444 South 16th Street Mall
Omaha NE 68102-2247

March 25, 2005
LIC-05-0033

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Reference: Docket No. 50-285

SUBJECT: Transmittal of Fort Calhoun Station Unit No. 1 (FCS) Core Operating Limit Report (COLR) Revisions 29 & 30

Pursuant to FCS Technical Specification 5.9.5.c, Omaha Public Power District is transmitting Revisions 29 and 30 (both issued on March 24, 2005) of the FCS COLR. Revision 29 incorporates the Cycle 23 core design and reload analysis. Revision 30 updates references to NRC approved methodologies to reflect implementation of Amendment 233 (CASMO-4).

If you have any questions, please contact Susan Baughn at (402) 533-7215.

Sincerely,

B. Herman
Manager
Nuclear Licensing

JBH/mle

Attachments: TDB-VI – Technical Data Book – Core Operating Limit Report – Revisions 29 & 30

Fort Calhoun Station
Unit 1

TDB-VI

TECHNICAL DATA BOOK

CORE OPERATING LIMIT REPORT

Change No.	EC 34584
Reason for Change	This change supports the Cycle 23 core design and reload analysis.
Requestor	Mathew Panicker
Preparer	Daniel A Hochstein
Editorial Correction	N/A
Issue Date	03-24-05 3:00pm

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Fort Calhoun Station, Unit 1

<u>**Core Operating Limit Report**</u>

Due to the critical aspects of the safety analysis inputs contained in this report, changes may not be made to this report without concurrence of the Nuclear Engineering Department.

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CORE OPERATING LIMIT REPORT

1. **INTRODUCTION**

This report provides the cycle-specific limits for operation of the Fort Calhoun Station Unit 1 for Cycle 23 operation. It includes limits for:

- TM/LP LSSS for 4 Pump Operation (P_{VAR})
- Core Inlet Temperature (T_{IN})
- Power Dependent Insertion Limit (PDIL)
- Allowable Peak Linear Heat Rate
- Excore Monitoring of LHR
- Integrated Radial Peaking Factor (F_R^T)
- DNB Monitoring
- FRT versus Power Trade-off Curve
- Refueling Boron Concentration
- Axial Power Distribution (APD)
- Shutdown Margin with $T_{COLD} > 210°F$
- Most Negative Moderator Temperature Coefficient

These limits are applicable for the duration of the cycle. For subsequent cycles the limits will be reviewed and revised as necessary. In addition, this report includes a number of cycle-specific coefficients used in the generation of certain reactor protective system trip setpoints or allowable increases in radial peaking factors.

2. **CORE OPERATING LIMITS**

All values and limits in this TDB section apply to Cycle 23 operation. This cycle must be operated within the bounds of these limits and all others specified in the Technical Specifications. This report has been prepared in accordance with the requirements of Technical Specification 5.9.5. The values and limits presented within this TDB section have been derived using the NRC approved methodologies listed below:

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- EMF-1961(P)(A), "Statistical Setpoint/Transient Methodology for Combustion Engineering Type Reactors", Revision 0, July 2000.

- XN-NF-621(P)(A), "Exxon Nuclear DNB Correlation for PWR Fuel Designs", Revision 1, September 1983.

- ANF-89-151(P)(A), "ANF-RELAP Methodology for Pressurized Water Reactors: Analysis of Non-LOCA Chapter 15 Events", Revision 0, May 1992.

- EMF-92-153(P)(A) and Supplement 1, "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel", March 1994.

- XN-NF-82-49(P)(A), Supplement 1, "Exxon Nuclear Company Evaluation Model Revised EXEM PWR Small Break Model", Revision 1, December 1994.

- EMF-2087(P)(A), "SEM/PWR-98: ECCS Evaluation Model for PWR LBLOCA Applications", Revision 0, June 1999.

- ANF-84-73 Appendix B (P)(A), "Advanced Nuclear Fuels Methodology for Pressurized Water Reactors: Analysis of Chapter 15 Events", Advanced Nuclear Fuels Corporation, Revision 5, July 1990.

- EMF-84-093(P)(A), "Steam Line Break Methodology for PWRs", Siemens Power Corporation, Revision 1, February 1999.

- EMF-2328(P)(A), "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based", Framatome ANP, Inc., Revision 0, March 2001.

- EMF-96-029(P)(A) Volume 1, EMF-96-029(P)(A) Volume 2, EMF-96-029(P)(A) Attachment, "Reactor Analysis System for PWRs, Volume 1 – Methodology Description, Volume 2 – Benchmarking Results", Framatome ANP, Inc., January 1997.

- EMF-2310(P)(A), "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors", Framatome ANP, Inc., Revision 1, May 2004.

3. **TM/LP LIMIT**

The TM/LP coefficients are shown below:

Table 1 -TM/LP Coefficients

Coefficient	Value
α	29.6
β	20.63
γ	-12372

The TM/LP setpoint is calculated by the P_{VAR} equation, shown below and in Figure 1:

$$P_{VAR} = 29.6\ PF(B)\ A1(Y)B + 20.63T_{IN} - 12372$$

$PF(B)$	$= 1.0$	for $B \geq 100\%$
	$= -0.008(B) + 1.8$	for $50\% < B < 100\%$
	$= 1.4$	for $B \leq 50\%$
$A1(Y)$	$= -0.6666(Y_1) + 1.000$	for $Y_1 \leq 0.00$
	$= +0.3333(Y_1) + 1.000$	for $Y_1 > 0.00$

Where:
> B = High Auctioneered thermal (ΔT) or Nuclear Power, % of rated power
> Y = Axial Shape Index, asiu
> T_{IN} = Core Inlet Temperature, °F
> P_{VAR} = Reactor Coolant System Pressure, psia

4. **MAXIMUM CORE INLET TEMPERATURE**

The maximum core inlet temperature (T_{IN}) shall not exceed **545°F**. This value includes instrumentation uncertainty of ±2°F (Ref: FCS Calculation FC06292, 6/9/95).

This limit is not applicable during either a thermal power ramp in excess of 5% of rated thermal power per minute or a thermal power step greater than 10% of rated thermal power.

5. **POWER DEPENDENT INSERTION LIMIT**

The power dependent insertion limit is defined in Figure 2.

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6. LINEAR HEAT RATE

The allowable peak linear heat rate is shown in Figure 3.

7. EXCORE MONITORING OF LHR

The allowable operation for power versus axial shape index for monitoring of LHR with excore detectors is shown in Figure 4.

8. PEAKING FACTOR LIMITS

The maximum full power value for the integrated radial peaking factor (F_R^T) is 1.732.

9. DNB MONITORING

The core operating limits for monitoring of DNB are provided in Figure 5. This figure provides the allowable power versus axial shape index for the cycle.

10. F_R^T AND CORE POWER LIMITATIONS

Core power limitations versus F_R^T are shown in Figure 6.

11. REFUELING BORON CONCENTRATION

The refueling boron concentration is required to ensure a shutdown margin of not less than 5% with all CEAs withdrawn. The refueling boron concentration must be at least **1,900 ppm** through the end of Cycle 22 operation and is valid until the beginning of core reload for Cycle 23.

Listed below in Table 2 are the refueling boron concentration values for cycle operations:

Table 2 - Refueling Boron Concentrations

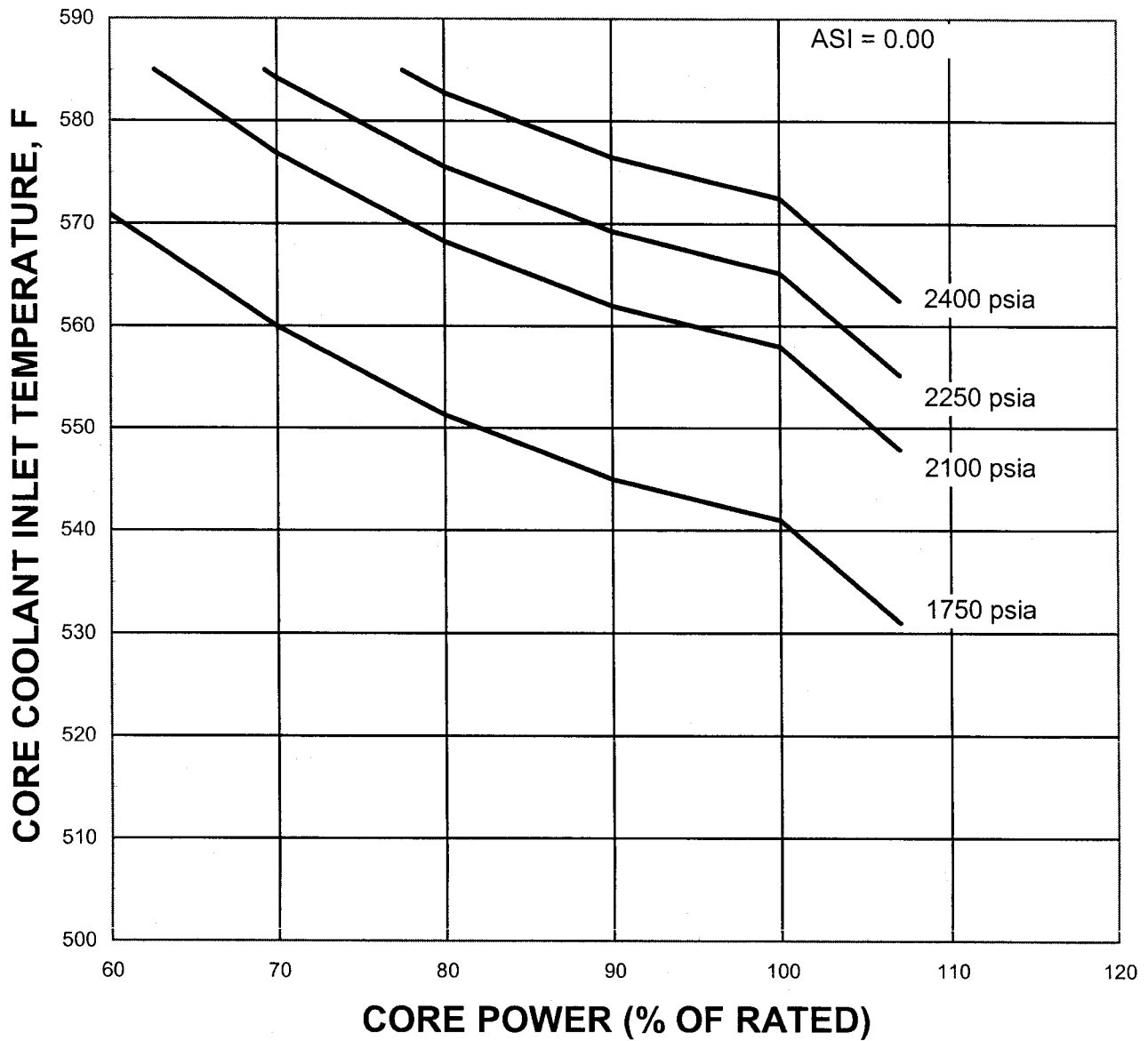| Cycle Average Burnup (MWD/MTU)	Refueling Boron Concentration (ppm)
BOC	2,141
$\geq 2,000$	2,014
$\geq 4,000$	1,900

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12. AXIAL POWER DISTRIBUTION

The axial power trip is provided to ensure that excessive axial peaking will not cause fuel damage. The Axial Shape Index is determined from the axially split excore detectors. The setpoint functions, shown in Figure 7 ensure that neither a DNBR of less than the minimum DNBR safety limit nor a maximum linear heat rate of more than 22 kW/ft (deposited in the fuel) will exist as a consequence of axial power maldistributions. Allowances have been made for instrumentation inaccuracies and uncertainties associated with the excore symmetric offset – incore axial peaking relationship. Figure 8 combines the LHR LCO tent from Figure 4, the DNB LCO tent from Figure 5, and the APD LSSS tent from Figure 7 into one figure for a visual comparison of the different limits.

13. SHUTDOWN MARGIN WITH $T_{cold} > 210°F$

Whenever the reactor is in hot shutdown, hot standby or power operation conditions, the shutdown margin shall be $\geq$**3.6% $\Delta k/k$**. With the shutdown margin <3.6% $\Delta k/k$, initiate and continue boration until the required shutdown margin is achieved.

14. Most Negative Moderator Temperature Coefficient

The moderator temperature coefficient (MTC) shall be more positive than **-3.30 x 10^{-4} $\Delta \rho/°F$**, including uncertainties, at rated power.

$$P_{VAR} = 29.6 \ PF(B)A1(Y)B + 20.63T_{IN} - 12372$$

$PF(B) = 1.0$	$B \geq 100\%$	$A1(Y) = -0.6666Y_1 + 1.000$	$Y_1 \leq 0.00$
$= -.008B + 1.8$	$50\% < B < 100\%$	$= +0.3333Y_1 + 1.000$	$Y_1 > 0.00$
$= 1.4$	$B \leq 50\%$		

CYCLE 23 COLR	THERMAL MARGIN / LOW PRESSURE FOR 4 PUMP OPERATION	FIGURE 1

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| CYCLE 23 COLR | POWER DEPENDENT INSERTION LIMIT | FIGURE 2 |

LINEAR HEAT RATE (KW/FT)

UNACCEPTABLE OPERATION

15.5 KW/FT

ACCEPTABLE OPERATION
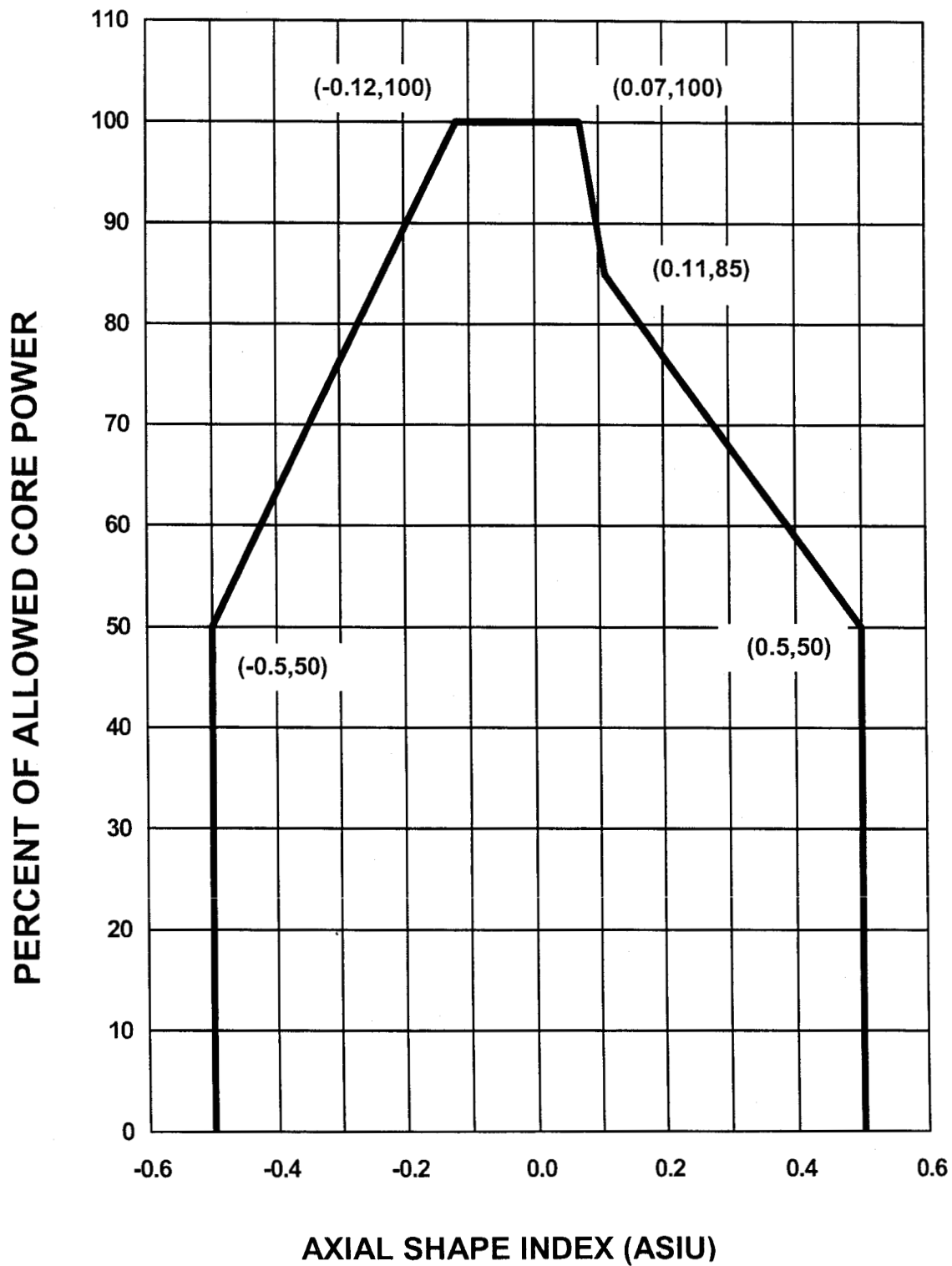
BURNUP (MWD/MTU)

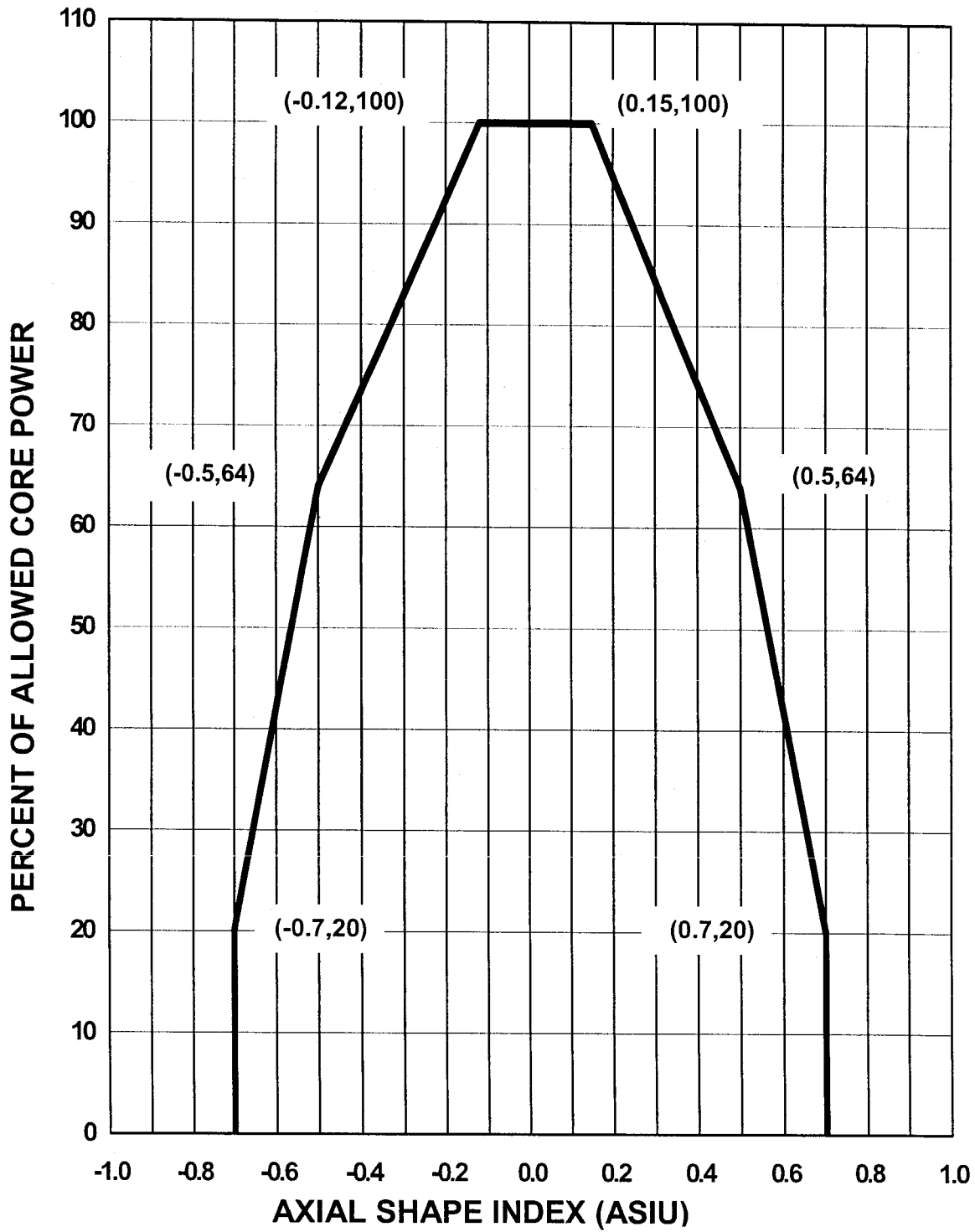| CYCLE 23 COLR | ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP | FIGURE 3 |

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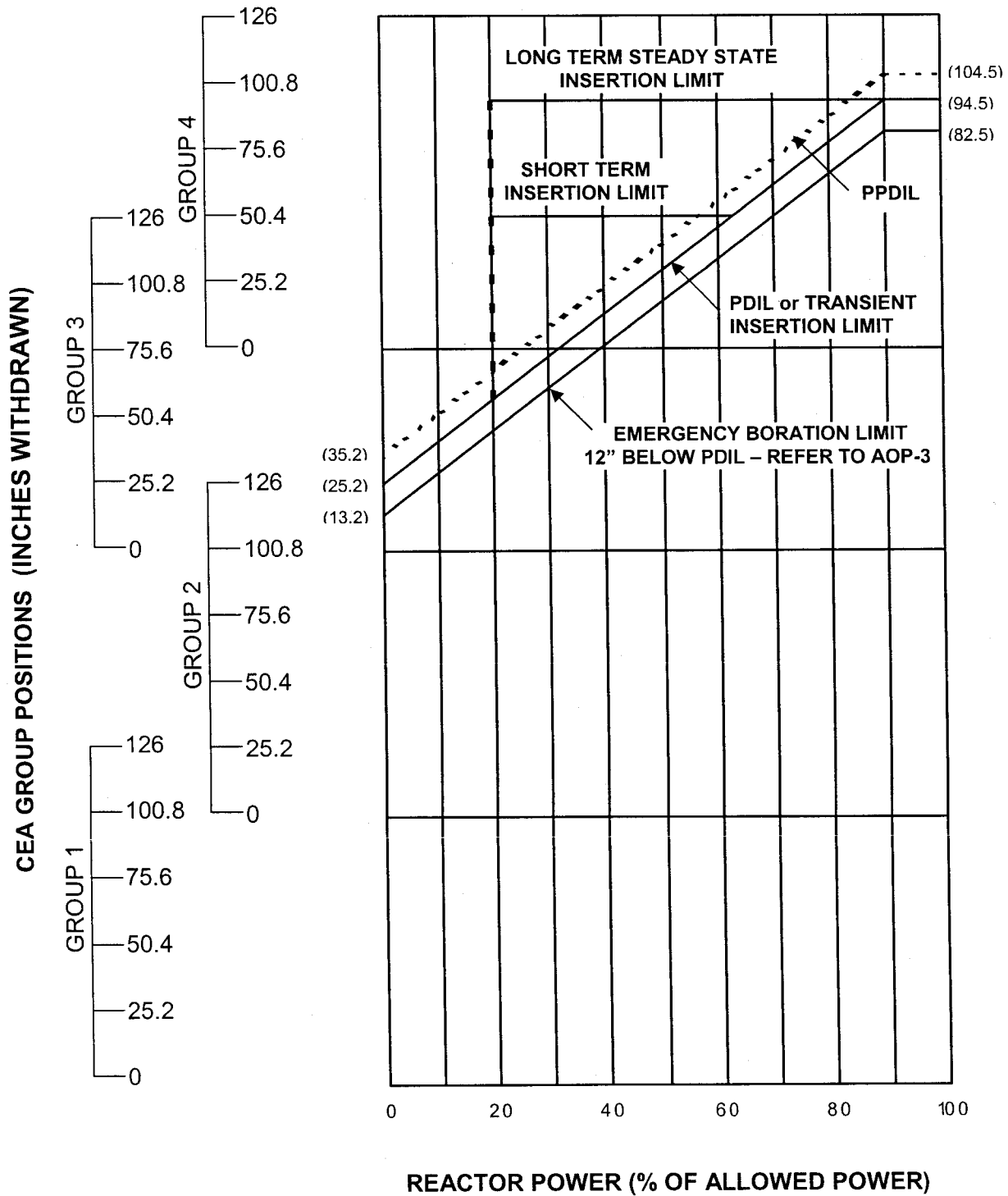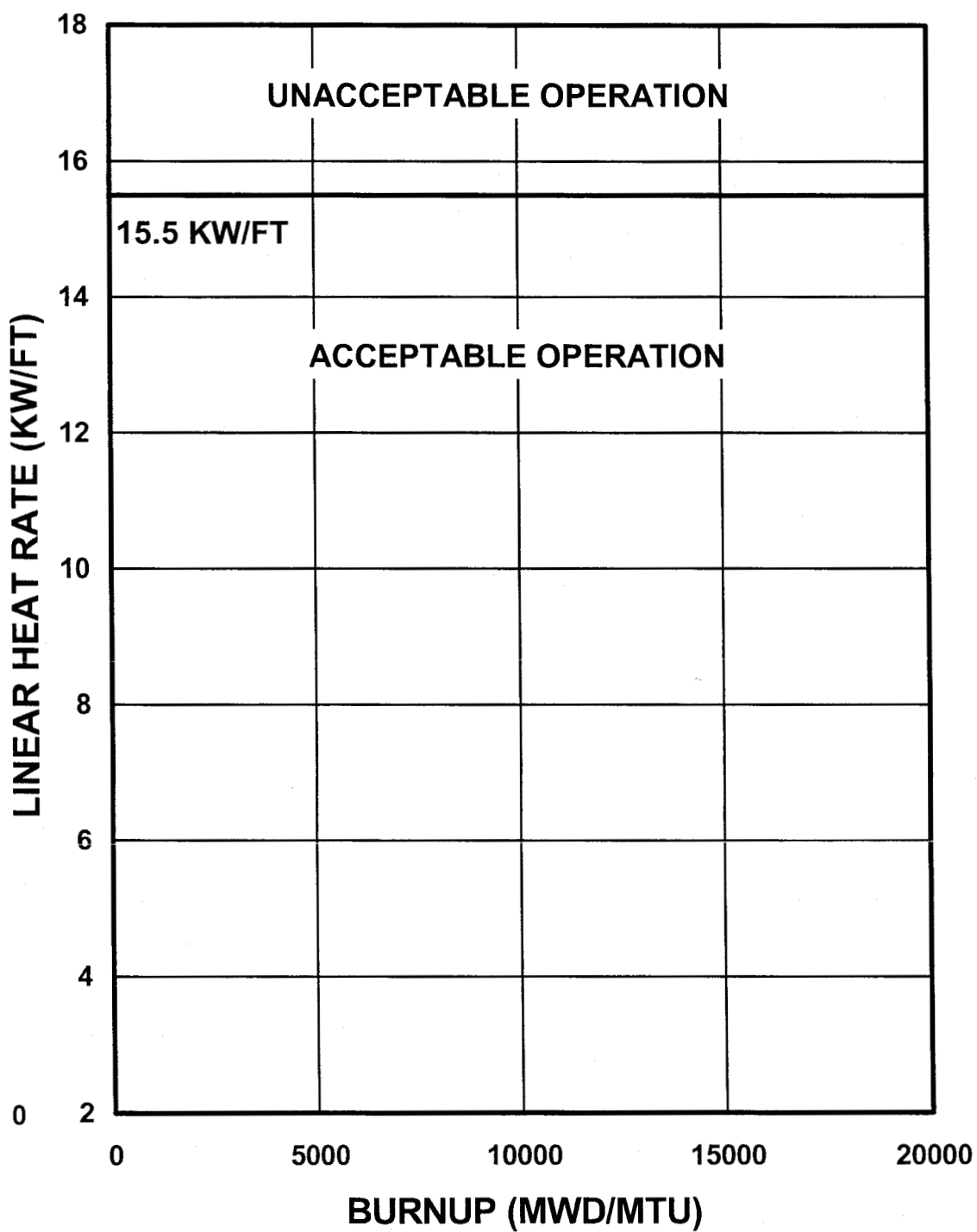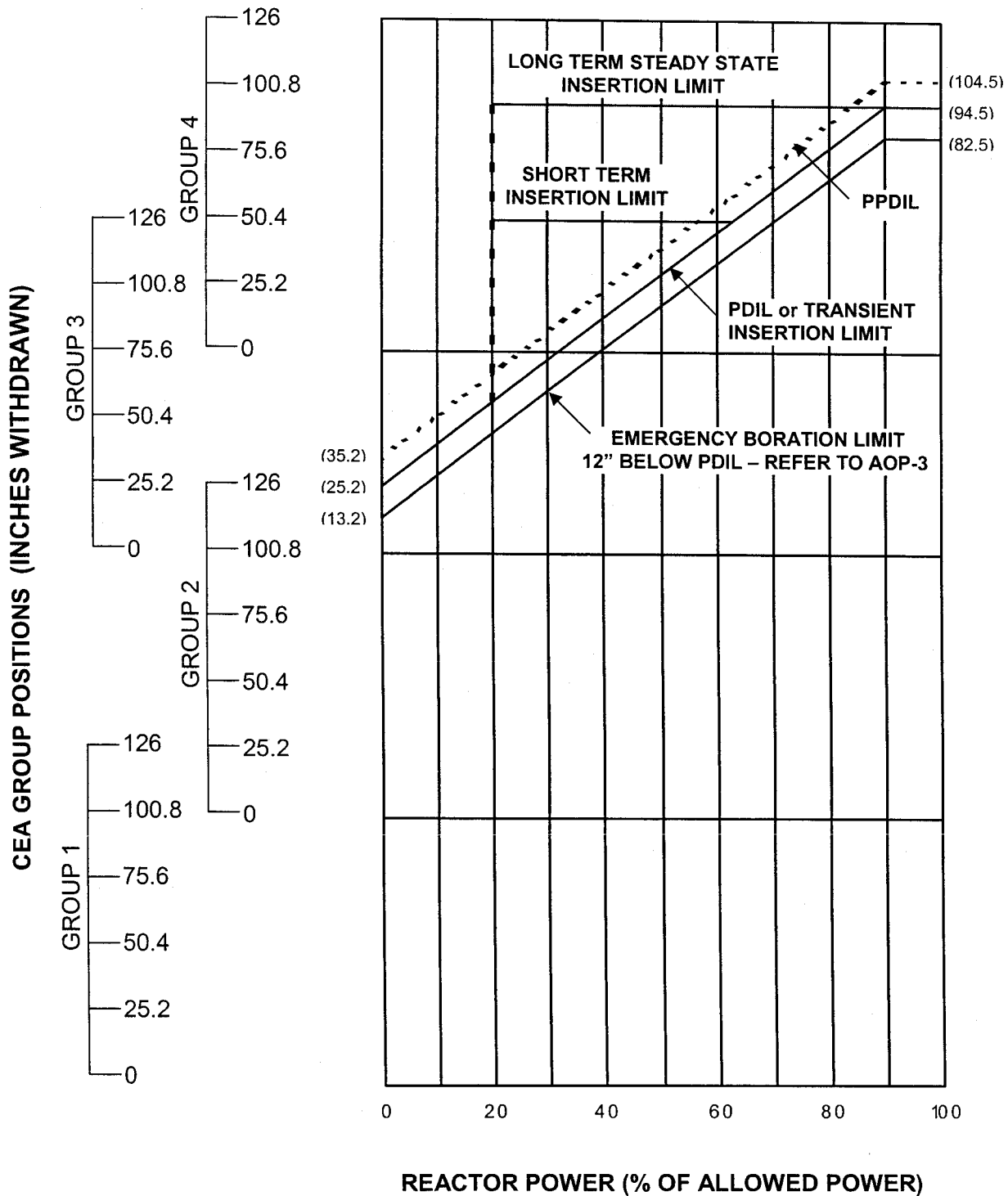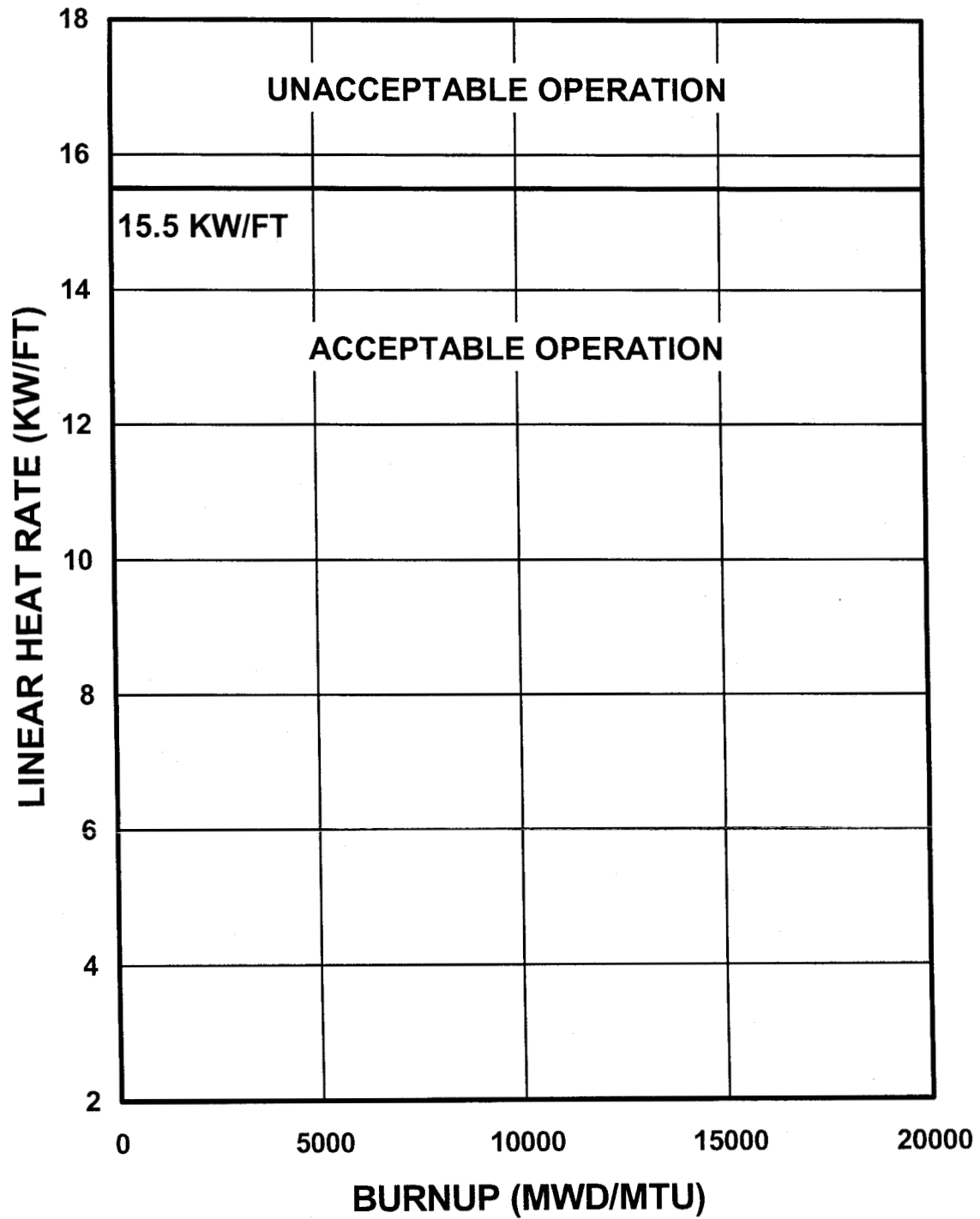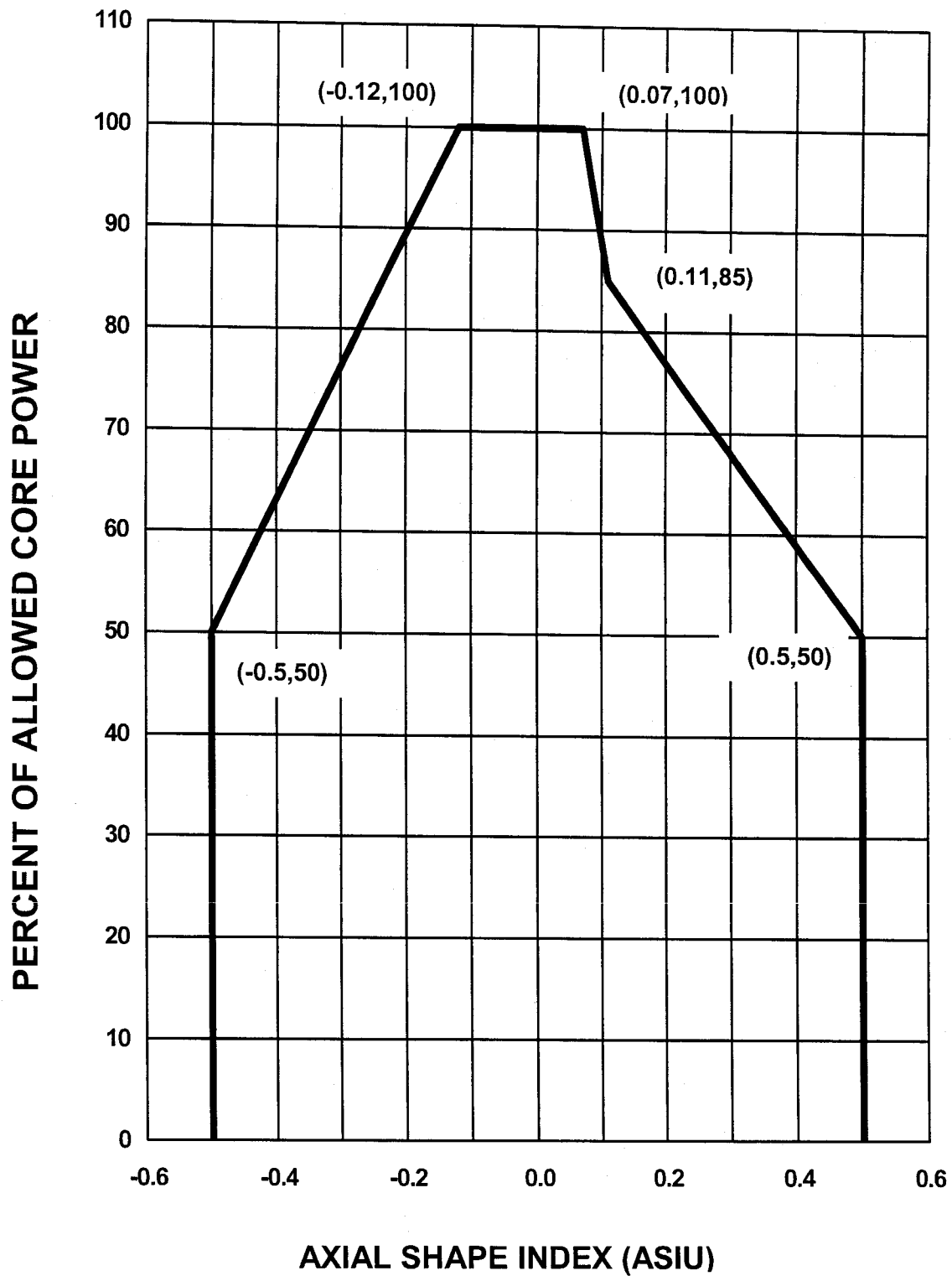
| CYCLE 23 COLR | EXCORE MONITORING OF LHR | FIGURE 4 |

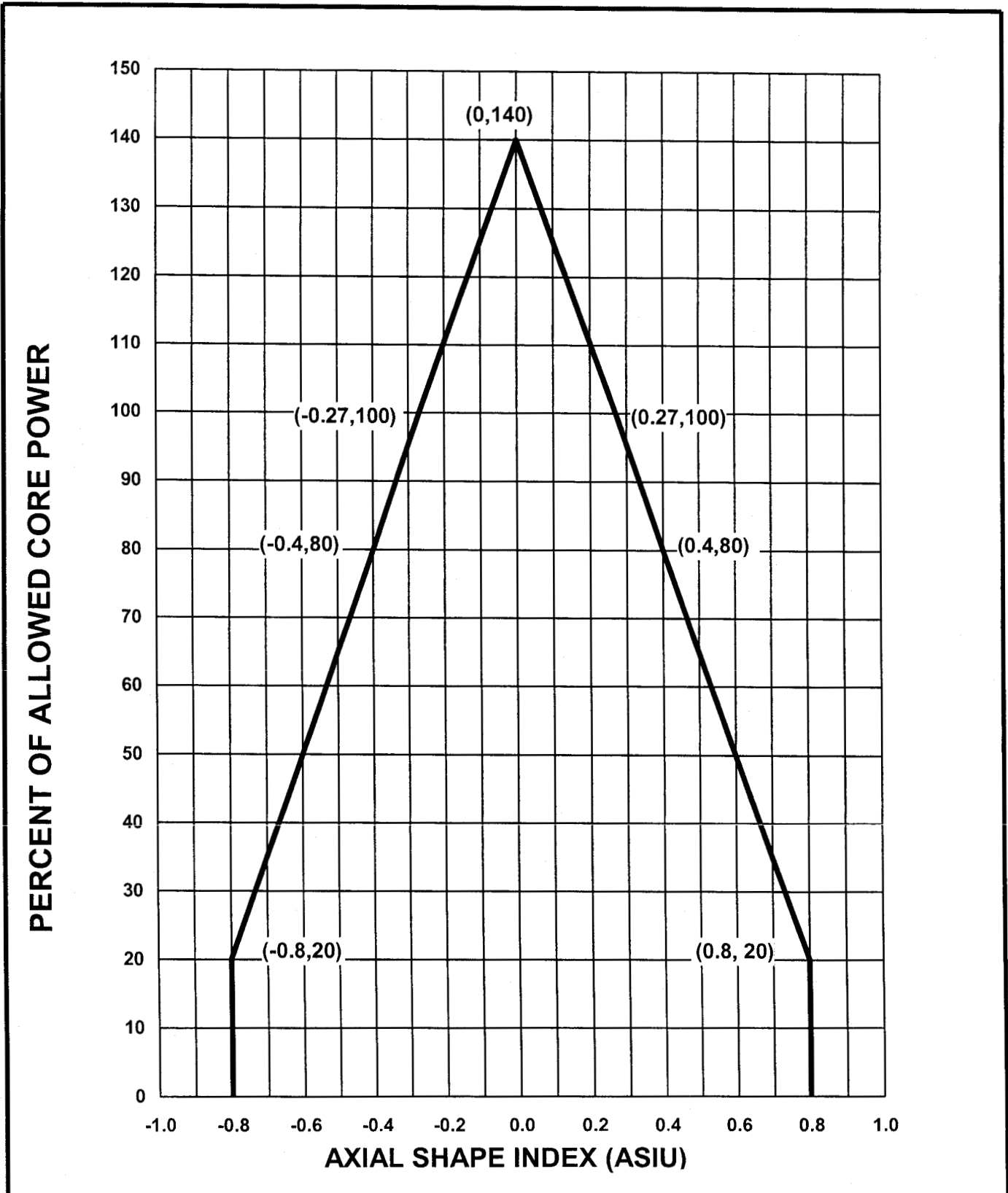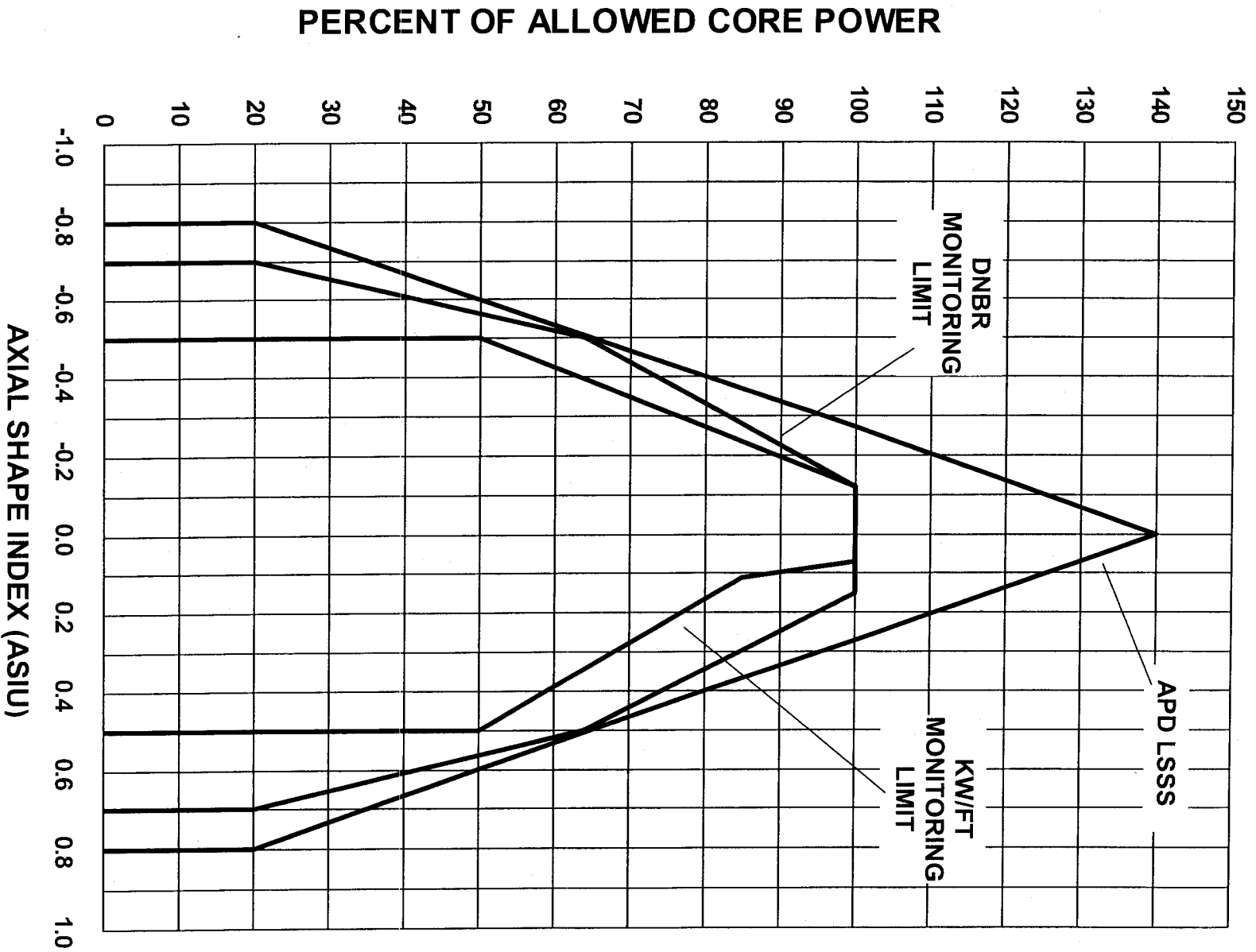| CYCLE 23 COLR	DNB MONITORING	FIGURE 5
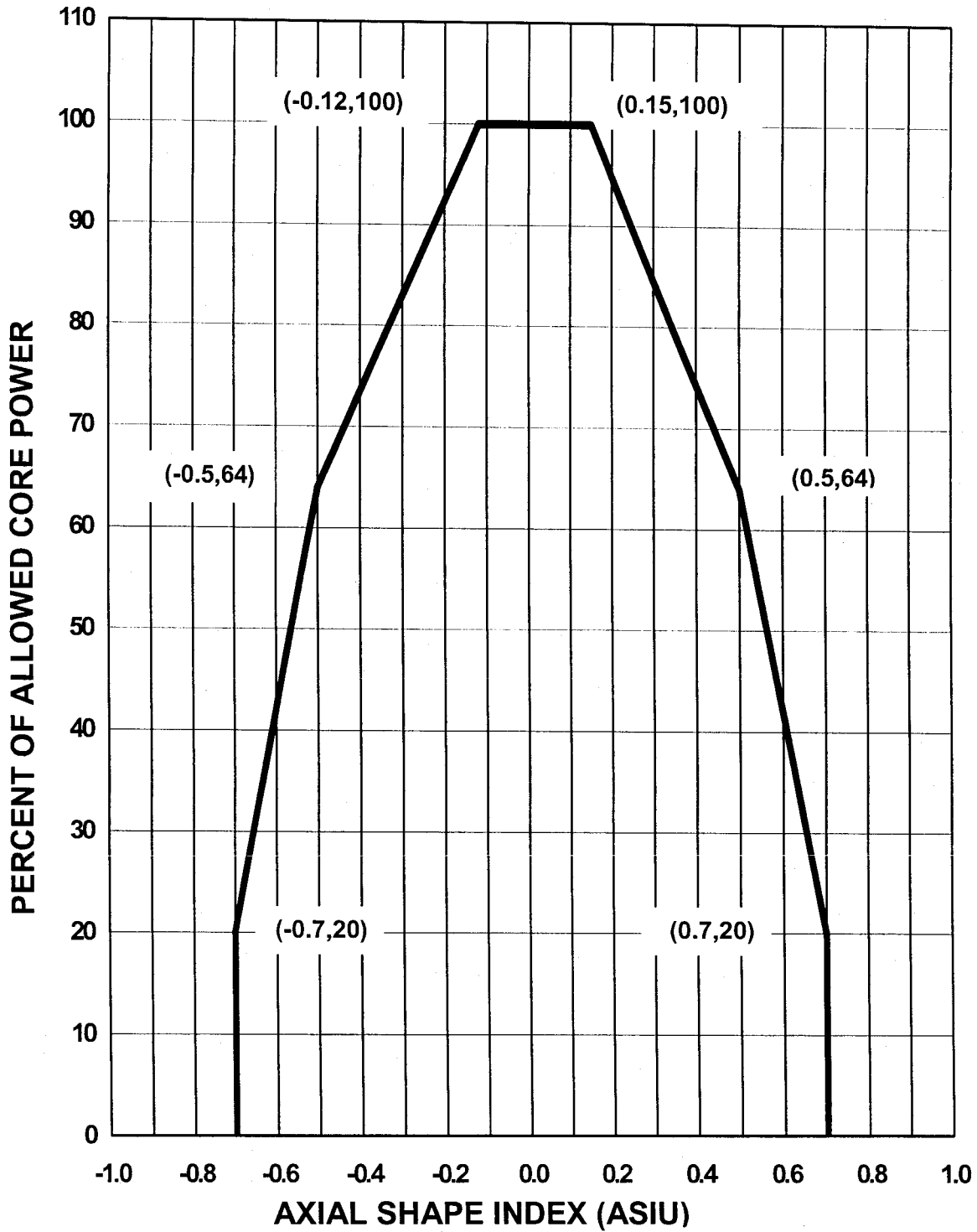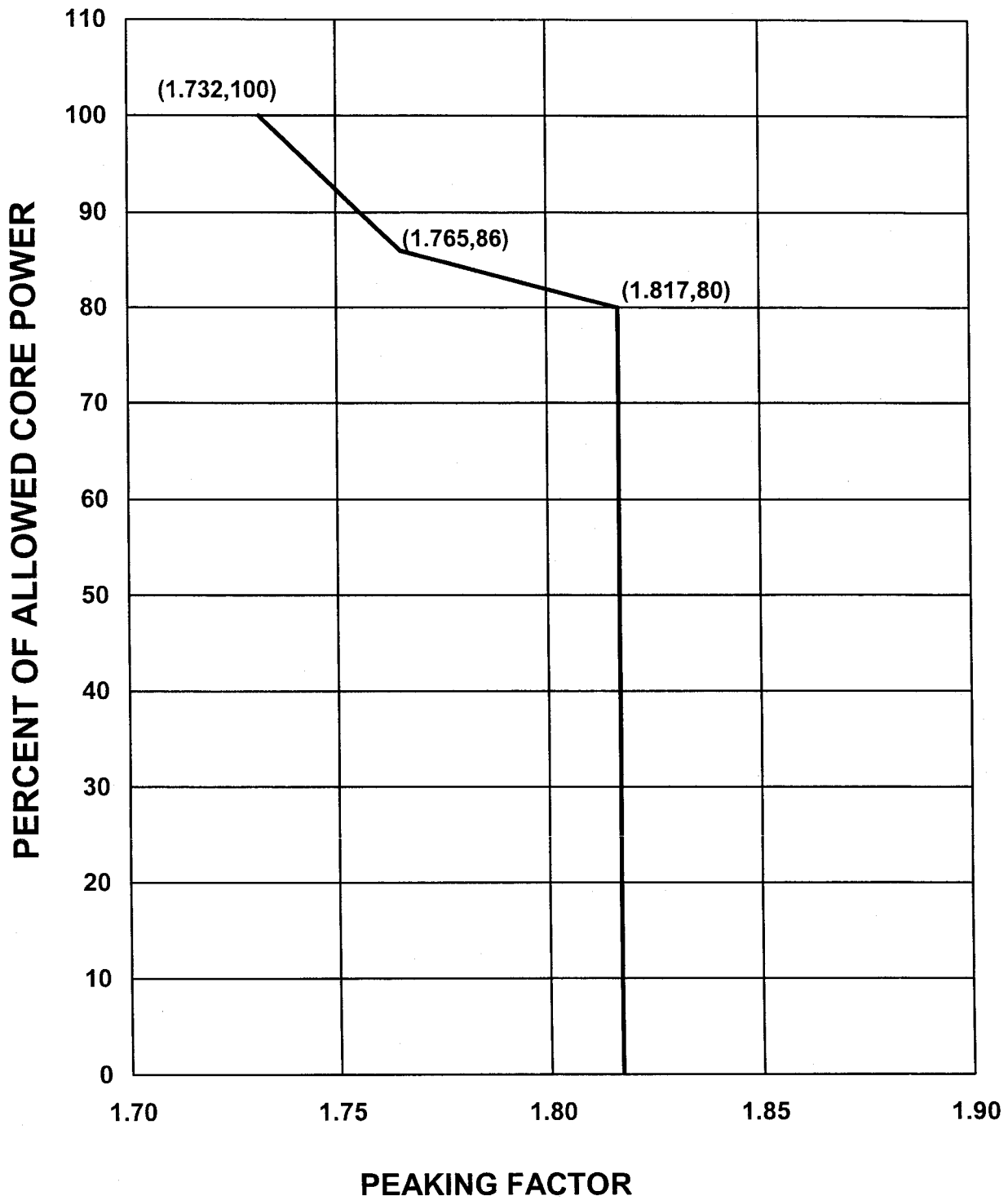
| CYCLE 23 COLR | F_R^T AND CORE POWER LIMITATIONS | FIGURE 6 |

| CYCLE 23 COLR | AXIAL POWER DISTRIBUTION LSSS FOR 4 PUMP OPERATION | FIGURE 7 |

PERCENT OF ALLOWED CORE POWER

DNBR MONITORING LIMIT

APD LSSS

KW/FT MONITORING LIMIT

AXIAL SHAPE INDEX (ASIU)

| CYCLE 23 COLR | AXIAL POWER DISTRIBUTION LIMITS FOR 4 PUMP OPERATION WITH INCORES INOPERABLE | FIGURE 8 |

CYCLE 23 COLR	MINIMUM BAST LEVEL vs. STORED BAST CONCENTRATION	FIGURE 9

Fort Calhoun Station
Unit 1

TDB-VI

TECHNICAL DATA BOOK

CORE OPERATING LIMIT REPORT

Change No.	EC 36138
Reason for Change	Updated and deleted references.
Requestor	Matthew Rybenski
Preparer	Daniel A Hochstein
Editorial Correction	N/A
Issue Date	03-24-05 3:00pm

R30

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Core Operating Limit Report

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5.   **POWER DEPENDENT INSERTION LIMIT**

The power dependent insertion limit is defined in Figure 2.

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The allowable peak linear heat rate is shown in Figure 3.

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Cycle Average Burnup (MWD/MTU)	Refueling Boron Concentration (ppm)
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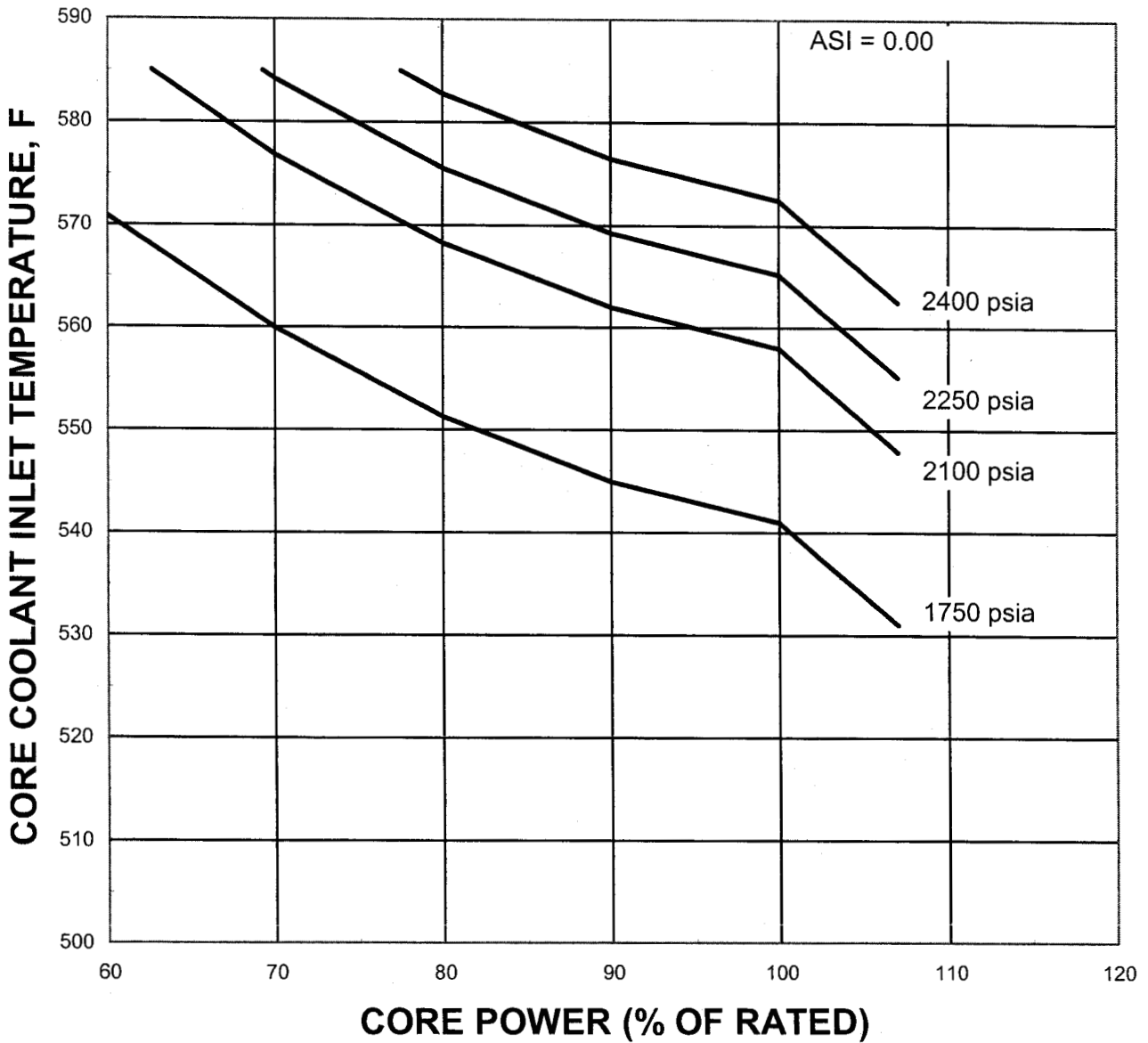## 12.   AXIAL POWER DISTRIBUTION

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14.   MOST NEGATIVE MODERATOR TEMPERATURE COEFFICIENT

The moderator temperature coefficient (MTC) shall be more positive than **-3.30 x 10^{-4} $\Delta\rho/°F$**, including uncertainties, at rated power.

Graph:
- Y-axis: CORE COOLANT INLET TEMPERATURE, F (500 to 590)
- X-axis: CORE POWER (% OF RATED) (60 to 120)
- ASI = 0.00
- Curves labeled: 2400 psia, 2250 psia, 2100 psia, 1750 psia

$$P_{VAR} = 29.6 \, PF(B)A1(Y)B + 20.63 T_{IN} - 12372$$

PF(B)	= 1.0	$B \geq 100\%$	A1(Y) = -0.6666Y_1 + 1.000	$Y_1 \leq 0.00$
	= -.008B+1.8	$50\% < B < 100\%$	= +0.3333Y_1 + 1.000	$Y_1 > 0.00$
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CYCLE 23 COLR	THERMAL MARGIN / LOW PRESSURE FOR 4 PUMP OPERATION	FIGURE 1

| CYCLE 23 COLR | POWER DEPENDENT INSERTION LIMIT | FIGURE 2 |

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Figure showing LINEAR HEAT RATE (KW/FT) vs BURNUP (MWD/MTU) with UNACCEPTABLE OPERATION above 15.5 KW/FT and ACCEPTABLE OPERATION below.

| CYCLE 23 COLR	ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP	FIGURE 3

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| CYCLE 23 COLR | EXCORE MONITORING OF LHR | FIGURE 4 |

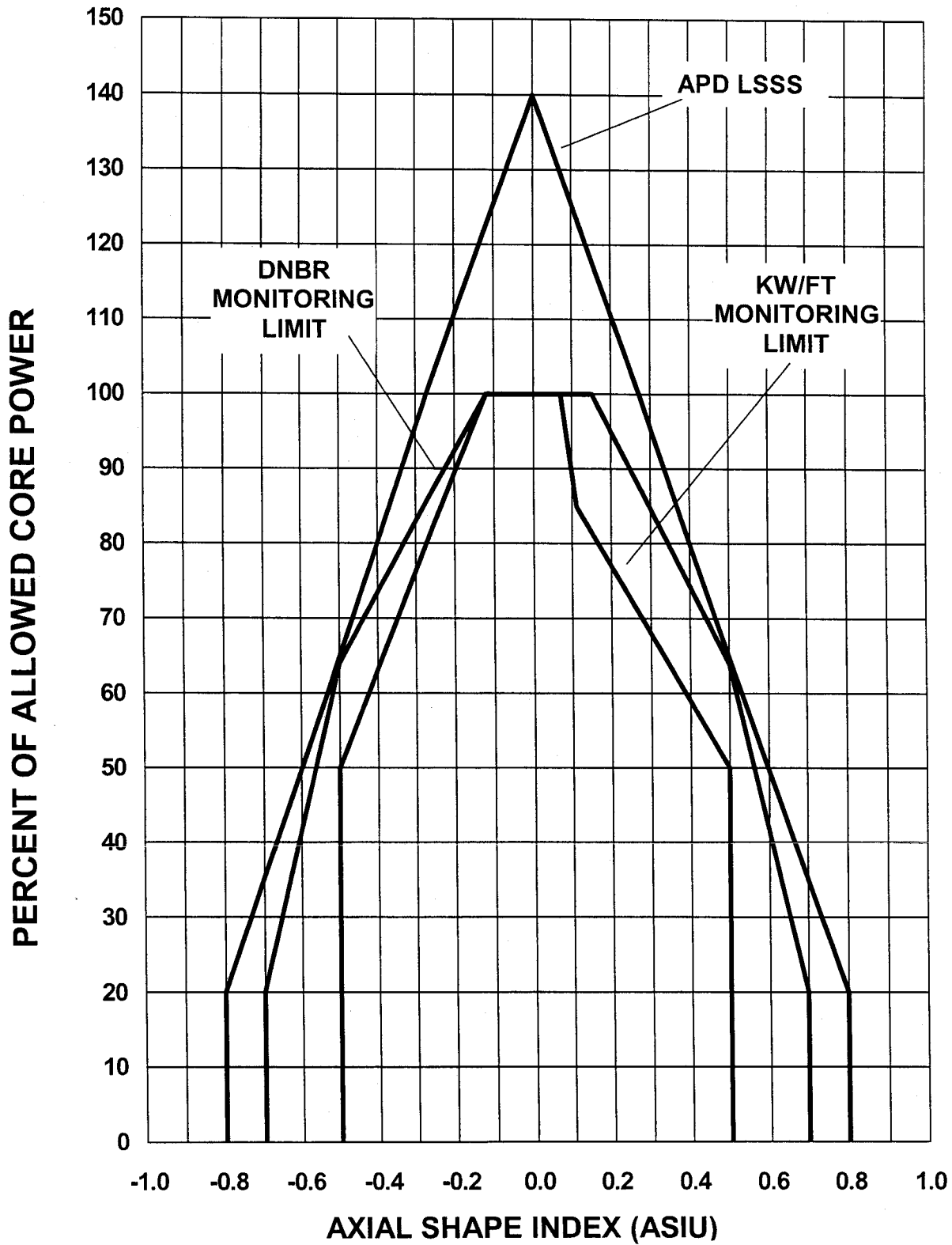| CYCLE 23 COLR | DNB MONITORING | FIGURE 5 |

CYCLE 23 COLR	F_R^T AND CORE POWER LIMITATIONS	FIGURE 6

PERCENT OF ALLOWED CORE POWER vs **AXIAL SHAPE INDEX (ASIU)**

Labeled points: (0,140), (-0.27,100), (0.27,100), (-0.4,80), (0.4,80), (-0.8,20), (0.8, 20)

CYCLE 23 COLR	AXIAL POWER DISTRIBUTION LSSS FOR 4 PUMP OPERATION	FIGURE 7

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CYCLE 23 COLR	AXIAL POWER DISTRIBUTION LIMITS FOR 4 PUMP OPERATION WITH INCORES INOPERABLE	FIGURE 8

MINIMUM BAST LEVEL (PERCENT INDICATOR) vs. **STORED BAST CONCENTRATION (WT % BORIC ACID)**

Legend:
- ▲ 1800 PPM IN SIRWT
- ✕ 1900 PPM IN SIRWT
- ● 2000 PPM IN SIRWT
- ■ 2150 PPM IN SIRWT
- + 2300 PPM IN SIRWT

CYCLE 23 COLR	MINIMUM BAST LEVEL vs. STORED BAST CONCENTRATION	FIGURE 9

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