Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

October 3, 2003
LIC-03-0140

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

Reference: Docket No. 50-285

SUBJECT: Transmittal of Fort Calhoun Station (FCS) Core Operating Limit Report (COLR) Revision 28

Pursuant to FCS Unit No. 1 Technical Specification 5.9.5.c, Omaha Public Power District is transmitting Revision 28 (dated September 29, 2003) of the FCS COLR. The COLR was revised to incorporate the Cycle 22 specific update.

If you have any questions, please contact Dr. Richard Jaworski at (402) 533-6833.

Sincerely,

R. T. Ridenoure
Division Manager
Nuclear Operations

RTR/mle

Attachment: TDB-VI – Technical Data Book – Core Operating Limit Report – Revision 28

c: B. S. Mallett, NRC Regional Administrator, Region IV
A. B. Wang, NRC Project Manager
J. G. Kramer, NRC Senior Resident Inspector

A001

Fort Calhoun Station
Unit No. 1

TDB-VI

TECHNICAL DATA BOOK

Title: CORE OPERATING LIMIT REPORT

FC-68 Number: EC 33044

Reason for Change: Update for Cycle 22.

Requestor: Matthew Rybenski

Preparer: Matthew Rybenski

Fort Calhoun Station, Unit 1

Core Operating Limit Report

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

1.0 Introduction

This report provides the cycle-specific limits for operation of the Fort Calhoun Station Unit 1 for Cycle 22 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
- F_R^T 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.

2.0 Core Operating Limits

All values and limits in this TDB section apply to Cycle 22 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:

- OPPD-NA-8301, "Reload Core Analysis Methodology Overview," Rev. 6, dated December 1994. (TAC No. M89455)
- OPPD-NA-8302, "Reload Core Analysis Methodology, Neutronics Design Methods and Verification," Rev. 4, dated December 1994. (TAC No. M89456)
- OPPD-NA-8303, "Reload Core Analysis Methodology, Transient and Accident Methods and Verification," Rev. 4, dated January 1993. (TAC No. M85845)

- XN-75-32(P)(A) Supplements 1, 2, 3, & 4, "Computational Procedure for Evaluating Fuel Rod Bowing," October 1983.
- XN-NF-82-06(P)(A) and Supplements 2, 4, and 5, "Qualification of Exxon Nuclear Fuel for Extended Burnup," Revision 1, October 1986.
- XN-NF-85-92(P)(A), "Exxon Nuclear Uranium Dioxide/Gadolinia Irradiation Examination and Thermal Conductivity Results," August 1985.
- ANF-88-133(P)(A) and Supplement 1, "Qualification of Advanced Nuclear Fuels PWR Design Methodology for Rod Burnups of 62 GWd/MTU," December 1991.
- EMF-92-116(P)(A), "Generic Mechanical Design Criteria for PWR Fuel Designs," Revision 0, February 1999.
- XN-NF-78-44(P)(A), "A Generic Analysis of the Control Rod Ejection Transient for Pressurized Water Reactors," October 1983.
- XN-NF-82-21(P)(A), "Application of Exxon Nuclear Company PWR Thermal Margin Methodology to Mixed Core Configurations," Revision 1, September 1983.
- 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 0, May 2001.

3.0 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

4.0 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.

5.0 Power Dependent Insertion Limit

The power dependent insertion limit is defined in Figure 2.

6.0 Linear Heat Rate

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

7.0 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.

8.0 Peaking Factor Limits

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

9.0 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.

10.0 F_R^T and Core Power Limitations

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

11.0 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 21 operation and is valid until the beginning of core reload for Cycle 22.

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	2,075
≥ 2,000	1,931
≥ 4,000	1,900

12.0 Axial Power Distribution

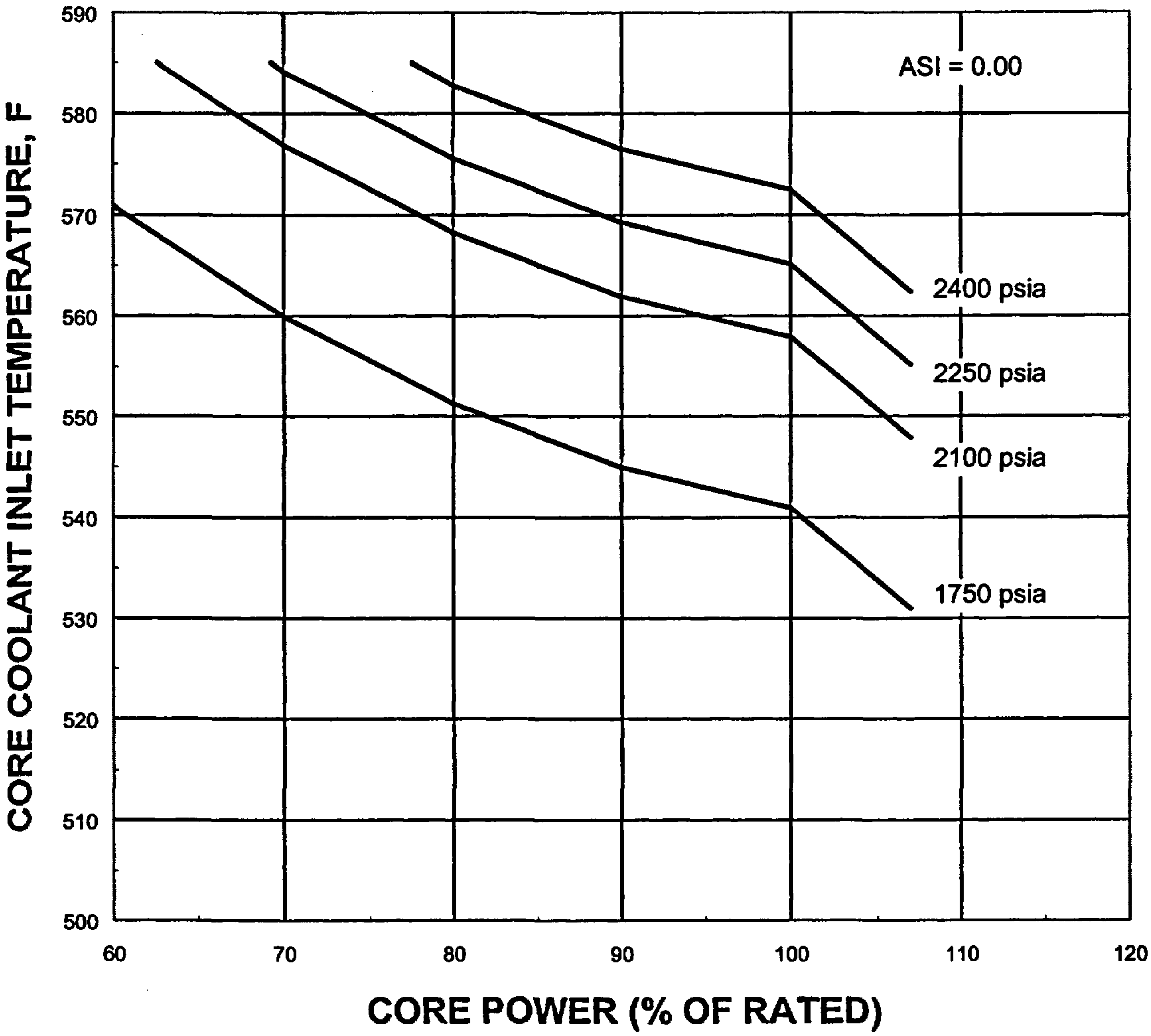
The axial power trip is provided to ensure that excessive axial peaking will not cause fuel damage. The Axial Shape Index is determined from the axially split excore detectors. The setpoint functions, shown in Figure 7 ensure that neither a DNBR of less than the minimum DNBR safety limit nor a maximum 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.

13.0 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 **≥3.6% Δk/k**. With the shutdown margin <3.6% Δk/k, initiate and continue boration until the required shutdown margin is achieved.

14.0 Most Negative Moderator Temperature Coefficient

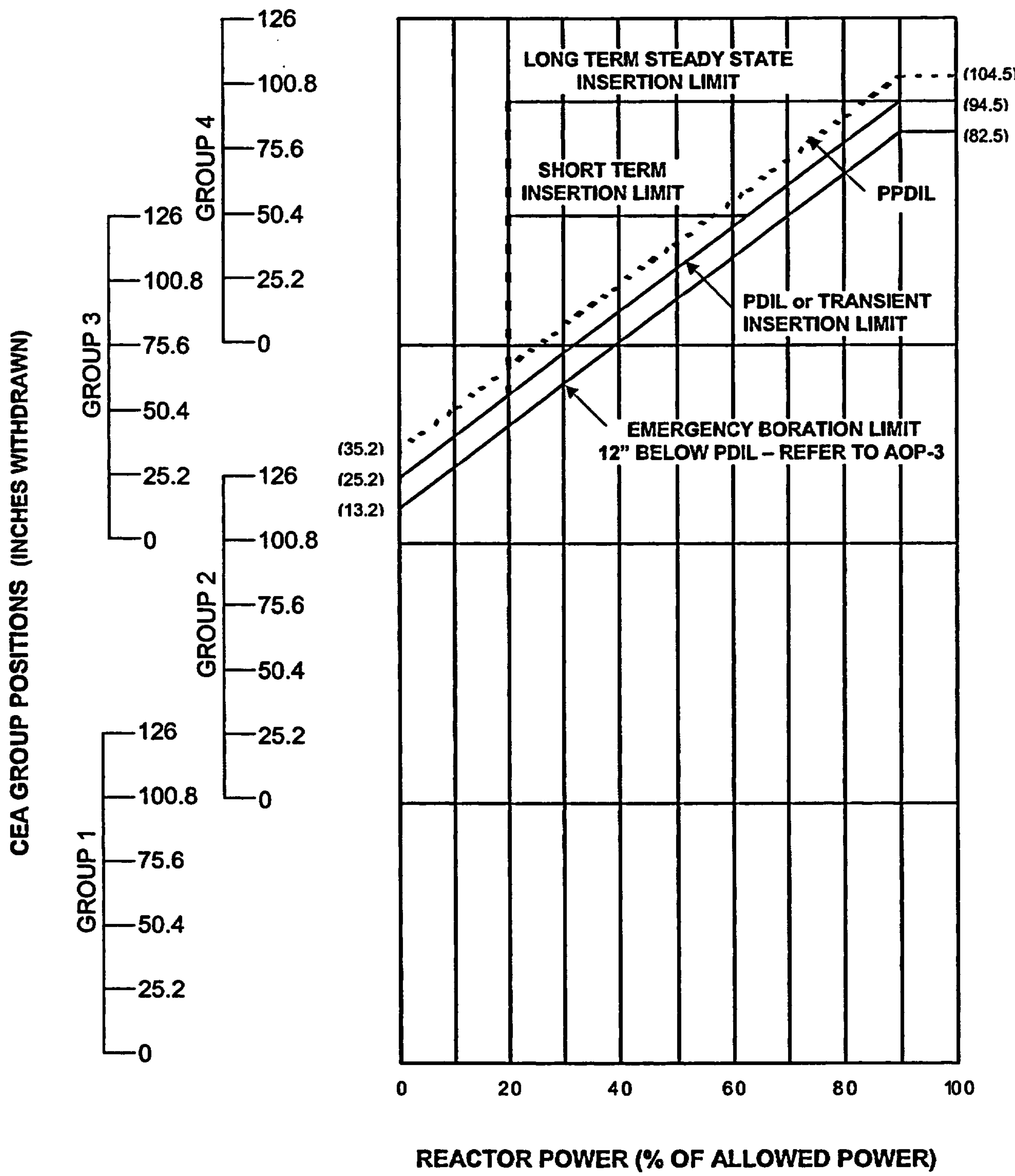
The moderator temperature coefficient (MTC) shall be more positive than **-3.05×10^{-4} Δρ/°F**, including uncertainties, at rated power.



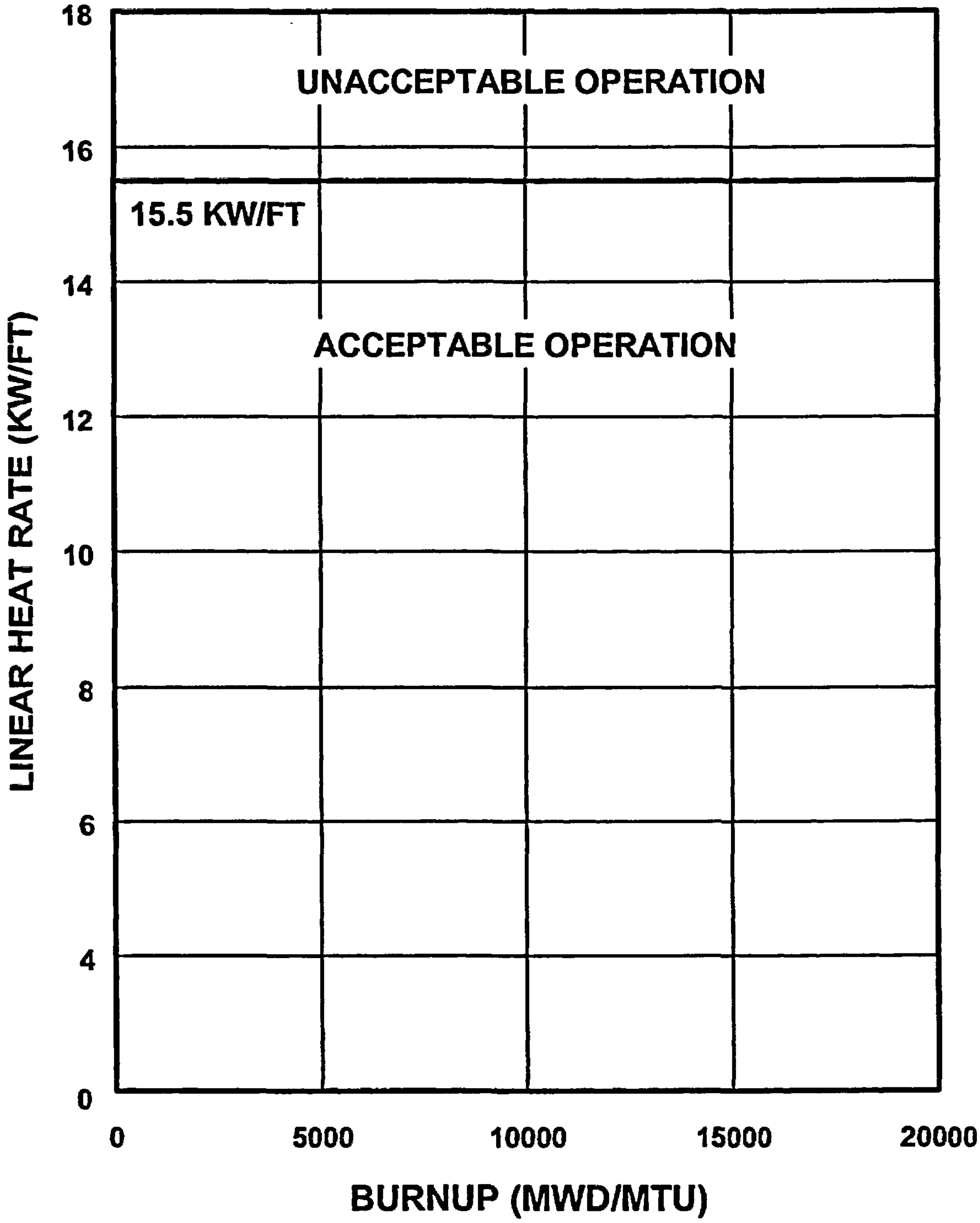
$$P_{VAR} = 29.6\ PF(B)A1(Y)B + 20.63T_{IN} - 12372$$

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

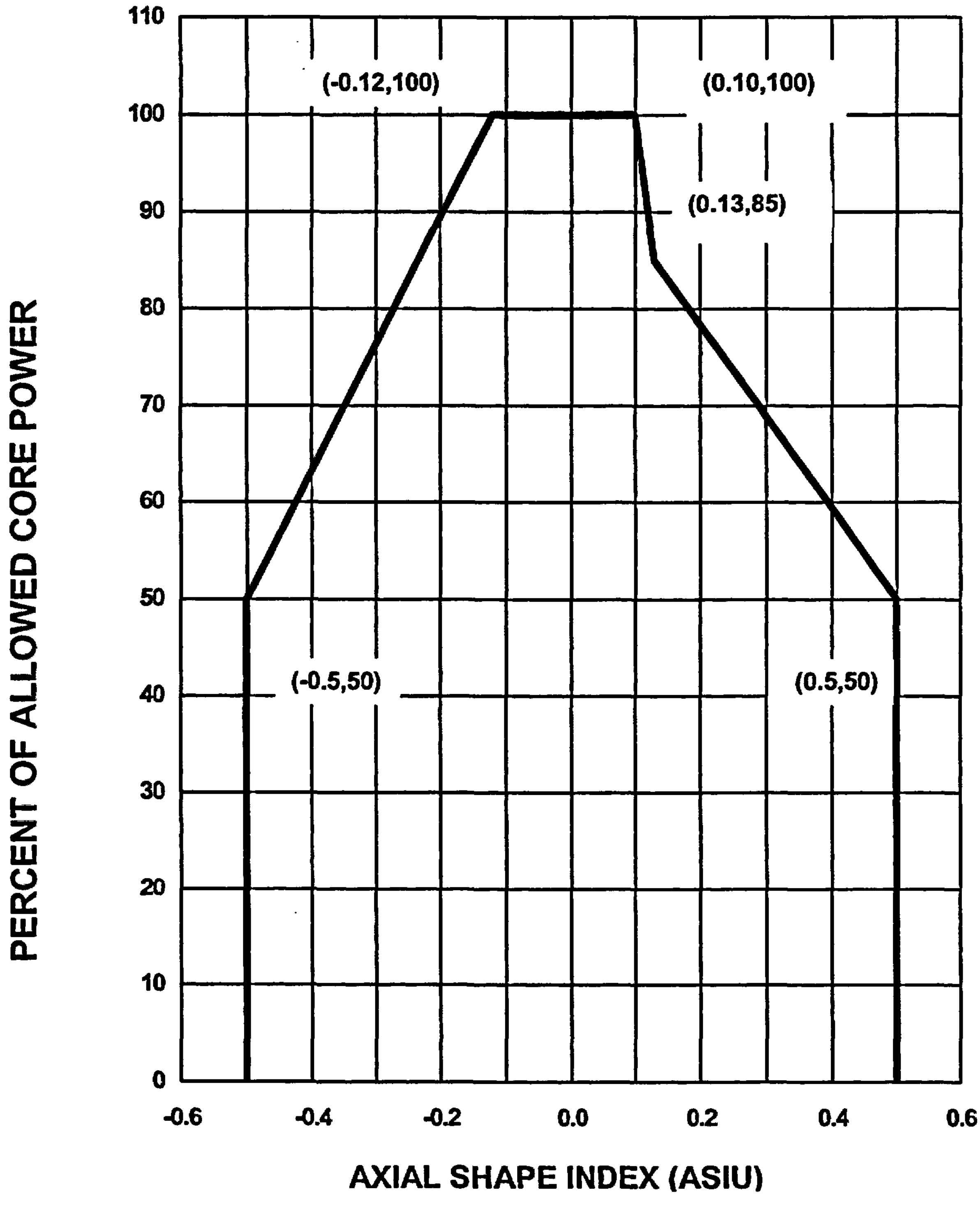
CYCLE 22 COLR	THERMAL MARGIN / LOW PRESSURE FOR 4 PUMP OPERATION	FIGURE 1



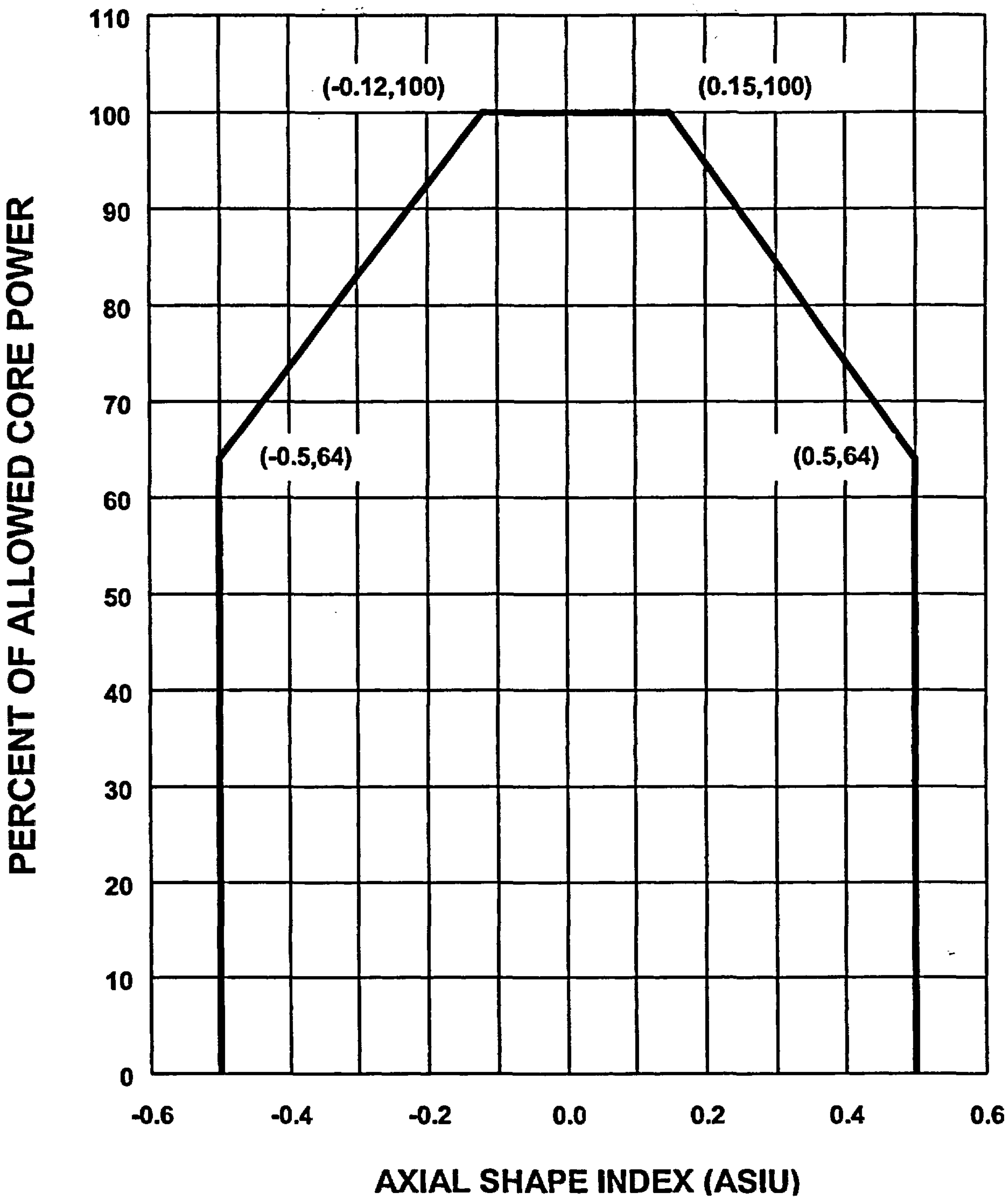
CYCLE 22 COLR	POWER DEPENDENT INSERTION LIMIT	FIGURE 2



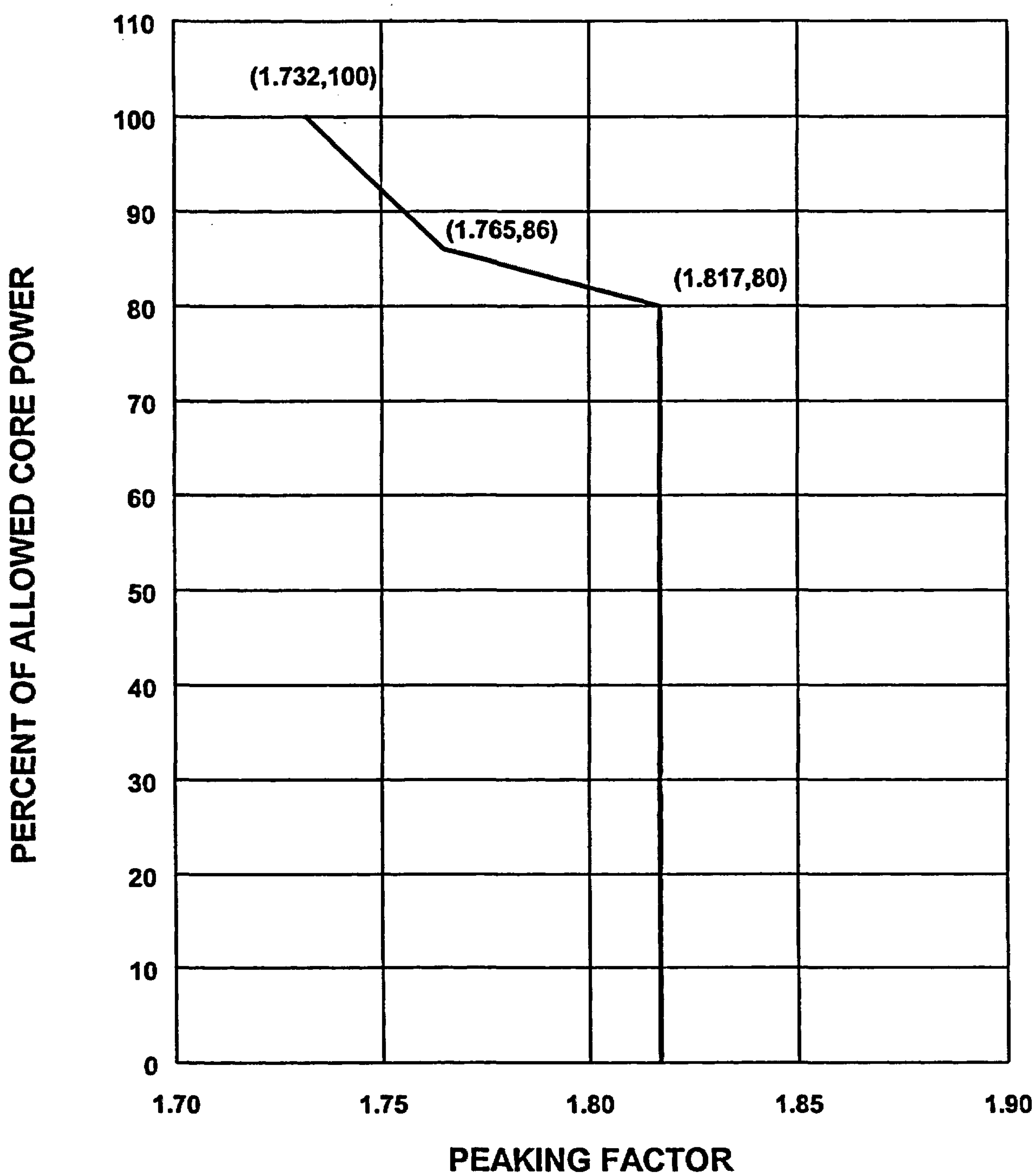
CYCLE 22 COLR	ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP	FIGURE 3



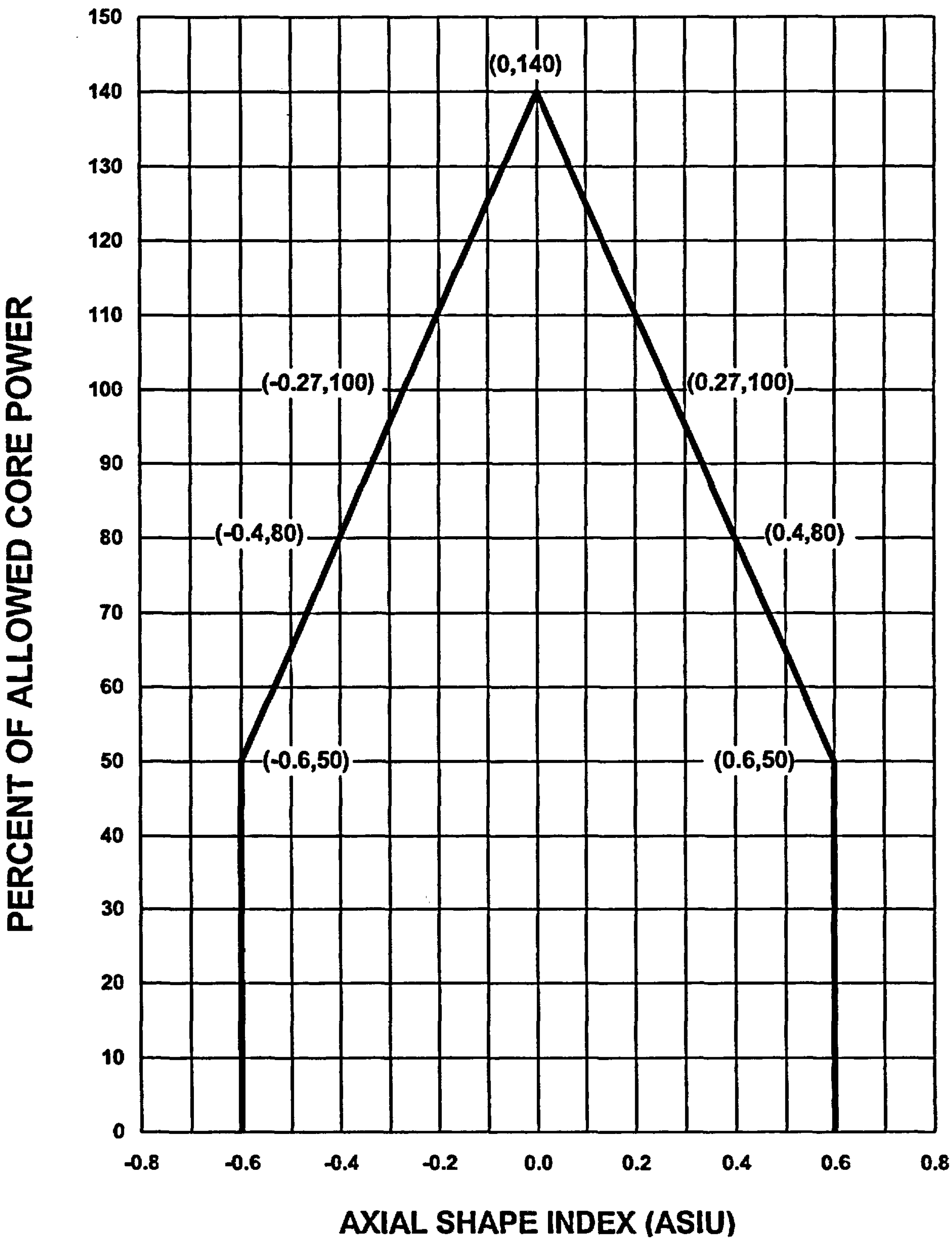
CYCLE 22 COLR	EXCORE MONITORING OF LHR	FIGURE 4



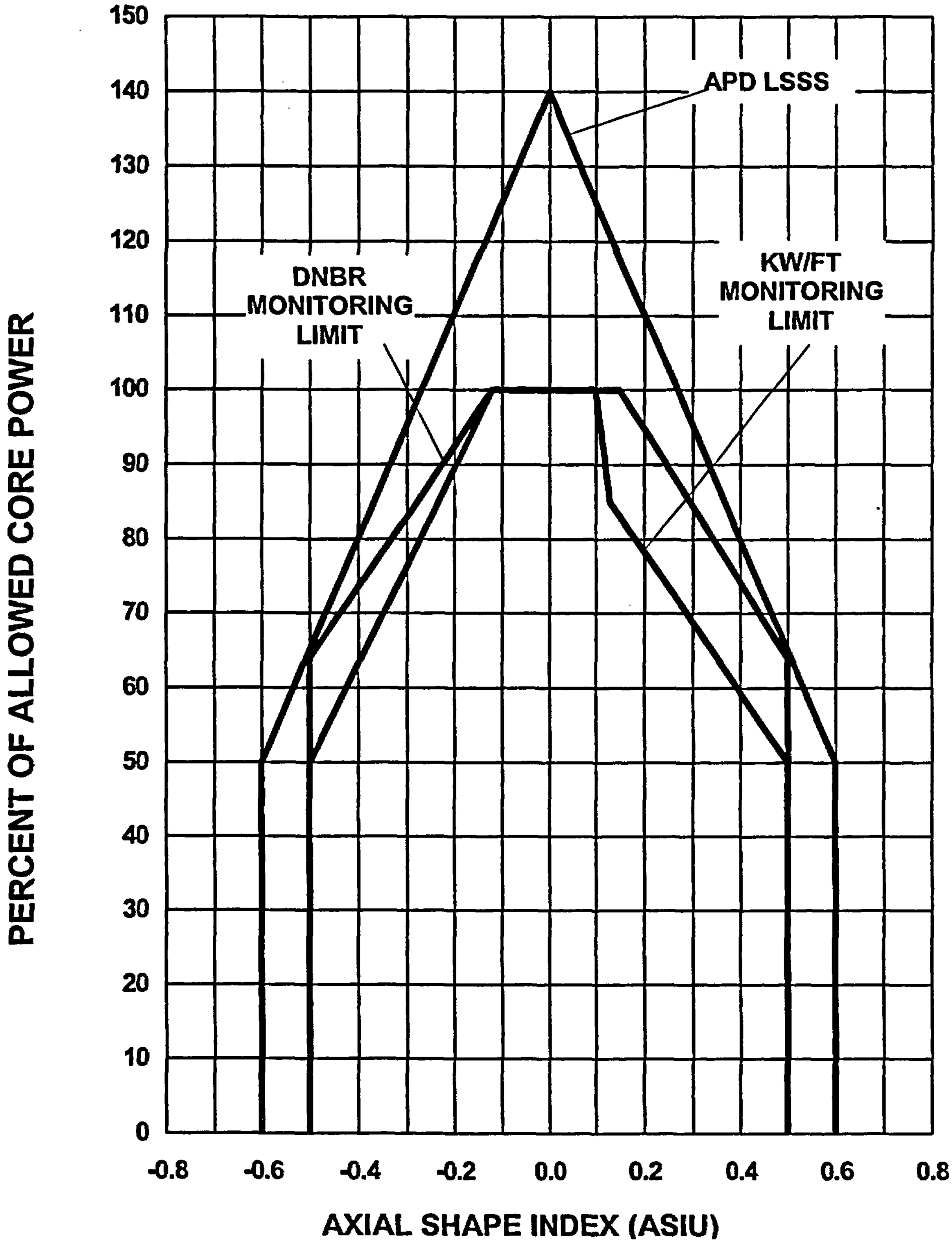
CYCLE 22 COLR	DNB MONITORING	FIGURE 5



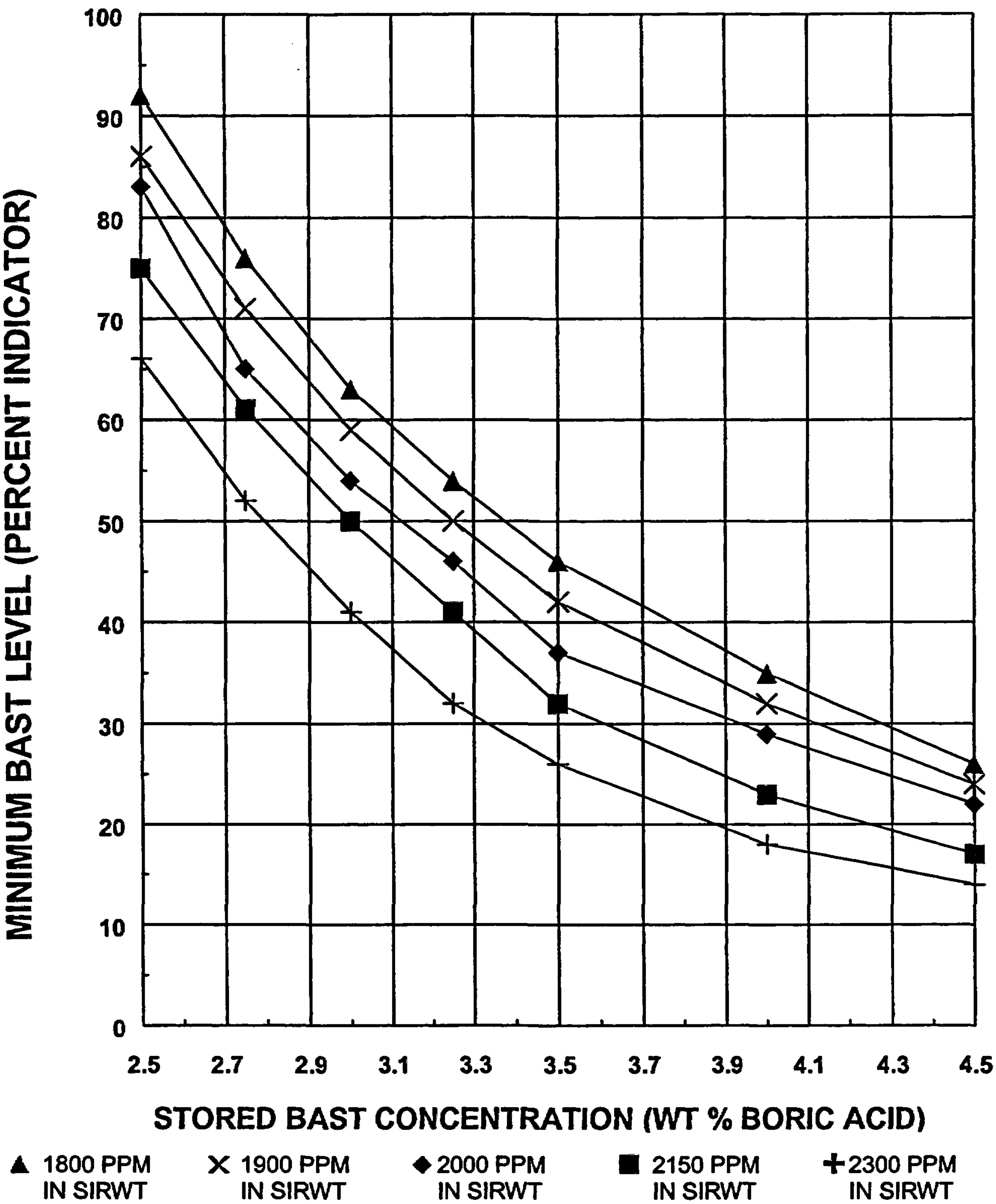
CYCLE 22 COLR	F_R^T AND CORE POWER LIMITATIONS	FIGURE 6



CYCLE 22 COLR	AXIAL POWER DISTRIBUTION LSSS FOR 4 PUMP OPERATION	FIGURE 7



CYCLE 22 COLR	AXIAL POWER DISTRIBUTION LIMITS FOR 4 PUMP OPERATION WITH INCORES INOPERABLE	FIGURE 8



CYCLE 22 COLR	MINIMUM BAST LEVEL vs. STORED BAST CONCENTRATION	FIGURE 9