WP8

Fort Calhoun Station
Unit No. 1

TDB-VI

TECHNICAL DATA BOOK

Title: CORE OPERATING LIMIT REPORT

FC-68 Number: DCR 11119

Reason for Change: Update for Cycle 19 operation.

Initiator: Marcus Guinn

Preparer: Marcus Guinn

ISSUED: 10-21-99 3:00 pm

R20

Fort Calhoun Station, Unit 1

Cycle 19 Core Operating Limits 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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Cycle 19 Core Operating Limits Report

1.0 Introduction

This report provides the cycle-specific limits for operation of the Fort Calhoun Station Unit 1 for Cycle 19 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
- Planar Radial Peaking Factor (F_{xy}^T)
- Integrated Radial Peaking Factor (F_R^T)
- DNB Monitoring
- F_R^T/F_{xy}^T versus Power Trade-off Curve
- Refueling Boron Concentration
- Axial Power Distribution
- Shutdown Margin With T_{cold} >210°F
- Most Negative Moderator Temperature Coefficient

These limits are applicable for the duration of Cycle 19. 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 19 operation. Cycle 19 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)

3.0 TM/LP Limit

The TM/LP coefficients for Cycle 19 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:

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

$$\begin{aligned} PF(B) &= 1.0 && \text{for } B \geq 100\% \\ &= -0.008(B) + 1.8 && \text{for } 50\% < B < 100\% \\ &= 1.4 && \text{for } B \leq 50\% \end{aligned}$$

$$\begin{aligned} A1(Y) &= -0.6666(Y_1) + 1.000 && \text{for } Y_1 \leq 0.00 \\ &= +0.3333(Y_1) + 1.000 && \text{for } Y_1 > 0.00 \end{aligned}$$

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}) for Cycle 19 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 for Cycle 19 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 for Cycle 19 is shown in Figure 4.

8.0 Peaking Factor Limits

The Cycle 19 maximum full power values for the unrodded planar radial peaking factor (F_{xy}^T) and integrated radial peaking factor (F_R^T) are shown in Table 2.

Table 2
Maximum Full Power F_R and F_{xy} Limits

Peaking Factor	Limit
F_R^T	1.732
F_{xy}^T	1.816

9.0 DNB Monitoring

With the Better Axial Shape Selection System (BASSS) operable during Cycle 19, the core power is limited as a function of the axial shape index, as shown in Figure 6, or as limited by BASSS. Figure 6 provides the limiting axial shape index as a function of power from the LOCA analyses.

The Cycle 19 limits for DNB as a function of axial shape index and core power are shown in Figure 5. If BASSS becomes inoperable, the allowable limits reduce to those in Figure 5.

10.0 F_R^T, F_{xy}^T and Core Power Limitations

Core power limitations versus F_R^T and F_{xy}^T are shown in Figure 7 for Cycle 19.

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 18 operation and is valid until the beginning of core reload for Cycle 19.

Listed below in Table 3 are the refueling boron concentration values for Cycle 19 operations:

Table 3
Refueling Boron Concentrations

Cycle 19 Average Burnup (MWD/MTU)	Refueling Boron Concentration (ppm)
BOC	2,100
$\geq$ 2,000	2,000
$\geq$ 4,500	1,900

12.0 Axial Power Distribution

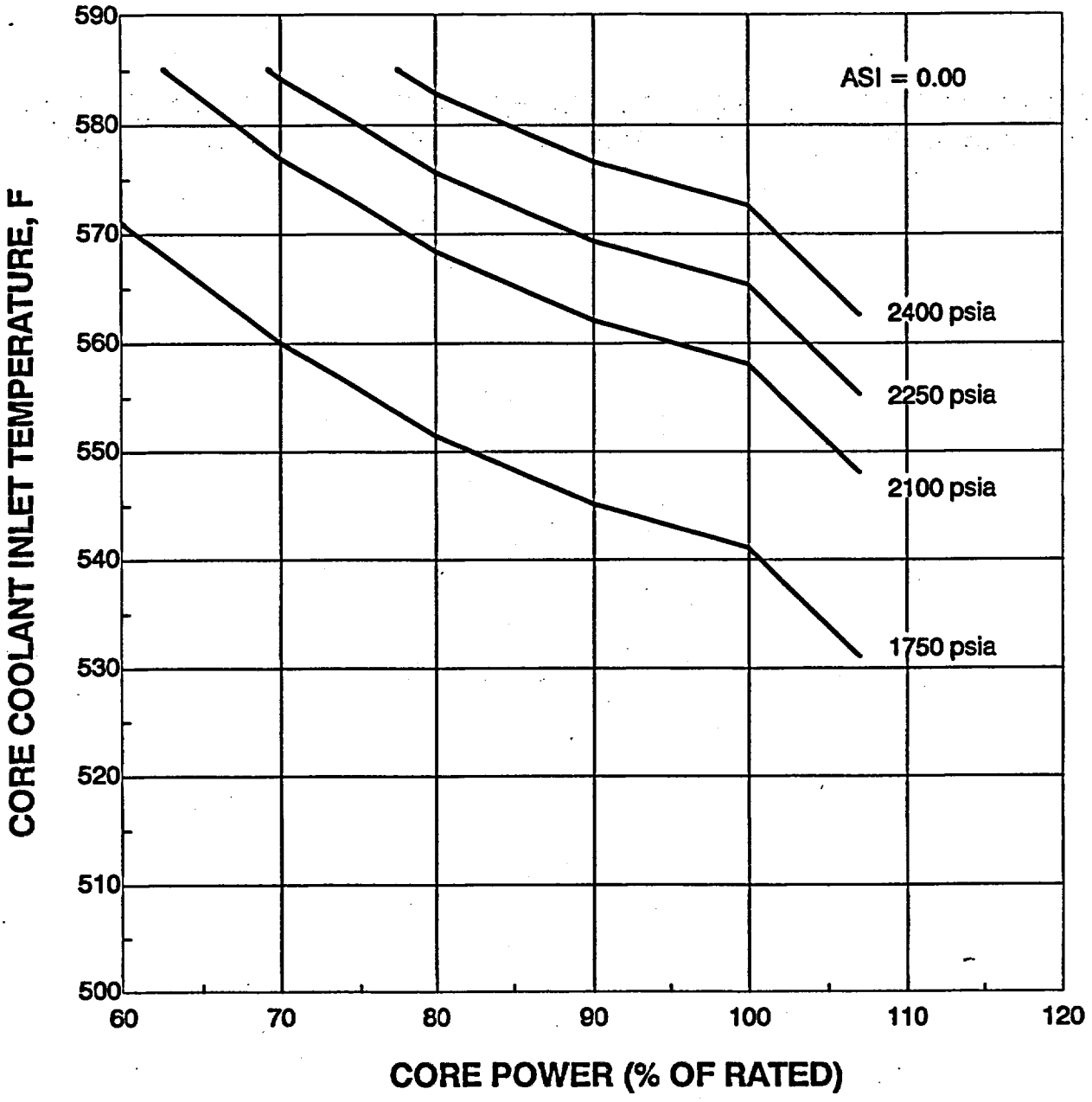
The axial power trip is provided to ensure that excessive axial peaking will not cause fuel damage. The Axial Shape Index is determined from the axially split excore detectors. The setpoint functions, shown in Figure 8 ensure that neither a DNBR of less than 1.18 nor a maximum linear heat rate of more 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 9 combines the LHR LCO tent from Figure 4, the DNB LCO tent from Figure 5, and the APD LSSS tent from Figure 8 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 $\geq$**4.0% Δk/k**. With the shutdown margin <4.0% 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 -3.5×10^{-4} Δρ/°F, including uncertainties, at rated power.

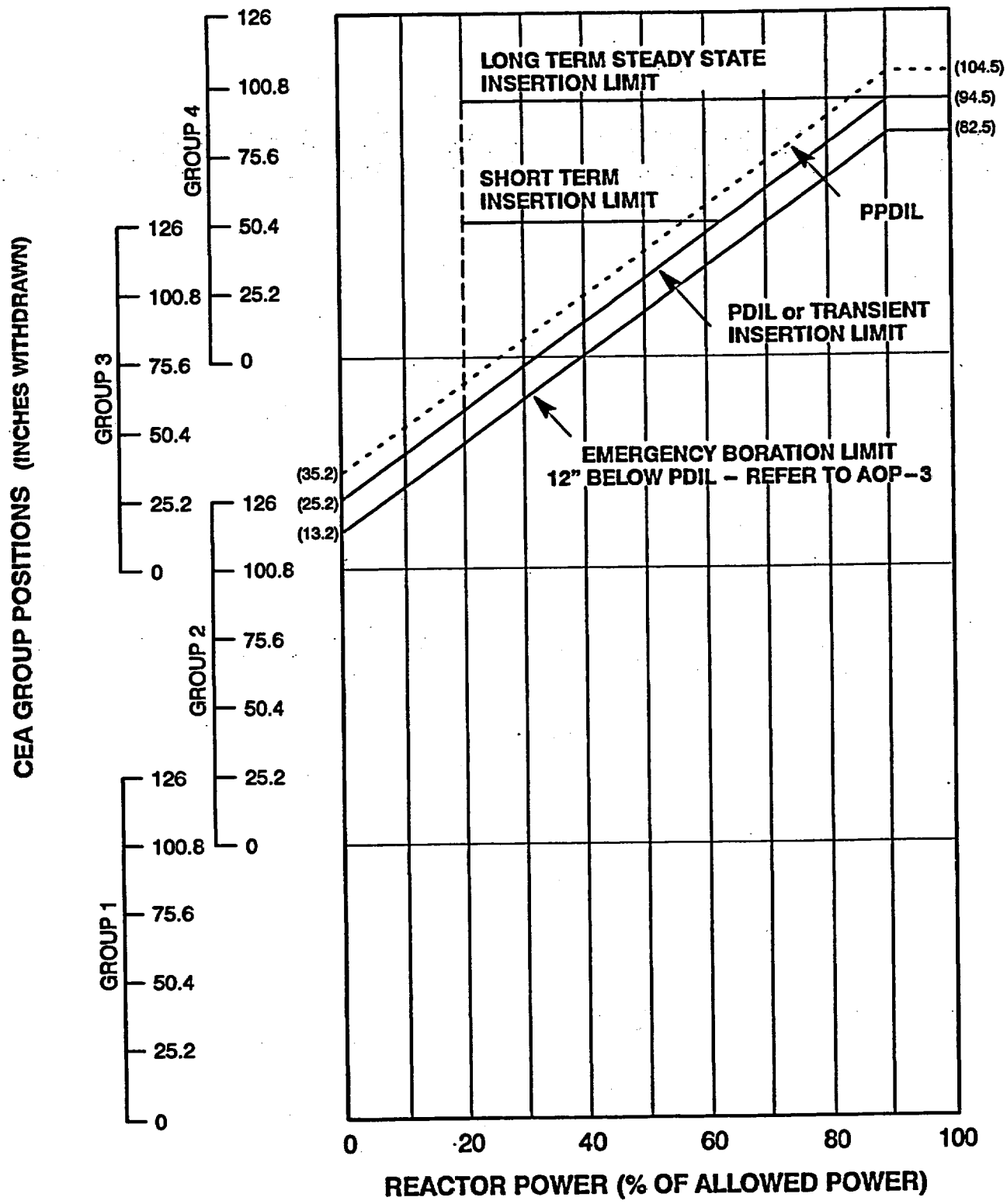


$$P_{VAR} = 29.6PF(B)A1(Y)B + 20.63T_{IN} - 12372$$

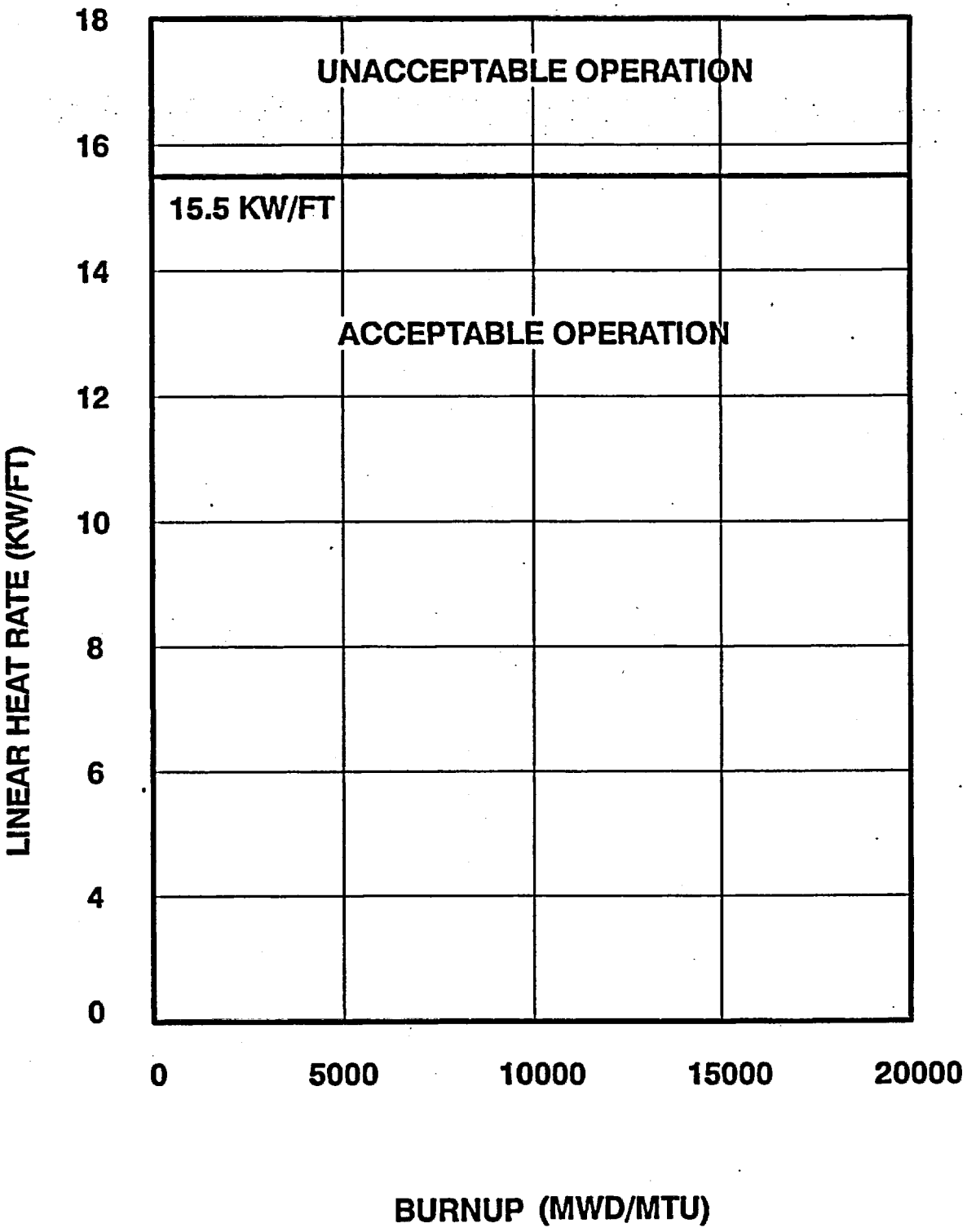
$$PF(B) = \begin{cases} 1.0 & B \geq 100\% \\ -.008B + 1.8 & 50\% < B < 100\% \\ 1.4 & B \leq 50\% \end{cases}$$

$$A1(Y) = \begin{cases} -0.6666Y_I + 1.000 & Y_I \leq 0.00 \\ +0.3333Y_I + 1.000 & Y_I > 0.00 \end{cases}$$

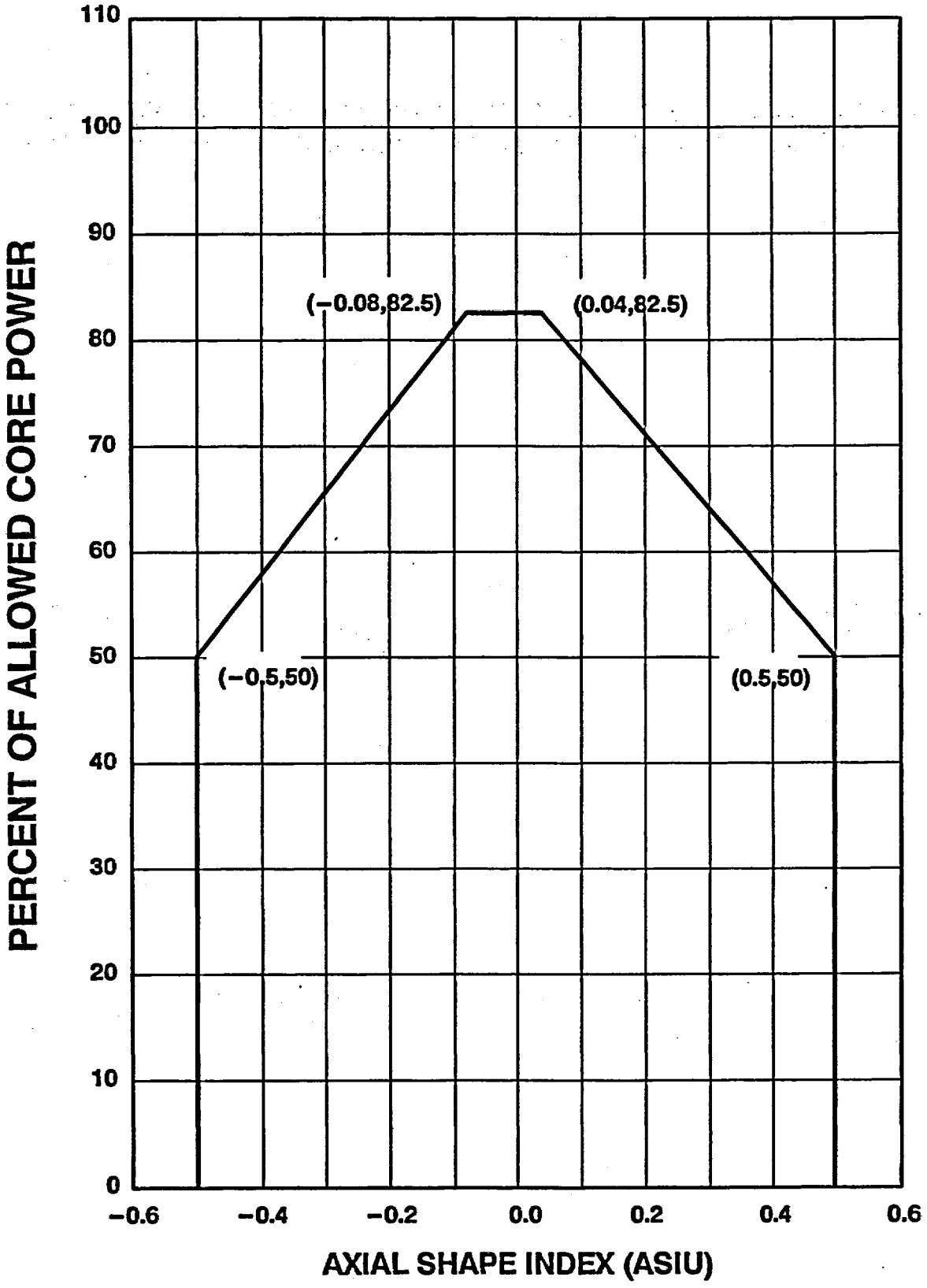
CYCLE 19 COLR	THERMAL MARGIN / LOW PRESSURE FOR 4 PUMP OPERATION	FIGURE 1



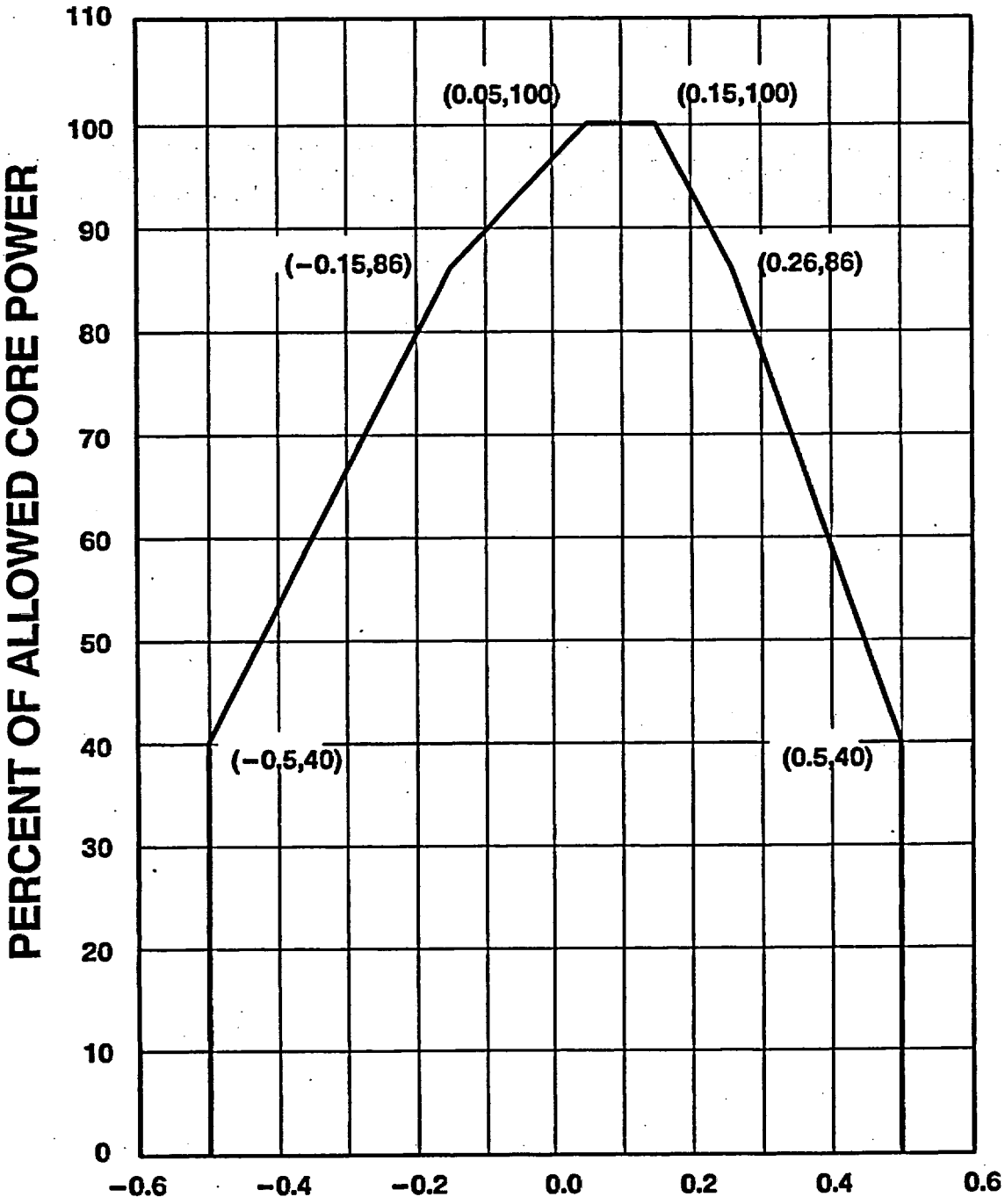
CYCLE 19 COLR	POWER DEPENDENT INSERTION LIMIT	FIGURE 2



CYCLE 19 COLR	ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP	FIGURE 3

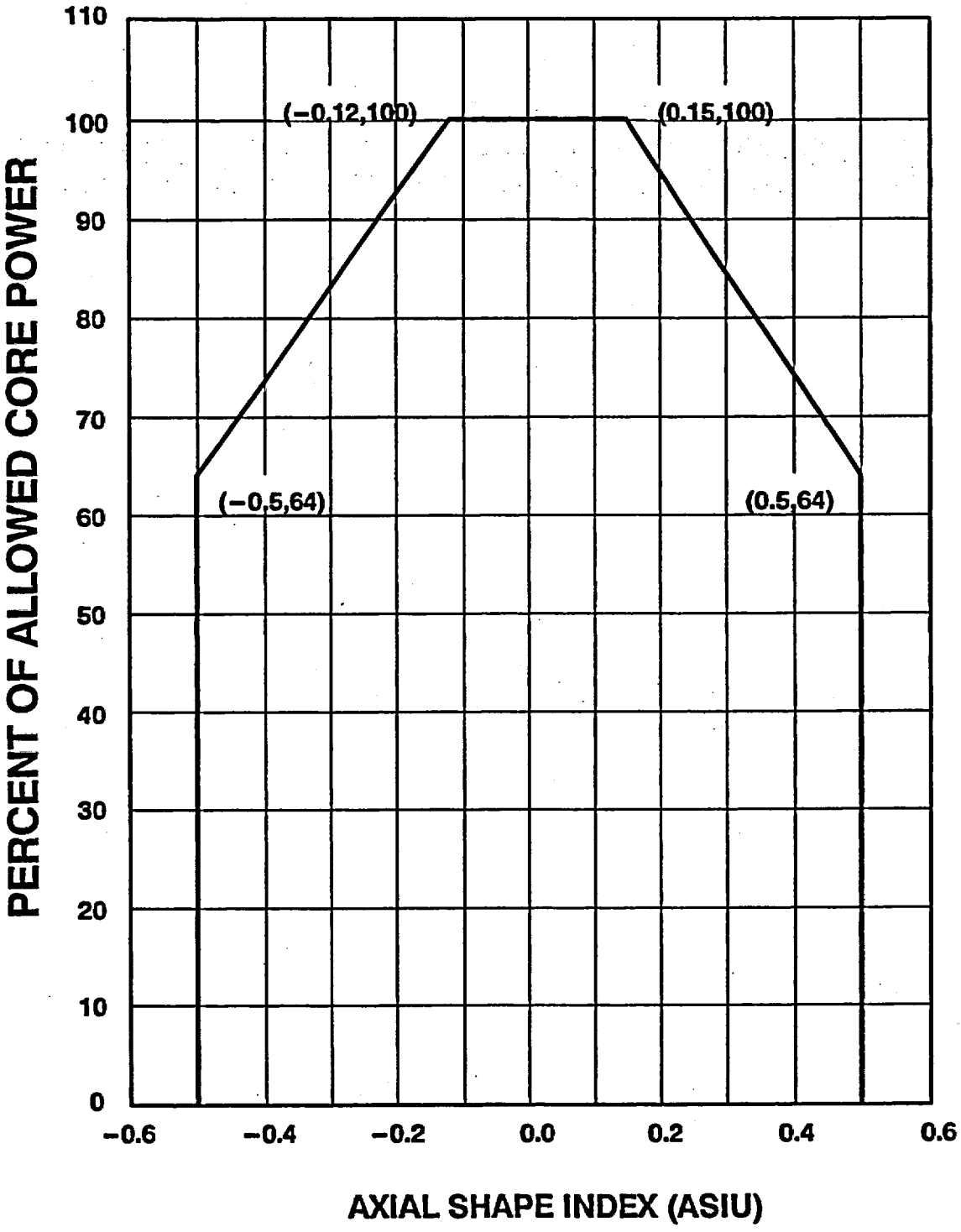


CYCLE 19 COLR	EXCORE MONITORING OF LHR	FIGURE 4

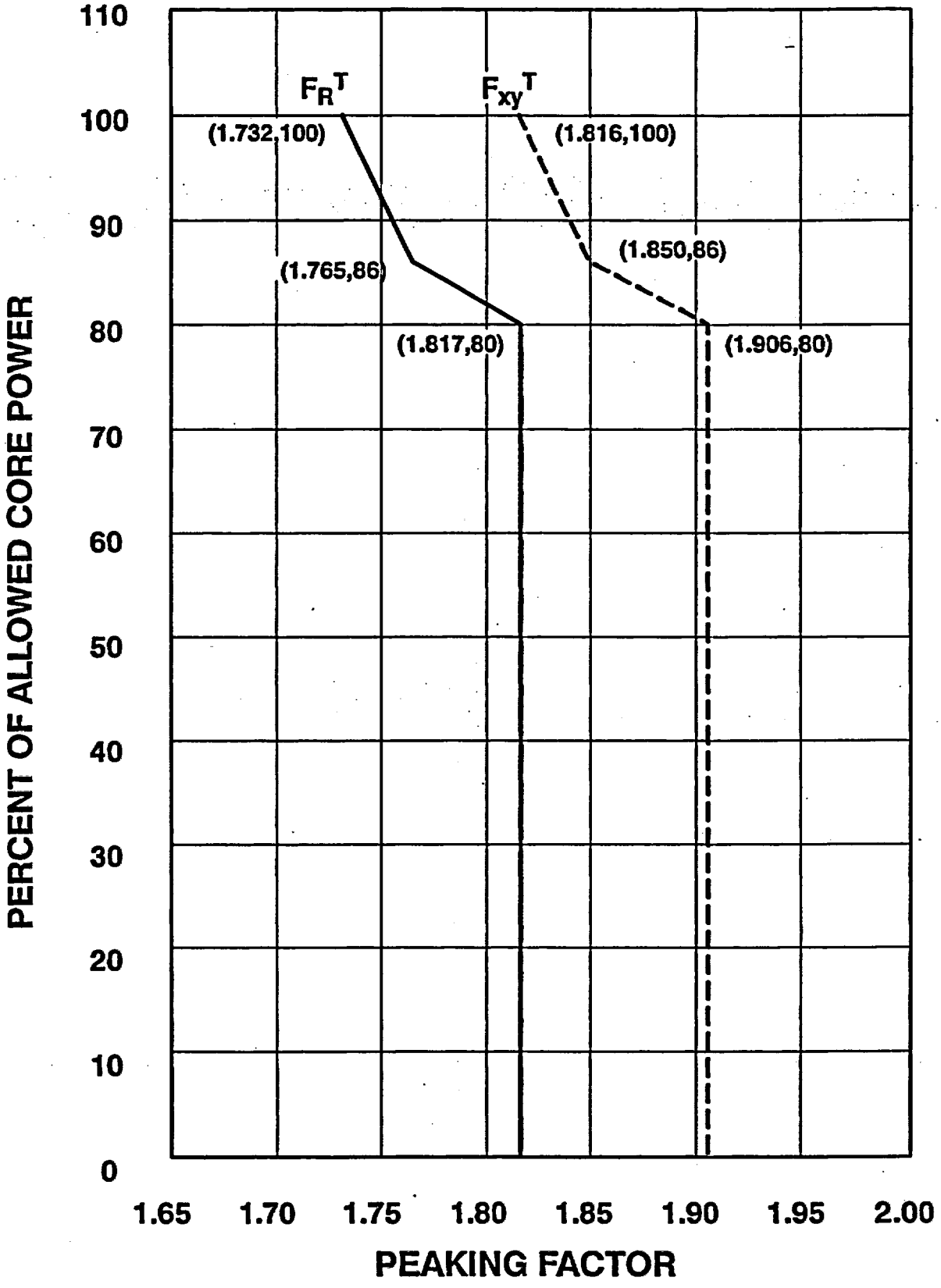


NOTE: **WHEN BASSS IS OPERABLE, THIS FIGURE IS SUPERCEDED BY FIGURE 6 – BASSS DNB ALLOWABLE POWER**

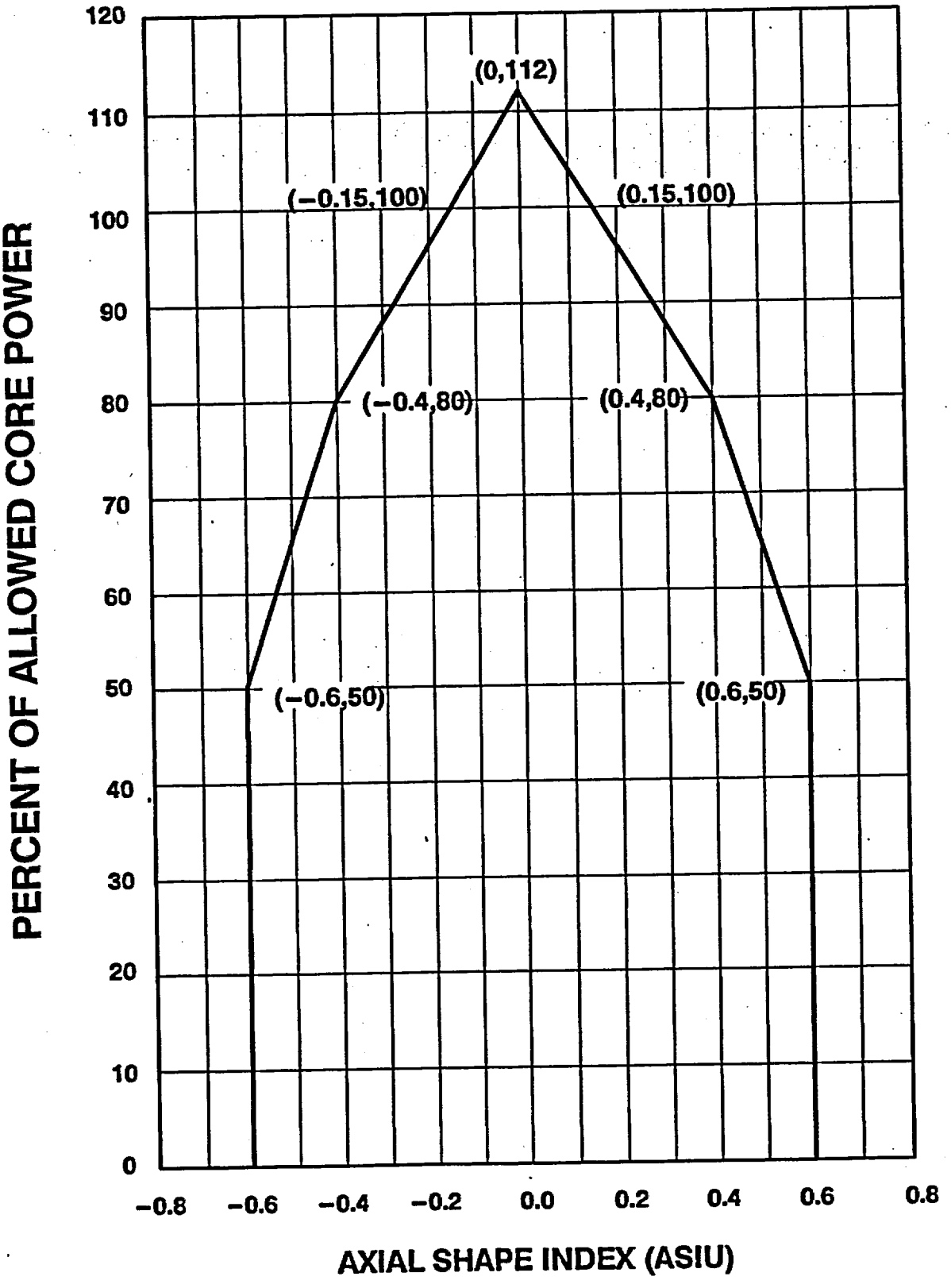
CYCLE 19 COLR	DNB MONITORING	FIGURE 5



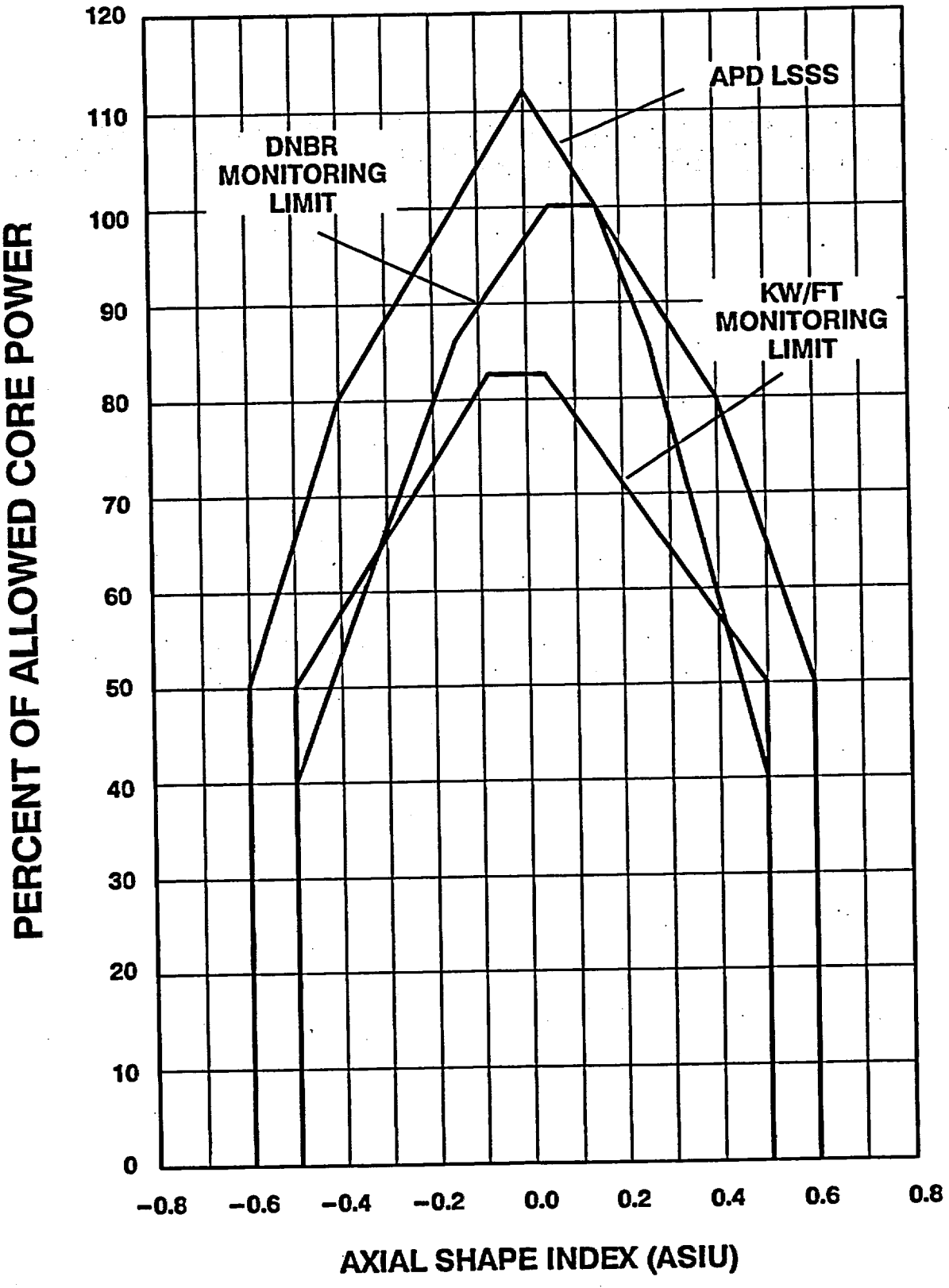
CYCLE 19 COLR	BASSS DNB ALLOWABLE POWER LCO	FIGURE 6



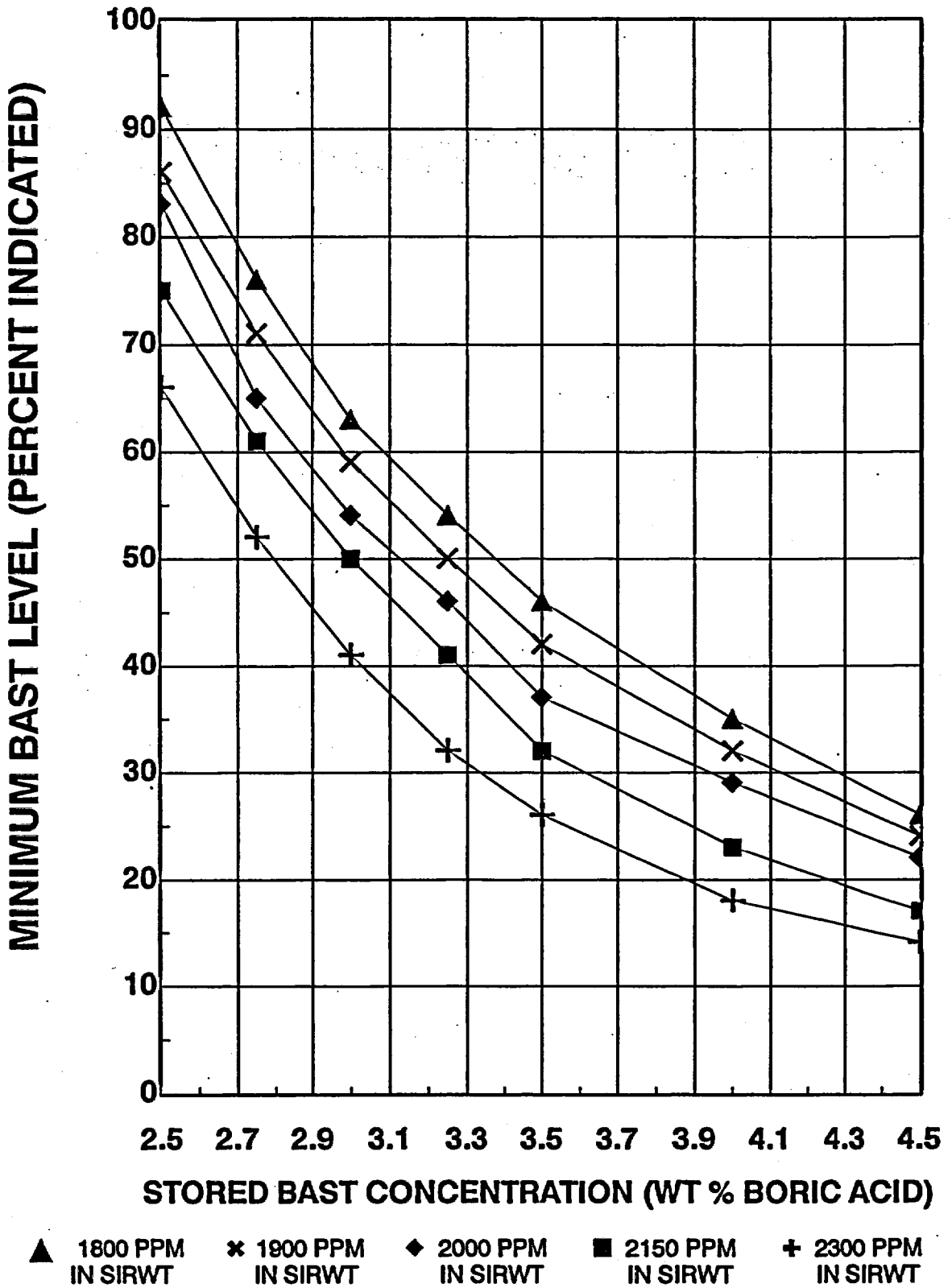
CYCLE 19 COLR	F_R^T, F_{xy}^T, AND CORE POWER LIMITATIONS	FIGURE 7



CYCLE 19 COLR	AXIAL POWER DISTRIBUTION LSSS FOR 4 PUMP OPERATION	FIGURE 8



CYCLE 19 COLR	AXIAL POWER DISTRIBUTION LIMITS FOR 4 PUMP OPERATION WITH INCORES INOPERABLE	FIGURE 9



CYCLE 19 COLR	MINIMUM BAST LEVEL vs. STORED BAST CONCENTRATION	FIGURE 10