energy harbor

Energy Harbor Nuclear Corp.
Davis-Besse Nuclear Power Station
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Terry J. Brown
Site Vice President, Davis-Besse Nuclear

419-321-7676

May 10, 2022
L-22-047

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No.1
Docket No. 50-346, License No. NPF-3
Core Operating Limits Report, Cycle 23, Revision 0 and Revision 1

Enclosed are Revision 0 and Revision 1 to the Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS) Cycle 23 Core Operating Limits Report (COLR). The only change in Revision 1 to the report is the correction of the cover page to remove the incorrect company name. Submittal of these revisions is in accordance with DBNPS Technical Specification 5.6.3, "CORE OPERATING LIMITS REPORT (COLR)."

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Phil H. Lashley, Manager - Fleet Licensing, at (330) 696-7208.

Sincerely,

Terry J. Brown

Enclosures:
1 Cycle 23, Core Operating Limits Report, Revision 0
2 Cycle 23, Core Operating Limits Report, Revision 1

cc: NRC Region III Administrator
NRC Resident Inspector
NRR Project Manager
Utility Radiological Safety Board

Enclosure 1
L-22-047

FirstEnergy Nuclear Operating Company
Davis-Besse Unit 1
Cycle 23, Core Operating Limits Report, Revision 0

(25 pages follow)

FIRSTENERGY NUCLEAR OPERATING COMPANY

DAVIS-BESSE UNIT 1

CYCLE 23

CORE OPERATING LIMITS REPORT

Prepared by _____ 2/21/22
D. B. Kelley

Reviewed by _____ 2/21/22
C. Glass

Approved by _____ 2/21/22
J. D. Brown

1.0 Core Operating Limits

This CORE OPERATING LIMITS REPORT for DB-1 Cycle 23 has been prepared in accordance with the requirements of Technical Specification 5.6.3. The Core Operating Limits have been developed using the methodology provided in Reference 2.0 (1). The licensed length of Cycle 23 is 700 EFPDs.

The following cycle-specific core Operating Limits, Protective Limit and Flux -∆ Flux -Flow Reactor Protection System Allowable Values are included in this report:

1. SL 2.1.1.1 Reactor Core Safety Limits
2. LCO 3.1.1 SHUTDOWN MARGIN (SDM)
3. LCO 3.1.3 Moderator Temperature Coefficient (MTC)
4. LCO 3.1.7 Position Indicator Channels
5. LCO 3.1.8 PHYSICS TESTS Exceptions – MODE 1
6. LCO 3.1.9 PHYSICS TESTS Exceptions – MODE 2
7. LCO 3.2.1 Regulating Rod Insertion Limits
8. LCO 3.2.2 AXIAL POWER SHAPING ROD (APSR) Insertion Limits
9. LCO 3.2.3 AXIAL POWER IMBALANCE Operating Limits
10. LCO 3.2.4 QUADRANT POWER TILT (QPT)
11. LCO 3.2.5 Power Peaking Factors
12. LCO 3.3.1 Reactor Protection Systems (RPS) Instrumentation
    Function 8: (Flux - ∆Flux – Flow) Allowable Values
13. LCO 3.9.1 Boron Concentration
14. TRM 8.1.3 Rod Program

2.0 References

1) BAW-10179P-A, Rev. 9, “Safety Criteria and Methodology for Acceptable Cycle Reload Analyses”, November 2017.

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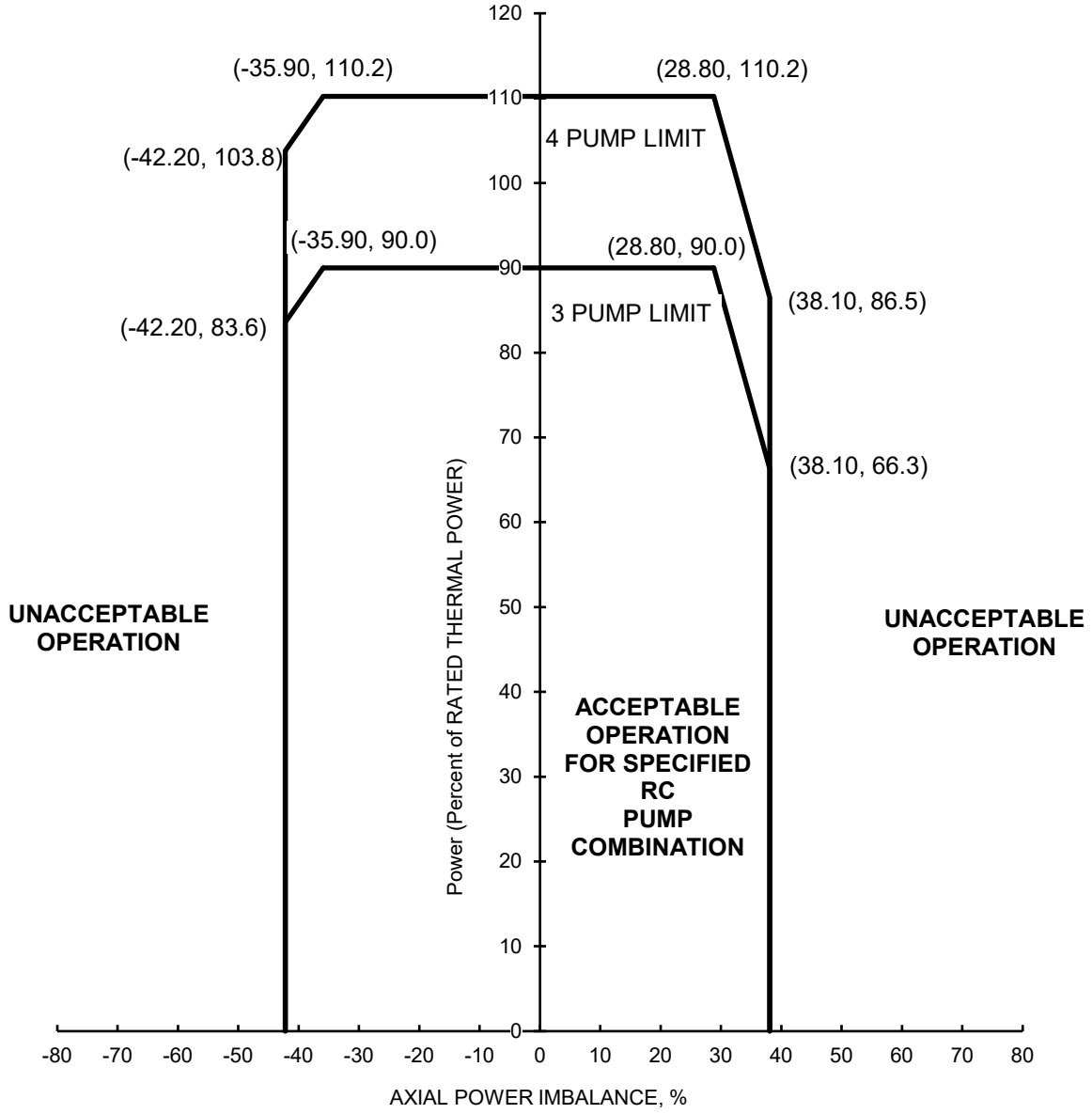
Figure 1 AXIAL POWER IMBALANCE Protective Limits
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 2.1.1.1



Pumps Operating	Reactor Coolant Flow, gpm	Required Measured Flow to Ensure Compliance, gpm
4	380,000	389,500
3	283,860	290,957

4 Pump		
Power Level	Negative Imbalance	Positive Imbalance
110.2	-35.90	28.80
103.8	-42.20	---
86.5	-42.20	38.10
0.0	-42.20	38.10

3 Pump		
Power Level	Negative Imbalance	Positive Imbalance
90.0	-35.90	28.80
83.6	-42.20	---
66.3	-42.20	38.10
0.0	-42.20	38.10

Table 1 Shutdown Margin Requirements for Davis-Besse, Cycle 23

Verify SHUTDOWN MARGIN per the table below.

APPLICABILITY	REQUIRED SHUTDOWN MARGIN	TECHNICAL SPECIFICATIONS 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 2a through 2d as required by Technical Specification 3.2.1.

** Entry into Mode 1 Physics Tests Exceptions is not supported by existing analyses. For example, Regulating Rod Shutdown Margin Insertion Limits assumptions may not be met and as such requires actual shutdown margin to be ≥ 1 %Δk/k via alternate verification or calculation.

***For the period from 0 to 300 EFPD and for power levels 60 %FP and above, rod insertion limits are established that reserve an additional 0.5 %Δk/k required rod worth to accommodate the SBLOCA model.

Table 2 Moderator Temperature Coefficient Limit for Davis-Besse, Cycle 23

These limits are referred to by Technical Specifications 3.1.3

1. Lower Limit:

   MTC at HFP ≥ -4.000x10^{-4} Δk/k/°F (-40.00 pcm/°F)

2. The following Upper Limits may not be exceeded without prior NRC approval:

   MTC <0.9 x 10^{-4} Δk/k/°F when Thermal Power <95% RTP

   MTC <0.0 x 10^{-4} Δk/k/°F when Thermal Power ≥95% RTP

3. The following Upper Limits may not be exceeded for operation in Modes 1 and 2:

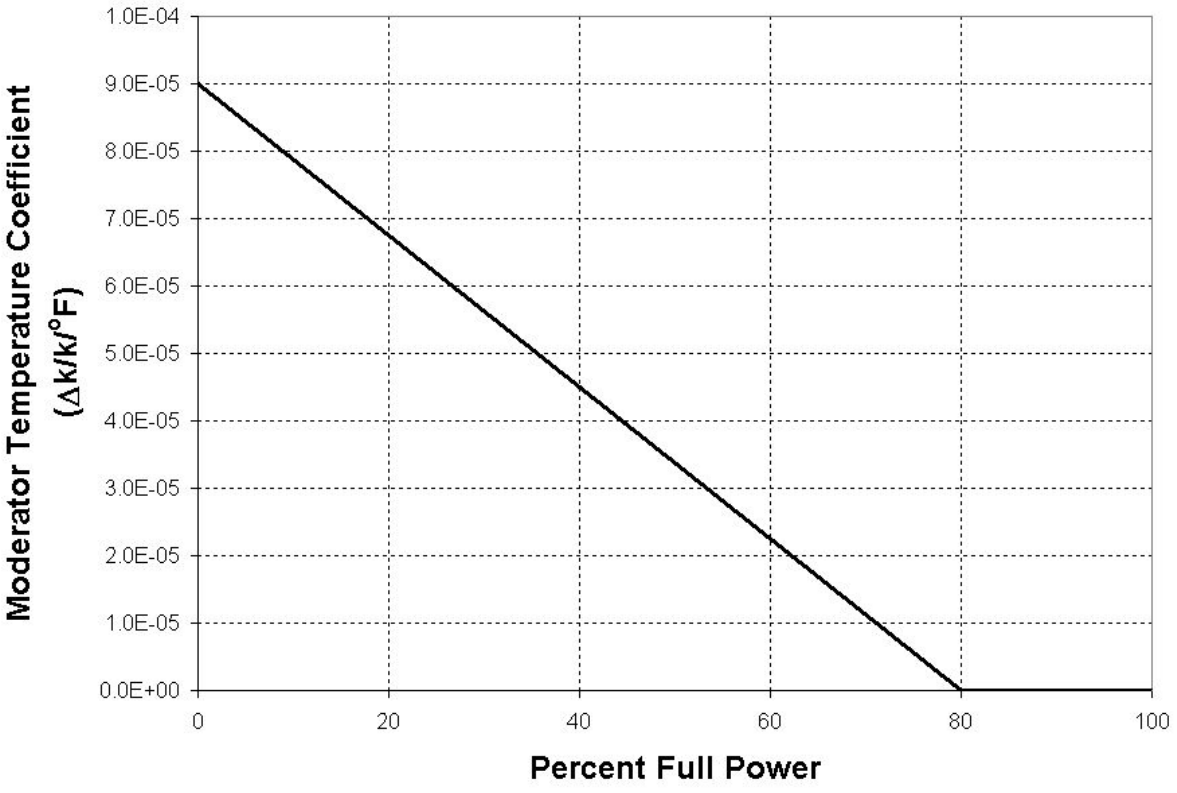


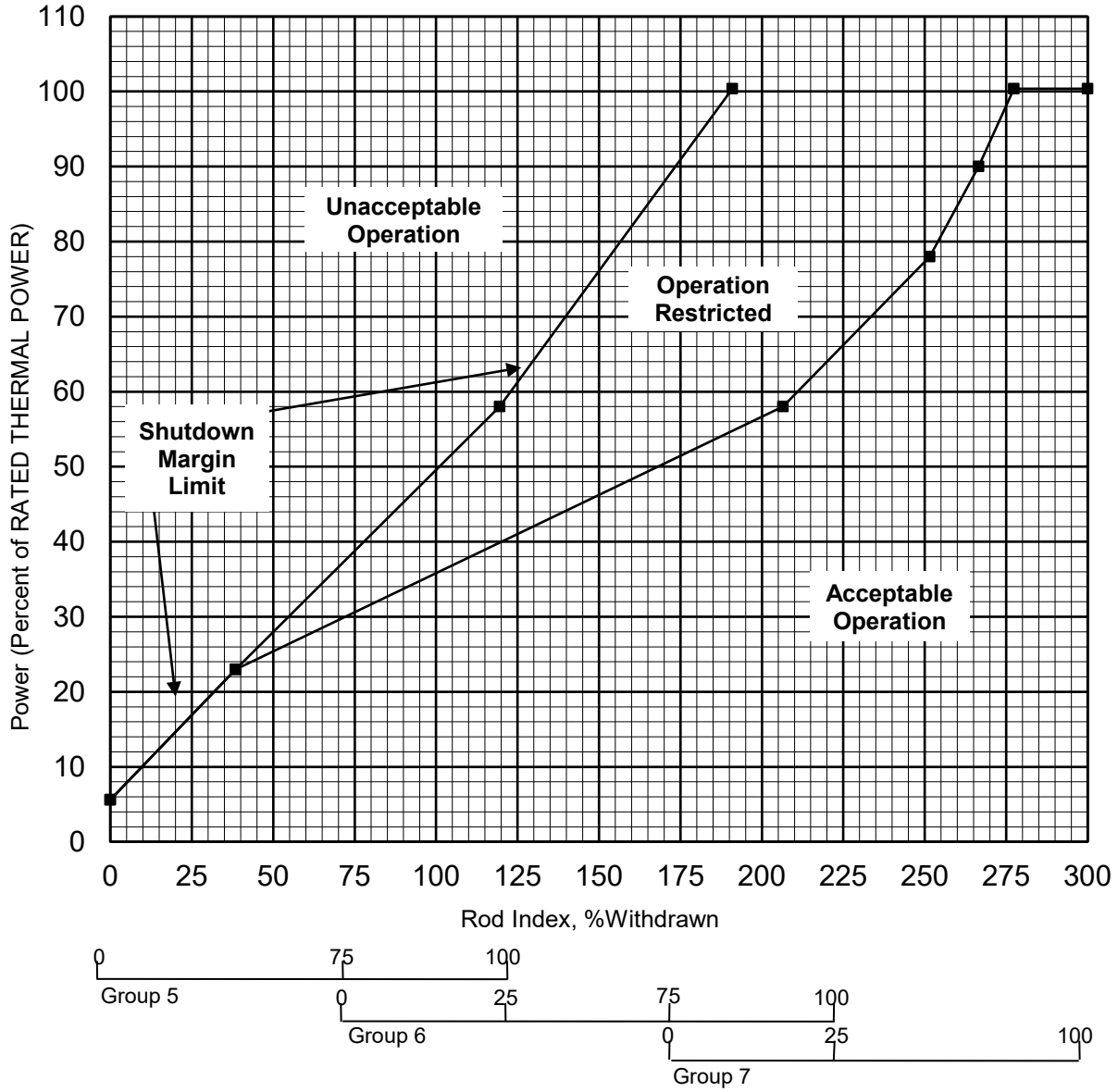
Table 3 Absolute Position Indicator (API) / Relative Position Indicator (RPI) Agreement Limit for Davis-Besse, Cycle 23

This limit is referred to by Technical Specifications 3.1.7

The absolute position indicator channels and the relative position indicator channels agree within 3.00%.

Figure 2a Regulating Group Position Operating Limits
0 to 300 ±10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



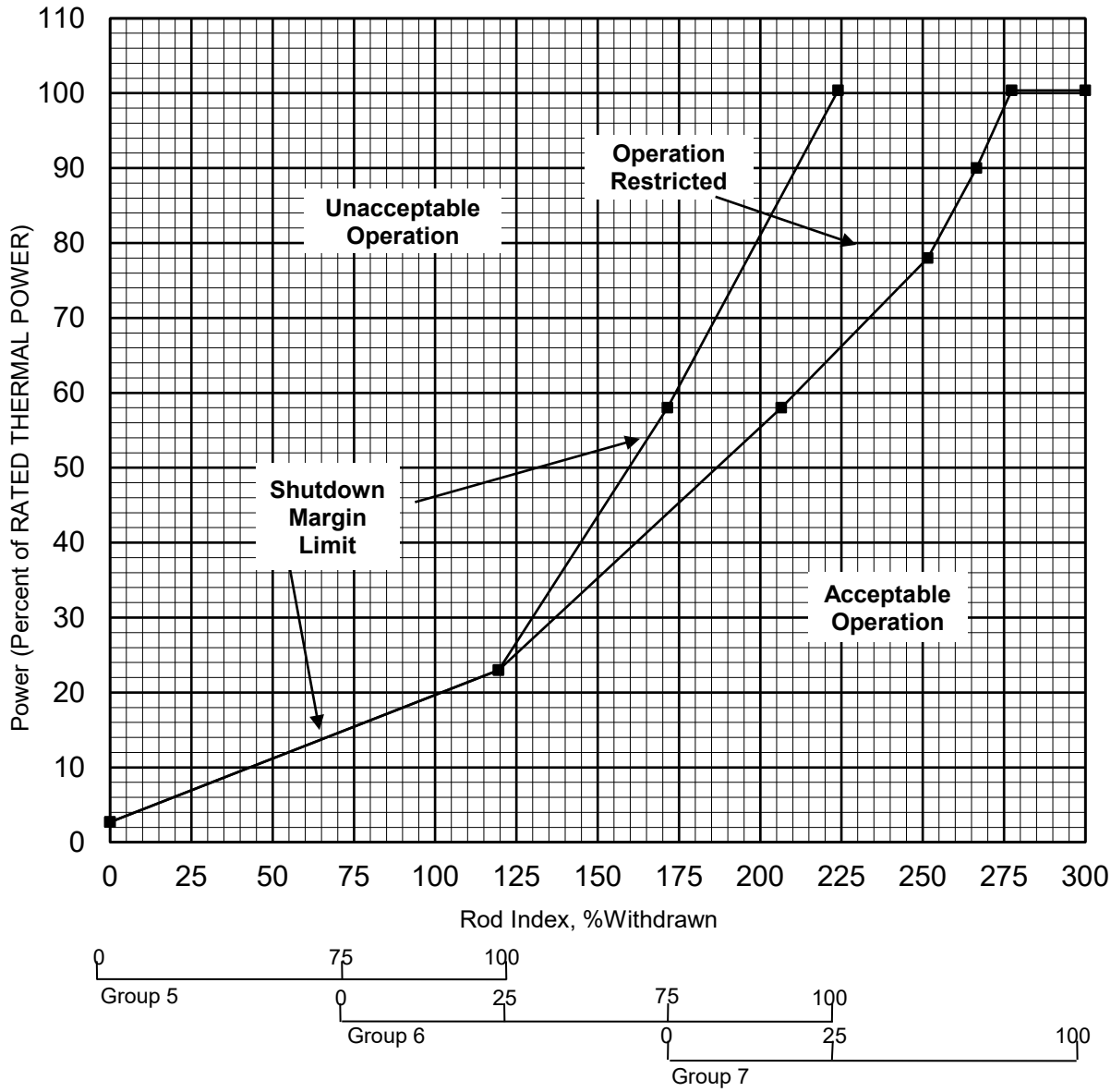
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	190.90
58.00	119.50
23.00	38.50
5.60	0.00

RI Limit	
Power	RI
100.37	300.00
100.37	277.40
90.00	266.50
78.00	251.50
58.00	206.50
23.00	38.50
5.60	0.00

Figure 2b Regulating Group Position Operating Limits
After 300 ±10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



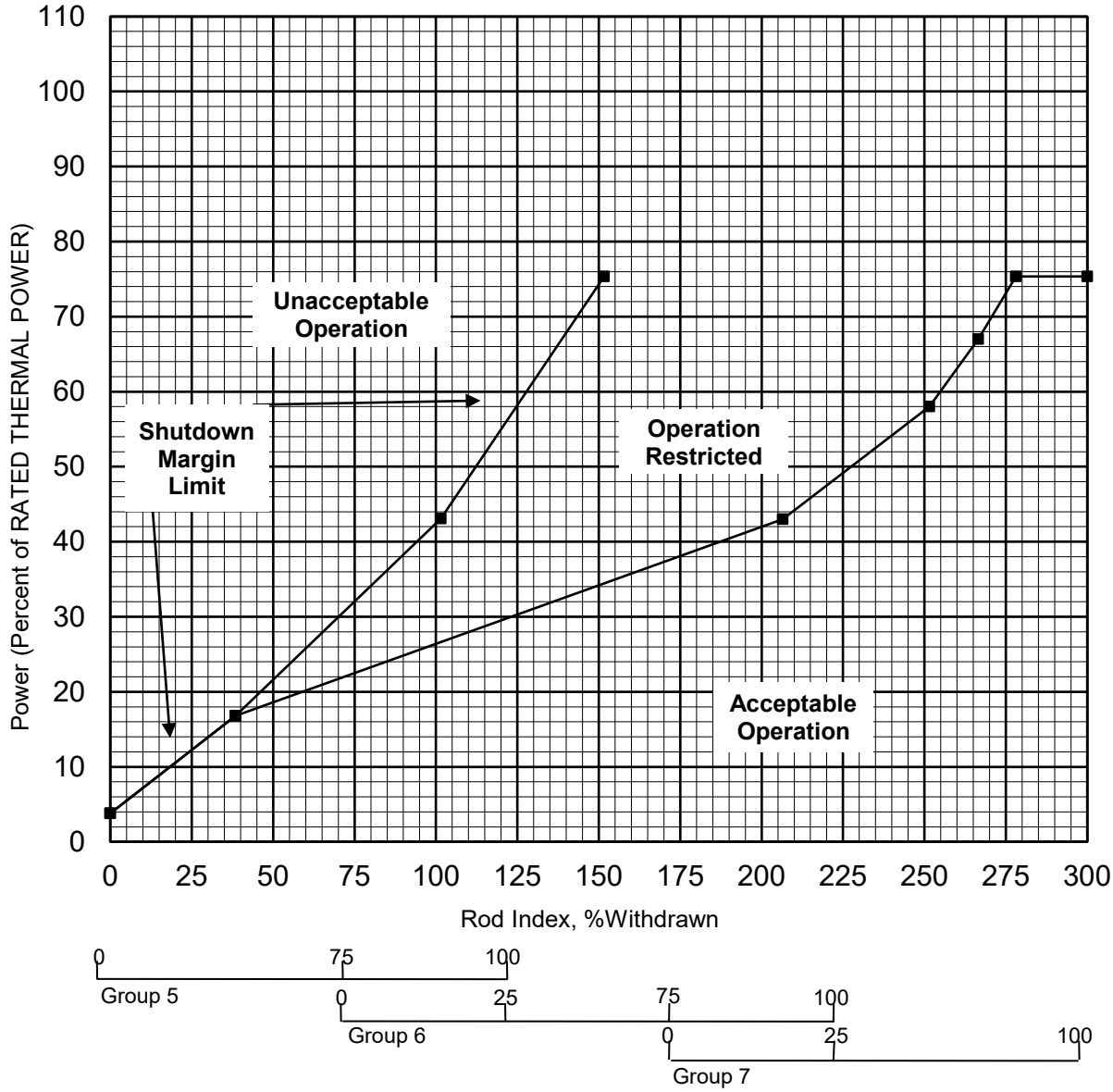
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	224.00
58.00	171.50
23.00	119.50
2.70	0.00

RI Limit	
Power	RI
100.37	300.00
100.37	277.40
90.00	266.50
78.00	251.50
58.00	206.50
23.00	119.50
2.70	0.00

Figure 2c Regulating Group Position Operating Limits
0 to 300 ±10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



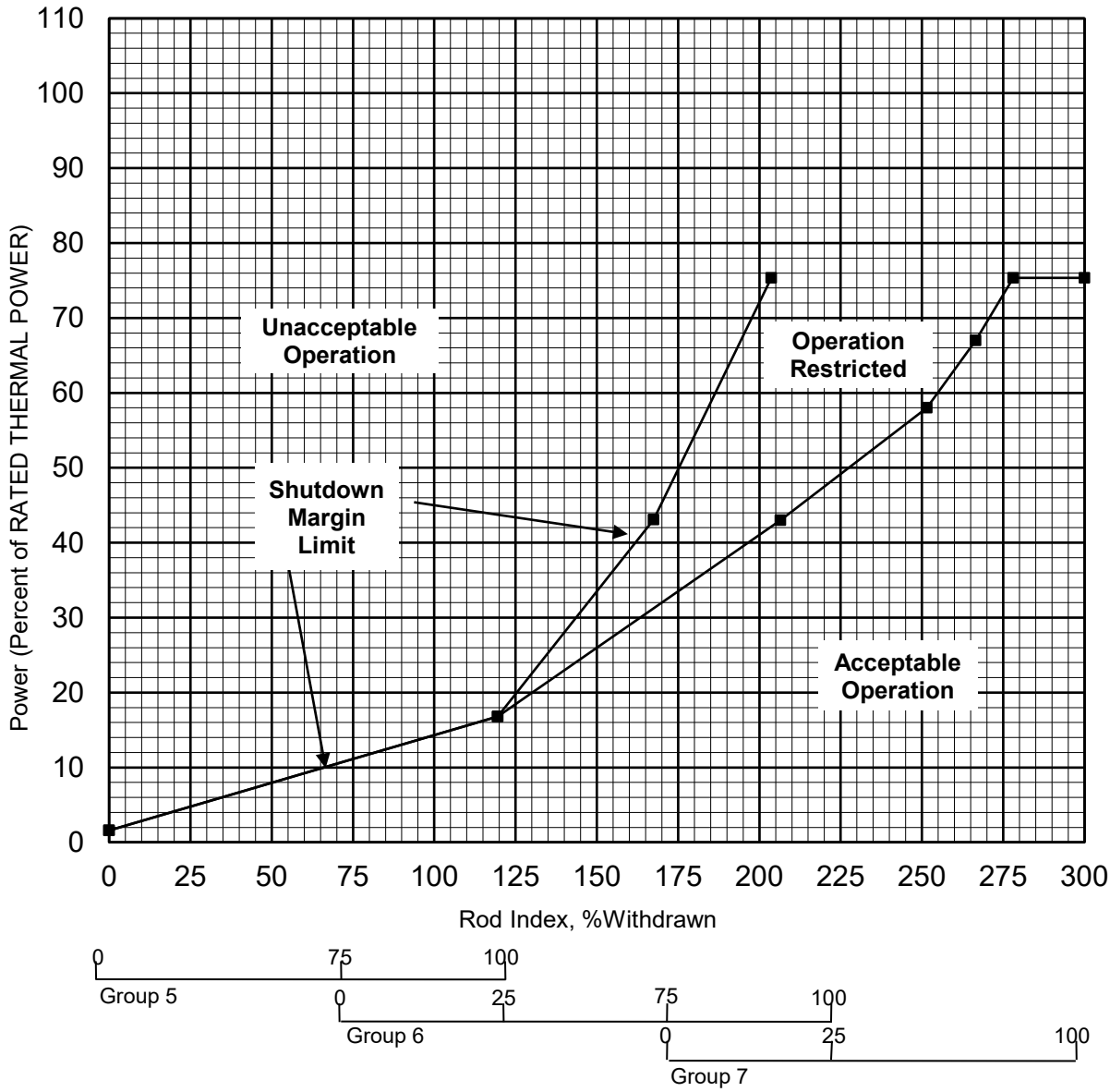
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 75.37 %RTP.

SDM Limit	
Power	RI
75.37	151.60
43.10	101.50
16.80	38.50
3.80	0.00

RI Limit	
Power	RI
75.37	300.00
75.37	278.10
67.00	266.50
58.00	251.50
43.00	206.50
16.80	38.50
3.80	0.00

Figure 2d Regulating Group Position Operating Limits
After 300 ±10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 75.37 %RTP.

SDM Limit	
Power	RI
75.37	203.70
43.10	167.50
16.80	119.50
1.60	0.00

RI Limit	
Power	RI
75.37	300.00
75.37	278.10
67.00	266.50
58.00	251.50
43.00	206.50
16.80	119.50
1.60	0.00

Figure 3 APSR Position Operating Limits for Davis-Besse, Cycle 23

This Figure is referred to by Technical Specifications 3.2.2

Before APSR Pull: 0 EFPD to 635 ± 10 EFPD,
Three or Four RC pumps operation*

Lower Limit: 0 %WD

Upper Limit: 100 %WD

After APSR Pull: 635 ± 10 EFPD to End-of-Cycle
Three or Four RC pumps operation*

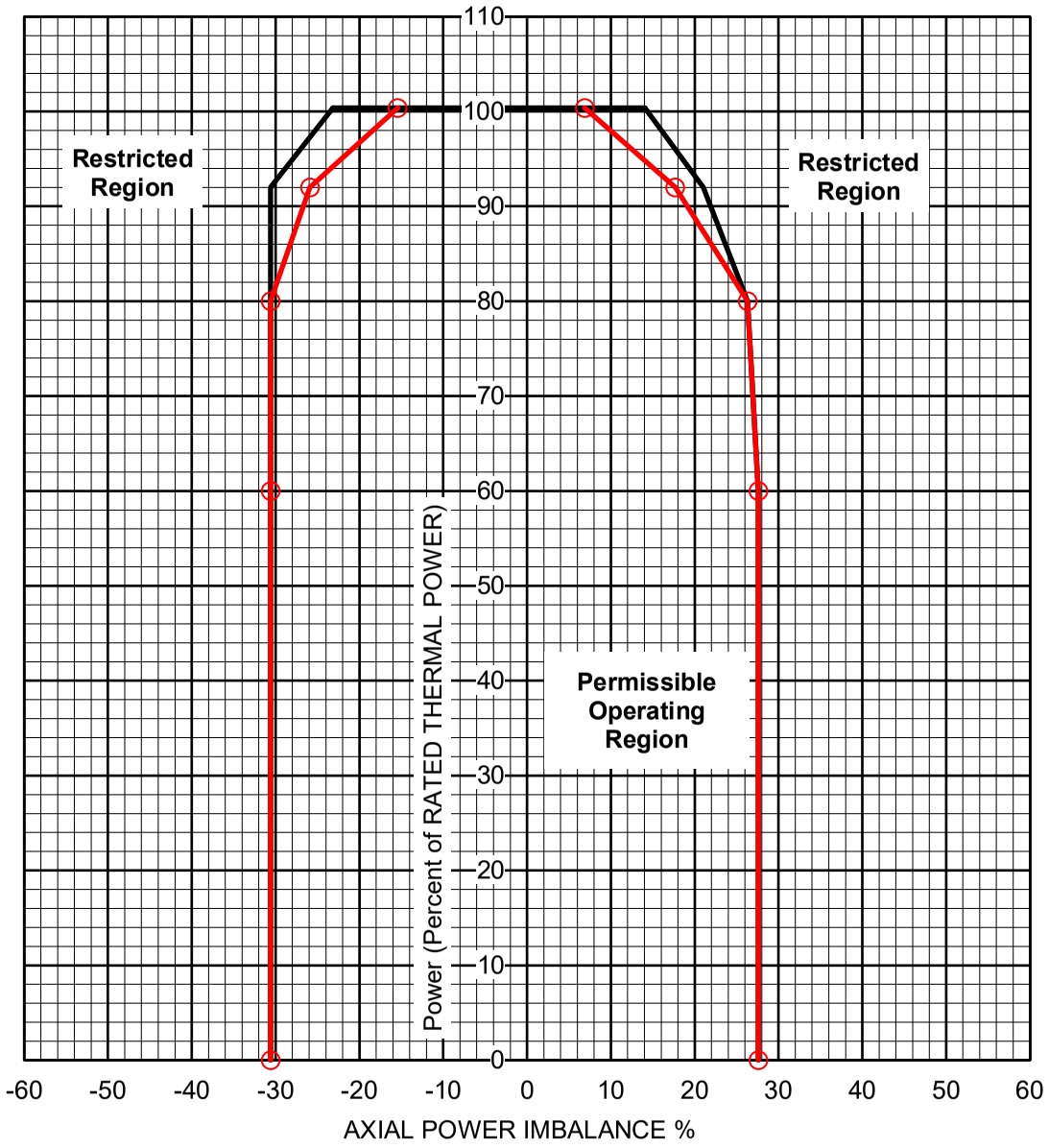
Insertion Prohibited (maintain ≥ 99%WD) **

* Power restricted to 75.37% for 3-pump operation, however, steam generator analyses limits power to 73.46 %RTP.

** Reinsertion is allowed only during the end of cycle shutdown when the reactor power is equal to, or less than, 30%RTP.

Figure 4a AXIAL POWER IMBALANCE Operating Limits
0 to 25 ± 10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



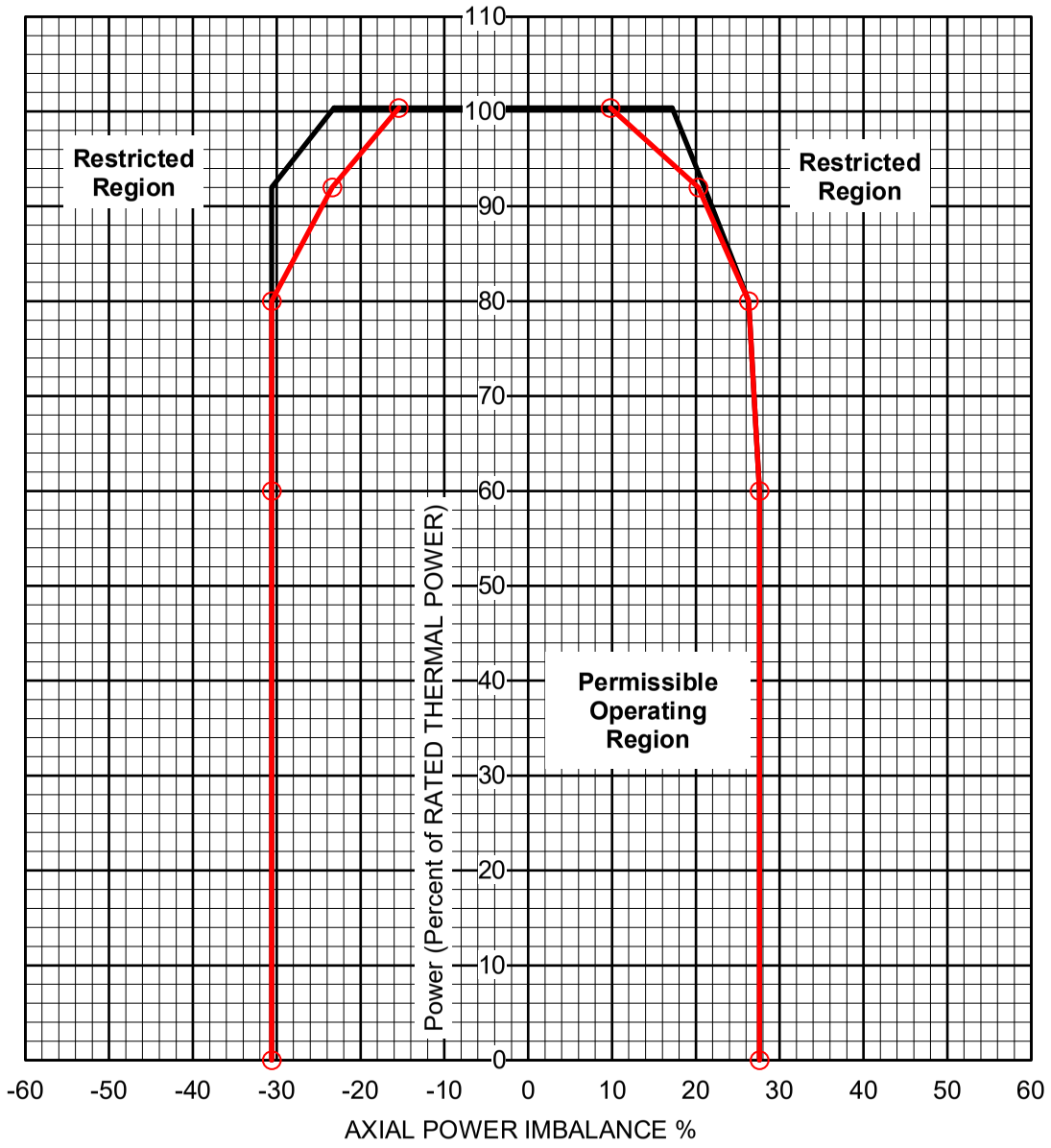
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 100.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
100.37	-23.17	14.06
92.00	-30.60	21.04
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
100.37	-15.43	6.88
92.00	-25.90	17.68
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4b AXIAL POWER IMBALANCE Operating Limits
25 ± 10 EFPD to EOC, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



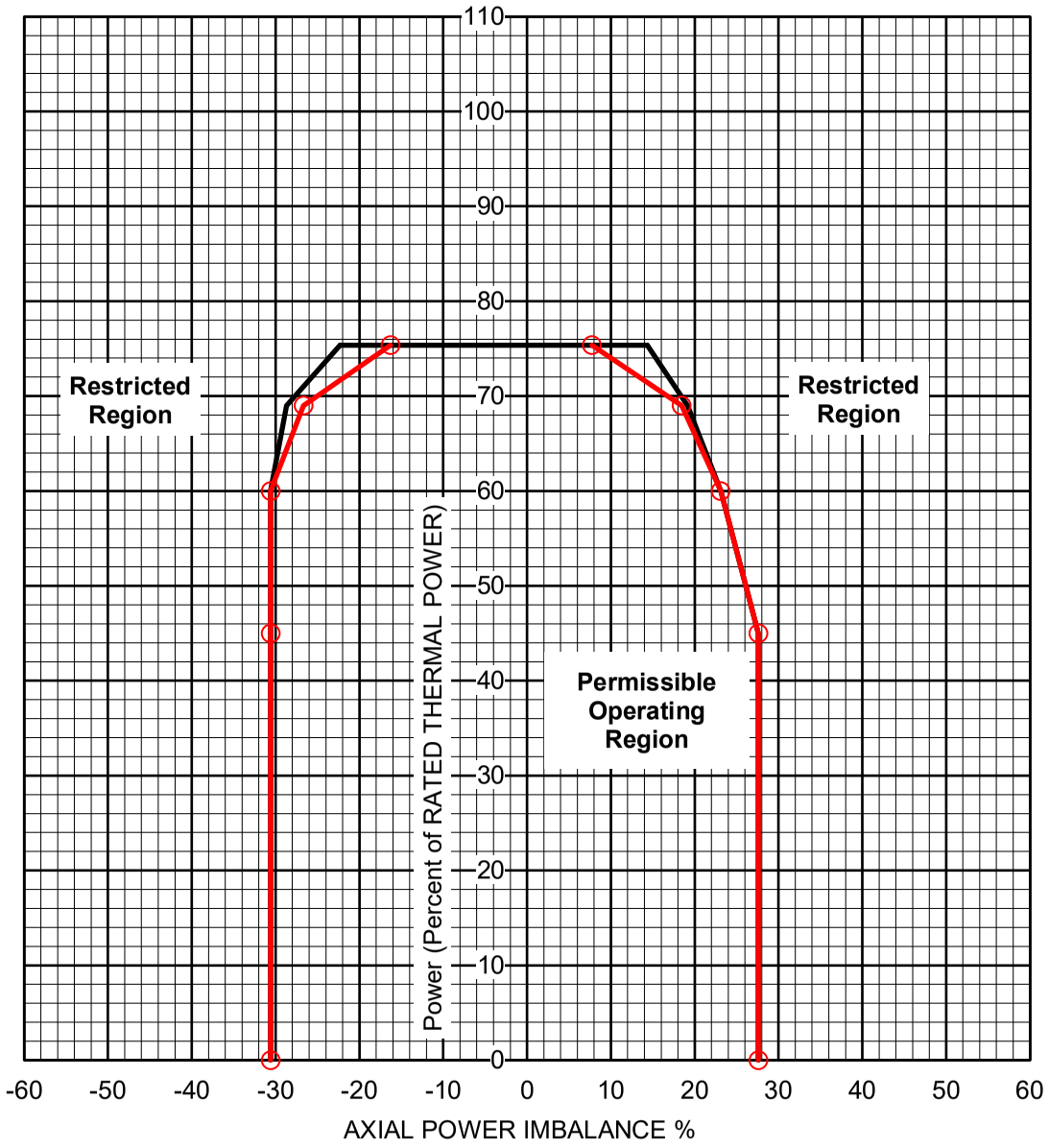
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 100.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
100.37	-23.17	17.18
92.00	-30.60	21.04
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
100.37	-15.43	9.81
92.00	-23.37	20.29
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4c AXIAL POWER IMBALANCE Operating Limits
0 to 25 ± 10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



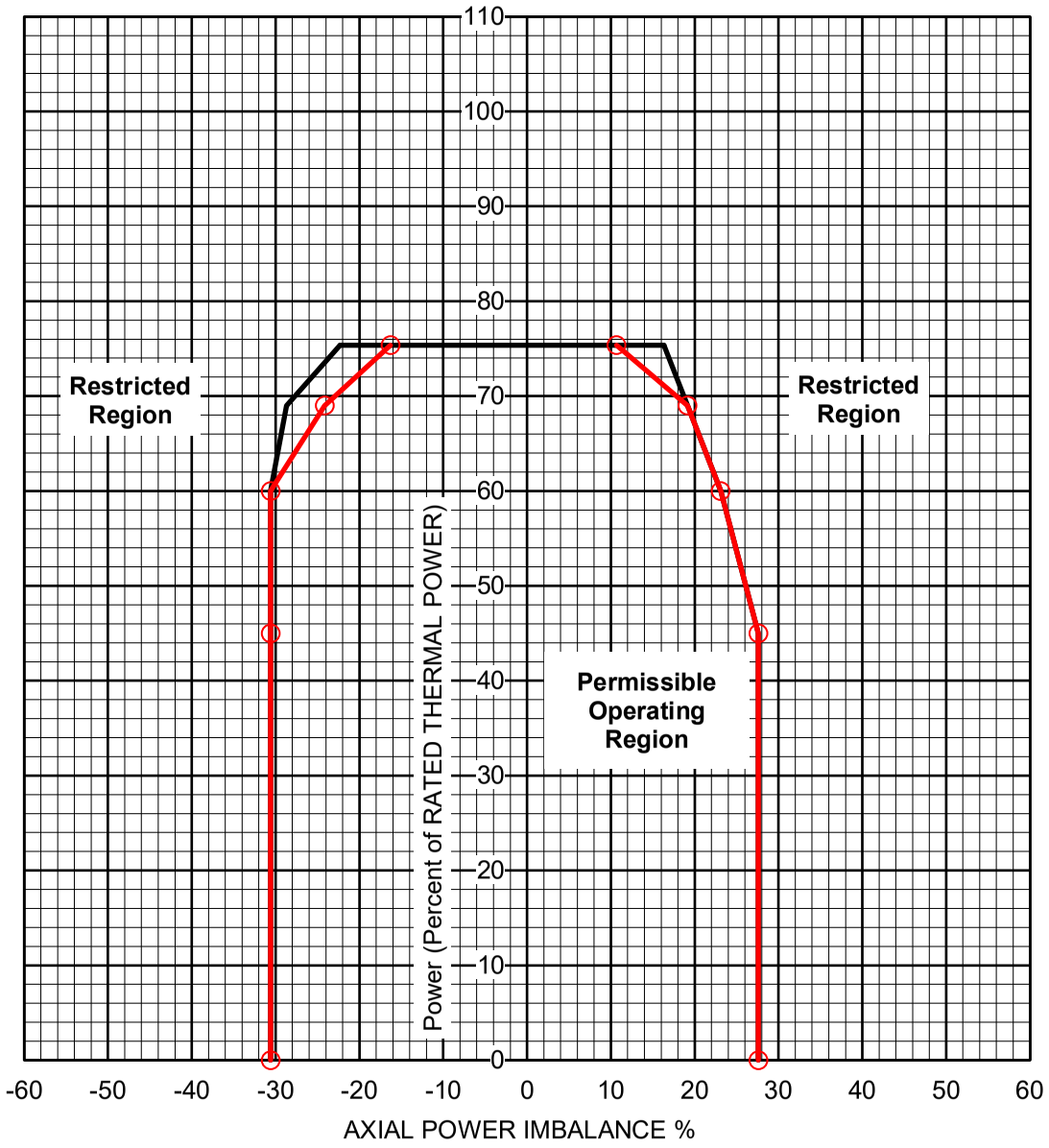
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 75.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
75.37	-22.31	14.35
69.00	-28.69	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
75.37	-16.30	7.75
69.00	-26.67	18.45
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4d AXIAL POWER IMBALANCE Operating Limits
25 ± 10 EFPD to EOC, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 75.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
75.37	-22.31	16.33
69.00	-28.69	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
75.37	-16.30	10.68
69.00	-24.14	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Table 4 QUADRANT POWER TILT Limits for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.4

QUADRANT POWER TILT as measured by:	From 0 EFPD to 300 EFPD			
	Steady-state Limit for THERMAL POWER ≤ 60% (%)	Steady-state Limit for THERMAL POWER >60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	5.85	10.03	20.00
Minimum Incore Detector System *	3.20	2.01	4.40	20.00

QUADRANT POWER TILT as measured by:	From 300 EFPD to EOC			
	Steady-state Limit for THERMAL POWER ≤ 60% (%)	Steady-state Limit for THERMAL POWER >60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	4.54	10.03	20.00
Minimum Incore Detector System *	3.20	1.90	4.40	20.00

* These operating limits are based on the condition that no individual long emitter detector affecting the Minimum Incore Detector System tilt calculation exceeds 73% sensitivity depletion, which is the case for Cycle 23.

Table 5 Power Peaking Factors - F_Q for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.5

Heat Flux Hot Channel Factor F_Q

F_Q shall be limited by the following relationships:

$F_Q \leq LHR^{allow}(Bu) / [LHR^{avg} * P]$ (for $P \leq 1.0$)

$LHR^{allow}(Bu)$ = See the following tables

LHR^{avg} = 6.4293 kW/ft at 2817 MWt for all fuel

P = ratio of THERMAL POWER / RATED THERMAL POWER (current fraction of power)

Bu = fuel burnup (MWd/mtU)

Note: The measured F_Q shall be increased by 1.4% to account for manufacturing tolerances and further increased by 7.5% to account for measurement uncertainty before comparing to the limits. The core monitoring system computer-generated FQ values are augmented by the required uncertainties.

UO_2 Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	62,000 MWd/mtU
0	17.8	17.8	12.8
2.506	17.8	17.8	12.8
4.264	17.6	17.6	12.8
6.021	17.0	17.0	12.8
7.779	17.0	17.0	12.8
9.536	16.4	16.4	12.8
12.000	15.5	15.5	12.1

(a) Linear interpolation for allowable LHR between specified burnup points is valid for this table.

Table 5 (continued)

4 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	16.2	15.6	12.2
2.506	16.2	15.6	12.2
4.264	16.0	15.4	12.1
6.021	15.4	14.9	12.0
7.779	15.4	14.9	12.0
9.536	14.9	14.4	11.9
12.000	14.1	13.6	11.3

6 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	15.6	15.3	11.9
2.506	15.6	15.3	11.9
4.264	15.4	15.1	11.9
6.021	14.9	14.6	11.7
7.779	14.9	14.6	11.7
9.536	14.4	14.1	11.7
12.000	13.6	13.3	11.1

8 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	15.1	14.9	11.6
2.506	15.1	14.9	11.6
4.264	14.9	14.7	11.6
6.021	14.4	14.2	11.5
7.779	14.4	14.2	11.5
9.536	13.9	13.7	11.4
12.000	13.2	13.0	10.8

[(a)] Linear interpolation for allowable LHR between specified burnup points is valid for these tables.

Table 6 Power Peaking Factors - $F^N_{\Delta H}$ for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.5

Enthalpy Rise Hot Channel Factors - $F^N_{\Delta H}$

$F^N_{\Delta H} \leq MARP\ [1 + (1/RH)\ (1 - P/P_m)]$ (see note below)

MARP = Maximum Allowable Radial Peak, see MARP Figures and data Tables

P = THERMAL POWER / RATED THERMAL POWER and P ≤ 1.0

P_m = 1.00 for 4-RCP operation

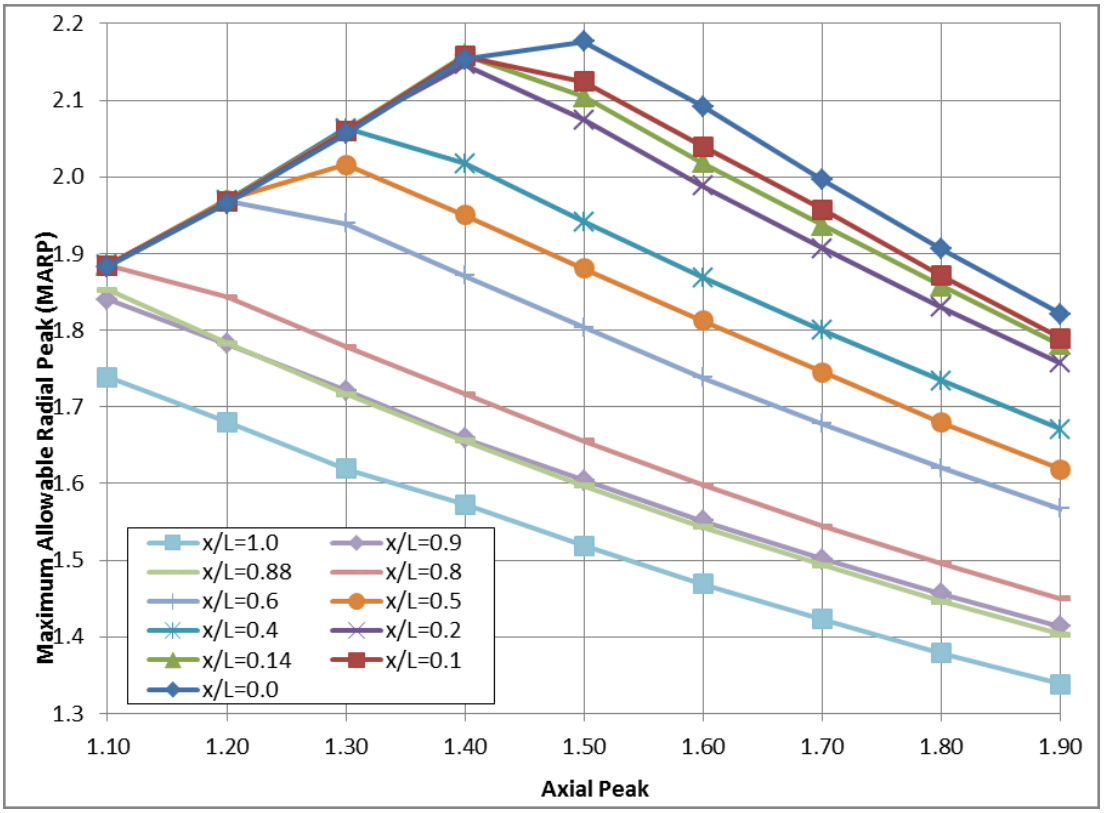
P_m = 0.75 for 3-RCP operation

1/RH = 0.3

RH = 3.333

Note: The measured $F^N_{\Delta H}$ shall be increased by 5.0% to account for measurement uncertainty prior to comparing to the limits. The core monitoring system-generated $F^N_{\Delta H}$ values are augmented by the required uncertainties.

Figure 5 Maximum Allowable Radial Peak for $F^N_{\Delta H}$ for Davis-Besse, Cycle 23 *



* Linear interpolation is acceptable.

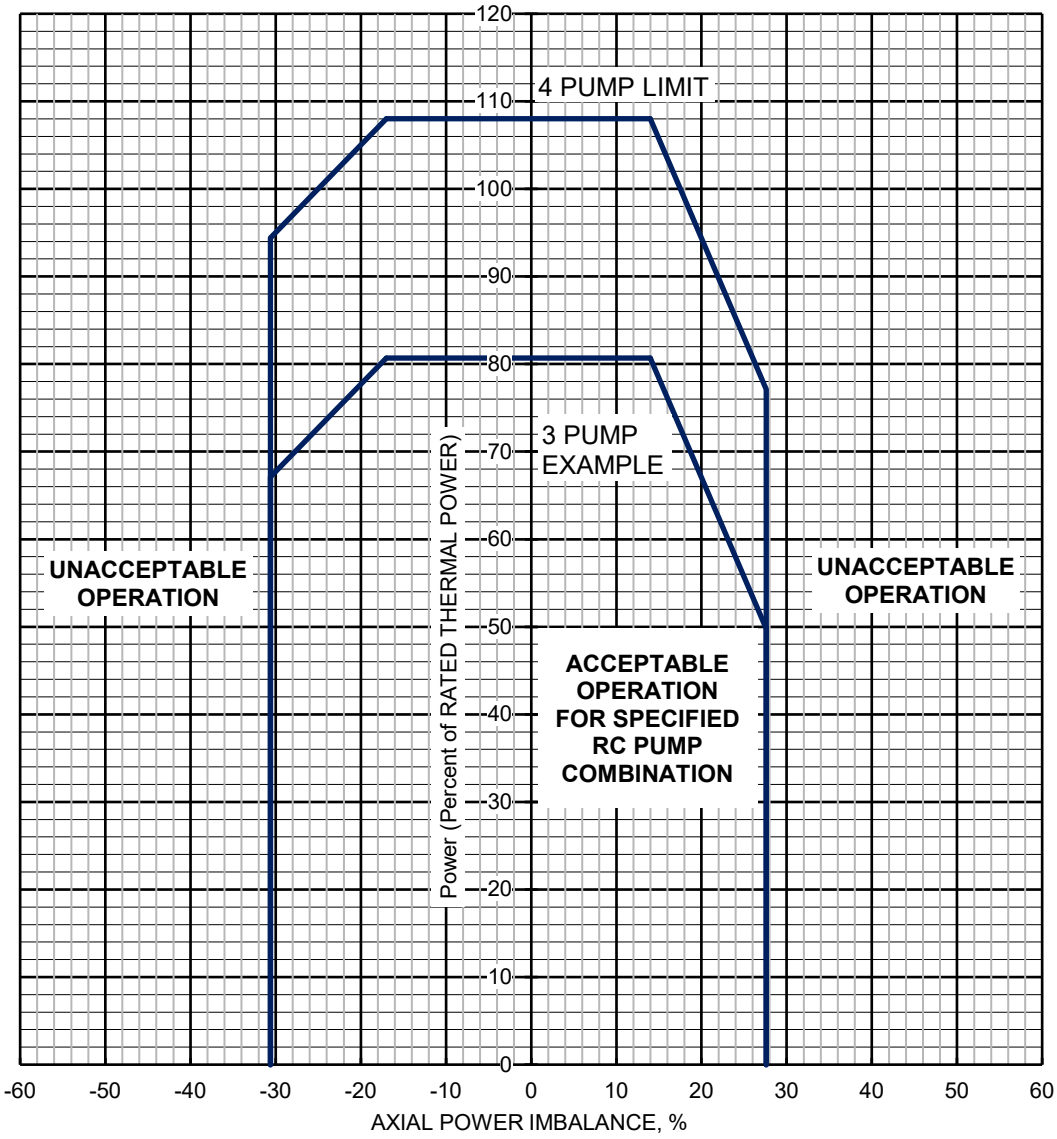
Table 7 Maximum Allowable Radial Peak for $F^N_{\Delta H}$ for Davis-Besse, Cycle 23

Axial Peak	x/L	Axial Height (inches)	MARP Limit	Axial Peak	x/L	Axial Height (inches)	MARP Limit
	0.0	0.00	1.88299		0.0	0.00	2.09189
	0.1	14.30	1.88398		0.1	14.30	2.03919
	0.14	20.02	1.88428		0.14	20.02	2.01827
	0.2	28.60	1.88461		0.2	28.60	1.98801
	0.4	57.20	1.88490		0.4	57.20	1.86840
1.1	0.5	71.50	1.88439	1.6	0.5	71.50	1.81257
	0.6	85.80	1.88451		0.6	85.80	1.73794
	0.8	114.40	1.88421		0.8	114.40	1.59754
	0.88	125.84	1.85239		0.88	125.84	1.54331
	0.9	128.70	1.83969		0.9	128.70	1.55084
	1.0	143.00	1.73842		1.0	143.00	1.46874
	0.0	0.00	1.96511		0.0	0.00	1.99604
	0.1	14.30	1.96705		0.1	14.30	1.95702
	0.14	20.02	1.96804		0.14	20.02	1.93661
	0.2	28.60	1.96825		0.2	28.60	1.90615
	0.4	57.20	1.96936		0.4	57.20	1.79933
1.2	0.5	71.50	1.96984	1.7	0.5	71.50	1.74468
	0.6	85.80	1.96919		0.6	85.80	1.67736
	0.8	114.40	1.84278		0.8	114.40	1.54415
	0.88	125.84	1.78287		0.88	125.84	1.49299
	0.9	128.70	1.78220		0.9	128.70	1.50138
	1.0	143.00	1.67994		1.0	143.00	1.42245
	0.0	0.00	2.05580		0.0	0.00	1.90606
	0.1	14.30	2.05912		0.1	14.30	1.87049
	0.14	20.02	2.06036		0.14	20.02	1.85710
	0.2	28.60	2.06155		0.2	28.60	1.82954
	0.4	57.20	2.06343		0.4	57.20	1.73365
1.3	0.5	71.50	2.01583	1.8	0.5	71.50	1.67902
	0.6	85.80	1.93900		0.6	85.80	1.62023
	0.8	114.40	1.77864		0.8	114.40	1.49550
	0.88	125.84	1.71670		0.88	125.84	1.44607
	0.9	128.70	1.72105		0.9	128.70	1.45590
	1.0	143.00	1.61890		1.0	143.00	1.37861
	0.0	0.00	2.15314		0.0	0.00	1.82131
	0.1	14.30	2.15758		0.1	14.30	1.78903
	0.14	20.02	2.15910		0.14	20.02	1.78024
	0.2	28.60	2.14648		0.2	28.60	1.75713
	0.4	57.20	2.01712		0.4	57.20	1.67040
1.4	0.5	71.50	1.95015	1.9	0.5	71.50	1.61847
	0.6	85.80	1.87083		0.6	85.80	1.56653
	0.8	114.40	1.71630		0.8	114.40	1.44958
	0.88	125.84	1.65545		0.88	125.84	1.40281
	0.9	128.70	1.65903		0.9	128.70	1.41322
	1.0	143.00	1.57207		1.0	143.00	1.33783
	0.0	0.00	2.17667				
	0.1	14.30	2.12413				
	0.14	20.02	2.10403				
	0.2	28.60	2.07451				
	0.4	57.20	1.94104				
1.5	0.5	71.50	1.88067				
	0.6	85.80	1.80330				
	0.8	114.40	1.65555				
	0.88	125.84	1.59706				
	0.9	128.70	1.60415				
	1.0	143.00	1.51859				

Figure 6

Flux-ΔFlux-Flow
(or Power/Imbalance/Flow)
Allowable Values,
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.3.1



Power Level	Negative Imbalance	Positive Imbalance
108.0	-17.0	14.0
94.4	-30.6	---
77.1	-30.6	27.6
0.0	-30.6	27.6

The 3 pump example curve shows allowable values for an approximately 25% flow reduction for three pump operation (283,860 gpm). The actual setpoint will be calculated by the Reactor Protection System and will be directly proportional to the actual RC flow with three pumps.
These limits are based on EC 19-0137 (C-ICE-058.01-008, Cycle 21) and are conservative relative to the actual Cycle 23 limits.

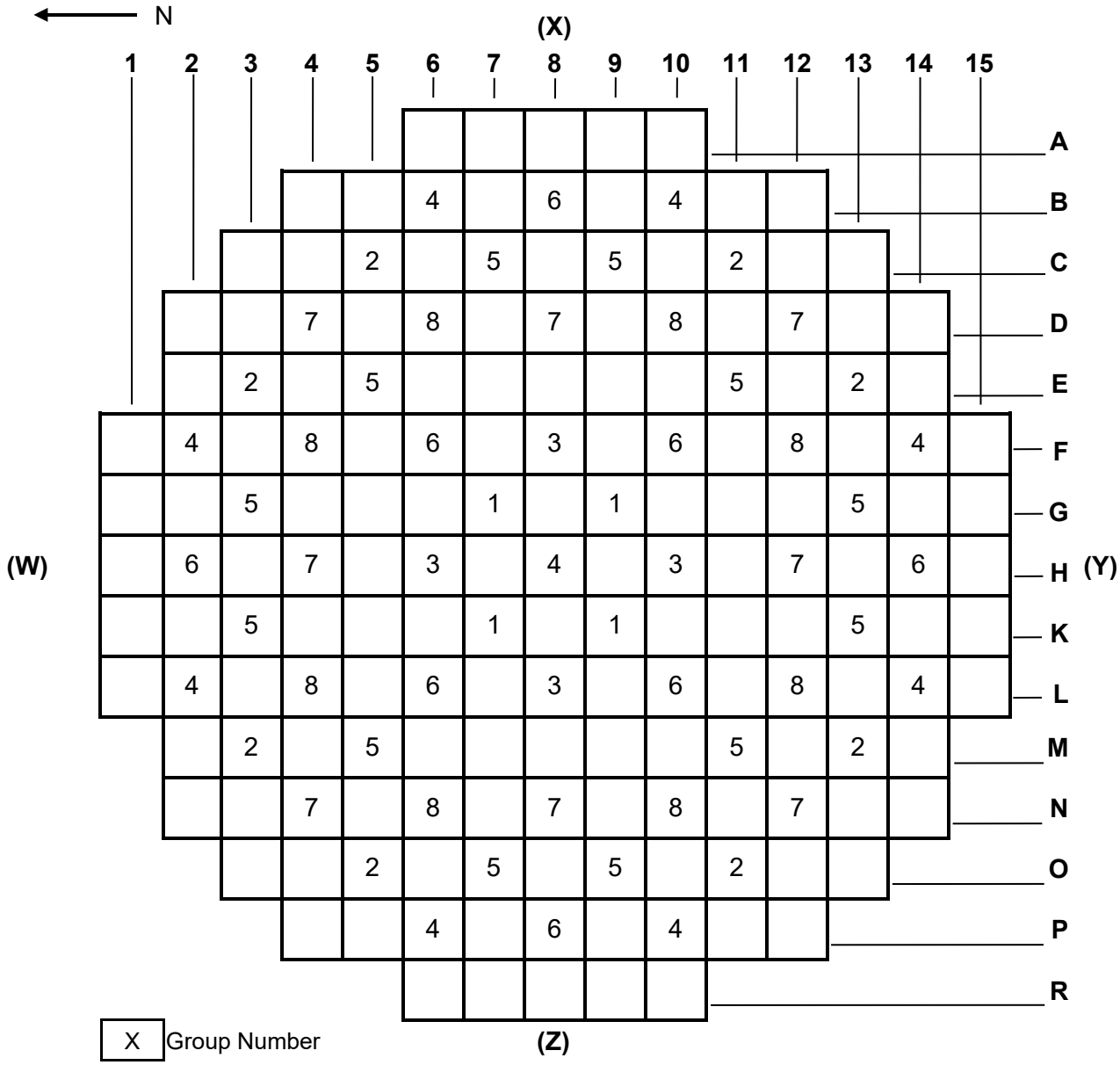
Table 8 Refueling Boron Concentration Limit for Davis-Besse, Cycle 23

This limit is referred to by Technical Specifications 3.9.1

The minimum required boron concentration for Mode 6 shall be sufficient to ensure a K_{eff} of 0.95 or less, plus an additional 1% $\Delta k/k$ conservatism allowance for uncertainties.

Figure 7 Control Rod Core Locations and Group Assignments for Davis-Besse, Cycle 23

This Figure is referred to by Technical Requirements Manual 8.1.3



Group	No of Rods	Function	Group	No of Rods	Function
1	4	Safety	5	12	Control
2	8	Safety	6	8	Control
3	4	Safety	7	8	Control
4	9	Safety	8	8	APSRs
		Total		61	

Enclosure 2
L-22-047

Davis-Besse Unit 1
Cycle 23, Core Operating Limits Report, Revision 1

(25 pages follow)

DAVIS-BESSE UNIT 1

CYCLE 23

CORE OPERATING LIMITS REPORT

Prepared by _____ 4/11/22
D. B. Kelley

Reviewed by _____ 4/12/22
C. Glass

Approved by _____ 4/20/22
J. D. Brown

1.0 Core Operating Limits

This CORE OPERATING LIMITS REPORT for DB-1 Cycle 23 has been prepared in accordance with the requirements of Technical Specification 5.6.3. The Core Operating Limits have been developed using the methodology provided in Reference 2.0 (1). The licensed length of Cycle 23 is 700 EFPDs.

The following cycle-specific core Operating Limits, Protective Limit and Flux -∆ Flux -Flow Reactor Protection System Allowable Values are included in this report:

1. SL 2.1.1.1 Reactor Core Safety Limits
2. LCO 3.1.1 SHUTDOWN MARGIN (SDM)
3. LCO 3.1.3 Moderator Temperature Coefficient (MTC)
4. LCO 3.1.7 Position Indicator Channels
5. LCO 3.1.8 PHYSICS TESTS Exceptions – MODE 1
6. LCO 3.1.9 PHYSICS TESTS Exceptions – MODE 2
7. LCO 3.2.1 Regulating Rod Insertion Limits
8. LCO 3.2.2 AXIAL POWER SHAPING ROD (APSR) Insertion Limits
9. LCO 3.2.3 AXIAL POWER IMBALANCE Operating Limits
10. LCO 3.2.4 QUADRANT POWER TILT (QPT)
11. LCO 3.2.5 Power Peaking Factors
12. LCO 3.3.1 Reactor Protection Systems (RPS) Instrumentation
    Function 8: (Flux - ∆Flux – Flow) Allowable Values
13. LCO 3.9.1 Boron Concentration
14. TRM 8.1.3 Rod Program

2.0 References

1) BAW-10179P-A, Rev. 9, “Safety Criteria and Methodology for Acceptable Cycle Reload Analyses”, November 2017.

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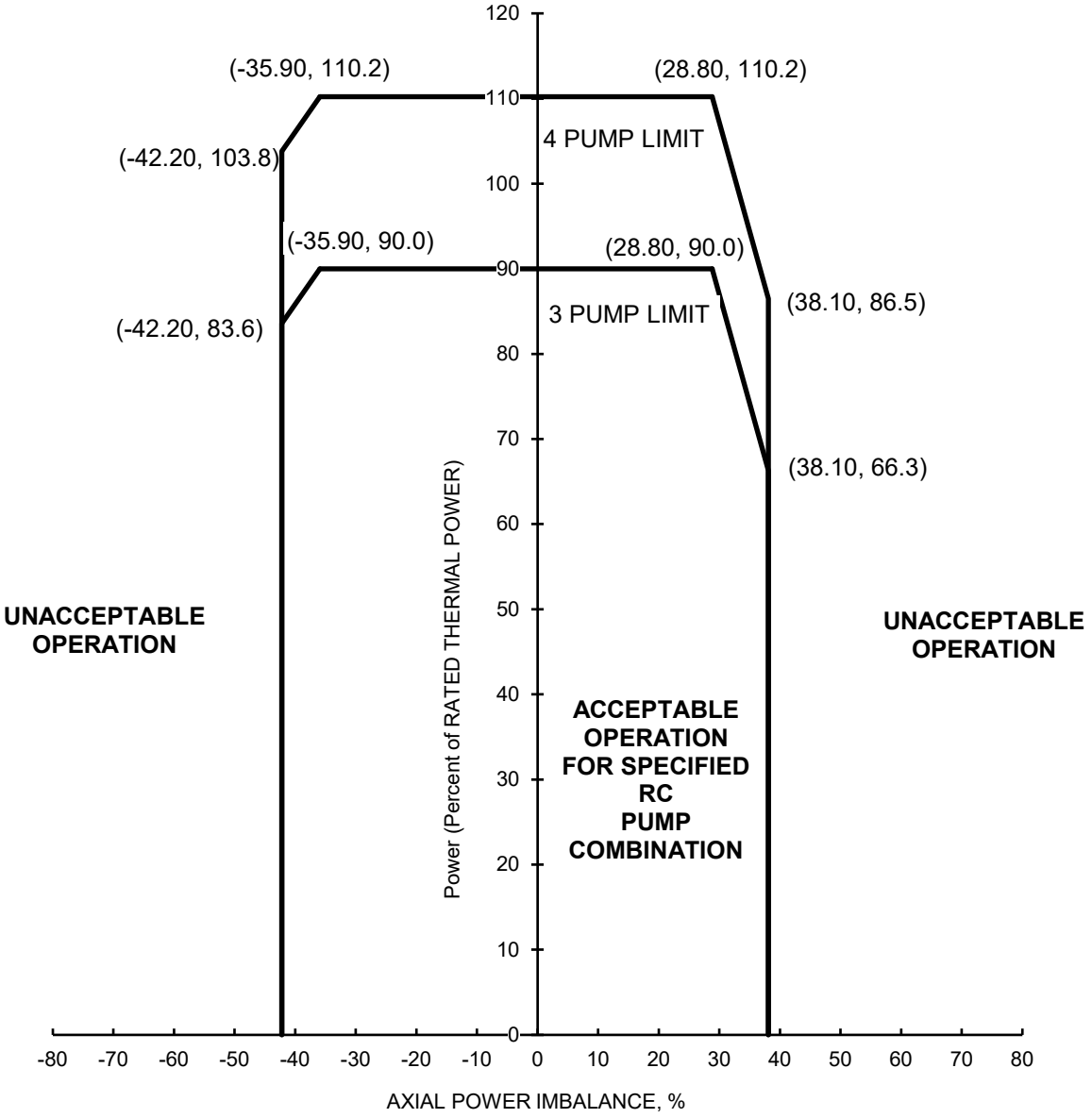
Figure 1 AXIAL POWER IMBALANCE Protective Limits
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 2.1.1.1



Pumps Operating	Reactor Coolant Flow, gpm	Required Measured Flow to Ensure Compliance, gpm
4	380,000	389,500
3	283,860	290,957

4 Pump		
Power Level	Negative Imbalance	Positive Imbalance
110.2	-35.90	28.80
103.8	-42.20	---
86.5	-42.20	38.10
0.0	-42.20	38.10

3 Pump		
Power Level	Negative Imbalance	Positive Imbalance
90.0	-35.90	28.80
83.6	-42.20	---
66.3	-42.20	38.10
0.0	-42.20	38.10

Table 1 Shutdown Margin Requirements for Davis-Besse, Cycle 23

Verify SHUTDOWN MARGIN per the table below.

APPLICABILITY	REQUIRED SHUTDOWN MARGIN	TECHNICAL SPECIFICATIONS 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 2a through 2d as required by Technical Specification 3.2.1.

** Entry into Mode 1 Physics Tests Exceptions is not supported by existing analyses. For example, Regulating Rod Shutdown Margin Insertion Limits assumptions may not be met and as such requires actual shutdown margin to be ≥ 1 %Δk/k via alternate verification or calculation.

***For the period from 0 to 300 EFPD and for power levels 60 %FP and above, rod insertion limits are established that reserve an additional 0.5 %Δk/k required rod worth to accommodate the SBLOCA model.

Table 2 Moderator Temperature Coefficient Limit for Davis-Besse, Cycle 23

These limits are referred to by Technical Specifications 3.1.3

1. Lower Limit:

   MTC at HFP ≥ -4.000x10^{-4} Δk/k/°F (-40.00 pcm/°F)

2. The following Upper Limits may not be exceeded without prior NRC approval:

   MTC <0.9 x 10^{-4} Δk/k/°F when Thermal Power <95% RTP

   MTC <0.0 x 10^{-4} Δk/k/°F when Thermal Power ≥95% RTP

3. The following Upper Limits may not be exceeded for operation in Modes 1 and 2:

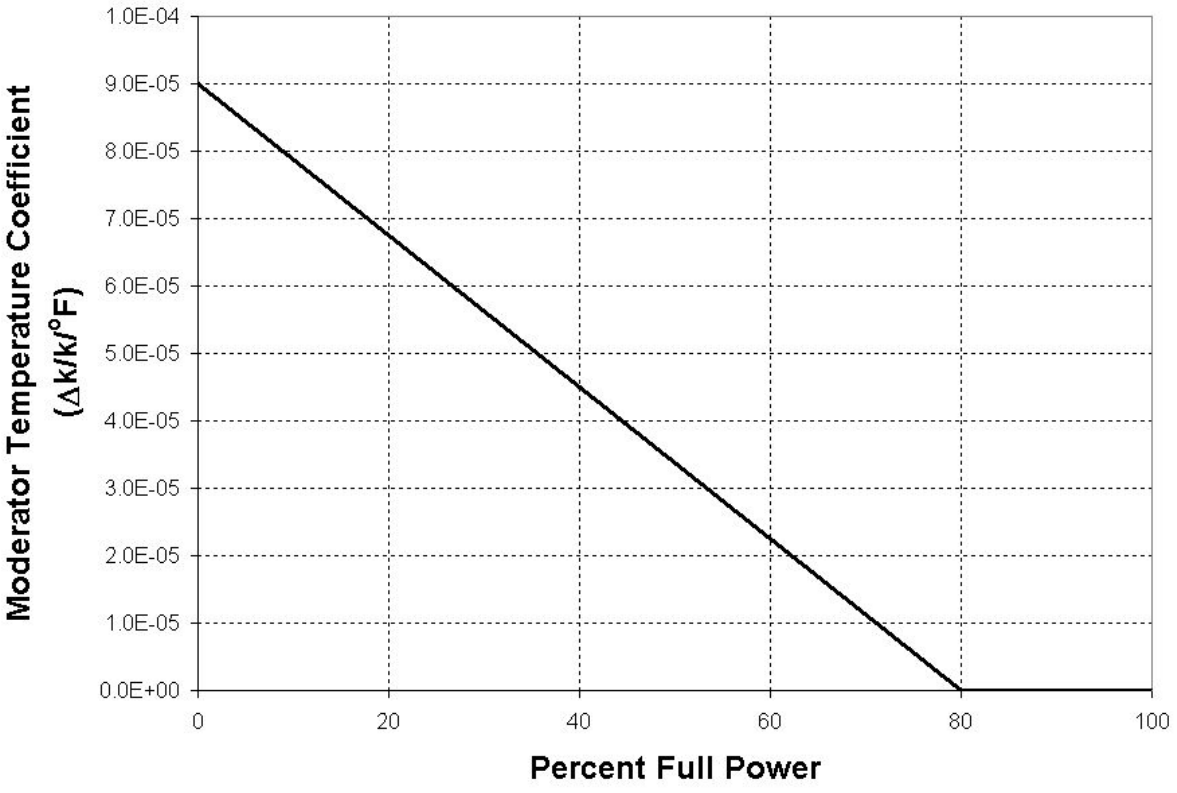


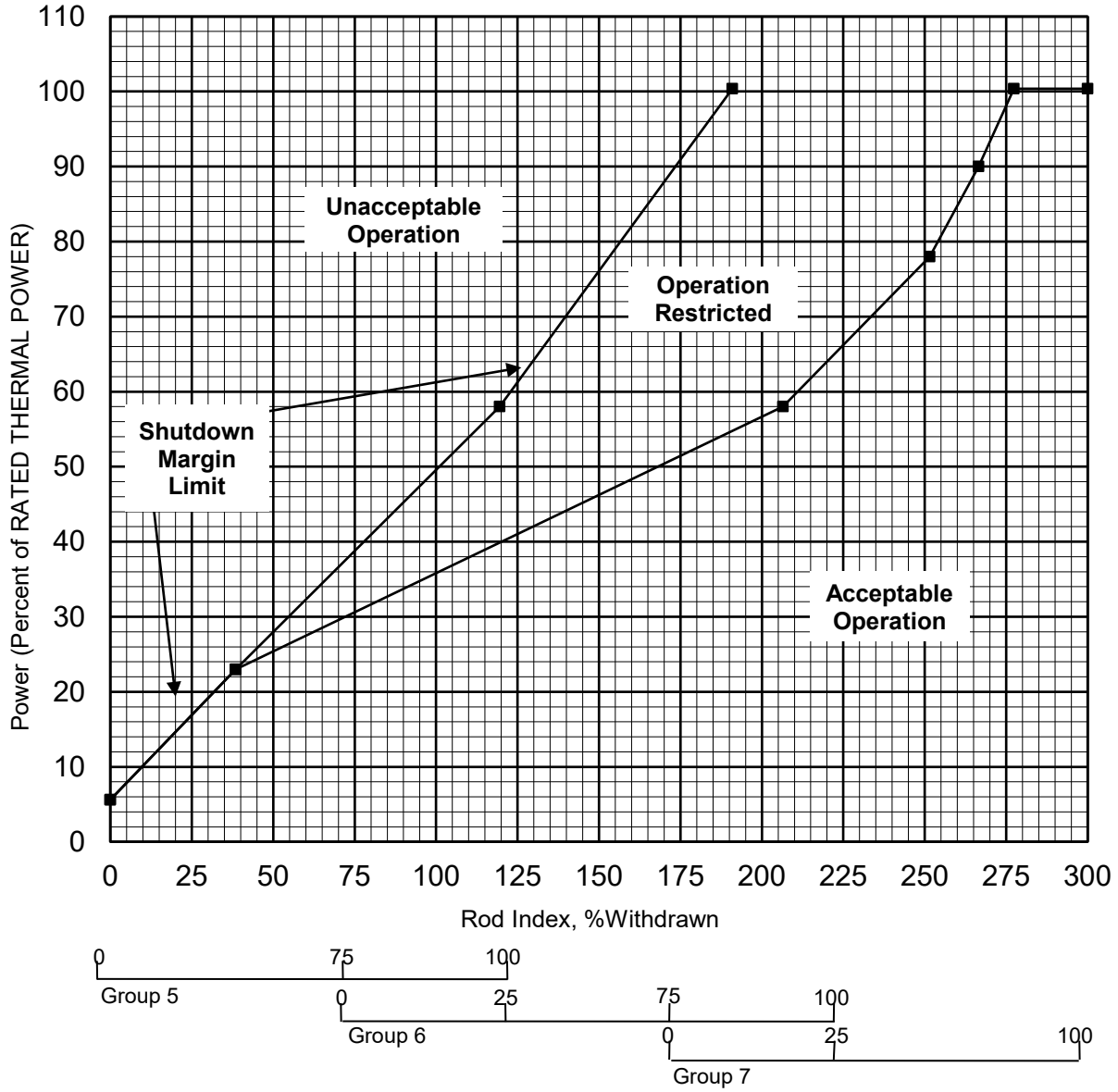
Table 3 Absolute Position Indicator (API) / Relative Position Indicator (RPI) Agreement Limit for Davis-Besse, Cycle 23

This limit is referred to by Technical Specifications 3.1.7

The absolute position indicator channels and the relative position indicator channels agree within 3.00%.

Figure 2a Regulating Group Position Operating Limits
0 to 300 ±10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



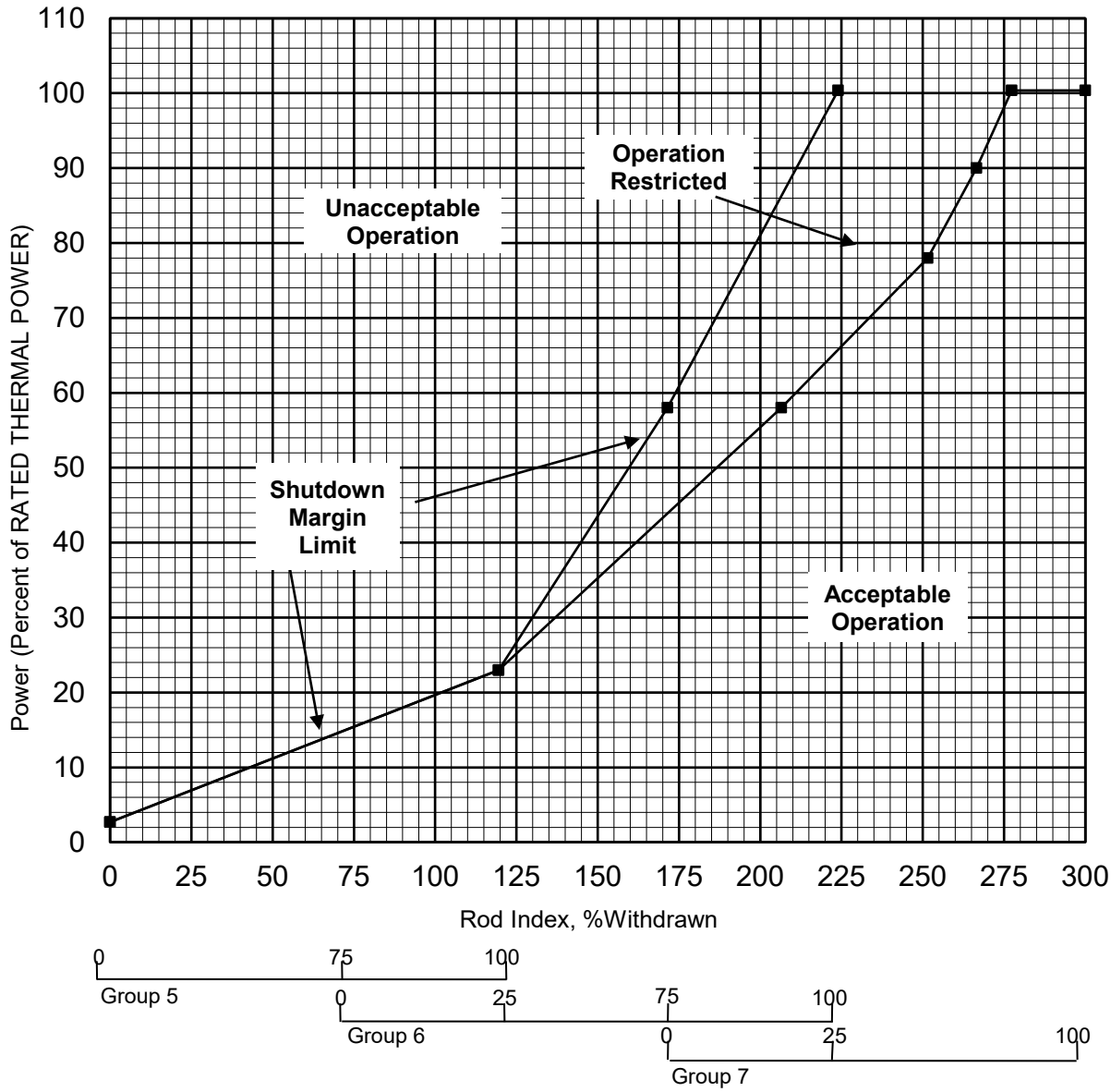
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	190.90
58.00	119.50
23.00	38.50
5.60	0.00

RI Limit	
Power	RI
100.37	300.00
100.37	277.40
90.00	266.50
78.00	251.50
58.00	206.50
23.00	38.50
5.60	0.00

Figure 2b Regulating Group Position Operating Limits
After 300 ±10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



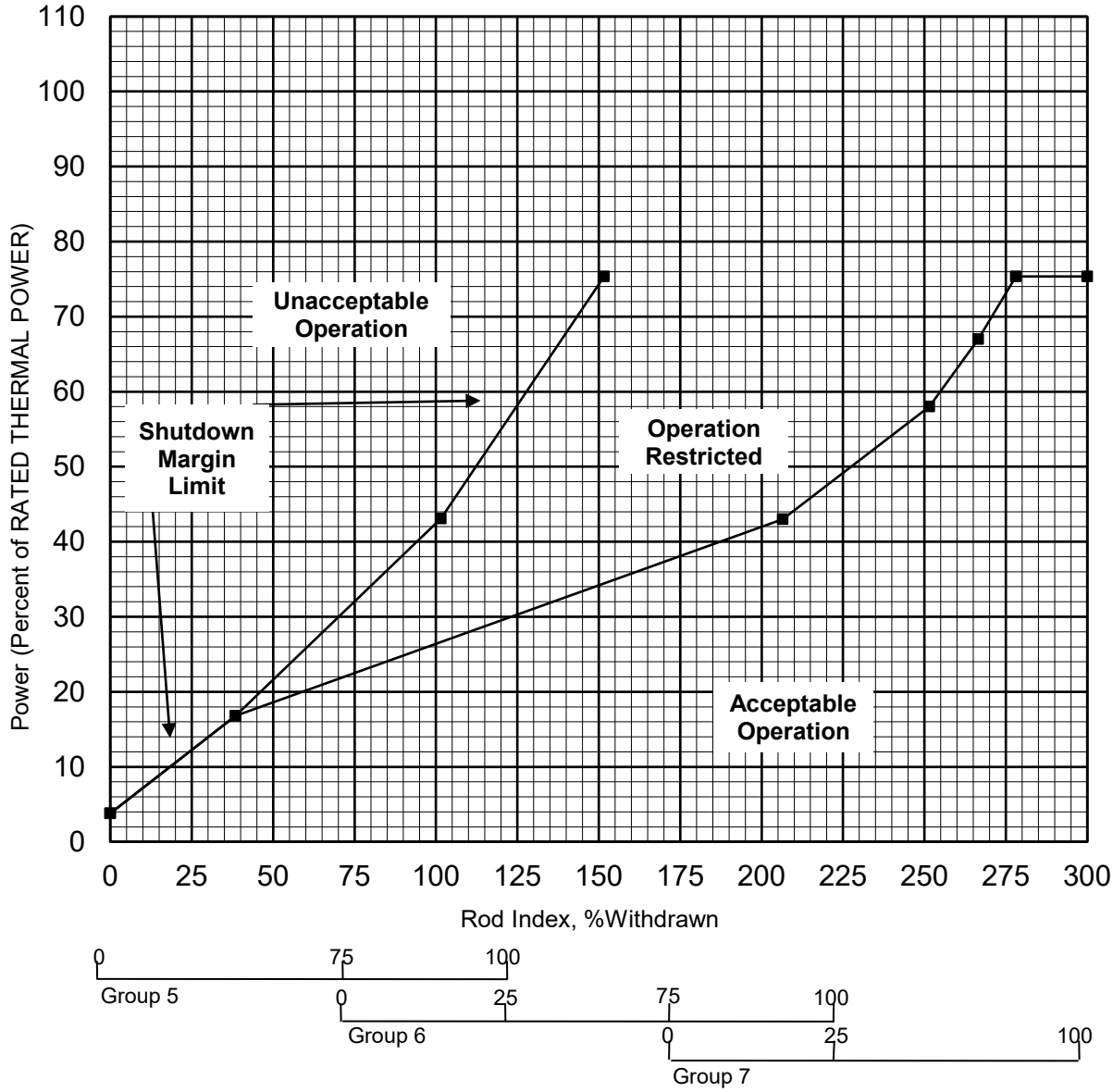
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	224.00
58.00	171.50
23.00	119.50
2.70	0.00

RI Limit	
Power	RI
100.37	300.00
100.37	277.40
90.00	266.50
78.00	251.50
58.00	206.50
23.00	119.50
2.70	0.00

Figure 2c Regulating Group Position Operating Limits
0 to 300 ±10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



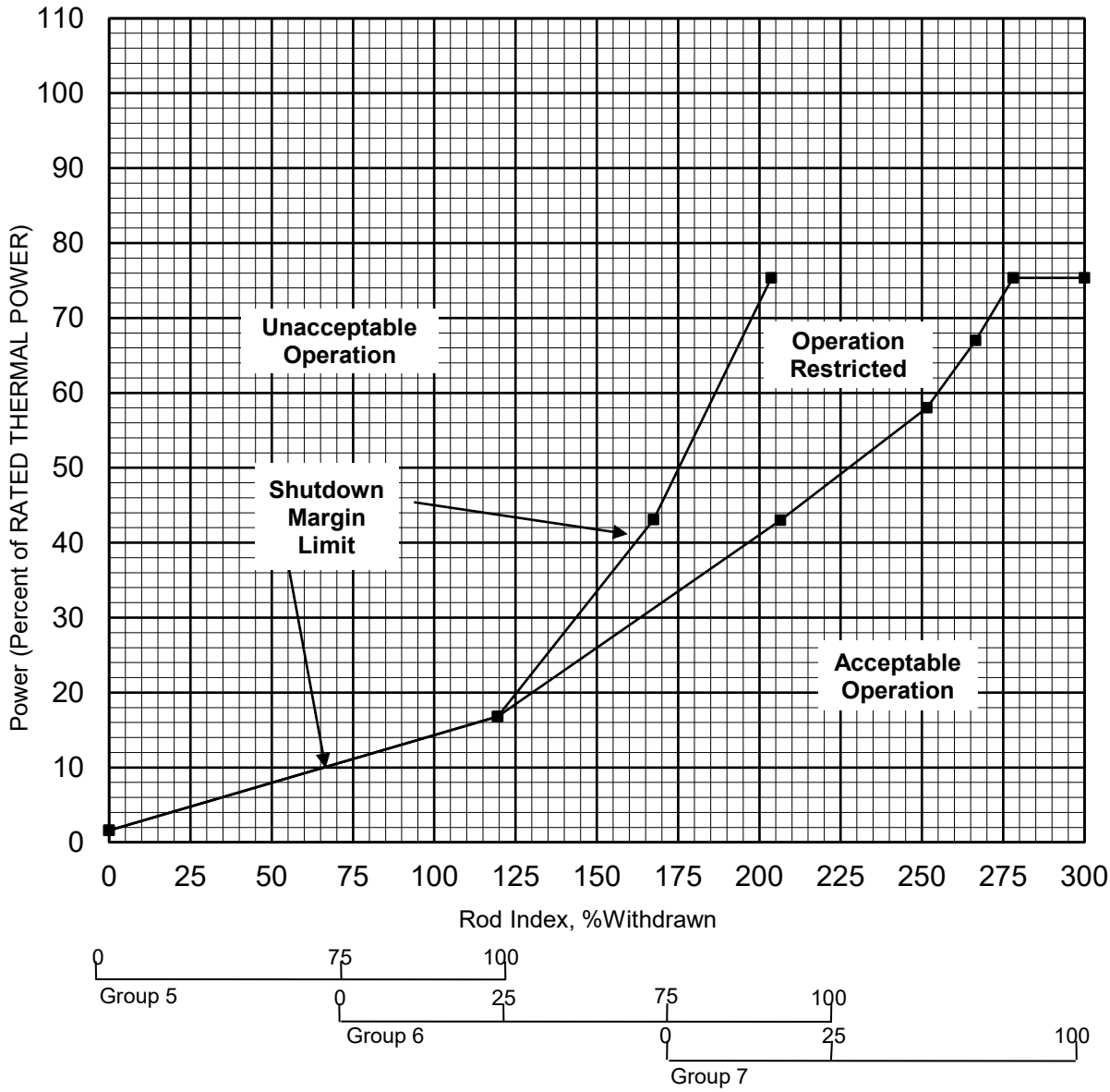
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 75.37 %RTP.

SDM Limit	
Power	RI
75.37	151.60
43.10	101.50
16.80	38.50
3.80	0.00

RI Limit	
Power	RI
75.37	300.00
75.37	278.10
67.00	266.50
58.00	251.50
43.00	206.50
16.80	38.50
3.80	0.00

Figure 2d Regulating Group Position Operating Limits
After 300 ±10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specifications 3.2.1



Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.
Note 2: Instrument error is accounted for in these Operating Limits.
Note 3: Maximum plotted power level is 75.37 %RTP.

SDM Limit	
Power	RI
75.37	203.70
43.10	167.50
16.80	119.50
1.60	0.00

RI Limit	
Power	RI
75.37	300.00
75.37	278.10
67.00	266.50
58.00	251.50
43.00	206.50
16.80	119.50
1.60	0.00

Figure 3 APSR Position Operating Limits for Davis-Besse, Cycle 23

This Figure is referred to by Technical Specifications 3.2.2

Before APSR Pull: 0 EFPD to 635 ± 10 EFPD,
Three or Four RC pumps operation*

Lower Limit: 0 %WD

Upper Limit: 100 %WD

After APSR Pull: 635 ± 10 EFPD to End-of-Cycle
Three or Four RC pumps operation*

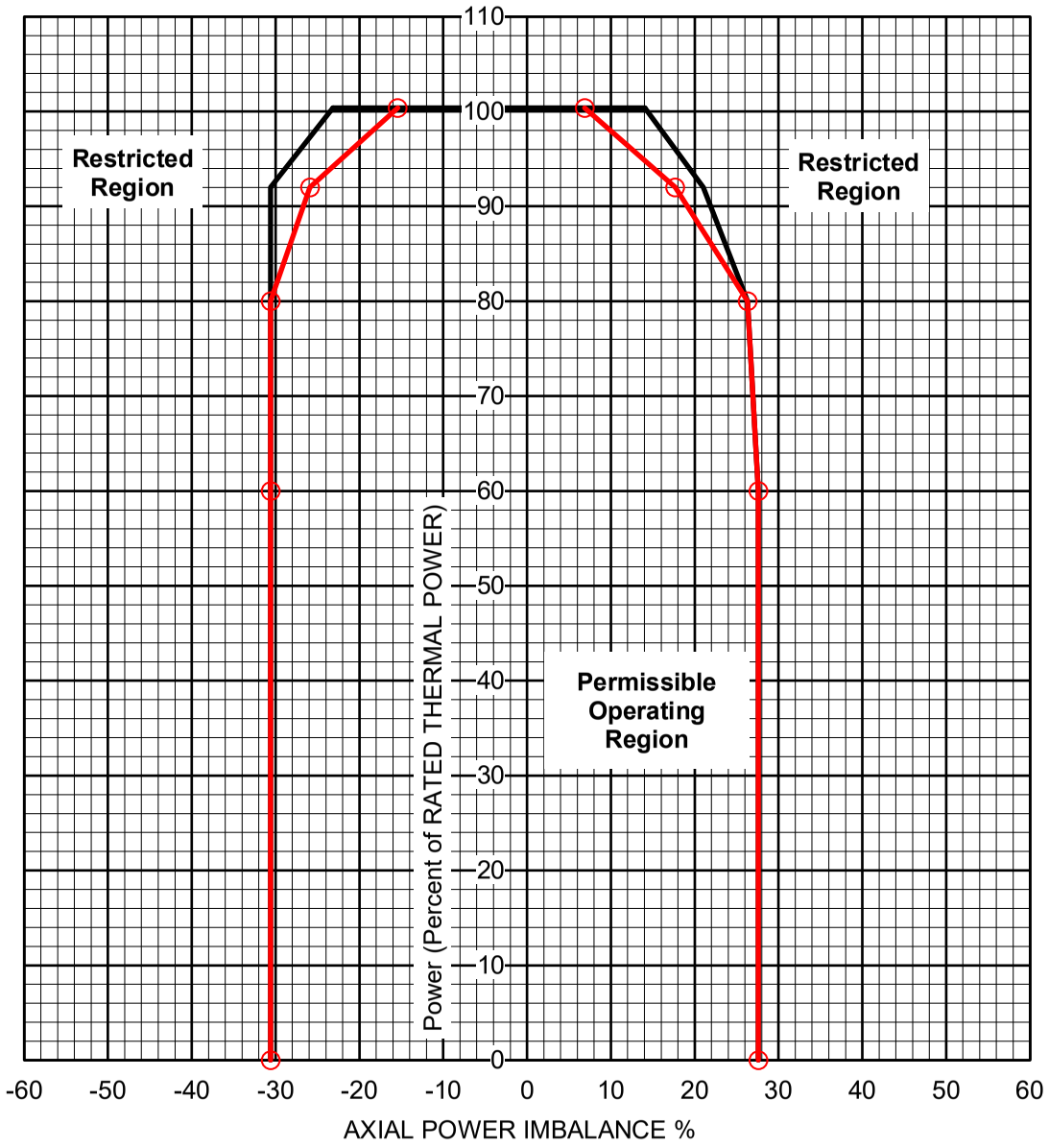
Insertion Prohibited (maintain ≥ 99%WD) **

* Power restricted to 75.37% for 3-pump operation, however, steam generator analyses limits power to 73.46 %RTP.

** Reinsertion is allowed only during the end of cycle shutdown when the reactor power is equal to, or less than, 30%RTP.

Figure 4a AXIAL POWER IMBALANCE Operating Limits
0 to 25 ± 10 EFPD, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



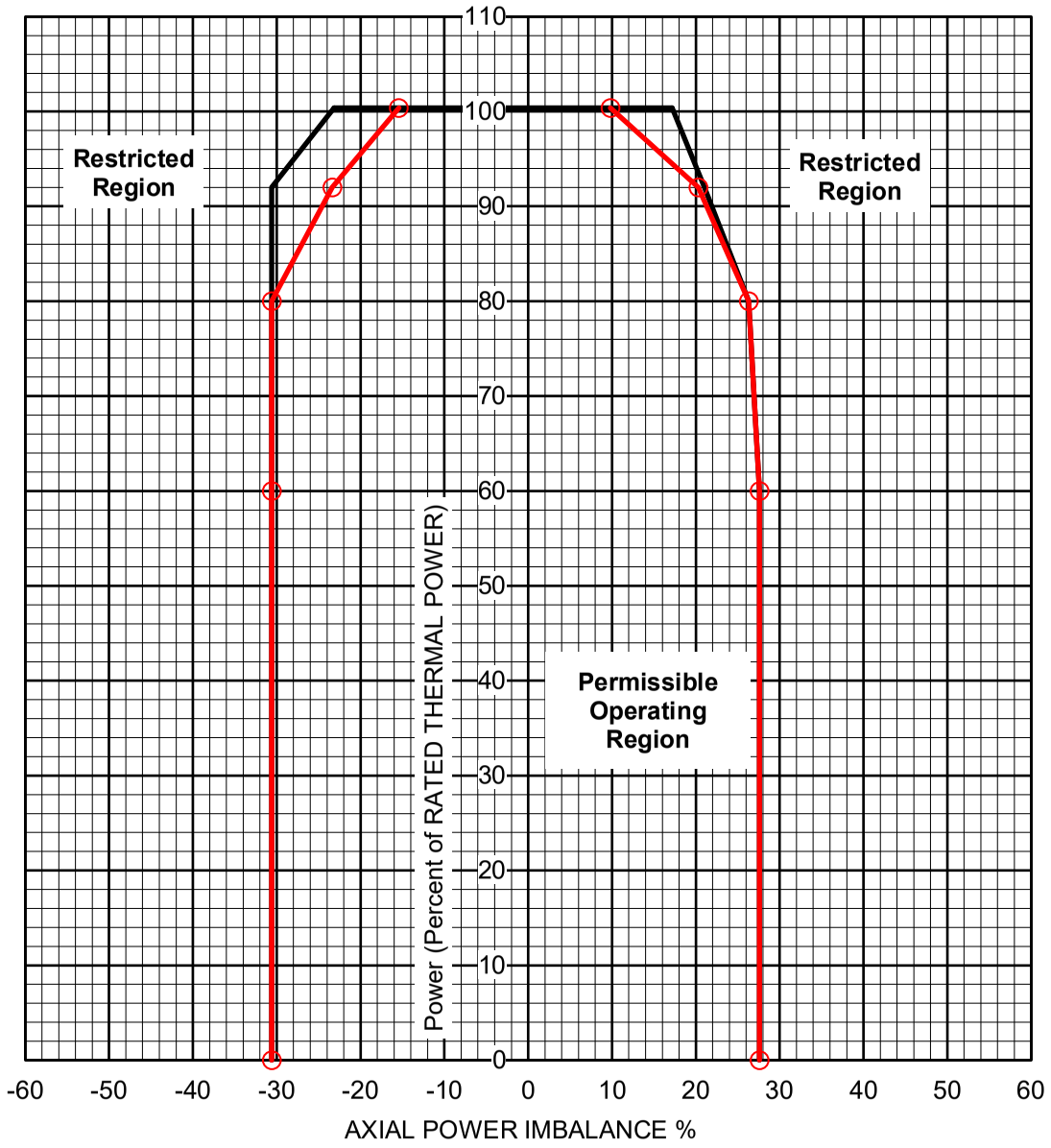
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 100.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
100.37	-23.17	14.06
92.00	-30.60	21.04
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
100.37	-15.43	6.88
92.00	-25.90	17.68
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4b AXIAL POWER IMBALANCE Operating Limits
25 ± 10 EFPD to EOC, Four RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



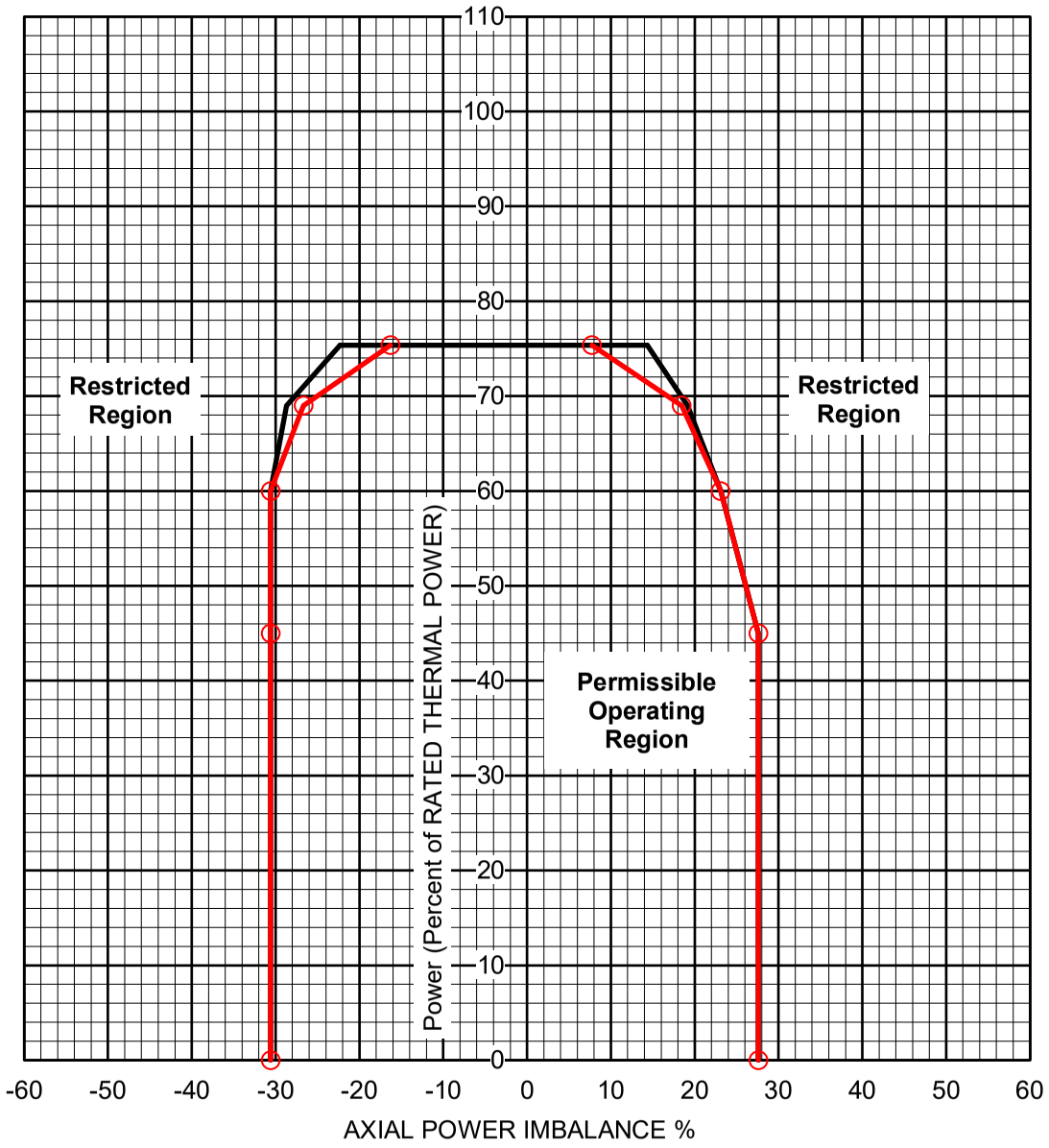
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 100.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
100.37	-23.17	17.18
92.00	-30.60	21.04
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
100.37	-15.43	9.81
92.00	-23.37	20.29
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4c AXIAL POWER IMBALANCE Operating Limits
0 to 25 ± 10 EFPD, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



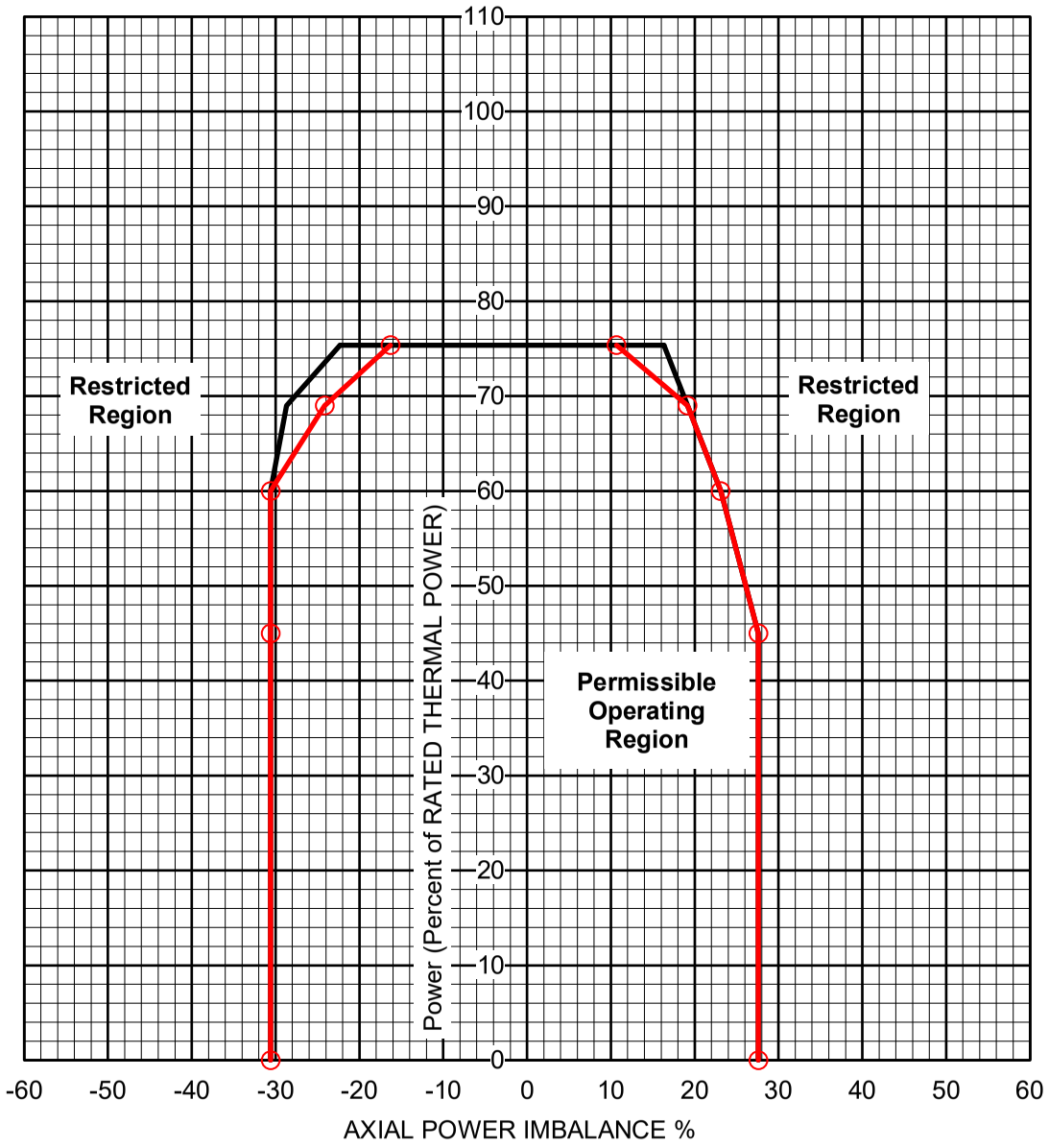
Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 75.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
75.37	-22.31	14.35
69.00	-28.69	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
75.37	-16.30	7.75
69.00	-26.67	18.45
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Figure 4d AXIAL POWER IMBALANCE Operating Limits
25 ± 10 EFPD to EOC, Three RC Pumps
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.2.3



Note 1: Instrument error is accounted for in these Operating Limits.
Note 2: The Excore Imbalance Operating Limits are available for use when the Full Incore system is non-functional.
Note 3: Maximum plotted power level is 75.37 %RTP.

Full Incore		
Power	Negative Imbalance	Positive Imbalance
75.37	-22.31	16.33
69.00	-28.69	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Excore		
Power	Negative Imbalance	Positive Imbalance
75.37	-16.30	10.68
69.00	-24.14	19.14
60.00	-30.60	23.10
45.00	-30.60	27.60
0.00	-30.60	27.60

Table 4 QUADRANT POWER TILT Limits for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.4

QUADRANT POWER TILT as measured by:	From 0 EFPD to 300 EFPD			
	Steady-state Limit for THERMAL POWER ≤ 60% (%)	Steady-state Limit for THERMAL POWER >60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	5.85	10.03	20.00
Minimum Incore Detector System *	3.20	2.01	4.40	20.00

QUADRANT POWER TILT as measured by:	From 300 EFPD to EOC			
	Steady-state Limit for THERMAL POWER ≤ 60% (%)	Steady-state Limit for THERMAL POWER >60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	4.54	10.03	20.00
Minimum Incore Detector System *	3.20	1.90	4.40	20.00

* These operating limits are based on the condition that no individual long emitter detector affecting the Minimum Incore Detector System tilt calculation exceeds 73% sensitivity depletion, which is the case for Cycle 23.

Table 5 Power Peaking Factors - F_Q for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.5

Heat Flux Hot Channel Factor F_Q

F_Q shall be limited by the following relationships:

$F_Q \leq LHR^{allow}(Bu) / [LHR^{avg} * P]$ (for $P \leq 1.0$)

$LHR^{allow}(Bu)$ = See the following tables

LHR^{avg} = 6.4293 kW/ft at 2817 MWt for all fuel

P = ratio of THERMAL POWER / RATED THERMAL POWER (current fraction of power)

Bu = fuel burnup (MWd/mtU)

Note: The measured F_Q shall be increased by 1.4% to account for manufacturing tolerances and further increased by 7.5% to account for measurement uncertainty before comparing to the limits. The core monitoring system computer-generated FQ values are augmented by the required uncertainties.

UO_2 Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	62,000 MWd/mtU
0	17.8	17.8	12.8
2.506	17.8	17.8	12.8
4.264	17.6	17.6	12.8
6.021	17.0	17.0	12.8
7.779	17.0	17.0	12.8
9.536	16.4	16.4	12.8
12.000	15.5	15.5	12.1

(a) Linear interpolation for allowable LHR between specified burnup points is valid for this table.

Table 5 (continued)

4 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	16.2	15.6	12.2
2.506	16.2	15.6	12.2
4.264	16.0	15.4	12.1
6.021	15.4	14.9	12.0
7.779	15.4	14.9	12.0
9.536	14.9	14.4	11.9
12.000	14.1	13.6	11.3

6 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	15.6	15.3	11.9
2.506	15.6	15.3	11.9
4.264	15.4	15.1	11.9
6.021	14.9	14.6	11.7
7.779	14.9	14.6	11.7
9.536	14.4	14.1	11.7
12.000	13.6	13.3	11.1

8 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR^{ALLOW} kW/ft[(a)]

Core Elevation (ft)	0 MWd/mtU	30,000 MWd/mtU	55,000 MWd/mtU
0	15.1	14.9	11.6
2.506	15.1	14.9	11.6
4.264	14.9	14.7	11.6
6.021	14.4	14.2	11.5
7.779	14.4	14.2	11.5
9.536	13.9	13.7	11.4
12.000	13.2	13.0	10.8

[(a)] Linear interpolation for allowable LHR between specified burnup points is valid for these tables.

Table 6 Power Peaking Factors - $F^N_{\Delta H}$ for Davis-Besse, Cycle 23

This Table is referred to by Technical Specifications 3.2.5

Enthalpy Rise Hot Channel Factors - $F^N_{\Delta H}$

$F^N_{\Delta H} \leq MARP\ [1 + (1/RH)\ (1 - P/P_m)]$ (see note below)

MARP = Maximum Allowable Radial Peak, see MARP Figures and data Tables

P = THERMAL POWER / RATED THERMAL POWER and P ≤ 1.0

P_m = 1.00 for 4-RCP operation

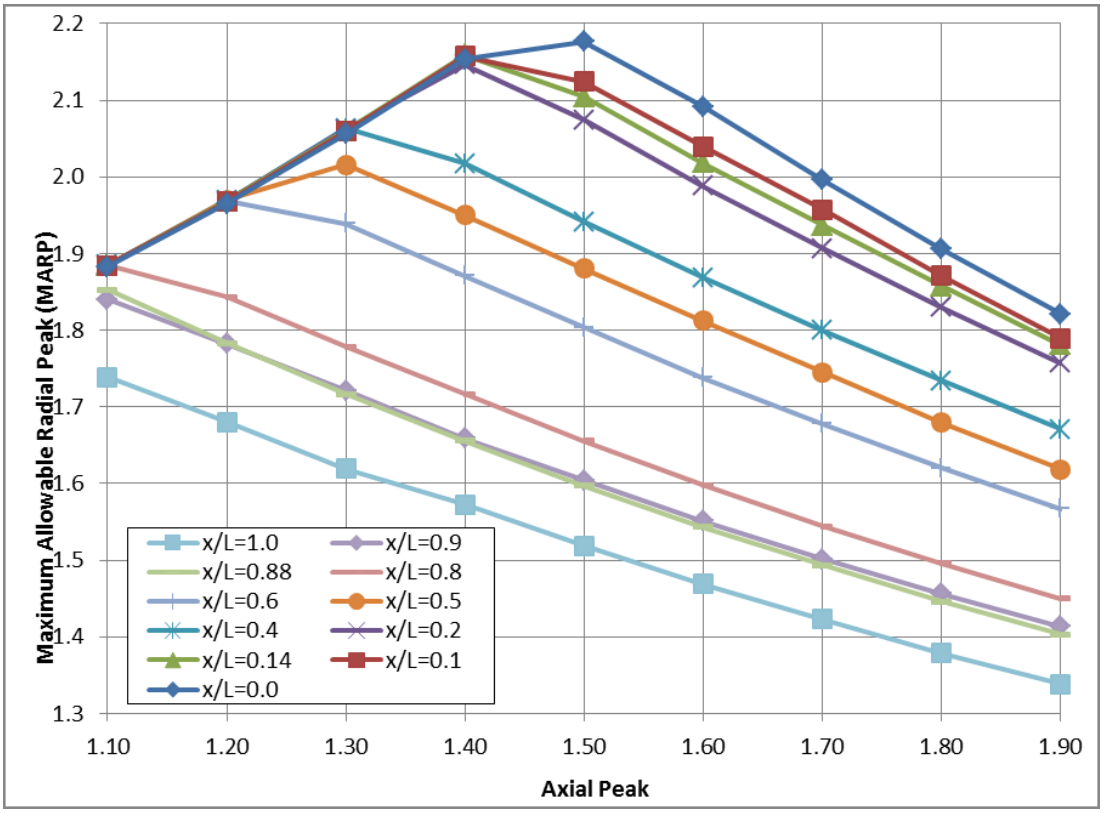
P_m = 0.75 for 3-RCP operation

1/RH = 0.3

RH = 3.333

Note: The measured $F^N_{\Delta H}$ shall be increased by 5.0% to account for measurement uncertainty prior to comparing to the limits. The core monitoring system-generated $F^N_{\Delta H}$ values are augmented by the required uncertainties.

Figure 5 Maximum Allowable Radial Peak for $F^N_{\Delta H}$ for Davis-Besse, Cycle 23 *



* Linear interpolation is acceptable.

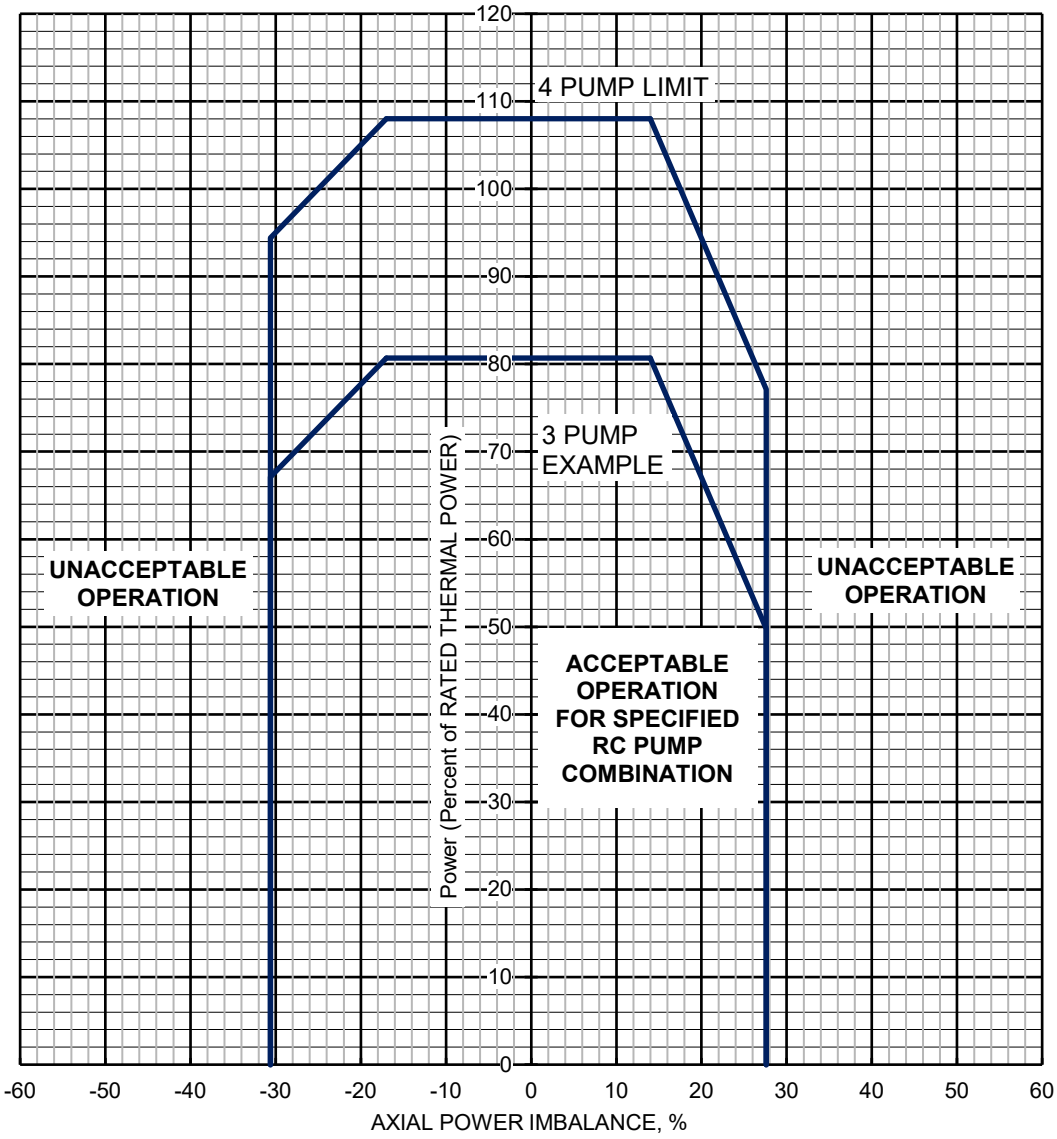
Table 7 Maximum Allowable Radial Peak for $F^N_{\Delta H}$ for Davis-Besse, Cycle 23

Axial Peak	x/L	Axial Height (inches)	MARP Limit	Axial Peak	x/L	Axial Height (inches)	MARP Limit
	0.0	0.00	1.88299		0.0	0.00	2.09189
	0.1	14.30	1.88398		0.1	14.30	2.03919
	0.14	20.02	1.88428		0.14	20.02	2.01827
	0.2	28.60	1.88461		0.2	28.60	1.98801
	0.4	57.20	1.88490		0.4	57.20	1.86840
1.1	0.5	71.50	1.88439	1.6	0.5	71.50	1.81257
	0.6	85.80	1.88451		0.6	85.80	1.73794
	0.8	114.40	1.88421		0.8	114.40	1.59754
	0.88	125.84	1.85239		0.88	125.84	1.54331
	0.9	128.70	1.83969		0.9	128.70	1.55084
	1.0	143.00	1.73842		1.0	143.00	1.46874
	0.0	0.00	1.96511		0.0	0.00	1.99604
	0.1	14.30	1.96705		0.1	14.30	1.95702
	0.14	20.02	1.96804		0.14	20.02	1.93661
	0.2	28.60	1.96825		0.2	28.60	1.90615
	0.4	57.20	1.96936		0.4	57.20	1.79933
1.2	0.5	71.50	1.96984	1.7	0.5	71.50	1.74468
	0.6	85.80	1.96919		0.6	85.80	1.67736
	0.8	114.40	1.84278		0.8	114.40	1.54415
	0.88	125.84	1.78287		0.88	125.84	1.49299
	0.9	128.70	1.78220		0.9	128.70	1.50138
	1.0	143.00	1.67994		1.0	143.00	1.42245
	0.0	0.00	2.05580		0.0	0.00	1.90606
	0.1	14.30	2.05912		0.1	14.30	1.87049
	0.14	20.02	2.06036		0.14	20.02	1.85710
	0.2	28.60	2.06155		0.2	28.60	1.82954
	0.4	57.20	2.06343		0.4	57.20	1.73365
1.3	0.5	71.50	2.01583	1.8	0.5	71.50	1.67902
	0.6	85.80	1.93900		0.6	85.80	1.62023
	0.8	114.40	1.77864		0.8	114.40	1.49550
	0.88	125.84	1.71670		0.88	125.84	1.44607
	0.9	128.70	1.72105		0.9	128.70	1.45590
	1.0	143.00	1.61890		1.0	143.00	1.37861
	0.0	0.00	2.15314		0.0	0.00	1.82131
	0.1	14.30	2.15758		0.1	14.30	1.78903
	0.14	20.02	2.15910		0.14	20.02	1.78024
	0.2	28.60	2.14648		0.2	28.60	1.75713
	0.4	57.20	2.01712		0.4	57.20	1.67040
1.4	0.5	71.50	1.95015	1.9	0.5	71.50	1.61847
	0.6	85.80	1.87083		0.6	85.80	1.56653
	0.8	114.40	1.71630		0.8	114.40	1.44958
	0.88	125.84	1.65545		0.88	125.84	1.40281
	0.9	128.70	1.65903		0.9	128.70	1.41322
	1.0	143.00	1.57207		1.0	143.00	1.33783
	0.0	0.00	2.17667				
	0.1	14.30	2.12413				
	0.14	20.02	2.10403				
	0.2	28.60	2.07451				
	0.4	57.20	1.94104				
1.5	0.5	71.50	1.88067				
	0.6	85.80	1.80330				
	0.8	114.40	1.65555				
	0.88	125.84	1.59706				
	0.9	128.70	1.60415				
	1.0	143.00	1.51859				

Figure 6

Flux-ΔFlux-Flow
(or Power/Imbalance/Flow)
Allowable Values,
Davis-Besse 1, Cycle 23

This Figure is referred to by Technical Specification 3.3.1



Power Level	Negative Imbalance	Positive Imbalance
108.0	-17.0	14.0
94.4	-30.6	---
77.1	-30.6	27.6
0.0	-30.6	27.6

The 3 pump example curve shows allowable values for an approximately 25% flow reduction for three pump operation (283,860 gpm). The actual setpoint will be calculated by the Reactor Protection System and will be directly proportional to the actual RC flow with three pumps.
These limits are based on EC 19-0137 (C-ICE-058.01-008, Cycle 21) and are conservative relative to the actual Cycle 23 limits.

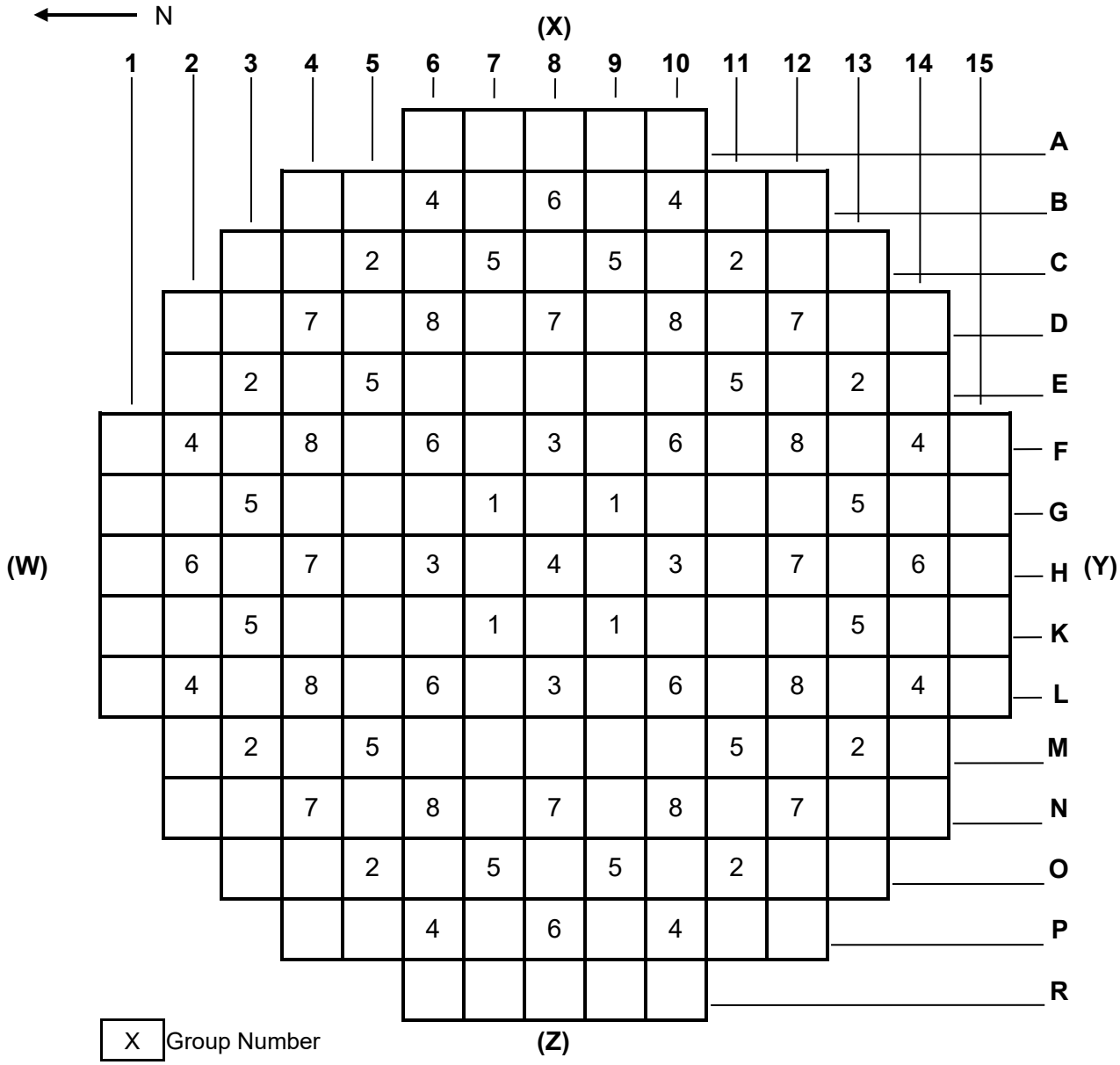
Table 8 Refueling Boron Concentration Limit for Davis-Besse, Cycle 23

This limit is referred to by Technical Specifications 3.9.1

The minimum required boron concentration for Mode 6 shall be sufficient to ensure a K_{eff} of 0.95 or less, plus an additional 1% $\Delta k/k$ conservatism allowance for uncertainties.

Figure 7 Control Rod Core Locations and Group Assignments for Davis-Besse, Cycle 23

This Figure is referred to by Technical Requirements Manual 8.1.3



Group	No of Rods	Function	Group	No of Rods	Function
1	4	Safety	5	12	Control
2	8	Safety	6	8	Control
3	4	Safety	7	8	Control
4	9	Safety	8	8	APSRs
		Total		61	