Fort Calhoun Station
Unit No. 1

# TDB-VI

TECHNICAL DATA BOOK PROCEDURE

**Title:** CORE OPERATING LIMIT REPORT

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| FC-68 Number: | 47372 |
| Reason for Change: | Add figure to COLR for "Axial Power Distribution LSSS for 4 Pump Operation". |
| Contact Person: | William O. Weber |
| Documentable Error (a): | Page 16 |

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**Fort Calhoun Station, Unit 1**

# Cycle 16 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 Production Engineering Division, Nuclear Engineering Department.

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# Cycle 16 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 16 operation. It includes limits for:

1.) TM/LP LSSS 4 Pump Operation ($P_{VAR}$)
2.) Core Inlet Temperature ($T_{IN}$)
3.) Power Dependent Insertion Limit (PDIL)
4.) Allowable Peak Linear Heat Rate
5.) Excore Monitoring of LHR
6.) Planar Radial Peaking Factor ($F_{xy}^T$)
7.) Integrated Radial Peaking Factor ($F_R^T$)
8.) DNB Monitoring
9.) $F_R^T/F_{xy}^T$ versus Power Trade off curve
10.) Refueling Boron Concentration
11.) Axial Power Distribution

These limits are applicable for the duration of Cycle 16. 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 16 operation. Cycle 16 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. 04, Dated January 1993. (TAC No. M85845)

## 3.0 TM/LP Limit

The TM/LP coefficients for Cycle 16 are shown below:

**Table 1**

| Coefficient | Value |
|---|---|
| $\alpha$ | 29.73 |
| $\beta$ | 18.44 |
| $\gamma$ | -.11470 |

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

$$P_{VAR} = 29.73\ PF(B)\ A1(Y)B + 18.44T_{IN} - 11470$$

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

$$A1(Y) = \begin{cases} -0.3529Y_1 + 1.0882 & Y_1 \leq 0.25 \\ 0.5714Y_1 + 0.857 & Y_1 > 0.25 \end{cases}$$

Where:

B = High Auctioneered thermal ($\Delta T$) 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 16 shall not exceed **545°F**.

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 for Cycle 16 operation.

## 6.0 Linear Heat Rate

The allowable peak linear heat rate vs. burnup for Cycle 16 is 15.5 kW/ft. The allowable peak linear heat rate for Cycle 16 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 16 is shown in Figure 4.

## 8.0 Peaking Factor Limits

The Cycle 16 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 | Limits |
|---|---|
| $F_R^T$ | 1.77 |
| $F_{xy}^T$ | 1.86 |

## 9.0 DNB Monitoring

The Cycle 16 limits for DNB as a function of axial shape index and core power is shown in Figure 5.

When the Better Axial Shape Selection System is operable, during Cycle 16, the core power is limited as a function of the axial shape index as shown in Figure 6. Figure 6 will eliminate the need for seperate LOCA and fuel performance limits to be maintained by the operators while operating with BASSS.

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

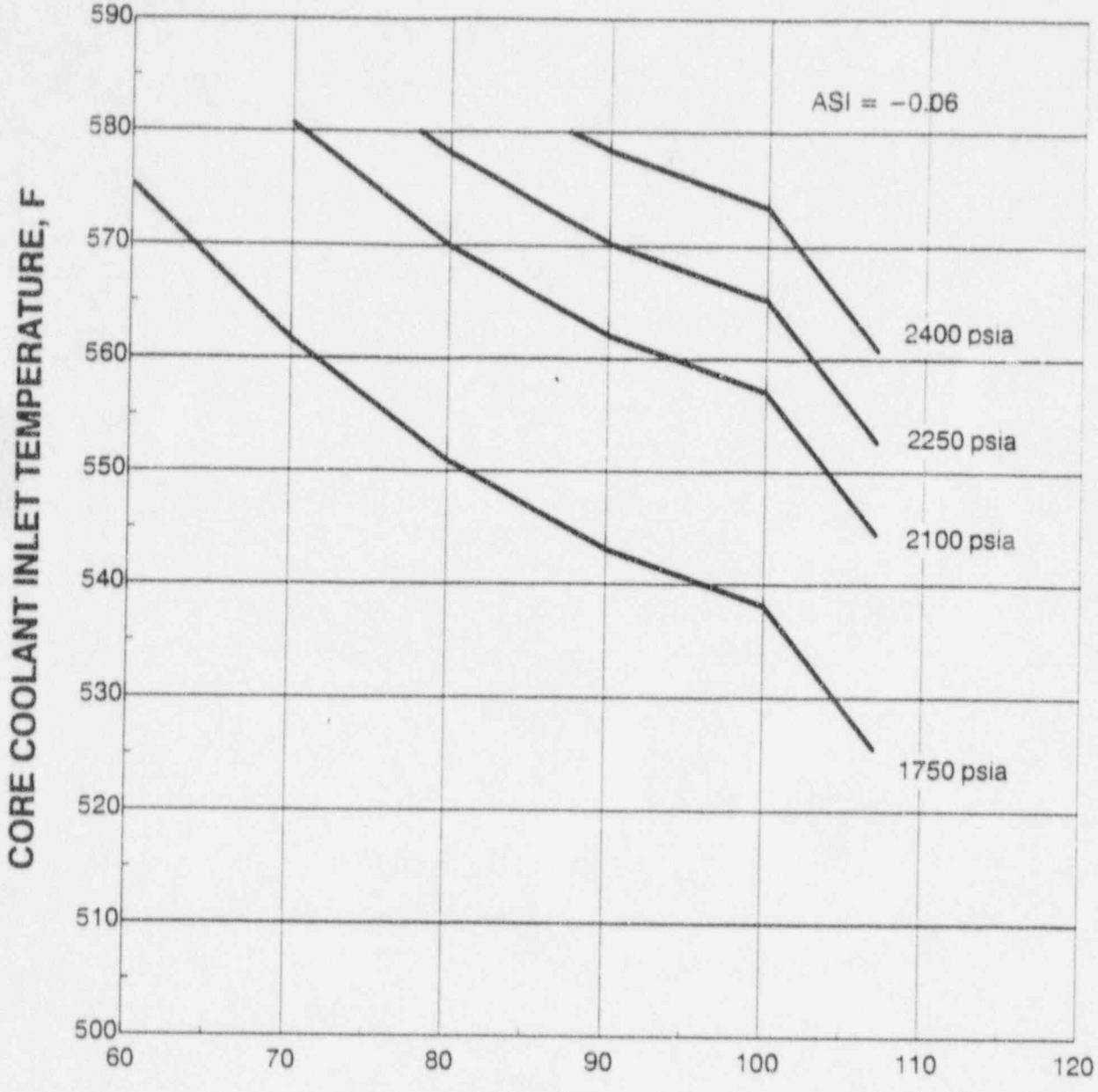
Core power limitations versus $F_R^T$ and $F_{xy}^T$ are shown in Figure 7 for Cycle 16.

## 11.0 Refueling Boron Concentration

The refueling boron concentration must be maintained with a boron concentration of at least **2000 ppm** in the reactor coolant system to ensure a shutdown margin of not less than 5% with all CEAs withdrawn.

## 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 set point 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.

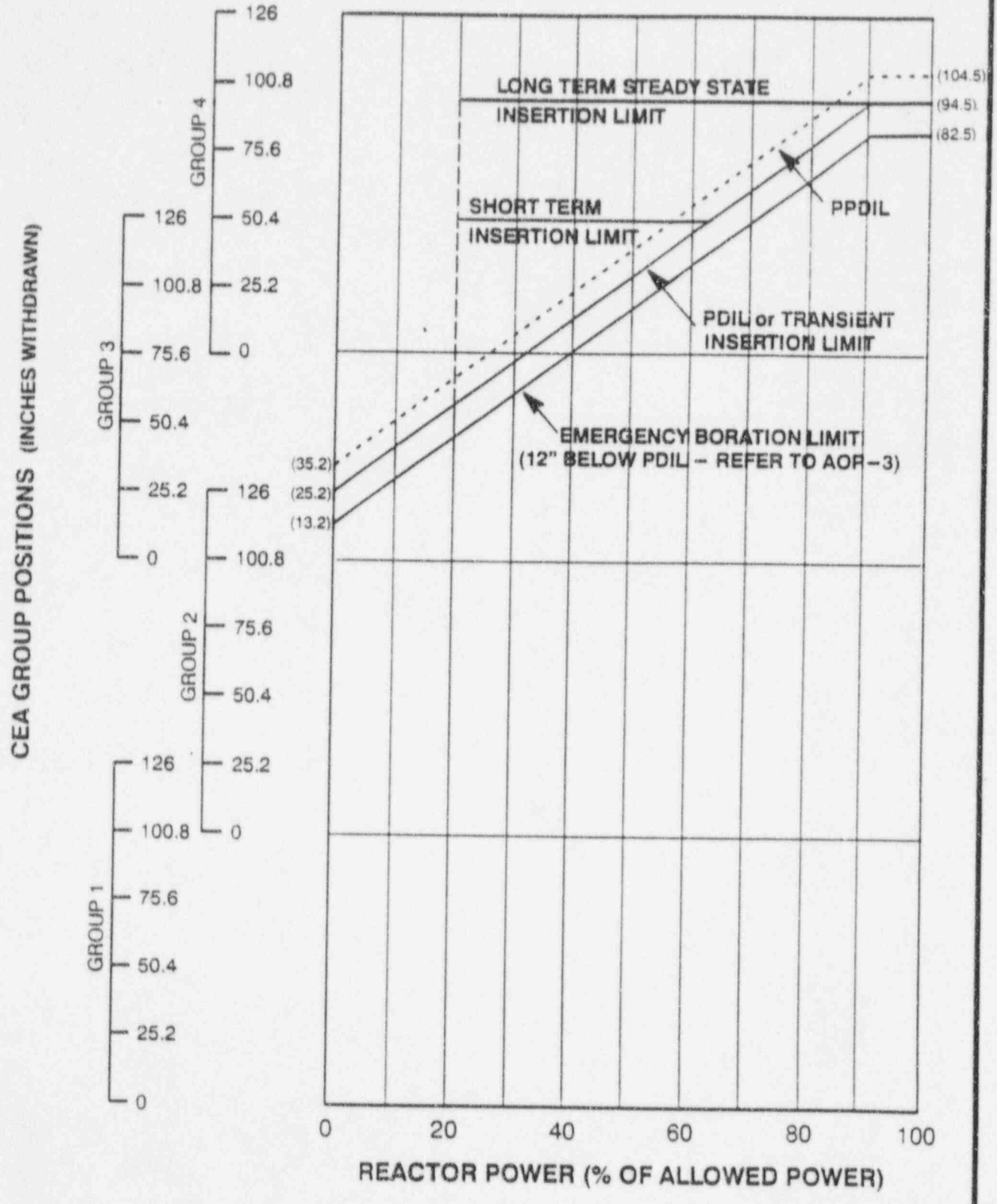



$$P_{VAR} = 29.73PF(B)A1(Y)B + 18.44T_{IN} - 11470$$

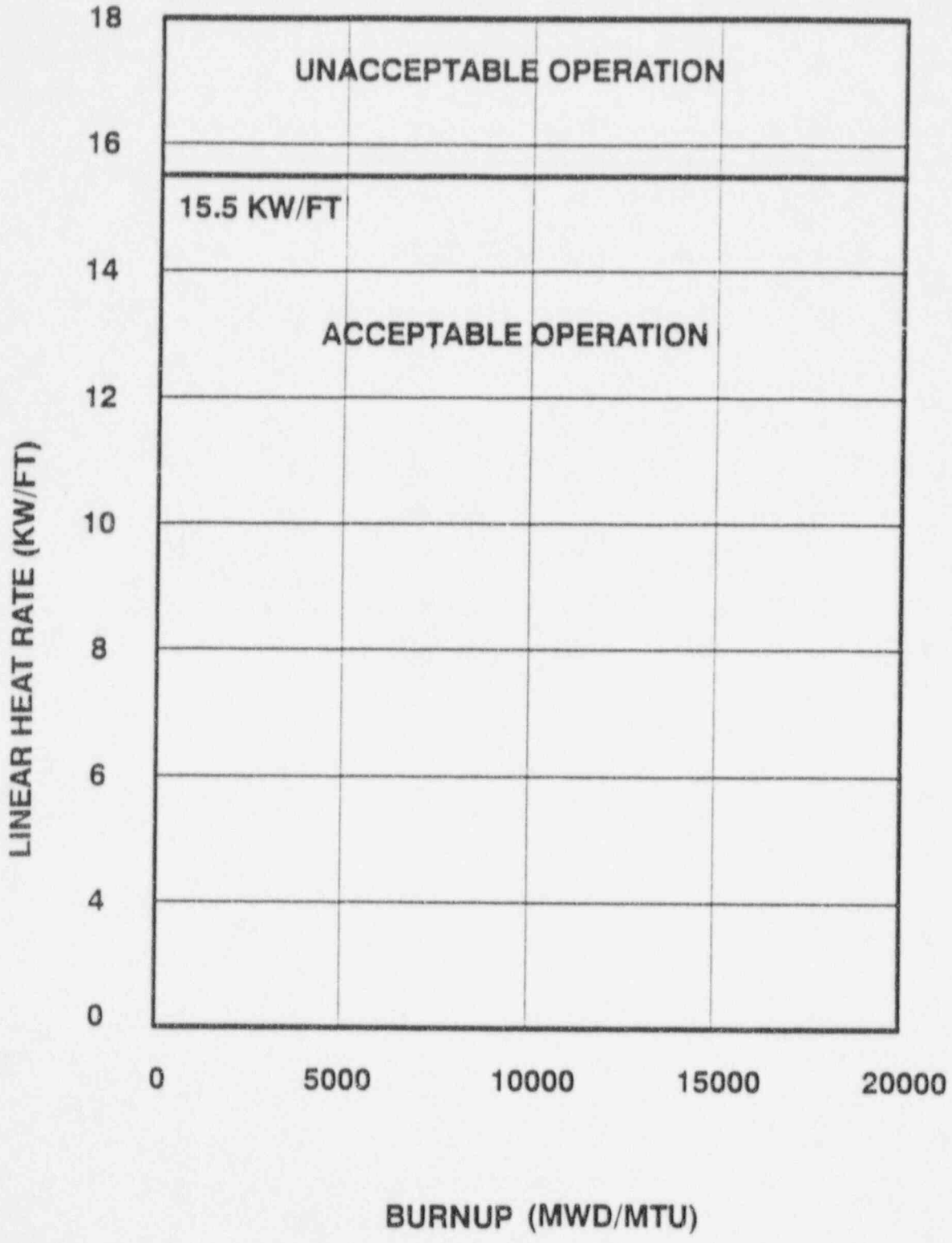
| | | |
|---|---|---|
| PF(B) | = 1.0 | $B \geq 100\%$ |
| | = −.008B + 1.8 | $50\% < B < 100\%$ |
| | = 1.4 | $B \leq 50\%$ |

| | | |
|---|---|---|
| A1(Y) | $= -0.3529Y_I + 1.0882$ | $Y_I \leq .25$ |
| | $= 0.5714Y_I + 0.857$ | $Y_I > .25$ |

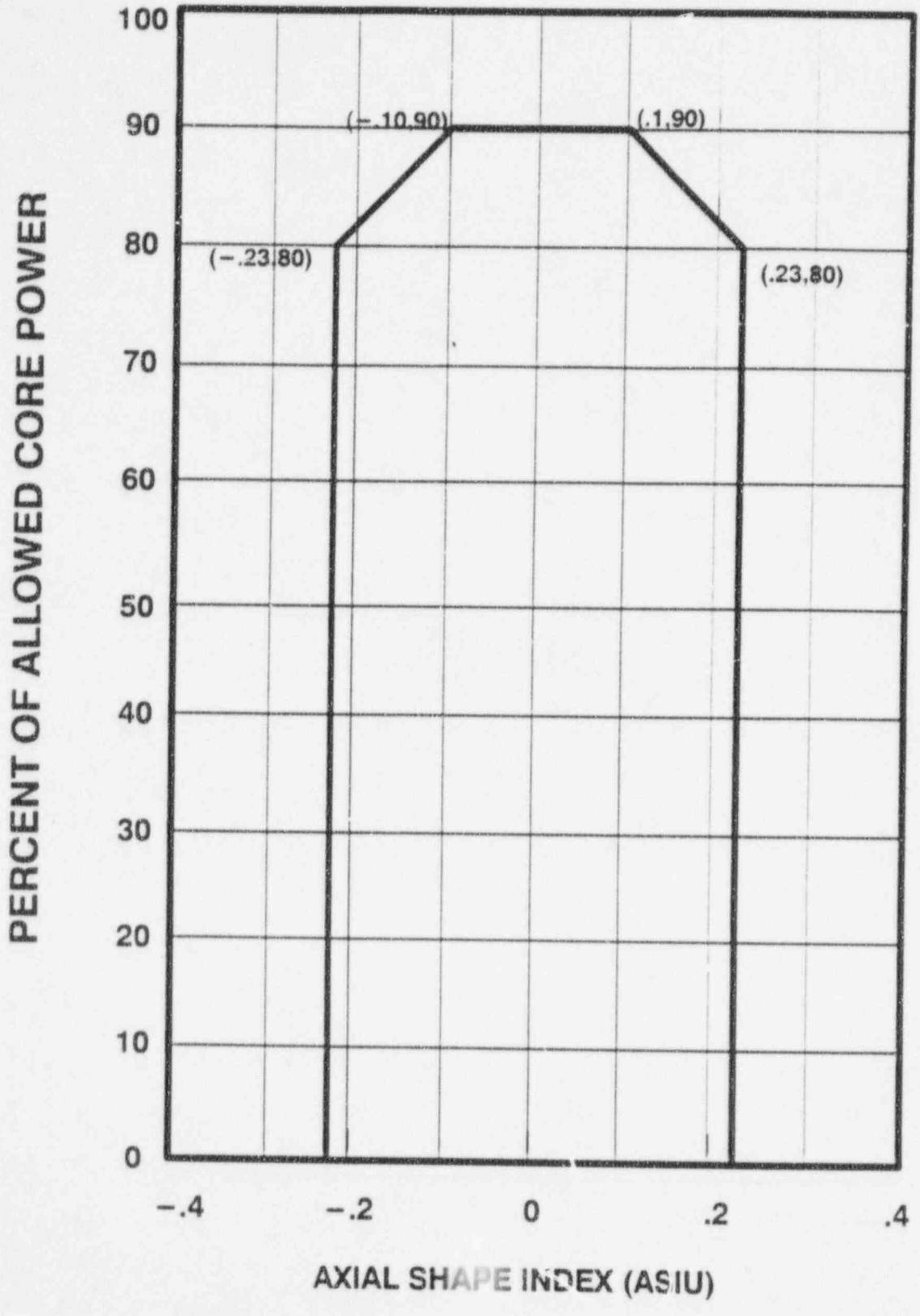
| | | |
|---|---|---|
| CYCLE 16 COLR | THERMAL MARGIN/ LOW PRESSURE 4 PUMP OPERATION | FIGURE 1 |



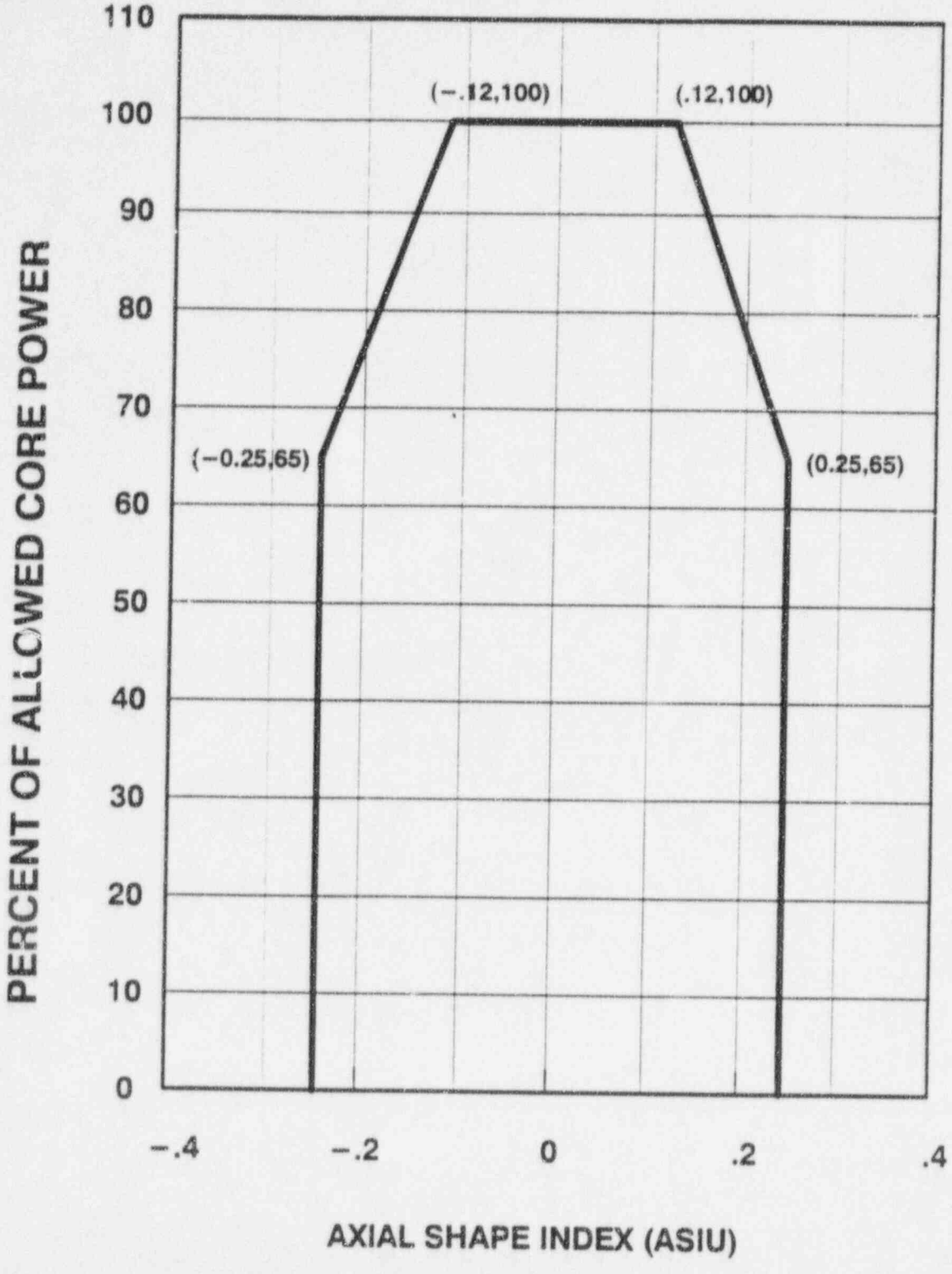

| CYCLE 16 COLR | POWER DEPENDENT INSERTION LIMIT | FIGURE 2 |
|---|---|---|




| CYCLE 16 COLR | ALLOWABLE PEAK LINEAR HEAT RATE VS. BURNUP | FIGURE 3 |
|---|---|---|

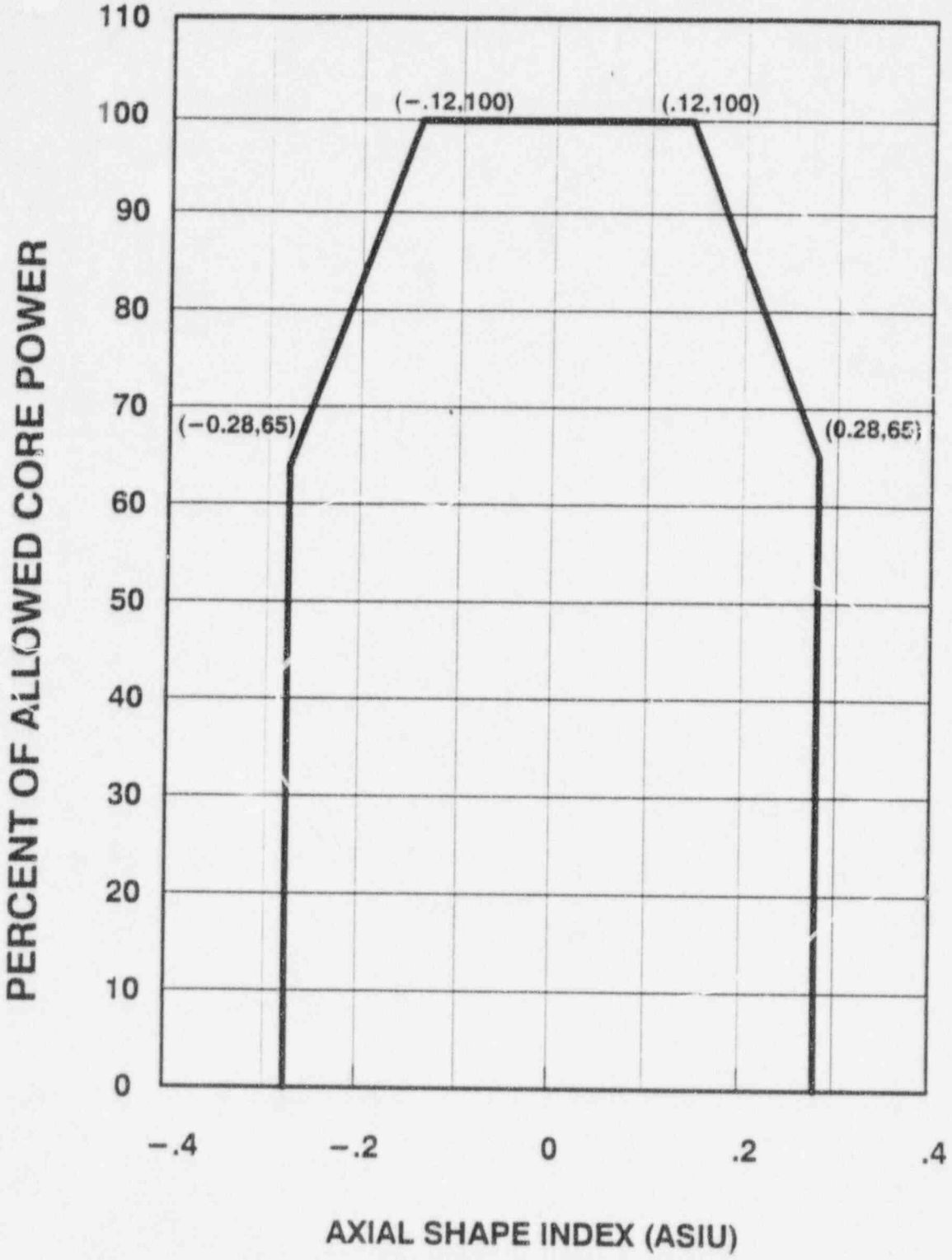



| CYCLE 16 COLR | EXCORE MONITORING OF LHR | FIGURE 4 |
|---|---|---|

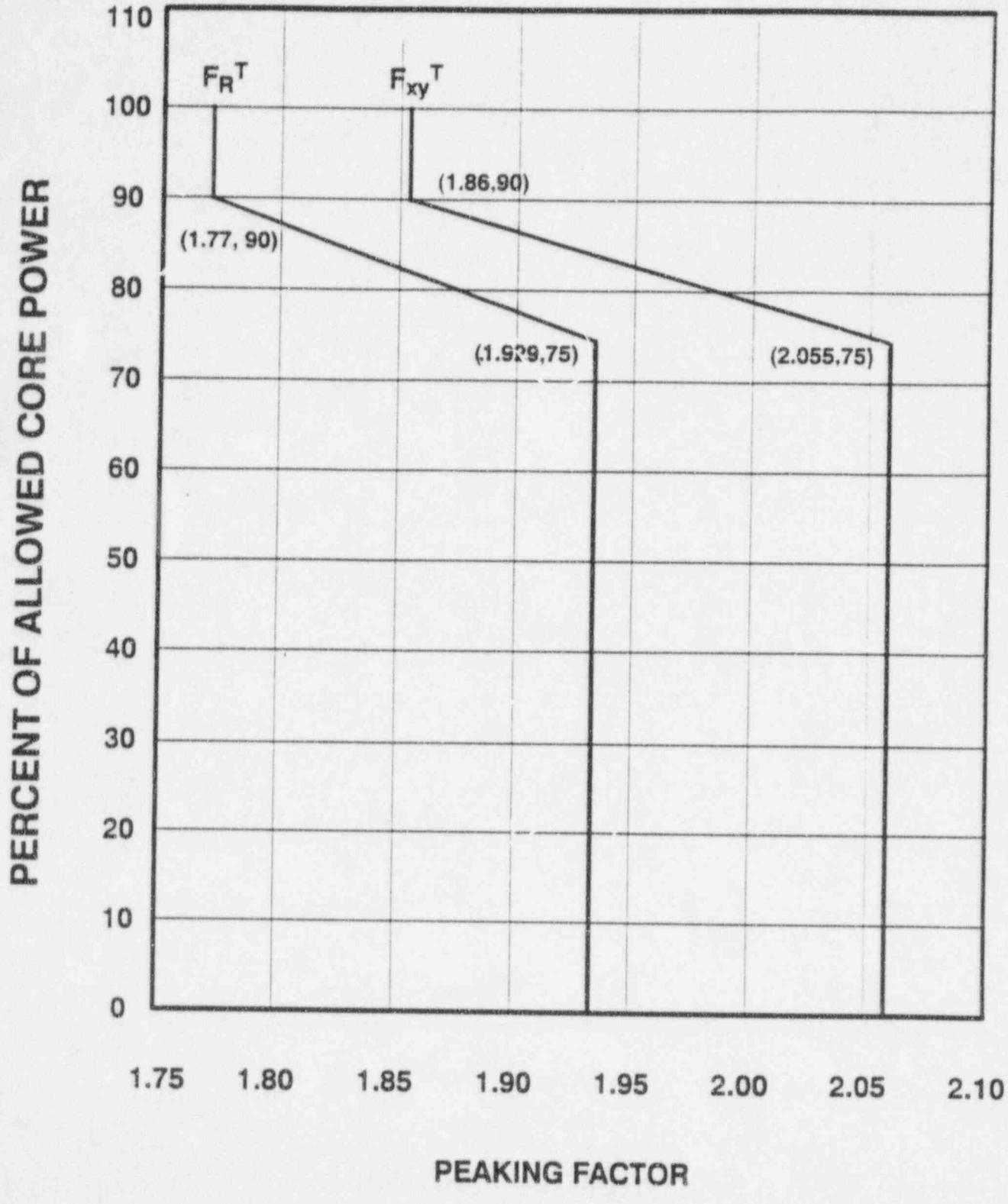



**NOTE: WHEN BASSS IS OPERABLE THIS FIGURE IS SUPERSCEDED BY FIGURE 6 – BASSS DNB ALLOWABLE POWER**

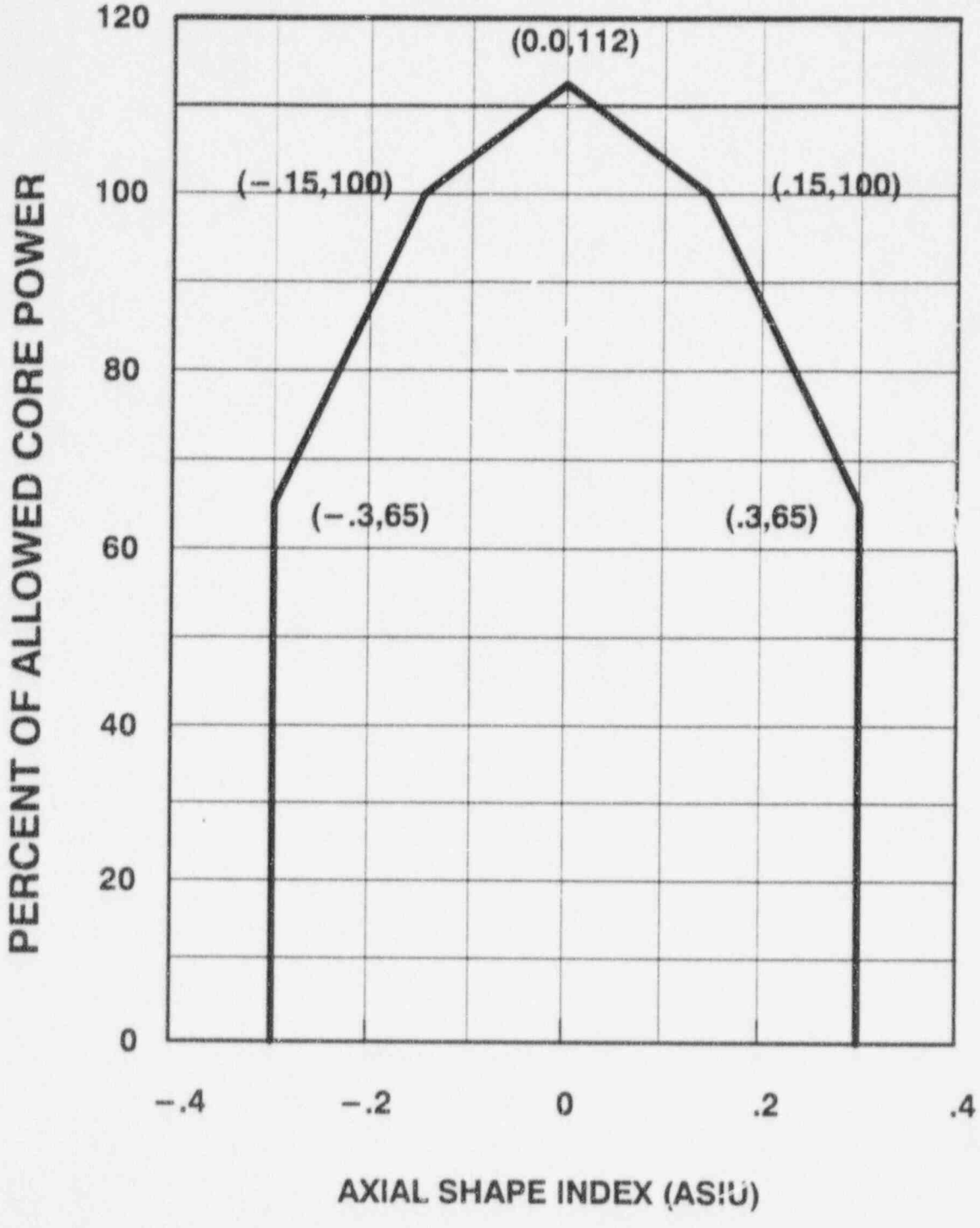
| CYCLE 16 COLR | DNB MONITORING | FIGURE 5 |
|---|---|---|




| CYCLE 16 COLR | BASSS DNB ALLOWABLE POWER LCO | FIGURE 6 |
|---|---|---|




| CYCLE 16 COLR | $F_R^T$, $F_{xy}^T$, and Core Power Limitations | FIGURE 7 |
|---|---|---|




| CYCLE 16 COLR | Axial Power Distribution LSSS for 4 Pump Operation | FIGURE 8 |
|---|---|---|