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Item	Facility	Type	Sub	Document Number	Sheet	Doc Status	Revision	Doc Date	Copy #	Media	Cpys
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Document	Document Title	Revision/Date
TDB-IV.10.a	Acid Reducing Conditions (Ammonia 0.4 ppm or less)	R0 04-04-06
TDB-IV.10.b	Acid Reducing Condition (Ammonia greater than 0.4 ppm)	R0 04-04-06
TDB-IV.11	Operable Real Time Radiation Monitor	R0 07-23-09
TDB-V – Work Sheets and Calculation Procedures		
TDB-V.1.B	Estimated Critical Conditions Worksheet	R22 05-18-08
TDB-V.3	Manual Group Mode Guide Table	R4 05-27-05
TDB-V.6	Indication of Reactor Power Based on ΔT	R7 07-05-05
TDB-V.9	Shutdown Margin Worksheet	R39 05-18-08
TDB-V.11	Instrument Bus Loads and Failure Modes	R42 06-03-08
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Fort Calhoun Station
Unit 1

TDB-VI

TECHNICAL DATA BOOK

CORE OPERATING LIMIT REPORT

Change No.	EC 44759
Reason for Change	Updated for Cycle 26 operation.
Requestor	D. Williamson
Preparer	L. Hautzinger
Issue Date	11-20-09 3:00 pm

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. INTRODUCTION

This report provides the cycle-specific limits for operation of the Fort Calhoun Station Unit 1 for Cycle 26 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. CORE OPERATING LIMITS

All values and limits in this TDB section apply to Cycle 26 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 list of references below are complete citations of topical reports and include the report number, title, revision, date, and any supplements in accordance with the basis for NRC approval of License Amendment No. 196 which eliminated these specific entries from Technical Specification 5.9.5. NRC approval of Amendment No. 196 is consistent with the requirements of the Technical Specification Task Force, Improved Standard Technical Specification Change Traveler, "Revise Topical Report References in ITS 5.6.5 COLR" (TSTF-363-A, Rev. 0). In accordance with this Traveler and Amendment No. 196, this information must be maintained within this TDB section.

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," Revision 8, dated August 2004. (TAC No. MC4304)
- OPPD-NA-8302, "Reload Core Analysis Methodology, Neutronics Design Methods and Verification," Revision 6, dated August 2004. (TAC No. MC4304)
- OPPD-NA-8303, "Reload Core Analysis Methodology, Transient and Accident Methods and Verification," Revision 7, dated August 2005. (TAC No. MC4304)
- XN-75-32(P)(A) Supplements 1, 2, 3, & 4, "Computational Procedure for Evaluating Fuel Rod Bowing," October 1983.
- XN-NF-79-56(P)(A), Revision 1, Supplement 1, "Gadolinia Fuel Properties of LWR Fuel Safety Evaluation," November 1981.
- 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.
- 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), "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel," Revision 1, January 2005.
- EMF-2103(P)(A), "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," Revision 0, April 2003.
- EMF-2328(P)(A), "PWR Small Break LOCA Evaluation Model, S-RELAP5 Based," 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," January 1997.
- EMF-2310(P)(A), "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," Revision 1, May 2004.
- BAW-10240(P)(A), "Incorporation of M5™ Properties in Framatome ANP Approved Methods," Revision 0, 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:

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

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.

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 25 operation and is valid until the beginning of core reload for Cycle 26.

Listed below in Table 2 are the refueling boron concentration values for Cycle 26 operations:

Table 2 - Refueling Boron Concentrations

Cycle Average Burnup (MWD/MTU)	Refueling Boron Concentration (ppm)
BOC	2,160
≥ 2,000	2,016
≥ 4,000	1,900

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 fuel centerline temperature greater than the associated safety limit (that which would result in fuel melting) will exist as a consequence of axial power maldistributions. The calculated cycle-specific FCM temperature for Cycle 26 corresponds to 22.845 kw/ft. 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

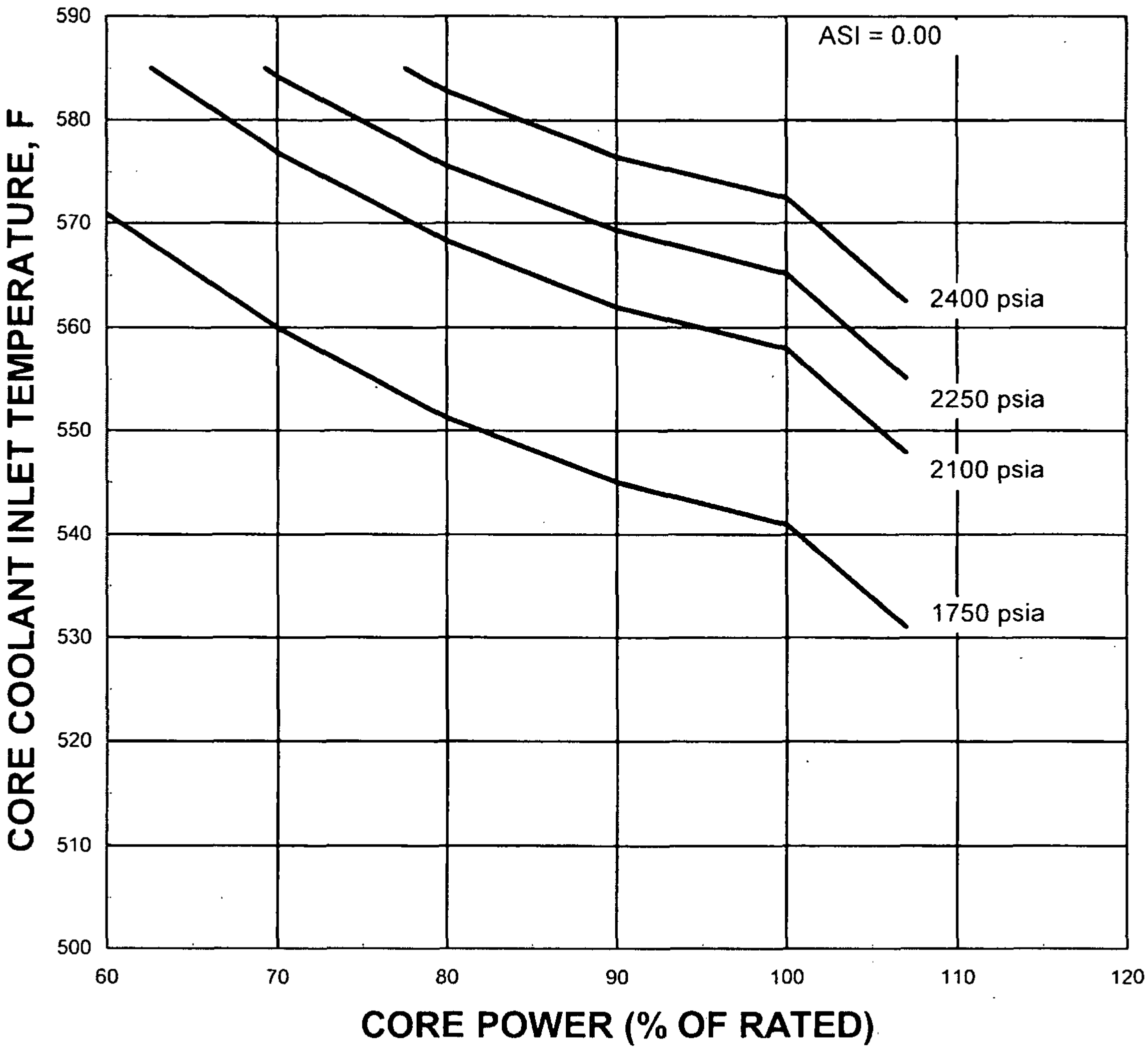
Whenever the reactor is in hot shutdown, hot standby or power operation conditions, the shutdown margin shall be **≥3.6% Δk/k**. With the shutdown margin <3.6% Δk/k, initiate and continue boration until the required shutdown margin is achieved.

14. MOST NEGATIVE MODERATOR TEMPERATURE COEFFICIENT

The moderator temperature coefficient (MTC) shall be more positive than **-3.25×10^{-4} Δρ/°F**, including uncertainties, at rated power.

15. STEAM GENERATOR DIFFERENTIAL PRESSURE

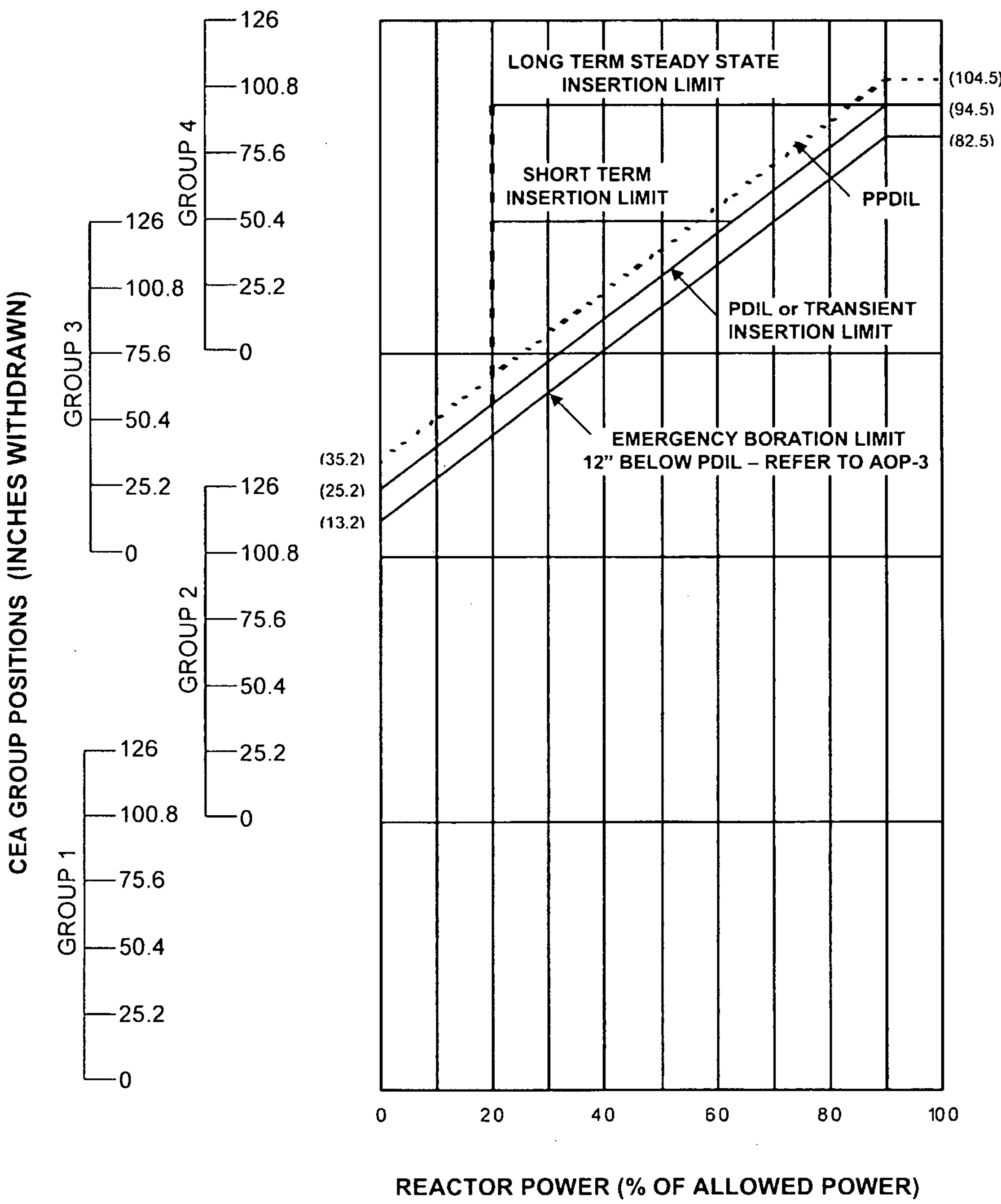
The steam generator differential pressure trip of Technical Specification Table 2-11, Item 9 at 135 psid ensures that neither a DNBR of less than the minimum DNBR safety limit nor a fuel centerline temperature greater than the associated safety limit (that which would result in fuel melting) will exist as a consequence of axial power maldistributions resulting from asymmetric steam generator transients. The calculated cycle-specific FCM temperature for Cycle 26 corresponds to 22.845 kw/ft.



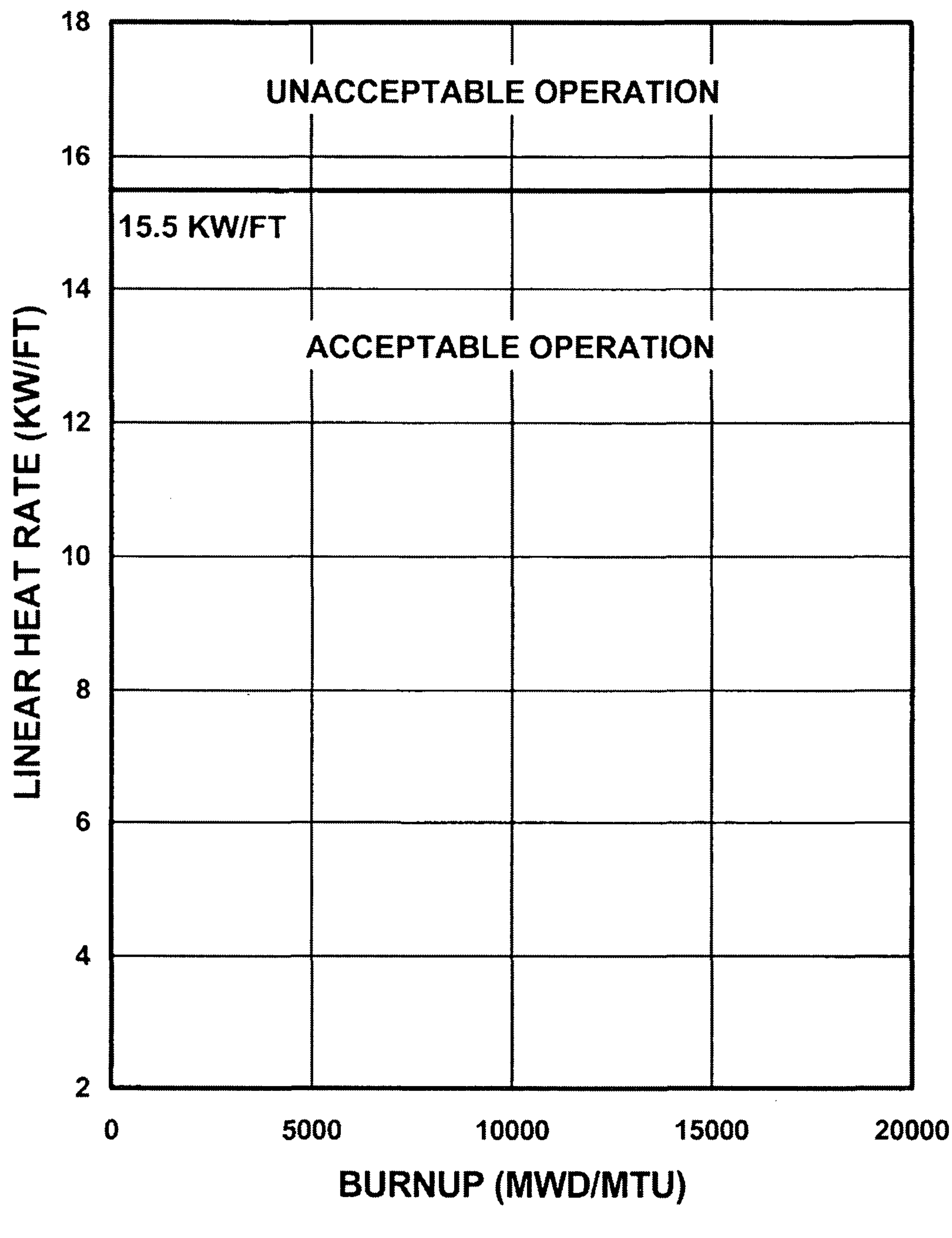
$$P_{VAR} = 29.6\ PF(B)A1(Y)B + 20.63T_{IN} - 12372$$

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	$B \leq 50\%$			

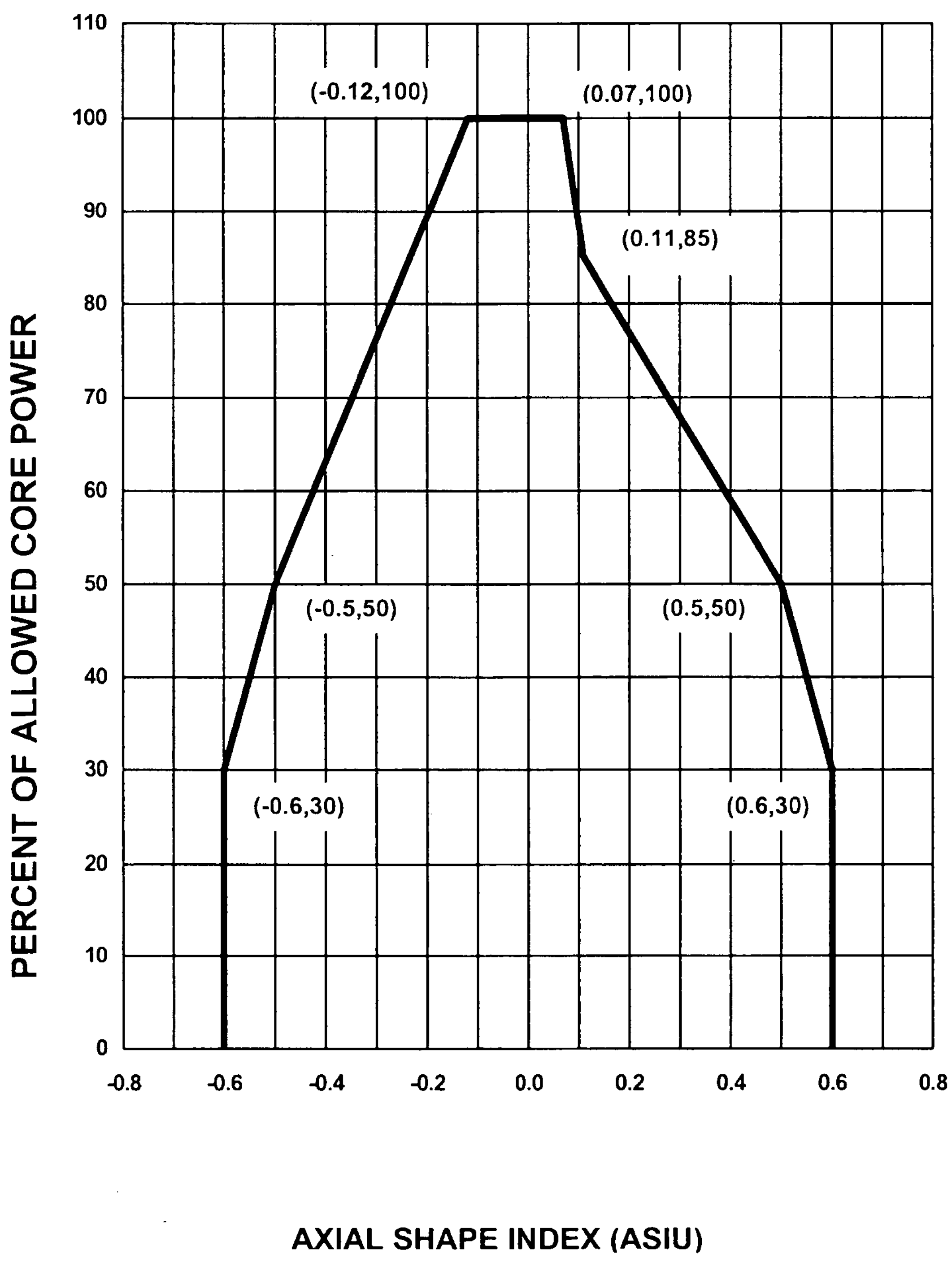
COLR	**THERMAL MARGIN / LOW PRESSURE FOR 4 PUMP OPERATION**	**FIGURE 1**



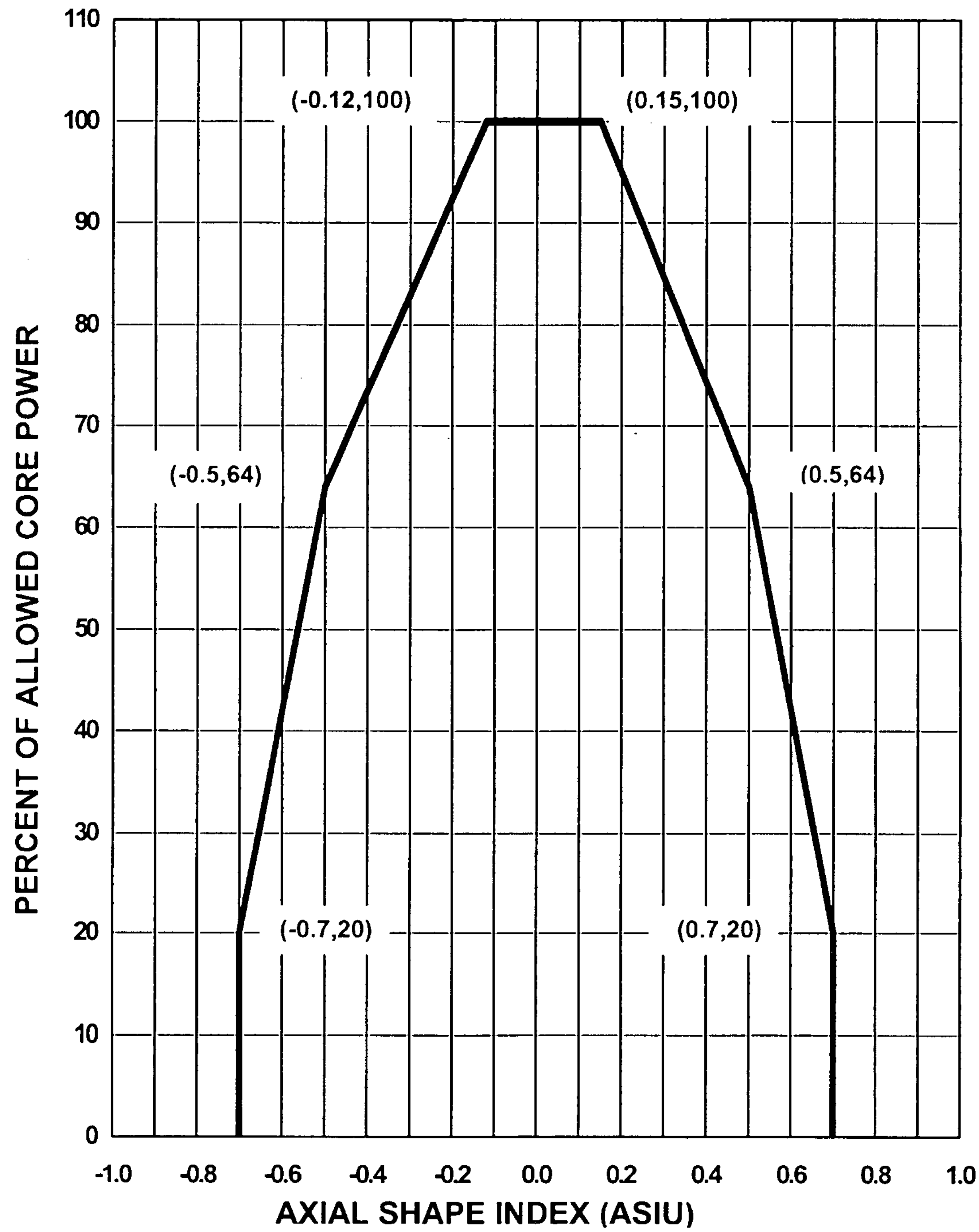
COLR	POWER DEPENDENT INSERTION LIMIT	FIGURE 2



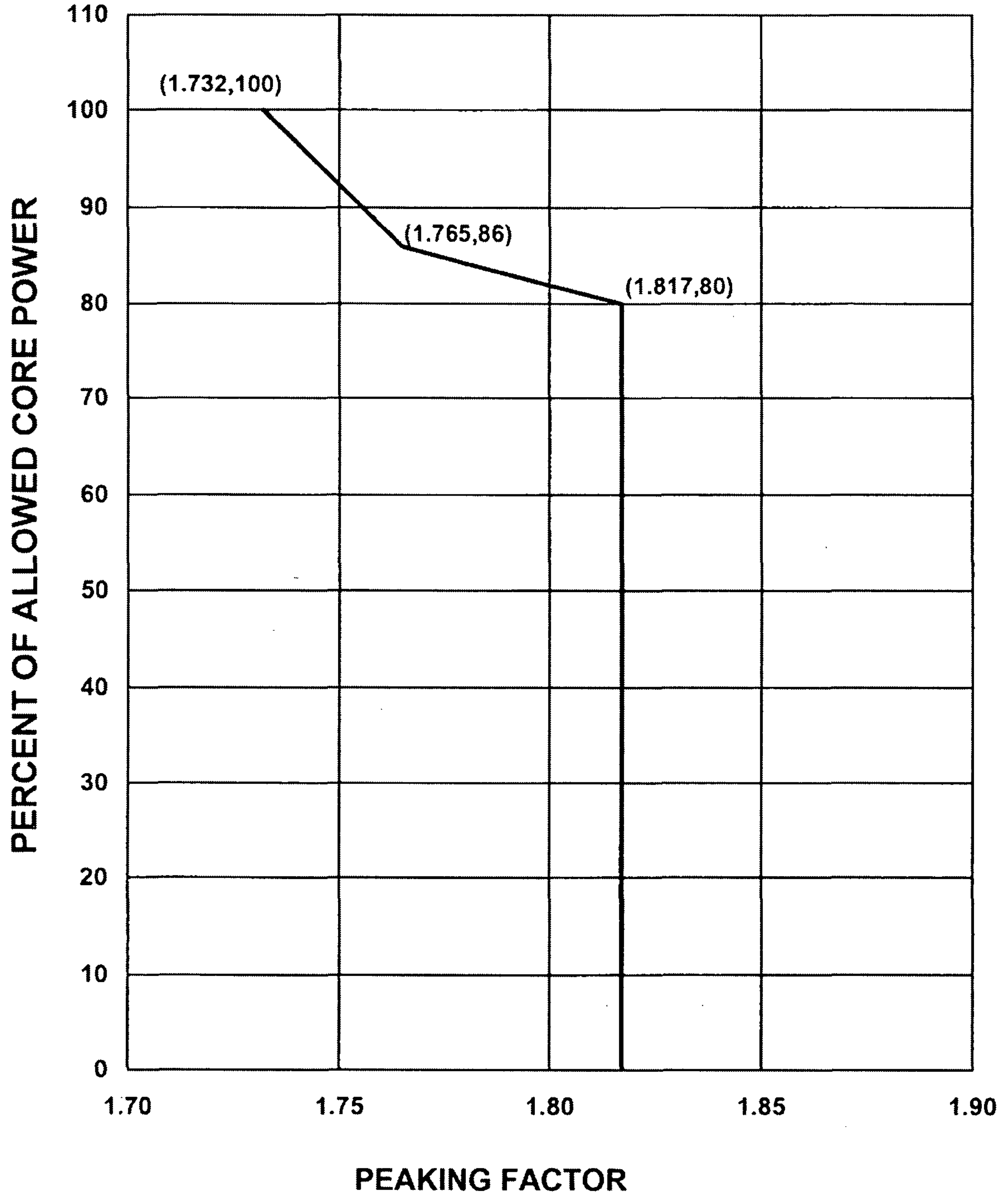
COLR	ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP	FIGURE 3



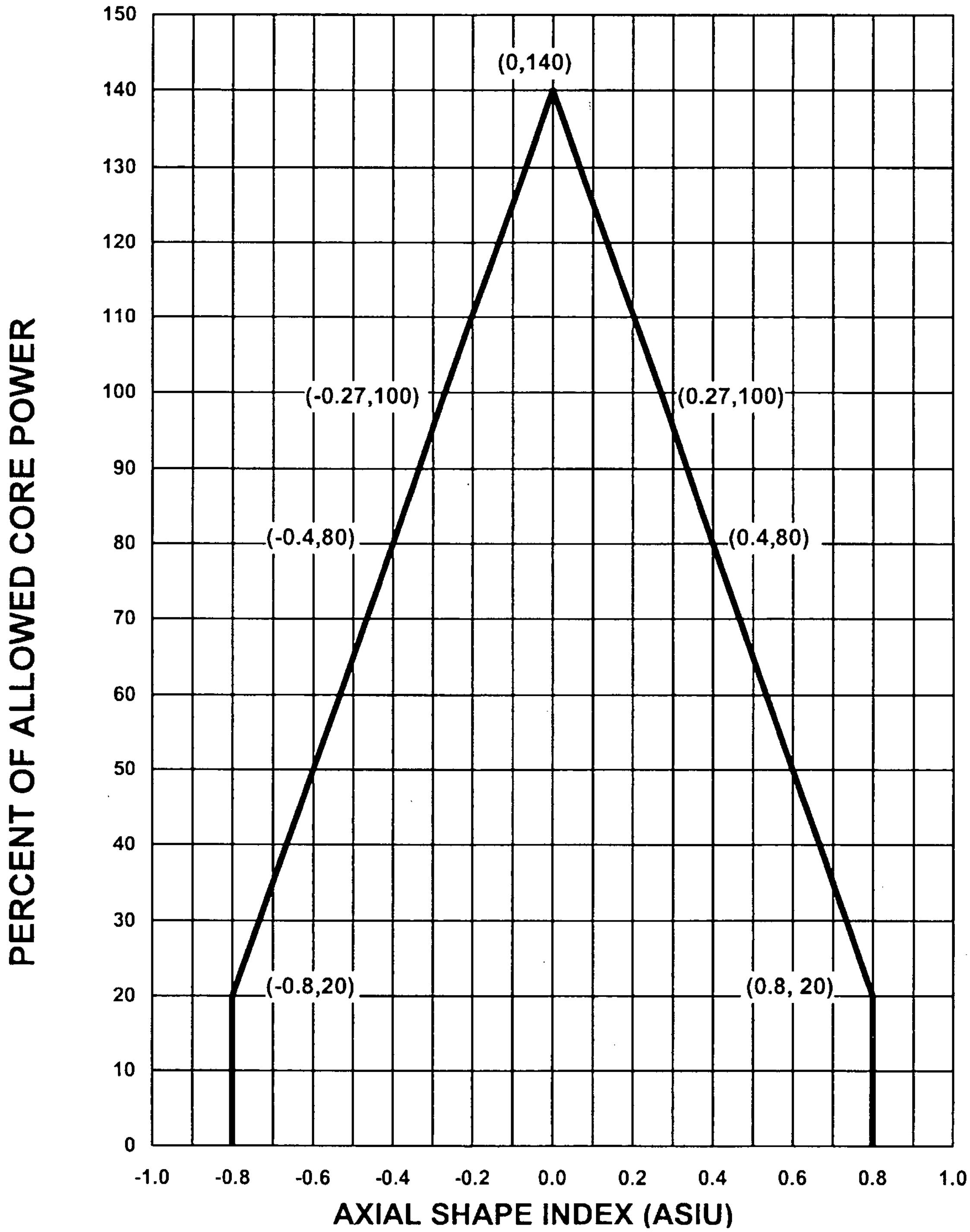
COLR	EXCORE MONITORING OF LHR	FIGURE 4



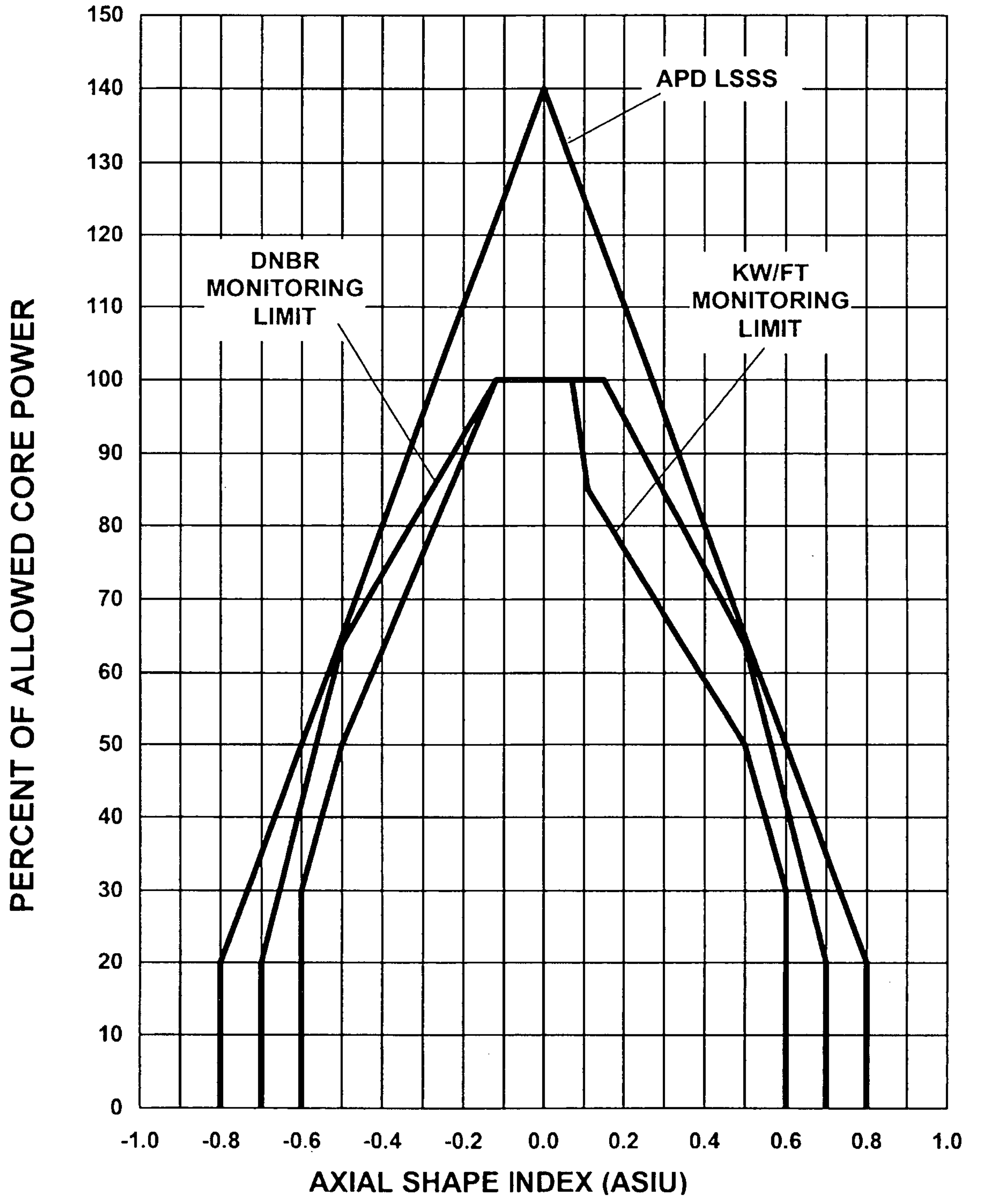
COLR	DNB MONITORING	FIGURE 5



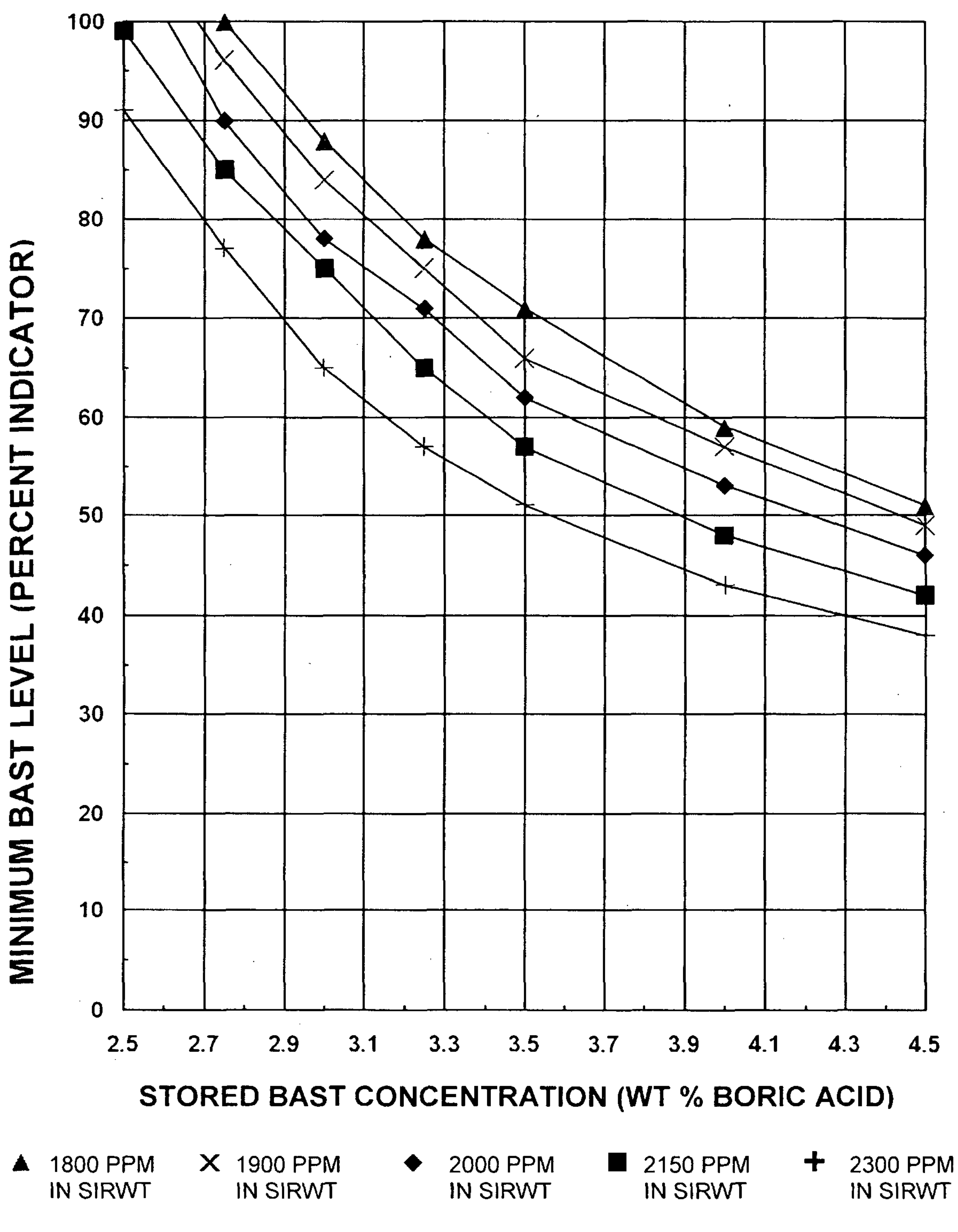
COLR	F_R^T AND CORE POWER LIMITATIONS	FIGURE 6



COLR	AXIAL POWER DISTRIBUTION LSSS FOR 4 PUMP OPERATION	FIGURE 7



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



COLR	MINIMUM BAST LEVEL vs. STORED BAST CONCENTRATION	FIGURE 9