Harris Unit 1 Cycle 8
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1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Shearon Harris Unit 1 Cycle 8 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:

3/4.1.1.2	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 - $F_{\Delta H}$
3/4.9.1.a	Boron Concentration During Refueling Operations

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 SHUTDOWN MARGIN - Modes 3, 4, and 5 (Specification 3/4.1.1.2)

The SHUTDOWN MARGIN versus RCS boron concentration - Modes 3, 4, and 5 is specified in Figure 1.

2.2 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.

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2.2 Moderator Temperature Coefficient (Specification 3/4.1.1.3) (continued)

2. The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to -37.65 pcm/°F.

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

2.3 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

Fully withdrawn for all shutdown rods shall be 225 steps.

2.4 Control Rod Insertion Limit (Specification 3/4.1.3.6)

The control rod banks shall be limited in physical insertion as specified in Figure 2. Fully withdrawn for all control rods shall be 225 steps.

2.5 Axial Flux Difference (Specification 3/4.2.1)

The AXIAL FLUX DIFFERENCE (AFD) target band is specified in Figure 3.

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

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

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

where: P = THERMAL POWER/RATED THERMAL POWER

a. $F_Q^{RTP} = 2.45$ for LOPAR fuel

b. $F_Q^{RTP} = 2.52$ for SPC fuel

c. K(Z) is specified in Figure 4.

d. V(Z) Curve for PDC-3 Operation is specified in Figure 5. The V(Z) curve is sufficient to determine the PDC-3 V(Z) versus core height for Cycle 8 burnups through the end of full power reactivity plus a coastdown for a maximum cycle energy of 513 EFPDs.

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2.7 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. $F_{\Delta H}^{RTP}$ = 1.73 for SPC fuel

c. $PF_{\Delta H}$ = 0.3 for LOPAR fuel

d. $PF_{\Delta H}$ = 0.35 for SPC fuel

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

Through the end of Cycle 8, the boron concentration required to maintain K_{eff} less than or equal to .95 is equal to 2300 ppm. Boron concentration must be maintained greater than or equal to 2300 ppm during refueling operations.

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 3.1.1.2 - SHUTDOWN MARGIN - Modes 3, 4, and 5, 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).

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3.0 METHODOLOGY REFERENCES (continued)

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).

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 3.1.1.2 - SHUTDOWN MARGIN - Modes 3, 4, and 5, 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).

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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4.0 OTHER REQUIREMENTS

4.1 Movable Incore Detection System

1. Operability: The Movable Incore Detection System shall be OPERABLE with:

R a. At least 38 detector thimbles at beginning of cycle (75% of the total number), where the beginning of cycle is defined in this instance as a flux map determination that the core is loaded consistent with design,

b. A minimum of 38 detector thimbles for the remainder of the operating cycle,

c. A minimum of two detector thimbles per core quadrant, and

d. Sufficient movable detectors, drive, and readout equipment to map these thimbles.

2. Applicability: When the Movable Incore Detection System is used for:

a. Recalibration of the Excore Neutron Flux Detection System, or

b. Monitoring the QUADRANT POWER TILT RATIO, or

c. Measurement of $F_{\Delta H}$ and $F_Q(Z)$

3. Surveillance Requirements: The Movable Incore Detection System shall be demonstrated OPERABLE, within 24 hours prior to use, by irradiating each detector used and determining the acceptability of its voltage curve when required for:

a. Recalibration of the Excore Neutron Flux Detection System, or

b. Monitoring the QUADRANT POWER TILT RATIO, or

c. Measurement of $F_{\Delta H}$ and $F_Q(Z)$

4. Bases

The OPERABILITY of the movable incore detectors with the specified minimum complement of equipment ensures that the measurements obtained from use of this system accurately represent the spatial neutron flux distribution of the core. The OPERABILITY of this system is demonstrated by irradiating each detector used and determining the acceptability of its voltage curve.

For the purpose of measuring $F_Q(Z)$ or $F_{\Delta H}$, a full incore flux map is used.

Quarter-core flux maps, as defined in WCAP-8648, June 1976, may be used in recalibration of the Excore Neutron Flux Detection System, and full incore flux maps or symmetric incore thimbles may be used for monitoring QUADRANT POWER TILT RATIO when one Power Range channel is inoperable.

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4.0 OTHER REQUIREMENTS (continued)

R 5. Evaluation Requirements

In order to change the requirements concerning the number and location of operable detectors, the NRC staff deems that a rigorous evaluation and justification is required. The following is a list of elements that must be part of a 50.59 determination and available for audit if the licensee wishes to change the requirements:

a. How an inadvertent loading of a fuel assembly into an improper location will be detected,

b. How the validity of the tilt estimates will be ensured,

c. How adequate core coverage will be maintained,

d. How the measurement uncertainties will be assured and why the added uncertainties are adequate to guarantee that measured nuclear heat flux hot channel factor, nuclear enthalpy rise hot channel factor, radial peaking factor and quadrant power tilt factor meet Technical Specification limits, and

e. How the Movable Incore Detection System will be restored to full (or nearly full) service before the beginning of each cycle.

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Figure 1

**Shutdown Margin Versus RCS Boron Concentration
Modes 3, 4, and 5/Drained**

* Applicable to Mode 4, with or without RCPs in operation

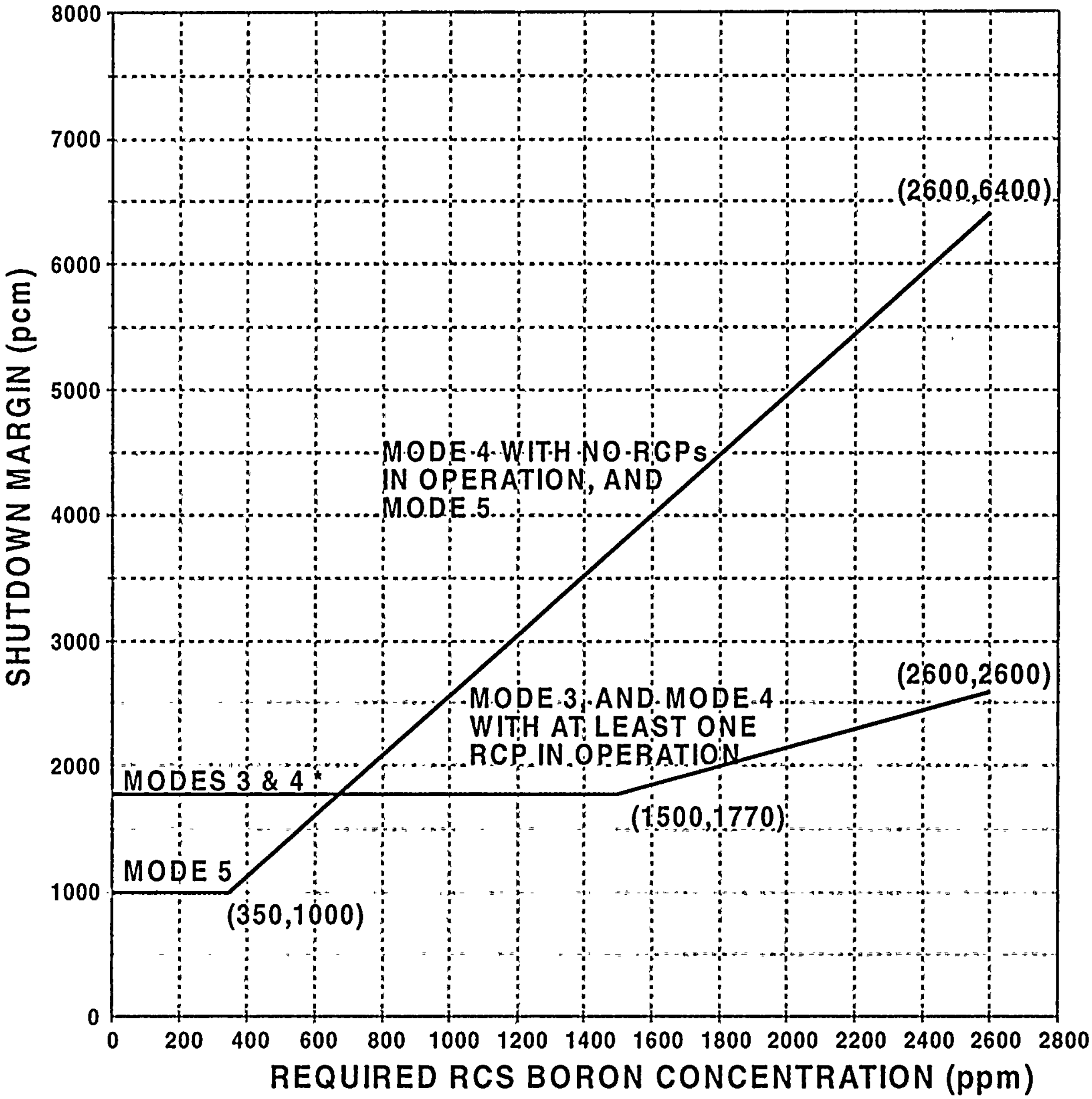

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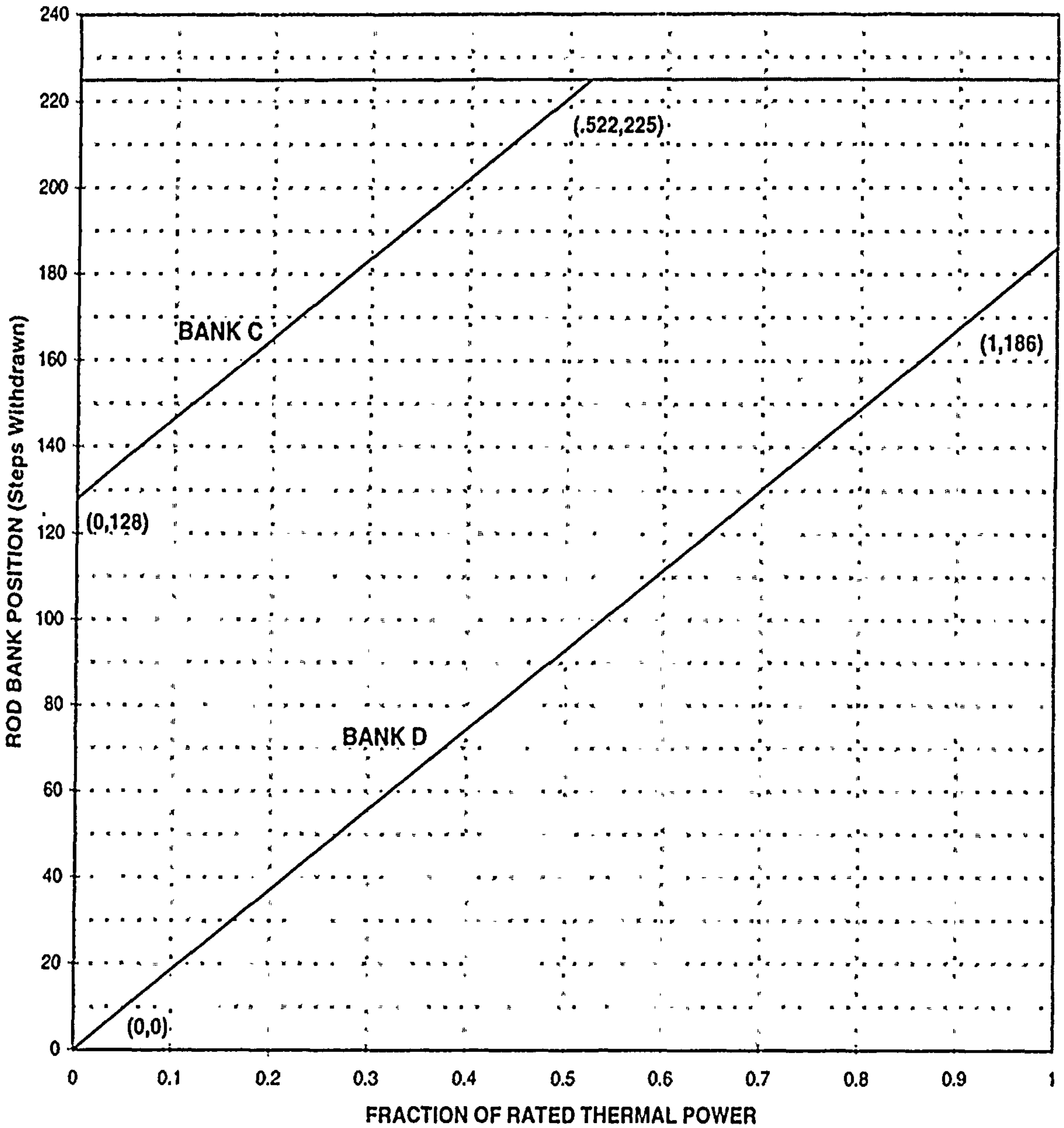
Figure 2

Rod Group Insertion Limits Versus Thermal Power
(Three-Loop Operation)



(Fully withdrawn shall be 225 steps)

Note: Control Banks A and B must be withdrawn from the core prior to power operation.

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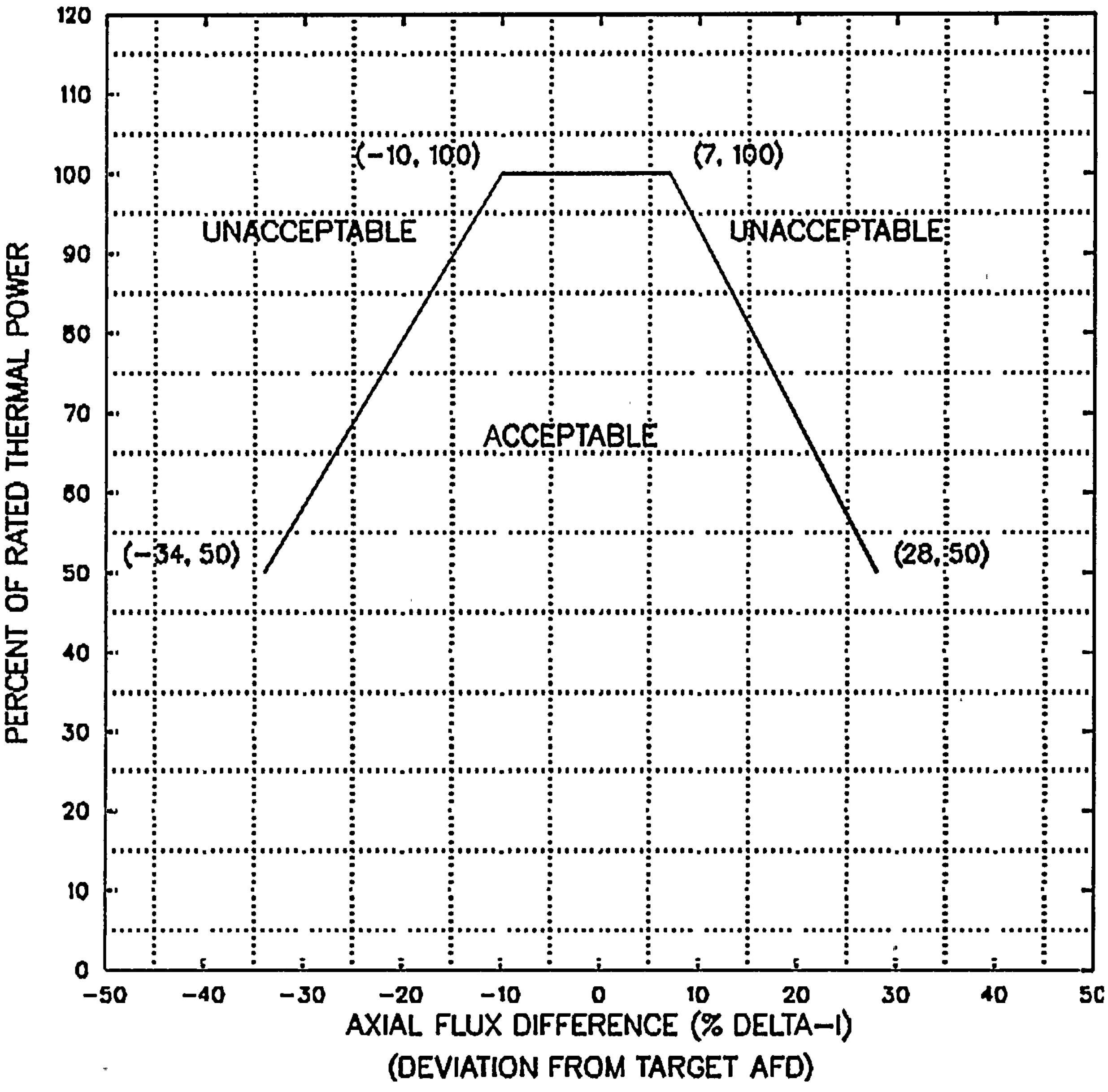
Figure 3

Axial Flux Difference Limits as a Function of
Rated Thermal Power



Note: At power levels less than HFP, the deviation is applied to the target AFD appropriate to that power level. The target AFD varies linearly between the HFP target and zero at zero power.

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Figure 4

K(Z) - Local Axial Penalty Function for FQ(Z)

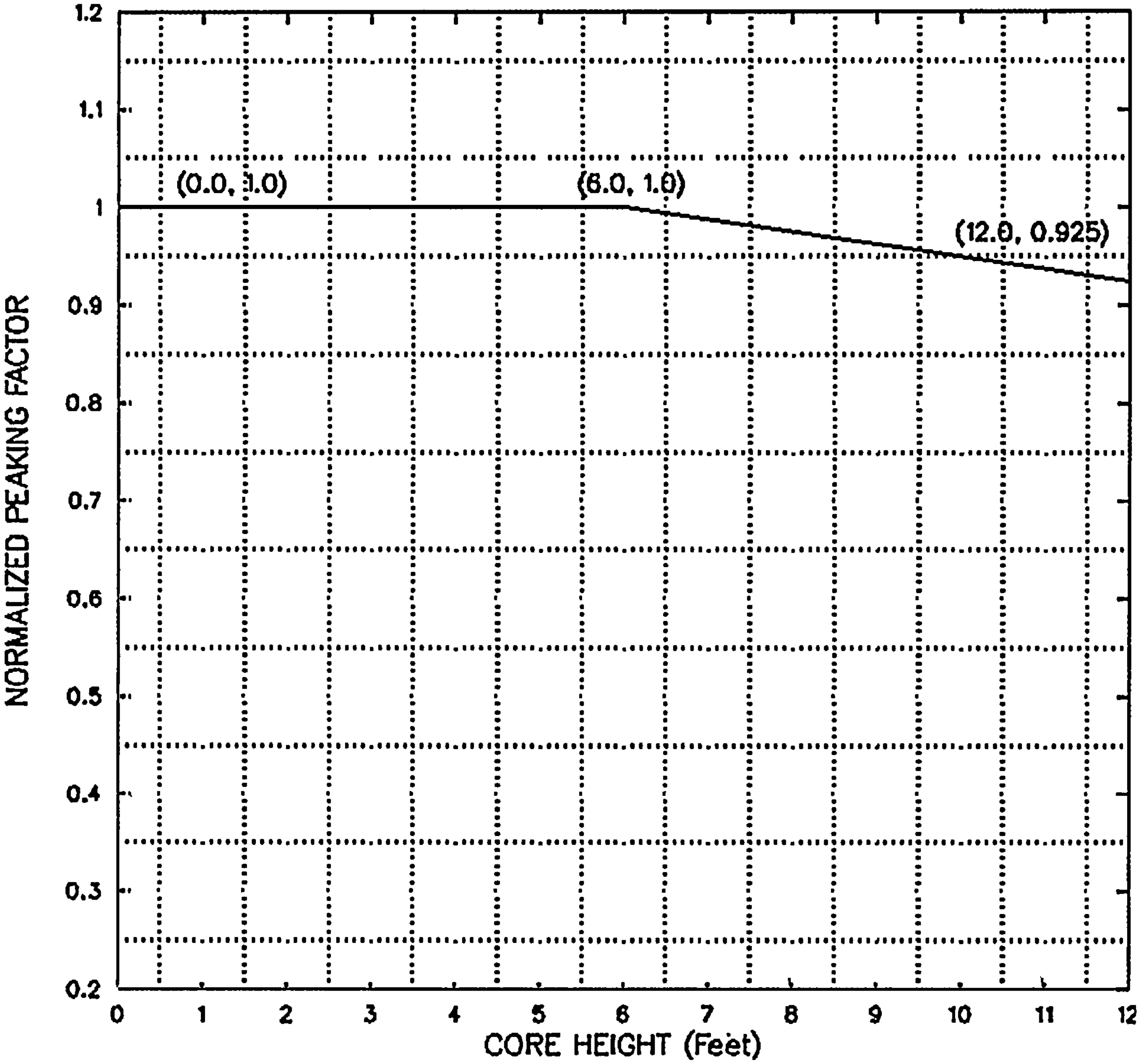

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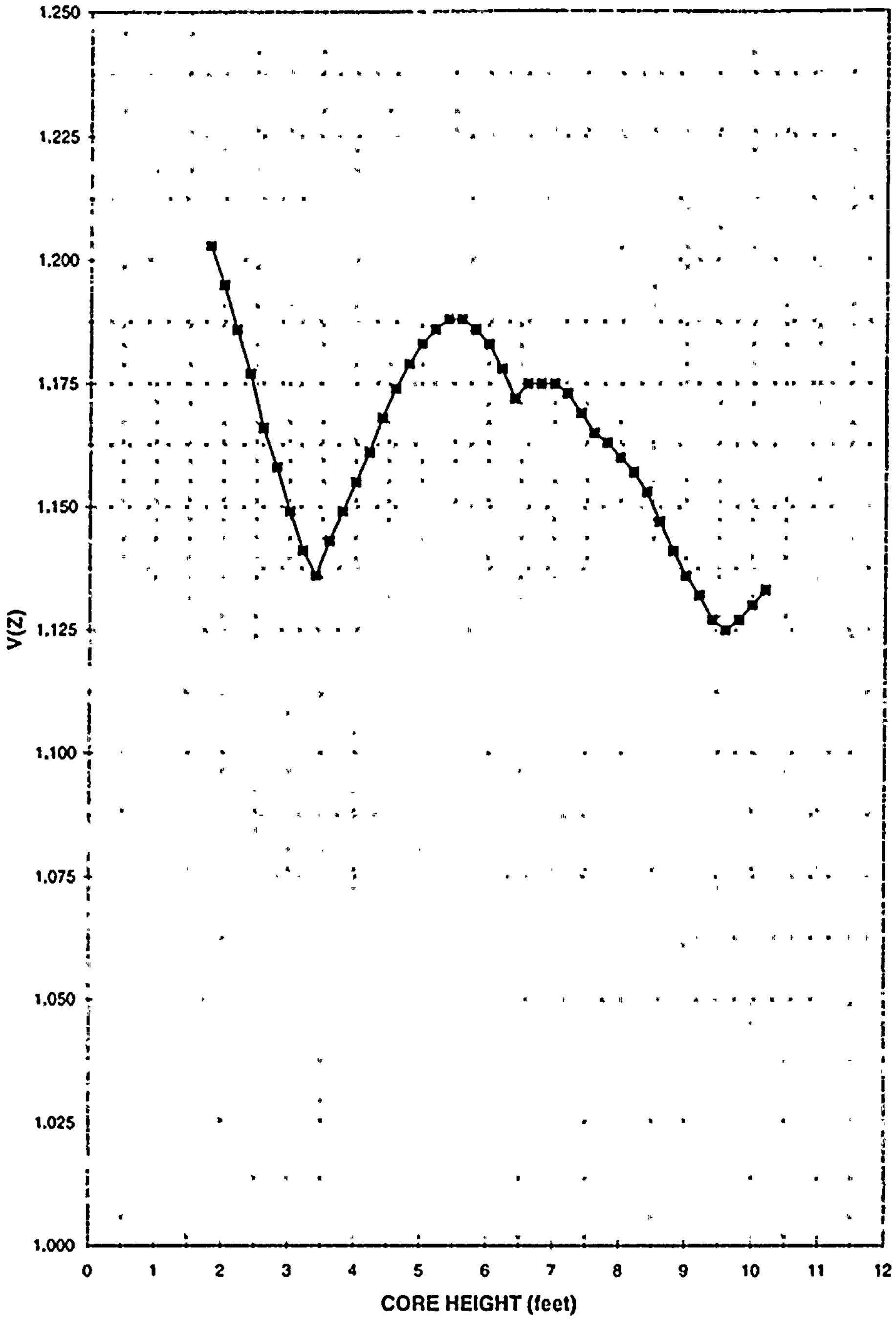
Figure 5
V(Z) Versus Core Height



Height (feet)	V(Z)
* 0.000	1.000
* 0.200	1.000
* 0.400	1.000
* 0.600	1.000
* 0.800	1.000
* 1.000	1.000
* 1.200	1.000
* 1.400	1.000
* 1.600	1.000
1.800	1.203
2.000	1.195
2.200	1.186
2.400	1.177
2.600	1.166
2.800	1.158
3.000	1.149
3.200	1.141
3.400	1.136
3.600	1.143
3.800	1.149
4.000	1.155
4.200	1.161
4.400	1.168
4.600	1.174
4.800	1.179
5.000	1.183
5.200	1.186
5.400	1.188
5.600	1.188
5.800	1.186
6.000	1.183
6.200	1.178
6.400	1.172
6.600	1.175
6.800	1.175
7.000	1.175
7.200	1.173
7.400	1.169
7.600	1.165
7.800	1.163
8.000	1.160
8.200	1.157
8.400	1.153
8.600	1.147
8.800	1.141
9.000	1.136
9.200	1.132
9.400	1.127
9.600	1.125
9.800	1.127
10.000	1.130
10.200	1.133
* 10.400	1.000
* 10.600	1.000
* 10.800	1.000
* 11.000	1.000
* 11.200	1.000
* 11.400	1.000
* 11.600	1.000
* 11.800	1.000
* 12.000	1.000

Note: Top and bottom 15% excluded as per Technical Specifications 4.2.2.2.g