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1CAN101902

October 18, 2019

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

SUBJECT: ANO-1 Cycle 29 COLR

Arkansas Nuclear One, Unit 1
NRC Docket No. 50-313
Renewed Facility Operating License No. DPR-51

Dear Sir or Madam:

Entergy Operations, Inc. (Entergy) Arkansas Nuclear One, Unit 1 (ANO-1) Technical Specification 5.6.5 requires the submittal of the Core Operating Limits Report (COLR) upon issuance for each reload cycle. Attached is the ANO-1 Cycle 29 COLR. Please note that the latest approved revision number of the Babcock and Wilcox Topical Report BAW-10179P-A is identified in the COLR as Revision 9, November 2017. In addition, the approved revision number of the Entergy Reactor Physics Methods Report is identified in the COLR as Revision 0, December 1993.

This letter contains no new regulatory commitments.

This completes the reporting requirement of the stated specification. Should you have any questions, please contact me.

Sincerely,

ORIGINAL SIGNED BY TIMOTHY L. ARNOLD

TLA/dbb

Enclosure: ANO-1 Cycle 29 Core Operating Limits Report (COLR) cc: NRC Region IV Regional Administrator

NRC Senior Resident Inspector – Arkansas Nuclear One

NRC Project Manager – Arkansas Nuclear One

Designated Arkansas State Official

Enclosure to

1CAN101902

ANO-1 Cycle 29 Core Operating Limits Report (COLR)

ENTERGY OPERATIONS

ARKANSAS NUCLEAR ONE
UNIT ONE

CYCLE 29

CORE OPERATING LIMITS REPORT

1.0 CORE OPERATING LIMITS

This Core Operating Limits Report for ANO-1 Cycle 29 has been prepared in accordance with the requirements of Technical Specification 5.6.5. The core operating limits have been developed using the methodology provided in the references.

The following cycle-specific core operating limits are included in this report:

1) 2.1.1.3 Variable Low RCS Pressure – Temperature Protective Limits
2) 3.1.1 Shutdown Margin (SDM)
3) 3.1.8 Physics Test Exceptions – Mode 1
4) 3.1.9 Physics Test Exceptions – Mode 2
5) 3.2.1 Regulating Rod Insertion Limits
6) 3.2.2 Axial Power Shaping Rods (APSR) Insertion Limits
7) 3.2.3 Axial Power Imbalance Operating Limits
8) 3.2.4 Quadrant Power Tilt (QPT)
9) 3.2.5 Power Peaking
10) 3.3.1 Reactor Protection System (RPS) Instrumentation
11) 3.4.1 RCS Pressure, Temperature, and Flow DNB Limits
12) 3.4.4 RCS Loops – MODES 1 and 2
13) 3.9.1 Boron Concentration

2.0 REFERENCES

1. "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses," BAW-10179P-A, Rev. 9, Framatome ANP, Inc., Lynchburg, Virginia, November 2017.
2. "Qualification of Reactor Physics Methods for the Pressurized Water Reactors of the Entergy System," ENEAD-01-P, Rev. 0, Entergy Operations, Inc., Jackson, Mississippi, December 1993.
3. "Transmittal of ANO1-29 Limits and Setpoints Document," Framatome Doc. No. FS1-0044851-1.0, July 3, 2019.
4. "Arkansas Nuclear One, Unit 1 – Cycle 29 Reload Report," ANP-3792, Rev. 0, August 2019 (CALC-ANO1-NE-19-00003, Revision 0).
5. "Transmittal of ANO1-29 Final Core Load Plan (CLP)," Framatome Letter FS1-0046020-01, September 5, 2019, (CALC-ANO1-NE-19-00004, Revision 0).
6. "IC (Initial Condition) DNB RCS Protection Criteria," CALC-96-E-0023-02, Rev. 7.
7. "Transmittal of the ANO1-29 Reload Technical Document (RTD)," Framatome Letter FS1-0045233-1.0, July 25, 2019 (CALC-ANO1-NE-19-00002).

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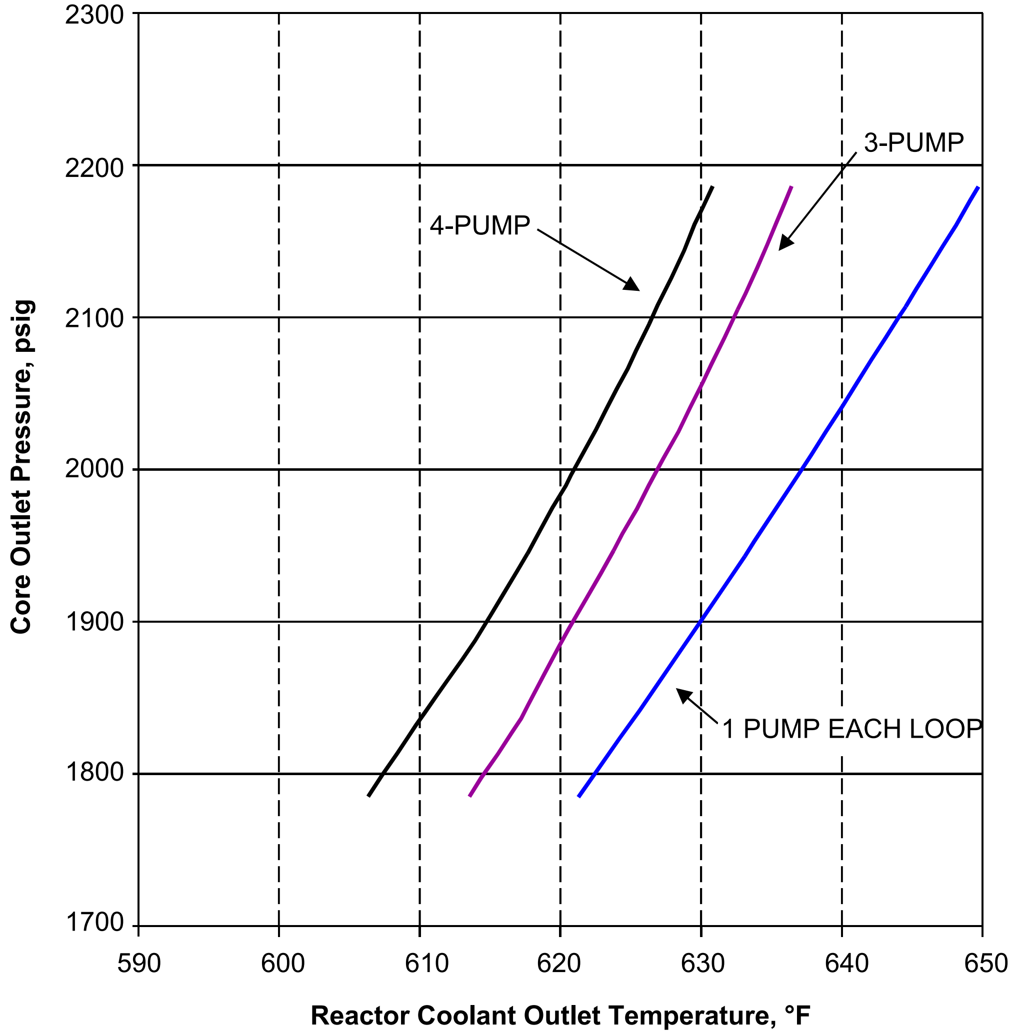
FIGURE 1

Variable Low RCS Pressure – Temperature Protective Limits

(Figure is referred to by Technical Specification 2.1.1.3)



PUMPS OPERATING (TYPE OF LIMIT)	GPM*	POWER**
FOUR PUMPS (DNBR LIMIT)	383,680 (100%)	110%
THREE PUMPS (DNBR LIMIT)	284,307 (74.1%)	89%
ONE PUMP IN EACH LOOP (DNBR LIMIT)	188,003 (49%)	62.2%

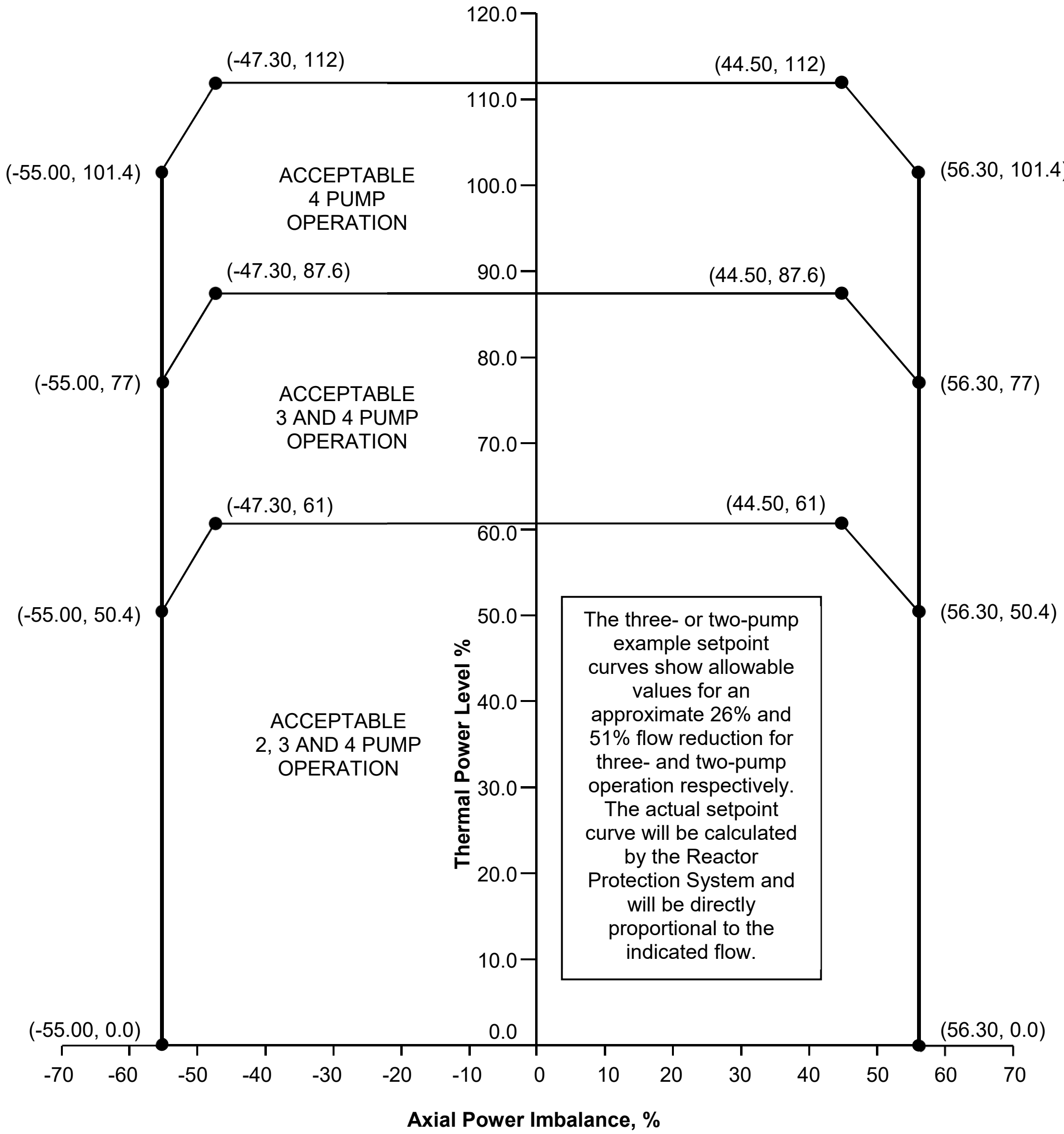
* 109% OF DESIGN FLOW (2.5% UNCERTAINTY INCLUDED IN STATISTICAL DESIGN LIMIT)

** AN ADDITIONAL 2% POWER UNCERTAINTY IS INCLUDED IN STATISTICAL DESIGN LIMIT

Figure 2

AXIAL POWER IMBALANCE PROTECTIVE LIMITS
(measurement system independent)

(Figure is referred to by Technical Specification 2.1.1 Bases)



SHUTDOWN MARGIN (SDM)

(Limits are referred to by Technical Specifications 3.1.1, 3.1.4, 3.1.5, 3.1.8, 3.1.9, and 3.3.9)

Verify SHUTDOWN MARGIN per the table below.

APPLICABILITY	REQUIRED SHUTDOWN MARGIN	TECHNICAL SPECIFICATION REFERENCE
MODE 1*	≥ 1 %Δk/k	3.1.4, 3.1.5
MODE 2*	≥ 1 %Δk/k	3.1.4, 3.1.5, 3.3.9
MODE 3	≥ 1 %Δk/k	3.1.1, 3.3.9
MODE 4	≥ 1 %Δk/k	3.1.1, 3.3.9
MODE 5	≥ 1 %Δk/k	3.1.1, 3.3.9
MODE 1 PHYSICS TESTS Exceptions**	≥ 1 %Δk/k	3.1.8
MODE 2 PHYSICS TESTS Exceptions	≥ 1 %Δk/k	3.1.9

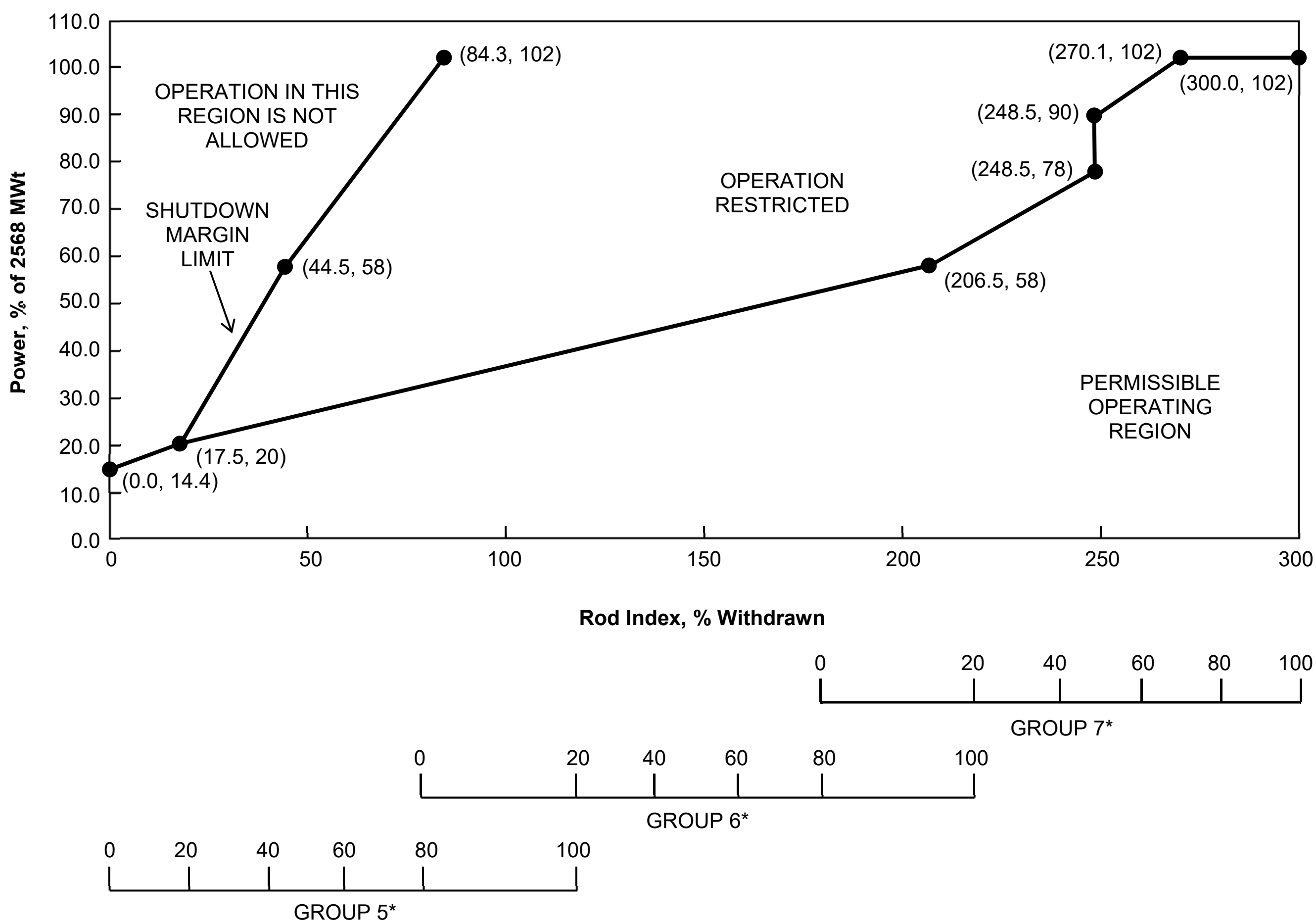
* The required Shutdown Margin capability of 1 %Δk/k in MODE 1 and MODE 2 is preserved by the Regulating Rod Insertion Limits specified in Figures 3-A&B, 4-A&B, and 5-A&B, as required by Technical Specification 3.2.1.

** Entry into Mode 1 Physics Tests Exceptions is not supported by existing analyses and as such requires <u>actual</u> shutdown margin to be ≥ 1 %Δk/k.

Figure 3-A

Regulating Rod Insertion Limits for Four-Pump Operation From 0 to 200 ± 10 EFPD

(Figure is referred to by Technical Specification 3.2.1)

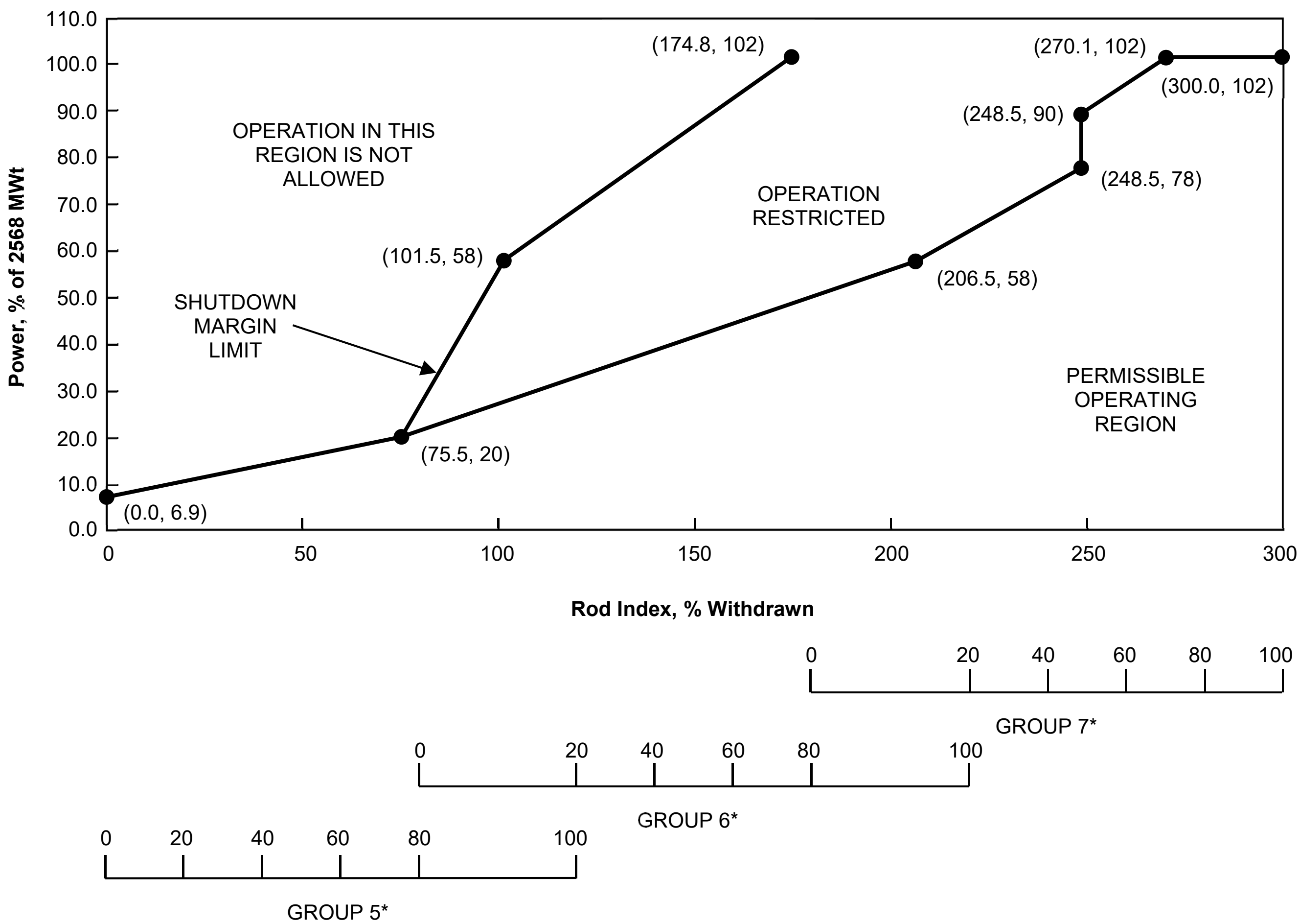


* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

Figure 3-B

Regulating Rod Insertion Limits for Four-Pump Operation From 200 ± 10 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.1)

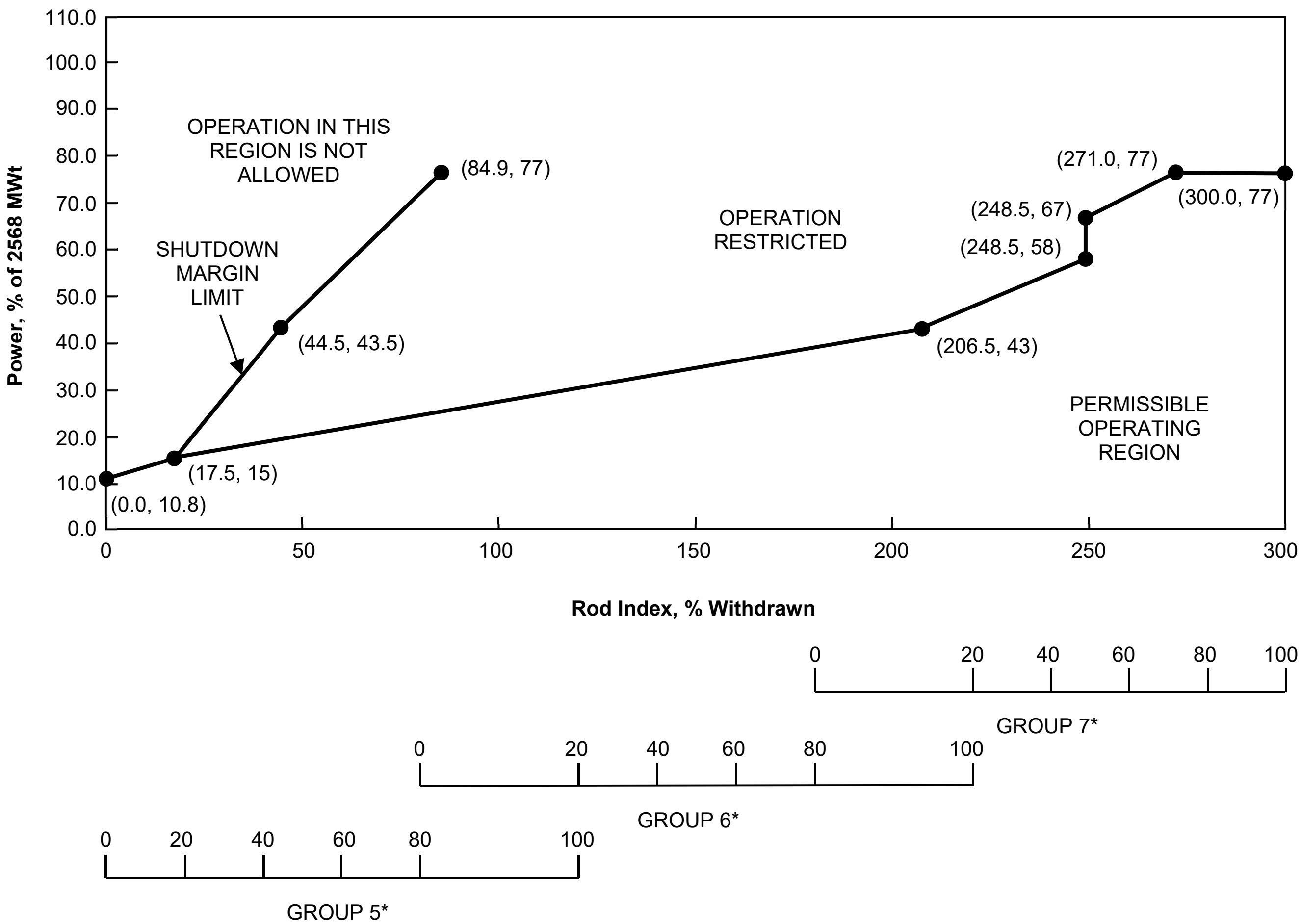


* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

Figure 4-A

Regulating Rod Insertion Limits for Three-Pump Operation From 0 to 200 ± 10 EFPD

(Figure is referred to by Technical Specification 3.2.1)

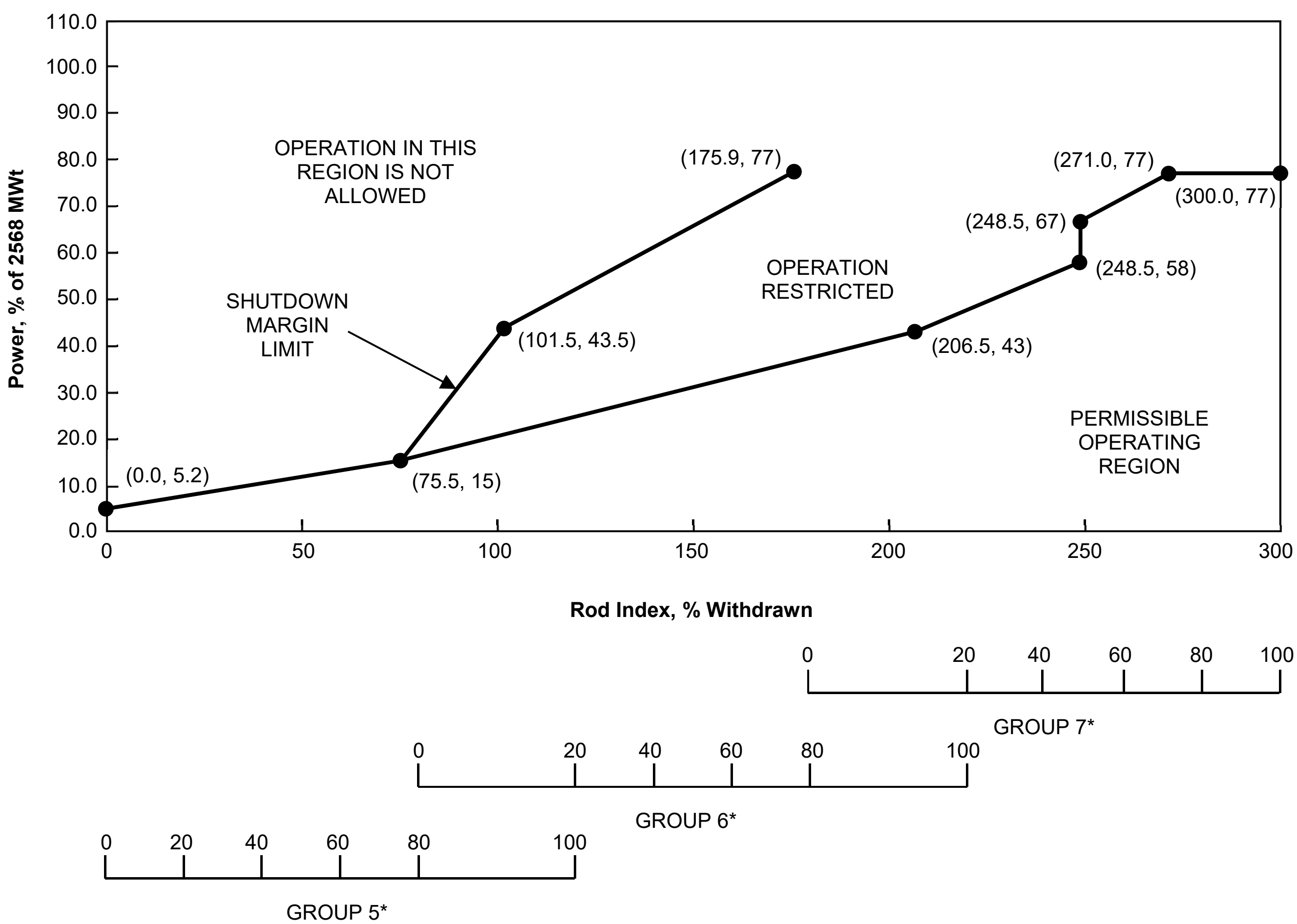


* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

Figure 4-B

Regulating Rod Insertion Limits for Three-Pump Operation From 200 ± 10 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.1)

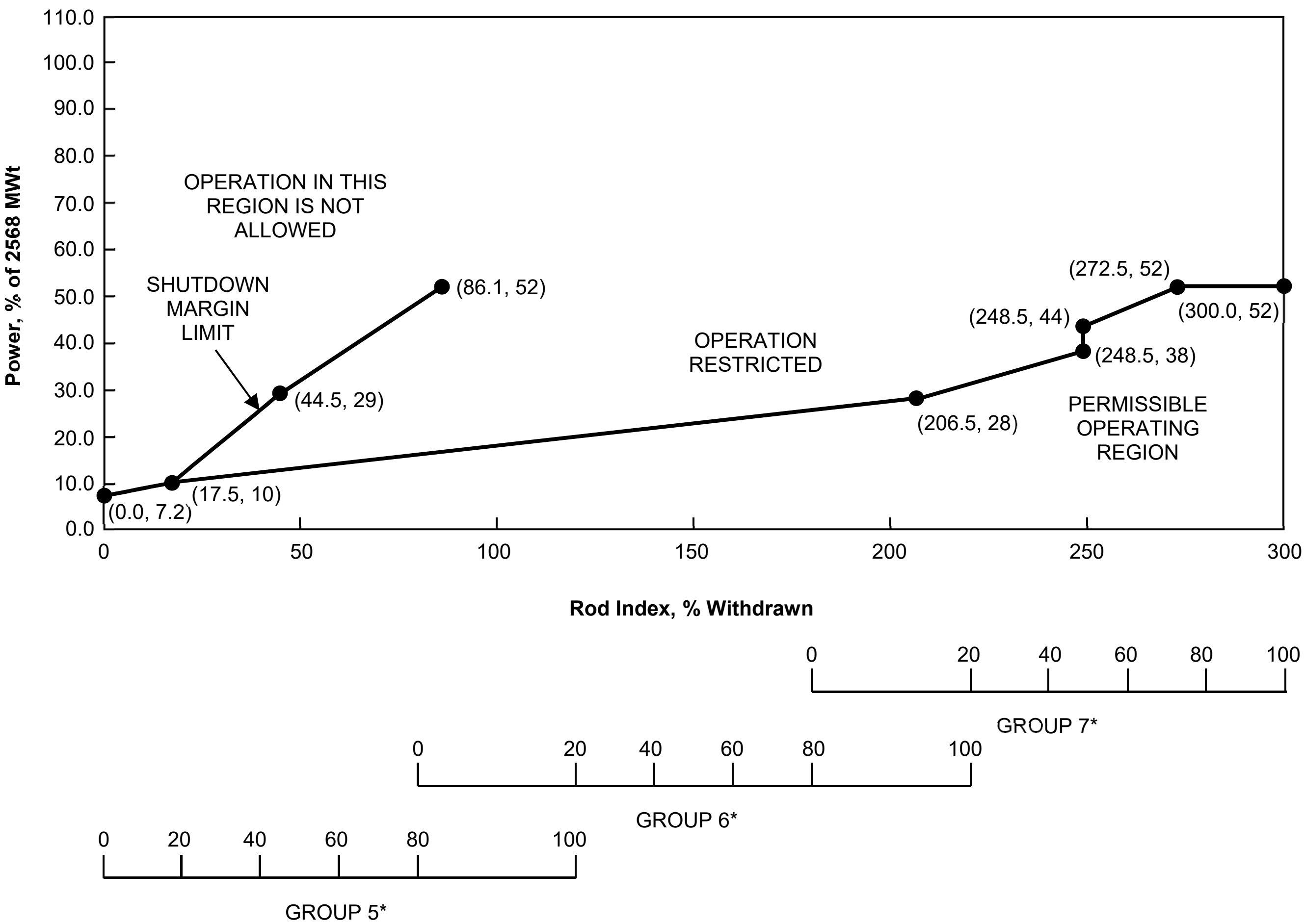


* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

Figure 5-A

Regulating Rod Insertion Limits for Two-Pump Operation From 0 to 200 ± 10 EFPD

(Figure is referred to by Technical Specification 3.2.1)

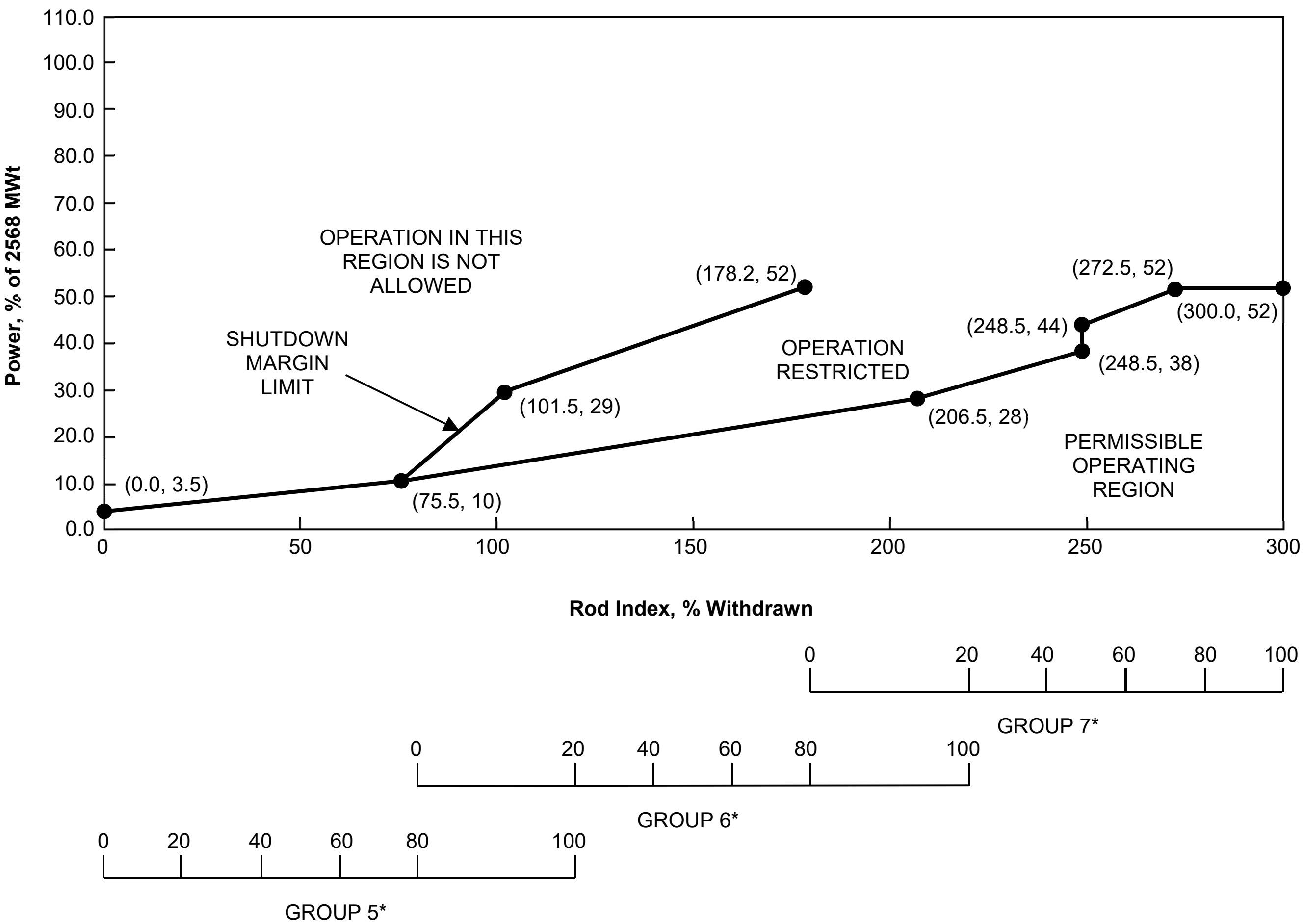


* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

Figure 5-B

Regulating Rod Insertion Limits for Two-Pump Operation From 200 ± 10 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.1)



* Operating rod group overlap is 20% ± 5% between two sequential groups, except for physics tests.

AXIAL POWER SHAPING RODS (APSR) INSERTION LIMITS

(Limits referred to by Technical Specification 3.2.2)

Up to 465 ± 10 EFPD, the APSRs may be positioned as necessary for transient imbalance control. However, the APSRs shall be fully withdrawn by 475 EFPD. After the APSR withdrawal at 465 ± 10 EFPD, the APSRs shall not be reinserted, except during the end of cycle shutdown when the reactor power is equal to, or less than, 30% FP.

Figure 6-A

AXIAL POWER IMBALANCE Setpoints for Full In-Core Conditions for Four-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

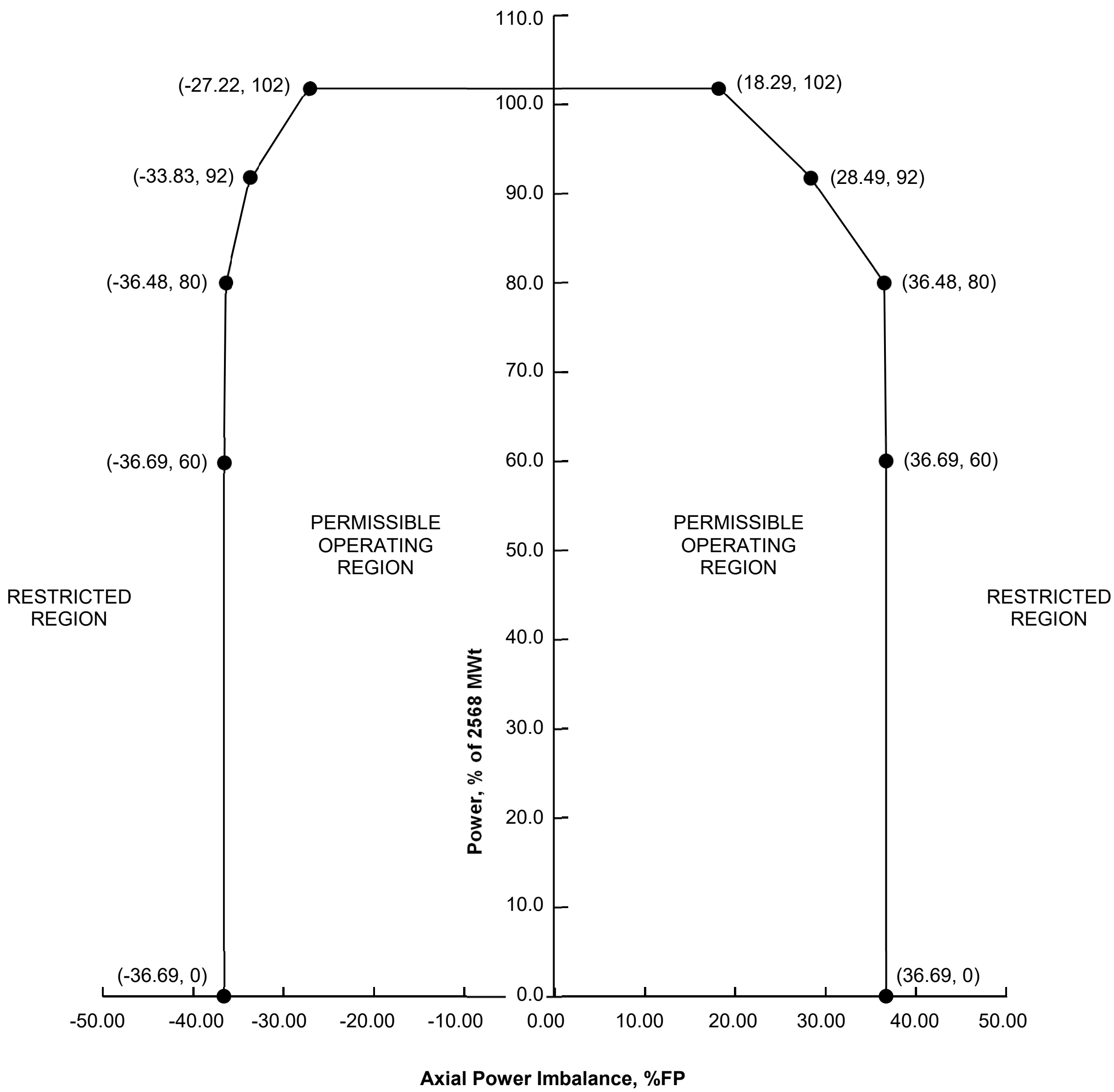
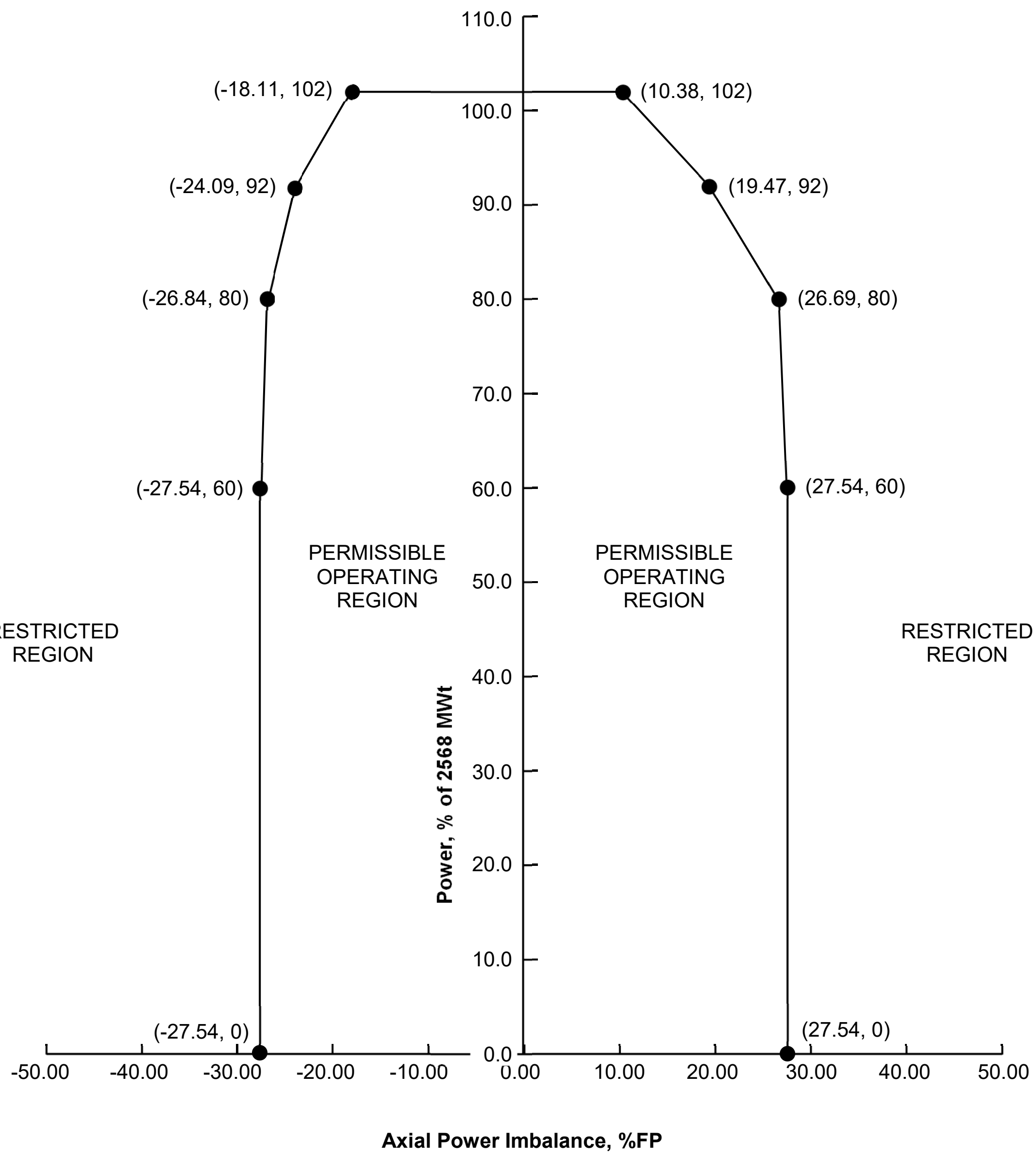


Figure 6-B

AXIAL POWER IMBALANCE Setpoints for Minimum In-Core Conditions* for Four-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)



* Assumes that no individual long emitter detector affecting the minimum incore imbalance calculation exceeds 73% sensitivity depletion. The imbalance setpoints for the minimum incore system must be reduced to 2.8% FP at the earliest time-in-life this assumption is no longer valid.

Figure 6-C

AXIAL POWER IMBALANCE Setpoints for Ex-Core Conditions for Four-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

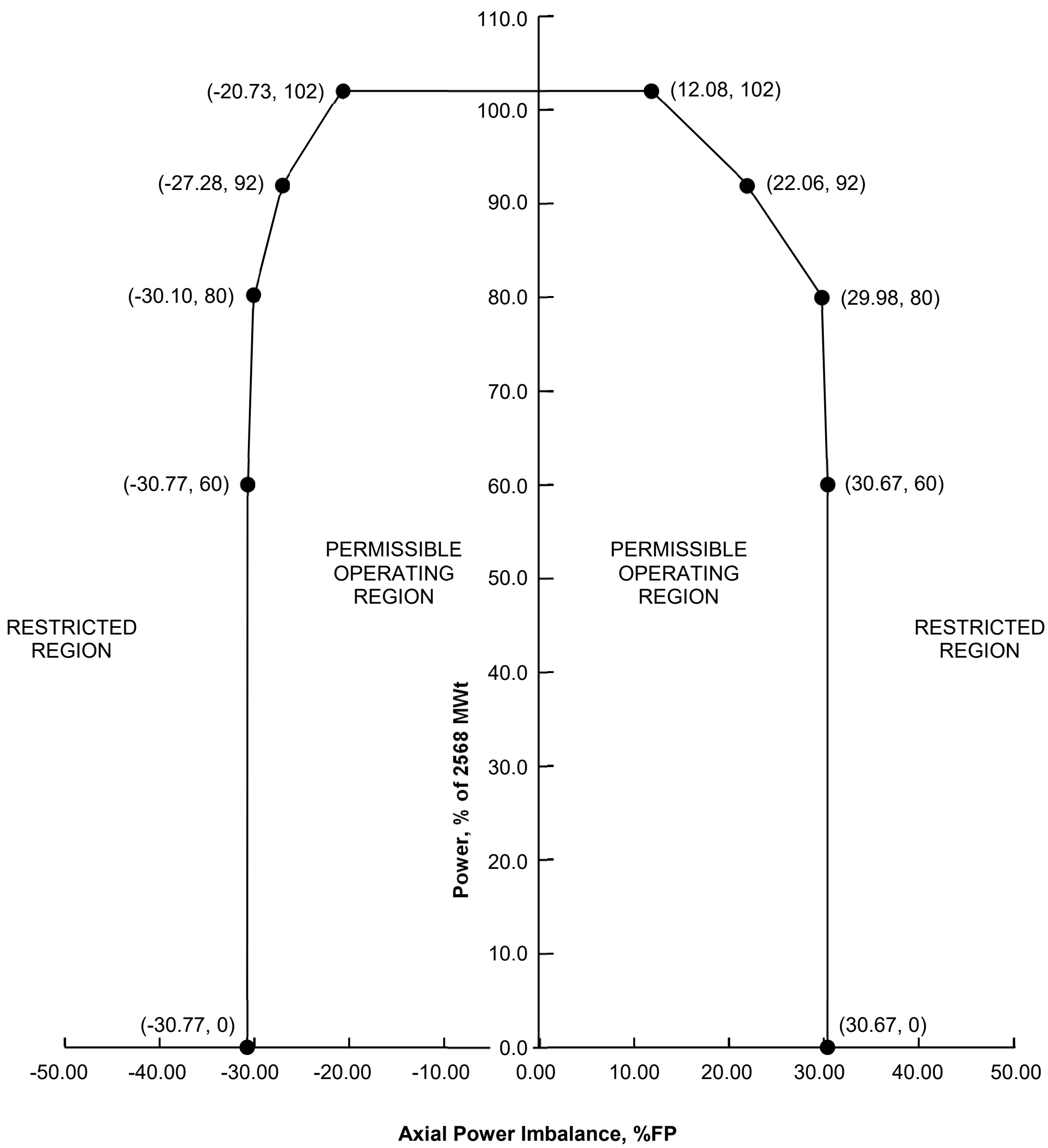


Figure 7-A

AXIAL POWER IMBALANCE Setpoints for Full In-Core Conditions for Three-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

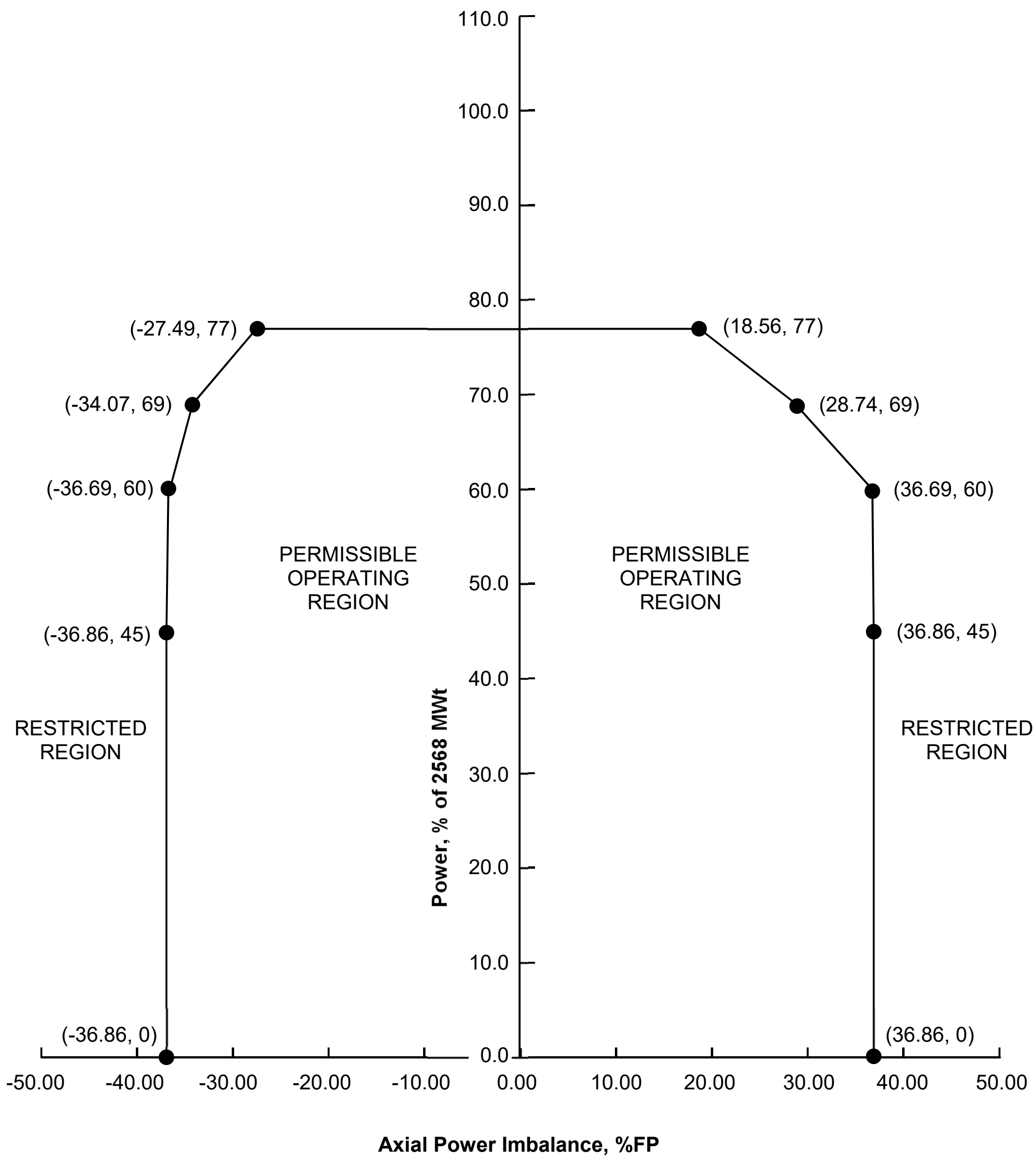
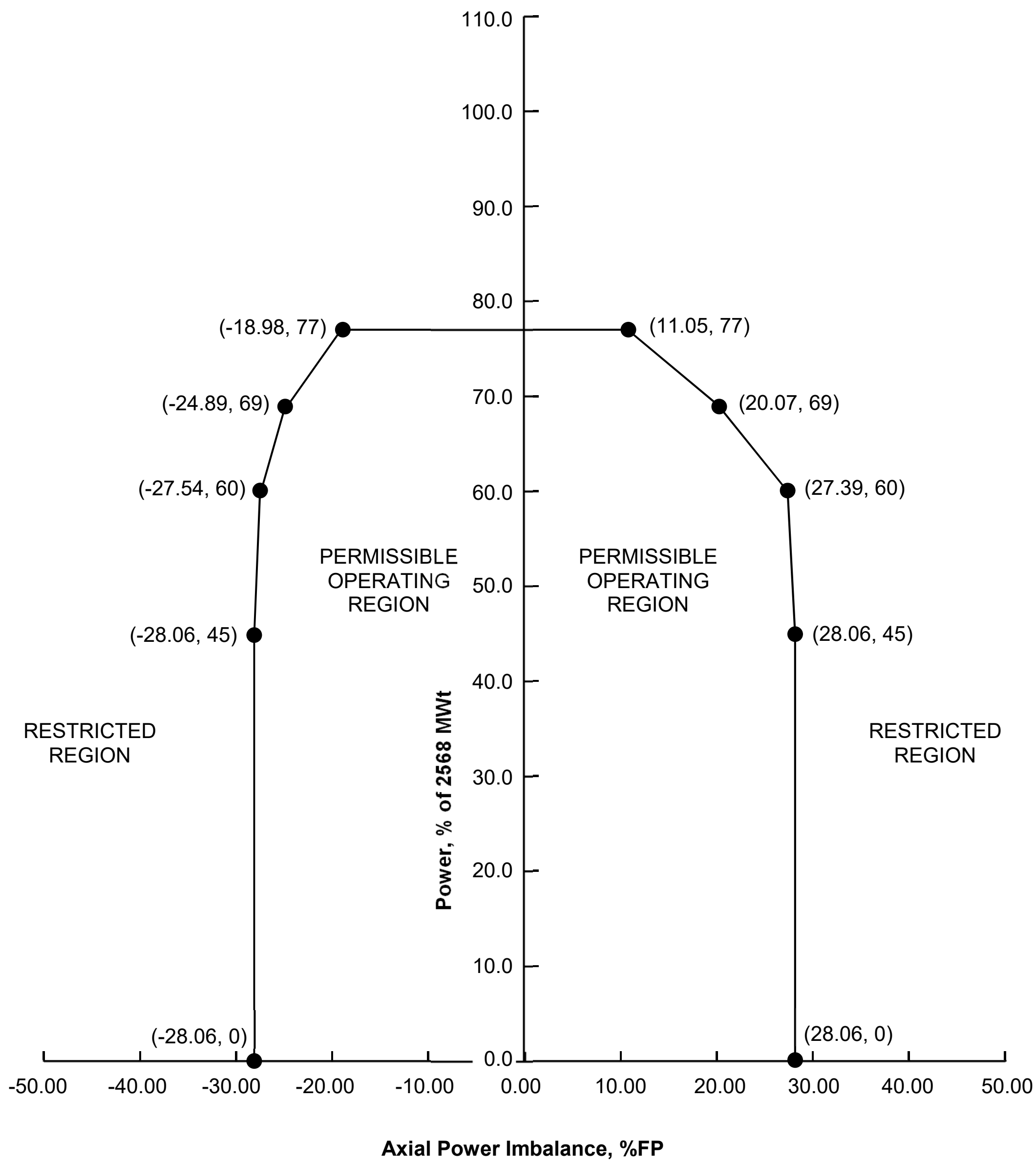


Figure 7-B

AXIAL POWER IMBALANCE Setpoints for Minimum In-Core Conditions* for Three-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)



* Assumes that no individual long emitter detector affecting the minimum incore imbalance calculation exceeds 73% sensitivity depletion. The imbalance setpoints for the minimum incore system must be reduced to 2.8% FP at the earliest time-in-life this assumption is no longer valid.

Figure 7-C

AXIAL POWER IMBALANCE Setpoints for Ex-Core Conditions for Three-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

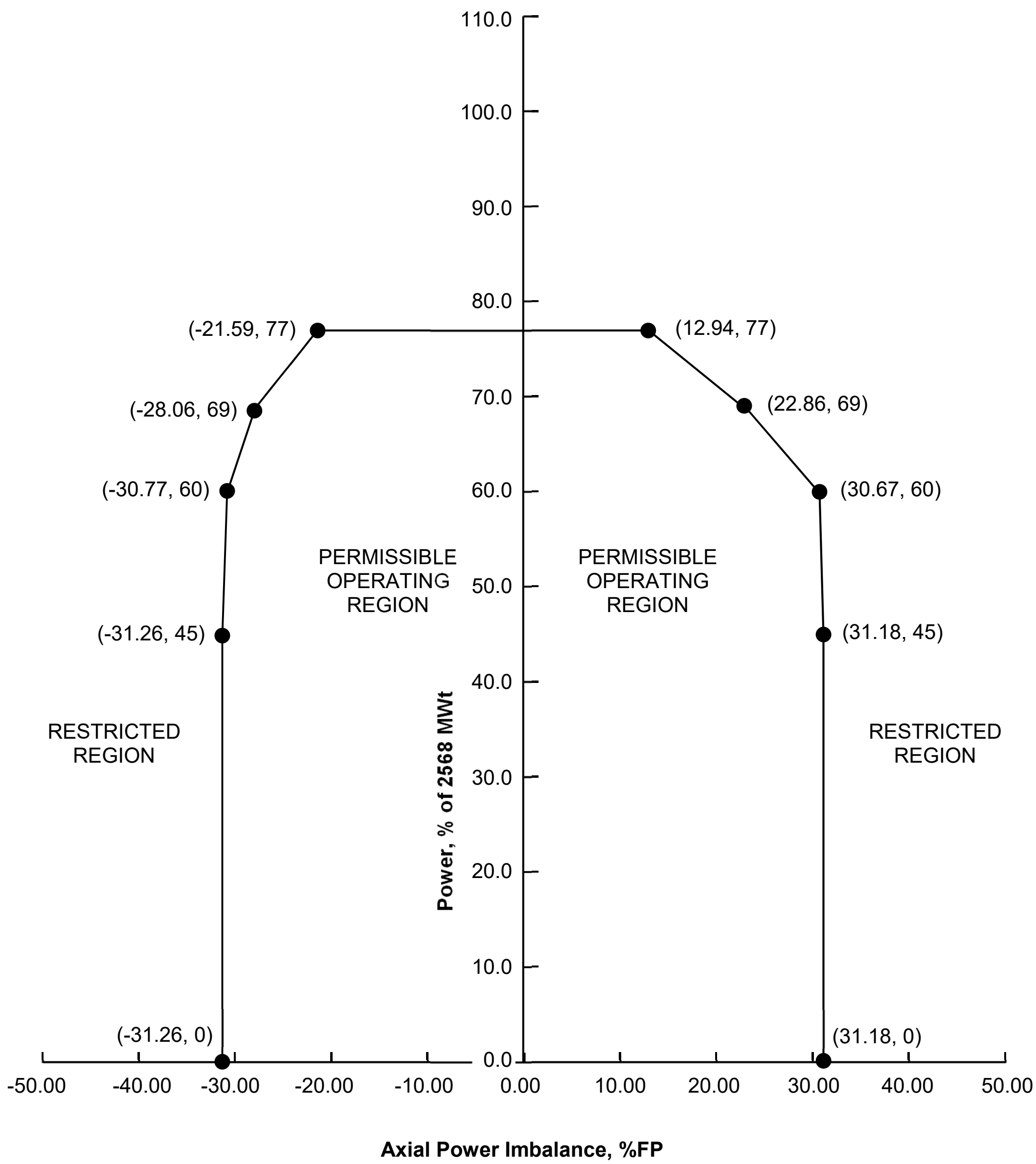


Figure 8-A

AXIAL POWER IMBALANCE Setpoints for Full In-Core Conditions for Two-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

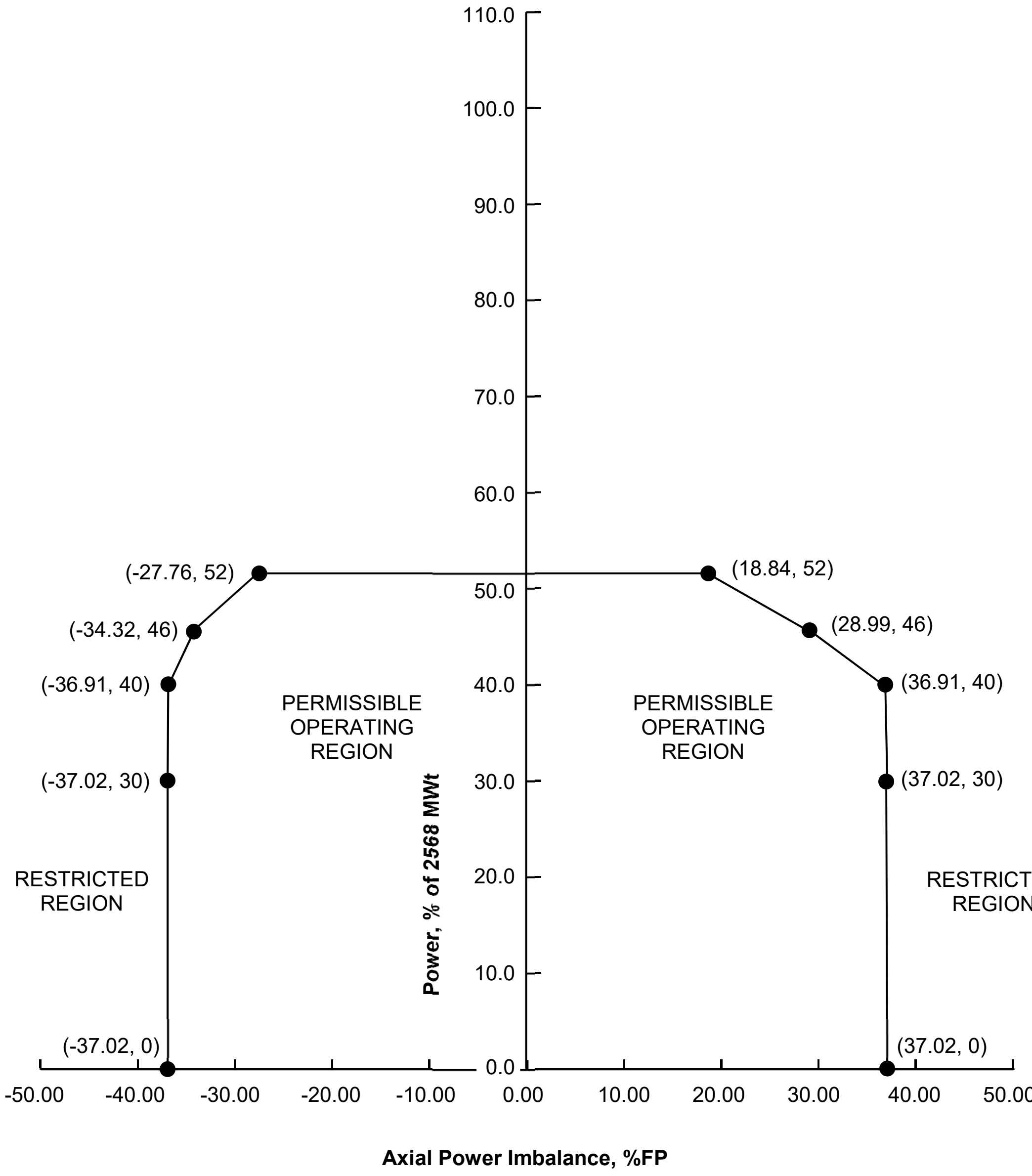
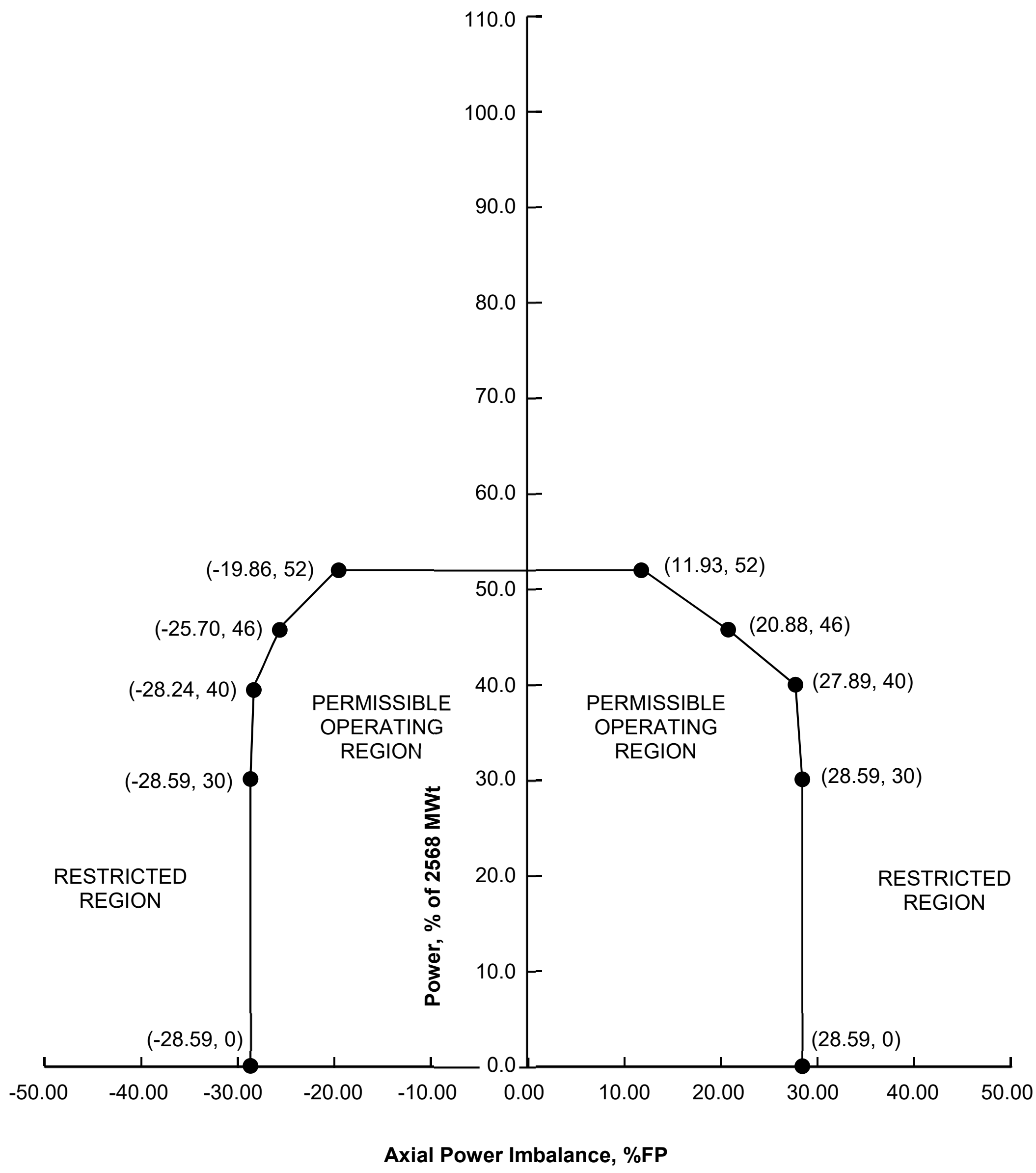


Figure 8-B

AXIAL POWER IMBALANCE Setpoints for Minimum In-Core Conditions* for Two-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)

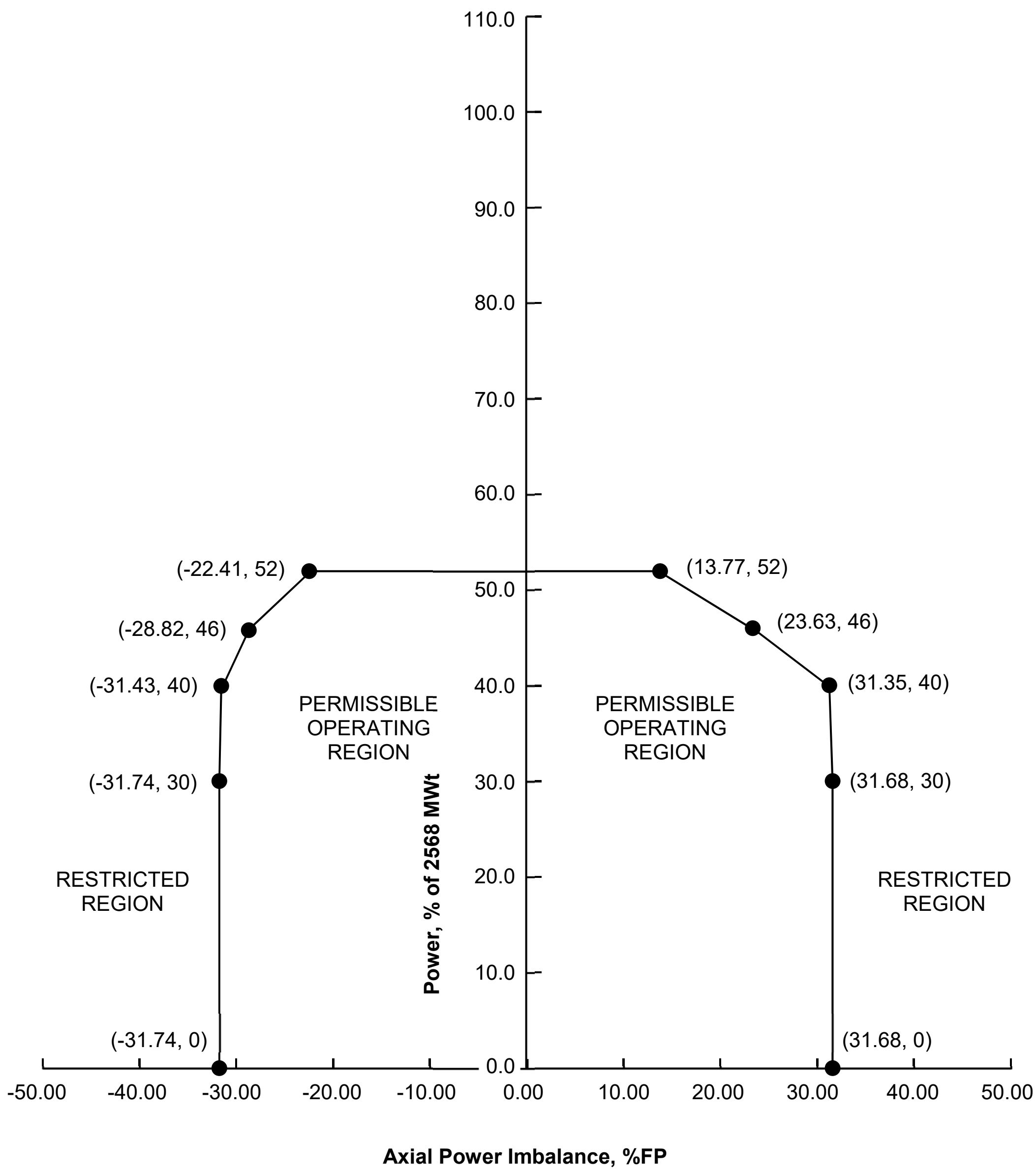


* Assumes that no individual long emitter detector affecting the minimum incore imbalance calculation exceeds 73% sensitivity depletion. The imbalance setpoints for the minimum incore system must be reduced to 2.8% FP at the earliest time-in-life this assumption is no longer valid.

Figure 8-C

AXIAL POWER IMBALANCE Setpoints for Ex-Core Conditions for Two-Pump Operation from 0 EFPD to EOC

(Figure is referred to by Technical Specification 3.2.3)



Quadrant Power Tilt Limits and Setpoints

(Limits are referred to by Technical Specification 3.2.4)

From 0 EFPD to EOC

Measurement System	Steady State Value (%)		Maximum Value (%)
	≤ 60 % FP	> 60 % FP	
Full In-core Detector System Setpoint	6.83	5.50	25.00
Minimum In-core Detector System Setpoint	2.78*	1.90*	25.00
Ex-core Power Range NI Channel Setpoint	4.05	1.96	25.00
Measurement System Independent Limit	7.50	4.92	25.00

* Assumes that no individual long emitter detector affecting the minimum in-core tilt calculation exceeds 73% sensitivity depletion. The setpoint must be reduced to 1.50% (power levels > 60% FP) and to 2.19% (power levels ≤ 60% FP) at the earliest time-in-life that this assumption is no longer valid.

Figure 9A

LOCA Linear Heat Rate Limits for Mark-B-HTP Fuel

(Figure is referred to by Technical Specification 3.1.8 and 3.2.5)

Allowable LOCA LHR Limits			
Core Elevation, ft	**LHR Limit for 0 MWd/mtU, kW/ft**	**LHR Limit for 28,000 MWd/mtU, kW/ft**	**LHR Limit for 62,000 MWd/mtU, kW/ft**
0.000	16.60	16.60	12.30
2.506	17.50	17.50	13.00
4.264	17.50	17.50	13.00
6.021	17.30	17.30	13.00
7.779	17.50	17.50	13.00
9.536	17.30	17.30	13.00
11.000	15.30	15.30	12.50
12.000	14.50	14.50	12.30

Allowable LOCA LHR Limits – Chrome-Coated Fuel Rods Only			
Core Elevation, ft	**LHR Limit for 0 MWd/mtU, kW/ft**	**LHR Limit for 28,000 MWd/mtU, kW/ft**	**LHR Limit for 62,000 MWd/mtU, kW/ft**
0.000	15.70	15.70	11.60
2.506	16.60	16.60	12.30
4.264	16.60	16.60	12.30
6.021	16.40	16.40	12.30
7.779	16.60	16.60	12.30
9.536	15.10	15.10	12.30
11.000	12.50	12.50	11.50
12.000	11.80	11.80	10.90

Note: The LOCA LHR limits may be linearly interpolated as a function of burnup between 0 MWd/mtU and 28,000 MWd/mtU, between 28,000 MWd/mtU and 62,000 MWd/mtU, and as a function of core elevation.

DNB Power Peaking Factors

(Limits are referred to by Technical Specification 3.1.8 and 3.2.5)

The following total power peaking factors define the Maximum Allowable Peaking (MAP) limits to protect the initial conditions assumed in the DNB Loss of Flow transient analysis. The total power peaking factors for IC-DNB 4-pump and 3-pump are identical; hence one set of IC-DNB values are provided for both 4-pump and 3-pump operation.

IC-DNB Total Power Peaking Factors

Mark-B-HTP								
Axial Peak	**x/L**	**IC MAP Limits**	**Axial Peak**	**x/L**	**IC MAP Limits**	**Axial Peak**	**x/L**	**IC MAP Limits**
	0.01	2.04426		0.01	2.94000		0.01	3.20469
	0.14	2.04515		0.14	2.94000		0.14	3.20469
	0.20	2.04535		0.20	2.93545		0.20	3.15423
	0.30	2.04551		0.30	2.84715		0.30	3.08083
	0.40	2.04470		0.40	2.76077		0.40	2.98064
1.1	0.50	2.04437	1.4	0.50	2.66671	1.7	0.50	2.89369
	0.60	2.04415		0.60	2.55808		0.60	2.78037
	0.70	2.04400		0.70	2.46508		0.70	2.68552
	0.80	2.04329		0.80	2.34973		0.80	2.56207
	0.89	2.00109		0.89	2.27714		0.89	2.49021
	0.99	1.90427		0.99	2.18525		0.99	2.39515
	0.01	2.33088		0.01	3.08066		0.01	3.24949
	0.14	2.33287		0.14	3.08066		0.14	3.24949
	0.20	2.33339		0.20	3.03513		0.20	3.20303
	0.30	2.33352		0.30	2.93856		0.30	3.13047
	0.40	2.33338		0.40	2.84115		0.40	3.04037
1.2	0.50	2.33285	1.5	0.50	2.75216	1.8	0.50	2.95027
	0.60	2.33232		0.60	2.63946		0.60	2.84225
	0.70	2.26721		0.70	2.54429		0.70	2.74696
	0.80	2.16931		0.80	2.42655		0.80	2.62489
	0.89	2.10460		0.89	2.35382		0.89	2.55373
	0.99	2.00767		0.99	2.26040		0.99	2.45882
	0.01	2.64464		0.01	3.14861		0.01	3.28611
	0.14	2.64863		0.14	3.14861		0.14	3.28611
	0.20	2.64909		0.20	3.09918		0.20	3.24461
	0.30	2.64997		0.30	3.01573		0.30	3.17163
	0.40	2.64949		0.40	2.91490		0.40	3.08589
1.3	0.50	2.56272	1.6	0.50	2.82718	1.9	0.50	3.00025
	0.60	2.46600		0.60	2.71210		0.60	2.89826
	0.70	2.37484		0.70	2.61653		0.70	2.80288
	0.80	2.26452		0.80	2.49634		0.80	2.68386
	0.89	2.19471		0.89	2.42370		0.89	2.61261
	0.99	2.09988		0.99	2.32955		0.99	2.51792

Notes

1. The values above are not error corrected.
2. The values above were generated using SCD methods which incorporate a 3.8% radial peak uncertainty in the DNBR design limit. Therefore, the above IC MAP limits can be compared to predicted peaks without the addition of up to 3.8% in radial peak calculation uncertainty. These limits, however, do not incorporate any grid bias uncertainty.
3. The present T-H methodology allows for an increase in the design radial-local peak for power levels below 100% full power. The equations defining the multipliers are as follows:

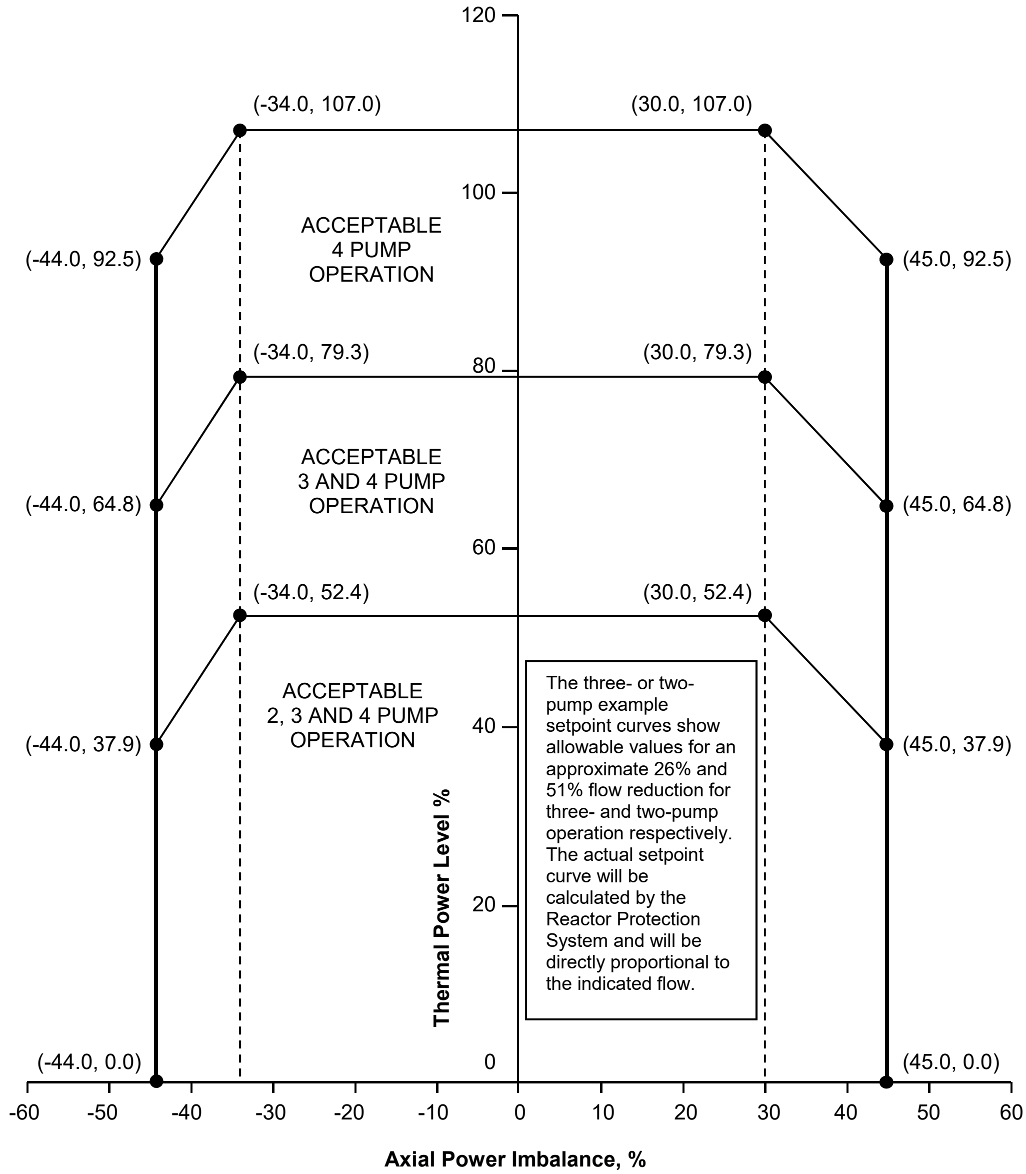
	$P/P_m = 1.00$	$P/P_m < 1.00$
MAP Multiplier	1.0	$1 + 0.3(1 - P/P_m)$

Where P = core power fraction, and
P_m = 1.00 for 4-pump operation, or
= 0.75 for 3-pump operation

Figure 10

Reactor Protection System Maximum Allowable Setpoints for Axial Power Imbalance

(Figure is referred to by Technical Specification 3.3.1 and Technical Specification Bases 2.1.1)

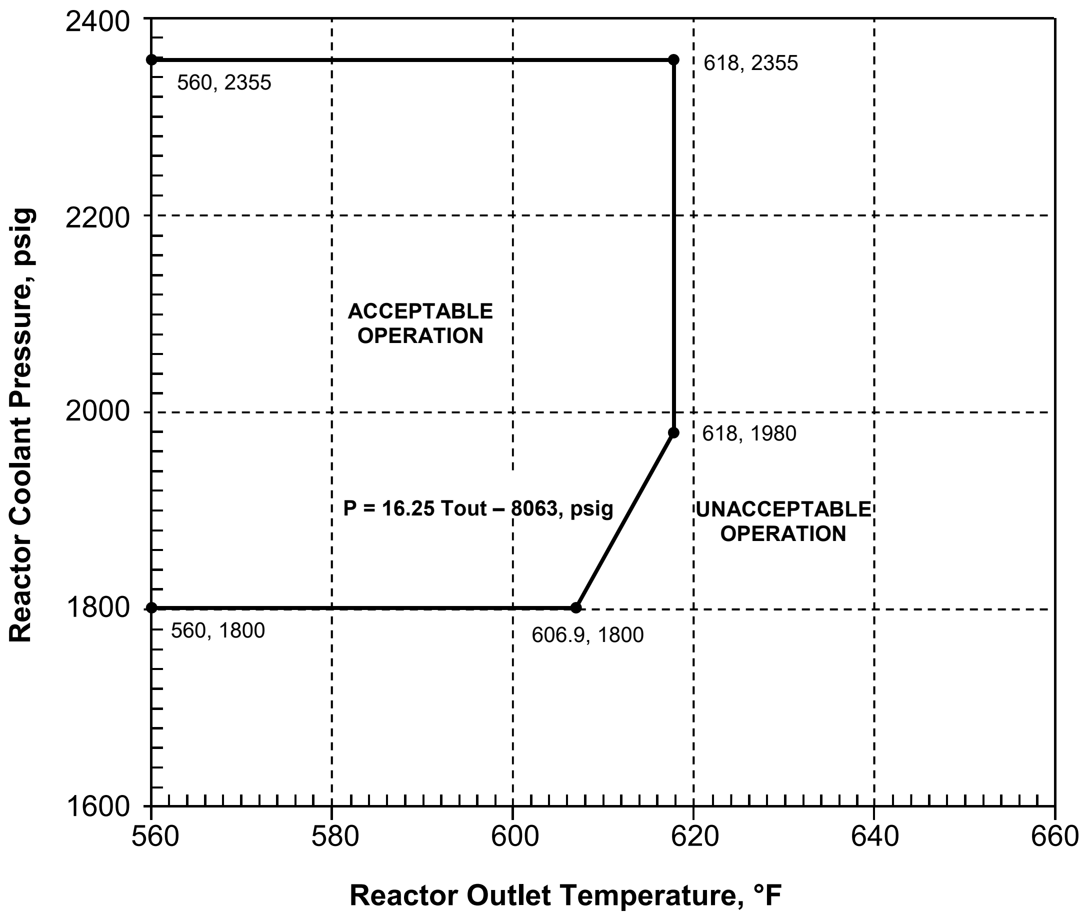


	Flux / Flow Setpoint (% Power / % Flow)
Four Pump Operation	1.07
Three Pump Operation	1.07
Two Pump Operation	1.07

Figure 11

Reactor Protection System Variable Low Pressure Temperature Envelope Setpoints

(Figure is referred to by Technical Specification 3.3.1)



RCS Pressure, Temperature, and Flow
DNB Surveillance Limits

(Limit is referred to by Technical Specification 3.4.1)

	Four-Pump Operation	Three-Pump Operation	Two-Pump Operation
Minimum RCS Hot Leg Pressure (psig) Note 1	2082.2	2081.2 Note 4 2120.4 Note 5	2118.1
Maximum RCS Hot Leg Temperature (°F) Note 2	602.6	602.9	603.15
Minimum RCS Total Flow (Mlb_m/hr) Note 3	143.36 Note 6 138.01 Note 9	106.46 Note 7 102.45 Note 9	70.64 Note 8 67.96 Note 9

Note 1 -- Using individual indications P1021, P1023, P1038 and P1039 (or equivalent) from the plant computer.

Note 2 -- Using individual indications T1011NR, T1014NR, T1039NR, T1042NR, T1012, T1013, T1040 and T1041 or averages TOUTA, XTOUTA, TOUTB, XTOUTB, TOUT, XTOUT from the plant computer.

Note 3 -- Using indication WRCFT (or equivalent) from the plant computer, and can be linearly interpolated between these values provided the T_{ave} versus Power level curve is followed.

Note 4 -- Applies to the RCS loop with two RCPs operating.

Note 5 -- Applies to the RCS loop with one RCP operating.

Note 6 -- For T_{cold} = 556.57 °F.

Note 7 -- For T_{cold} = 556.3 °F.

Note 8 -- For T_{cold} = 556.1 °F.

Note 9 -- For T_{cold} = 580 °F.

RCS Loops – Mode 1 and Mode 2

(Limit is referred to by Technical Specification 3.4.4)

	Nominal Operating Power Level (% Power)
Four Pump Operation	100
Three Pump Operation	75
Two Pump Operation*	49

* Technical Specification 3.4.4 does not allow indefinite operation in Modes 1 and 2 with only two pumps operating.

Refueling Boron Concentration

(Limit is referred to by Technical Specification 3.9.1)

The minimum required boron concentration (which includes uncertainties) for use during refueling as a function of the End of Cycle 28 (EOC-28) EFPD is:

EOC-28 EFPD	Refueling Boron (ppm)[1]
438	2212
441	2206
444	2200
447	2194
450	2188
453	2182
456	2176
459	2170
462	2164
465	2158
≥ 468	2152

[1] The Refueling Boron may be linearly interpolated as a function of EOC-28 EFPD between 438 and 468 EFPD.