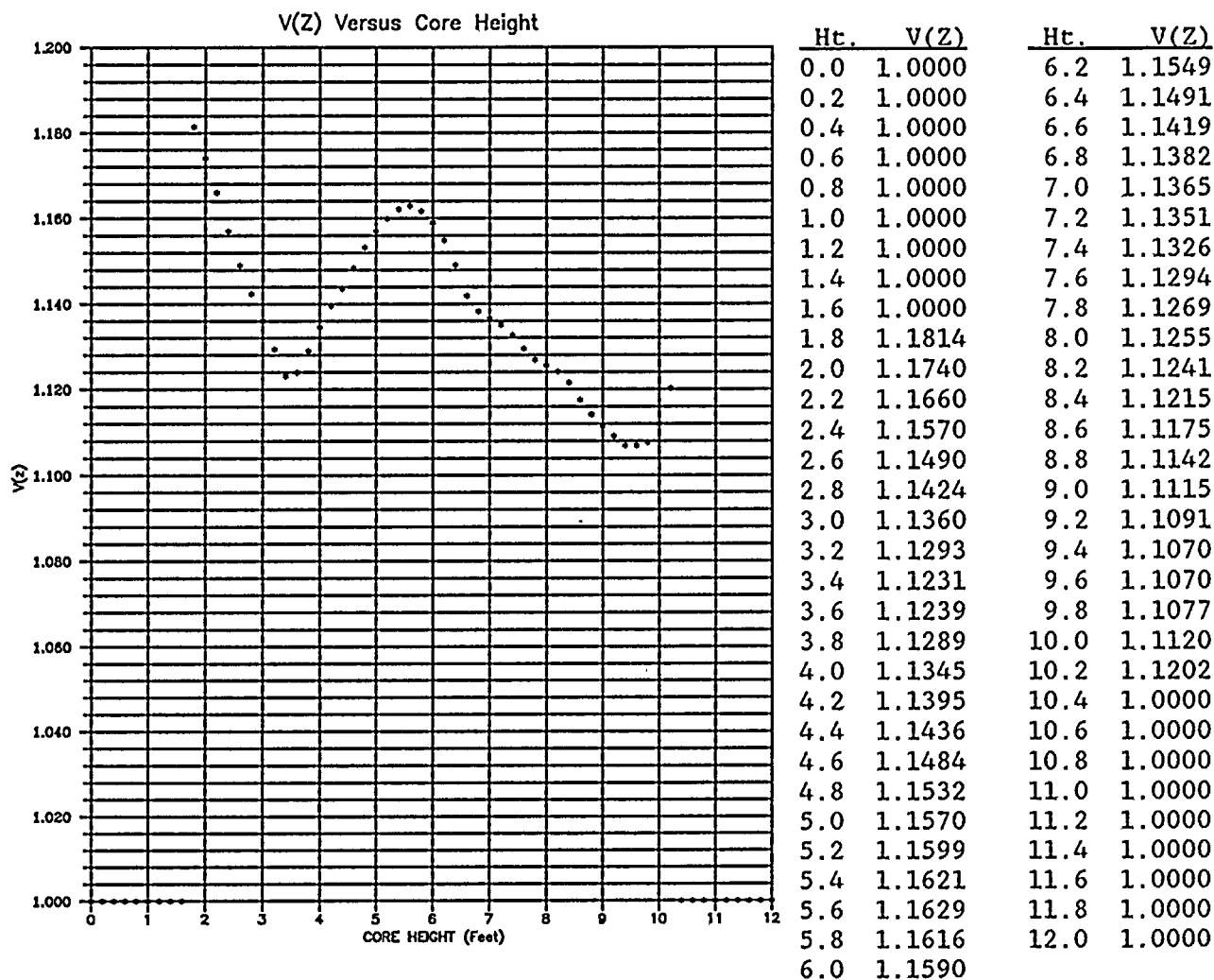
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FIGURE 3
K(Z) - LOCAL AXIAL PENALTY FUNCTION FOR FQ(Z)



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Figure 4



* Note that the top and bottom 15% are excluded per Technical Specification 4.2.2.2.