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March 30, 2020  
L-20-085

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 22, Revision 0

Enclosed is Revision 0 to the Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS) Cycle 22 Core Operating Limits Report (COLR). Submittal of this revision 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, Acting Manager, Nuclear Licensing and Regulatory Affairs, at (330) 315-6808.

Sincerely,

A handwritten signature in dark ink, appearing to read "Mark B. Bezilla".

Mark B. Bezilla

Enclosure:  
Cycle 22, Core Operating Limits Report, Revision 0

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

Enclosure  
L-20-085

Cycle 22, Core Operating Limits Report, Revision 0

(23 pages follow)

FIRSTENERGY NUCLEAR OPERATING COMPANY  
DAVIS-BESSE UNIT 1  
CYCLE 22  
CORE OPERATING LIMITS REPORT

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D. B. Kelley

Reviewed by Clayton Glass 2/26/2020  
C. Glass

Approved by JD Brown 2/27/20  
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## 1.0 Core Operating Limits

This CORE OPERATING LIMITS REPORT for DB-1 Cycle 22 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 22 is 710 EFPDs.

The following cycle-specific core Operating Limits, Protective Limit and Flux - $\Delta$  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 -  $\Delta$ 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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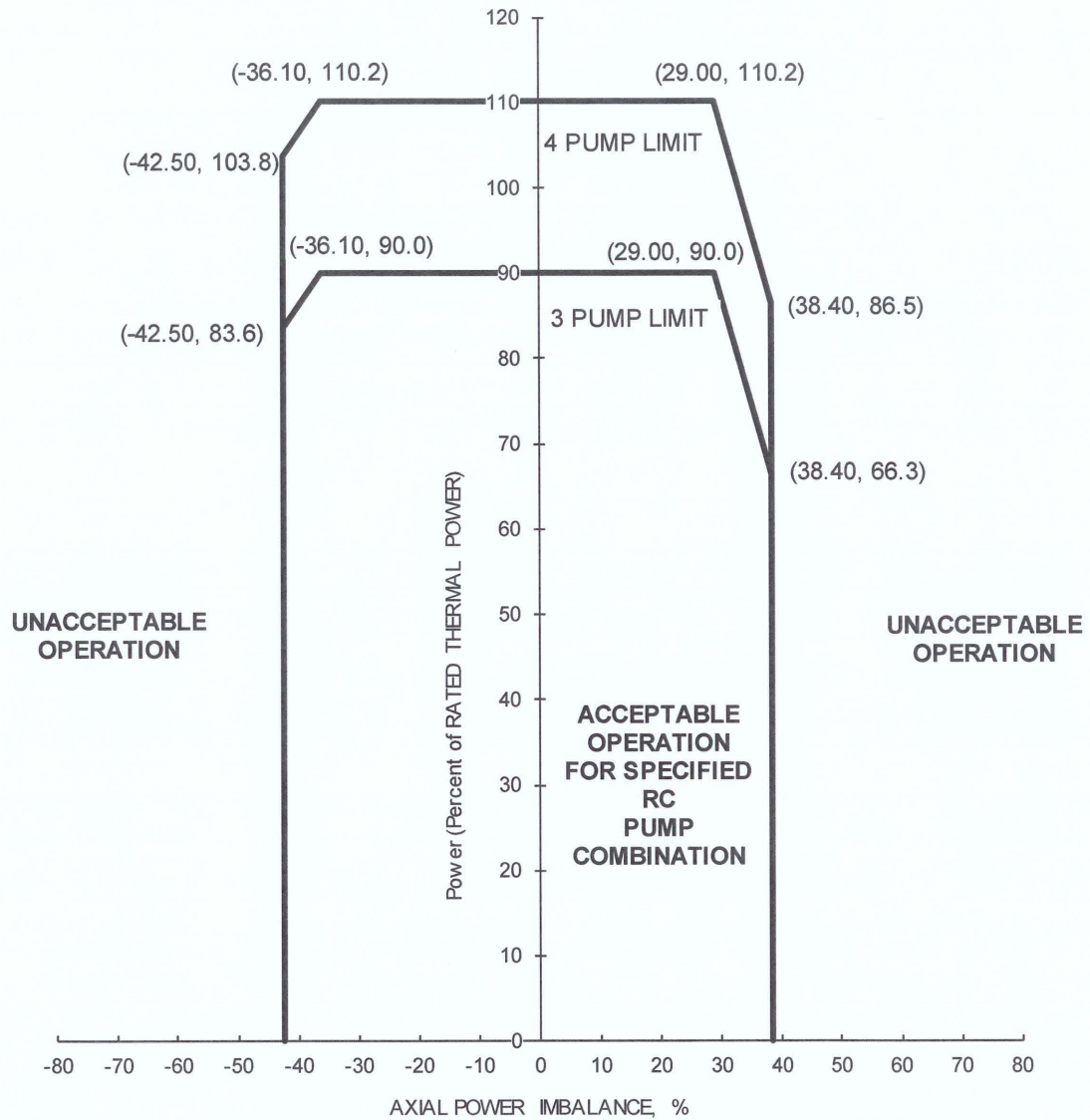
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Figure 1 AXIAL POWER IMBALANCE Protective Limits  
 Davis-Besse 1, Cycle 22

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	-36.10	29.00
103.8	-42.50	—
86.5	-42.50	38.40
0.0	-42.50	38.40

3 Pump		
Power Level	Negative Imbalance	Positive Imbalance
90.0	-36.10	29.00
83.6	-42.50	—
66.3	-42.50	38.40
0.0	-42.50	38.40

Table 1 Shutdown Margin Requirements for Davis-Besse, Cycle 22

Verify SHUTDOWN MARGIN per the table below.

APPLICABILITY	REQUIRED SHUTDOWN MARGIN	TECHNICAL SPECIFICATIONS REFERENCE
MODE 1 *	$\geq 1 \% \Delta k/k$ ***	3.1.4, 3.1.5
MODE 2 *	$\geq 1 \% \Delta k/k$	3.1.4, 3.1.5, 3.3.9
MODE 3	$\geq 1 \% \Delta k/k$	3.1.1, 3.3.9
MODE 4	$\geq 1 \% \Delta k/k$	3.1.1, 3.3.9
MODE 5	$\geq 1 \% \Delta k/k$	3.1.1, 3.3.9
MODE 1 PHYSICS TESTS Exceptions **	$\geq 1 \% \Delta k/k$	3.1.8
MODE 2 PHYSICS TESTS Exceptions	$\geq 1 \% \Delta k/k$	3.1.9

\* The required Shutdown Margin capability of  $1 \% \Delta k/k$  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  $\geq 1 \% \Delta k/k$  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  $0.5 \% \Delta k/k$  required rod worth to accommodate the SBLOCA model.



Table 2 Moderator Temperature Coefficient Limit for Davis-Besse, Cycle 22

These limits are referred to by Technical Specifications 3.1.3

1. Lower Limit:

MTC at HFP  $\geq -3.891 \times 10^{-4} \Delta k/k/^{\circ}F$  (-38.91 pcm/ $^{\circ}F$ )

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

MTC  $< 0.9 \times 10^{-4} \Delta k/k/^{\circ}F$  when Thermal Power  $< 95\%$  RTP

MTC  $< 0.0 \times 10^{-4} \Delta k/k/^{\circ}F$  when Thermal Power  $\geq 95\%$  RTP

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

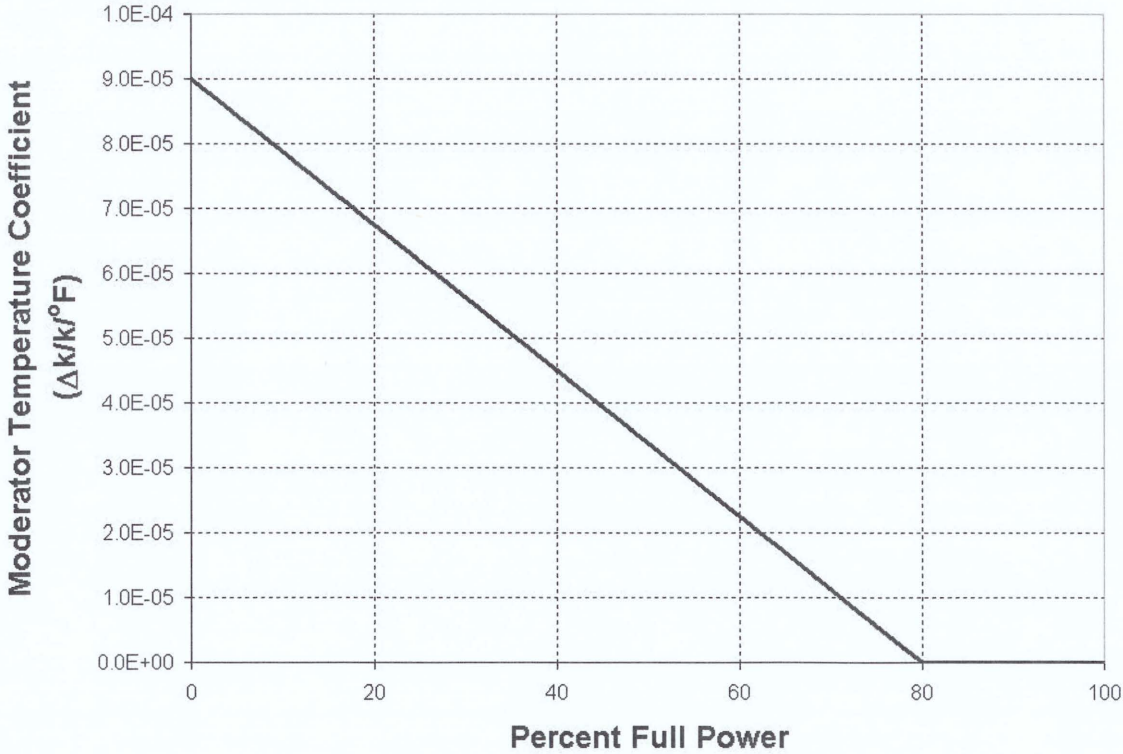


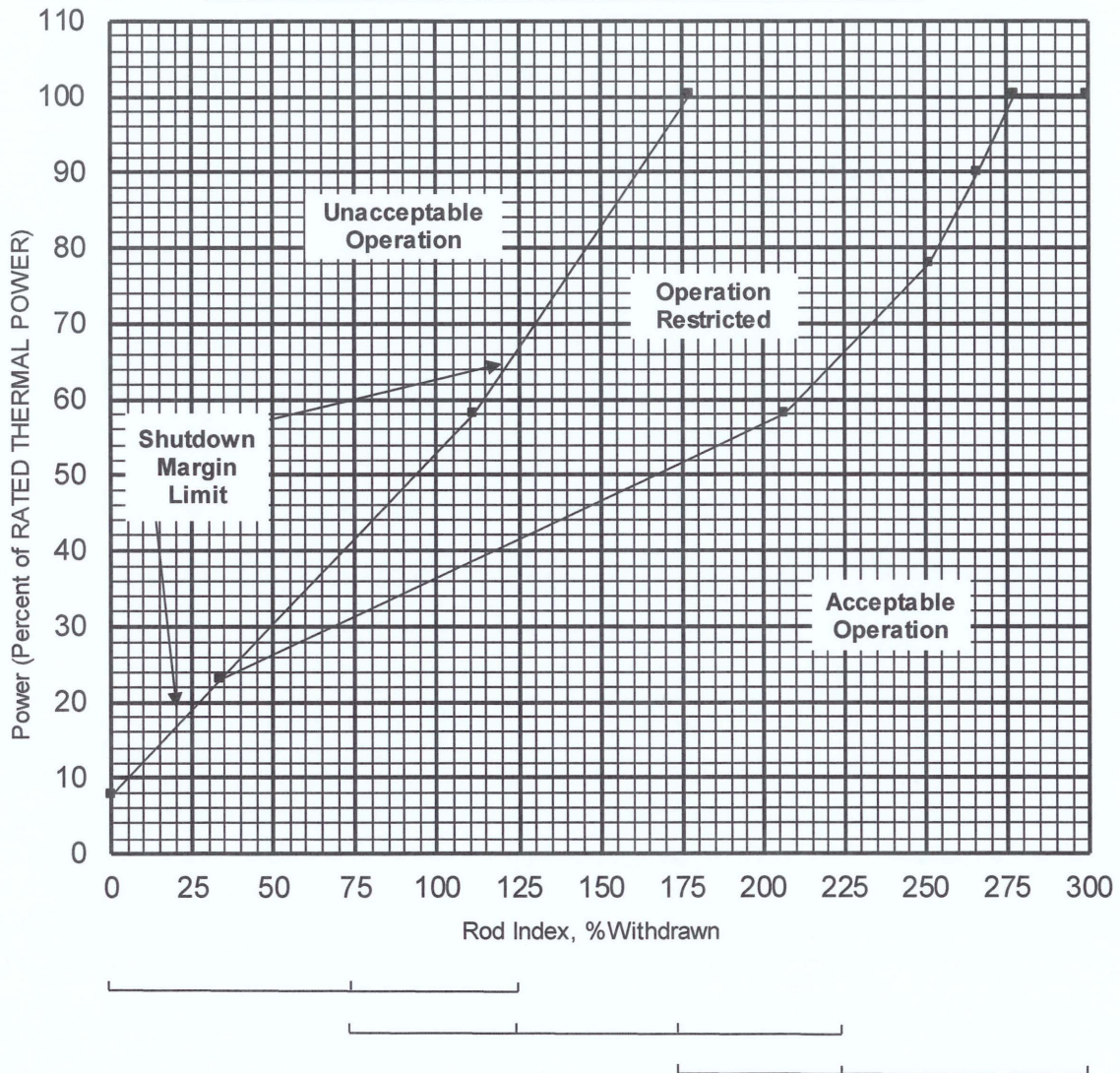
Table 3 Absolute Position Indicator (API) / Relative Position Indicator (RPI)  
Agreement Limit for Davis-Besse, Cycle 22

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 22

This Figure is referred to by Technical Specifications 3.2.1

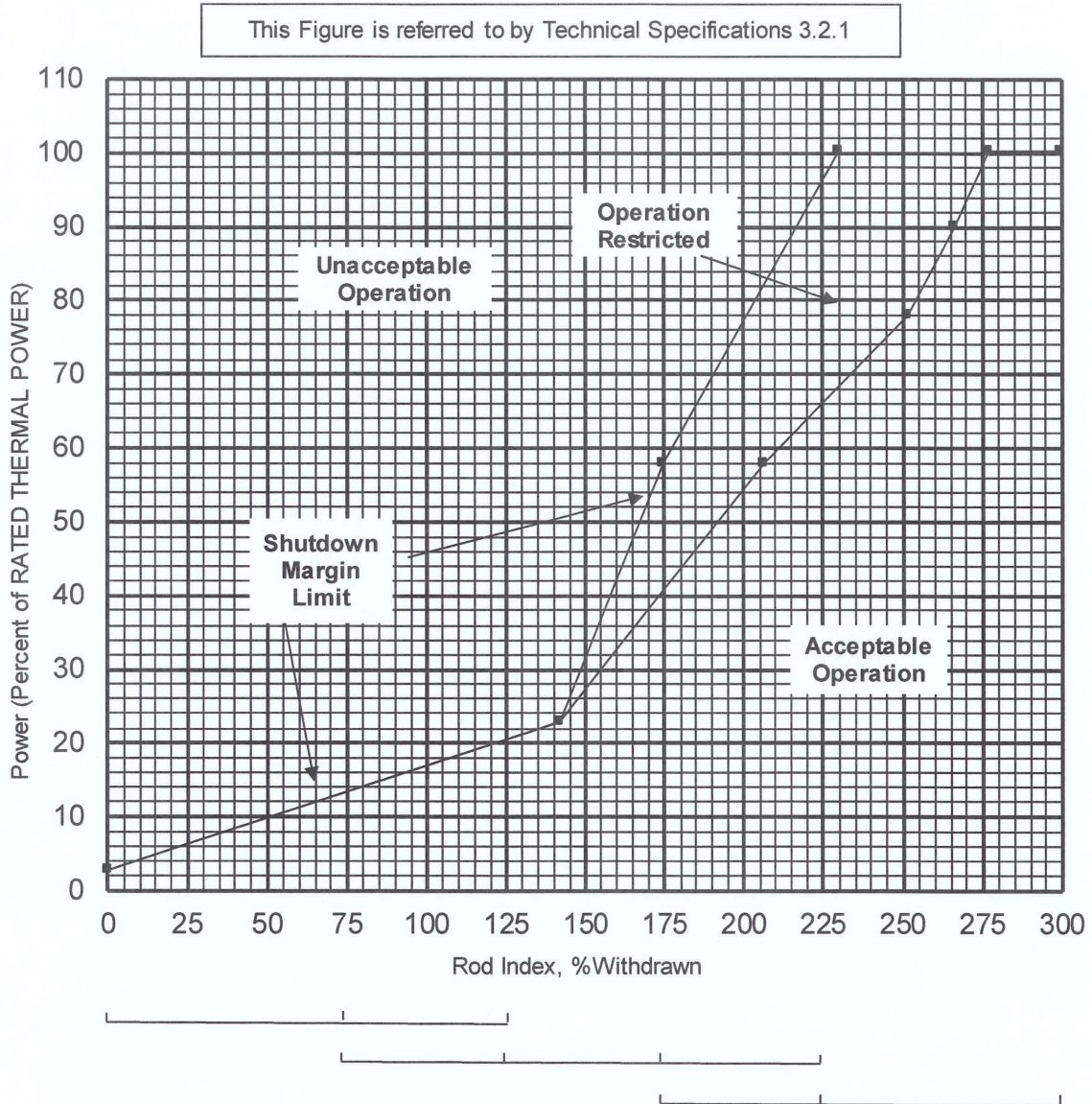


Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.  
 Note 2: Instrument error is accounted for in these Operating Limits.  
 Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	177.60
58.00	111.50
23.00	33.50
7.70	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	33.50
7.70	0.00

Figure 2b Regulating Group Position Operating Limits  
 After  $300 \pm 10$  EFPD, Four RC Pumps  
 Davis-Besse 1, Cycle 22



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.

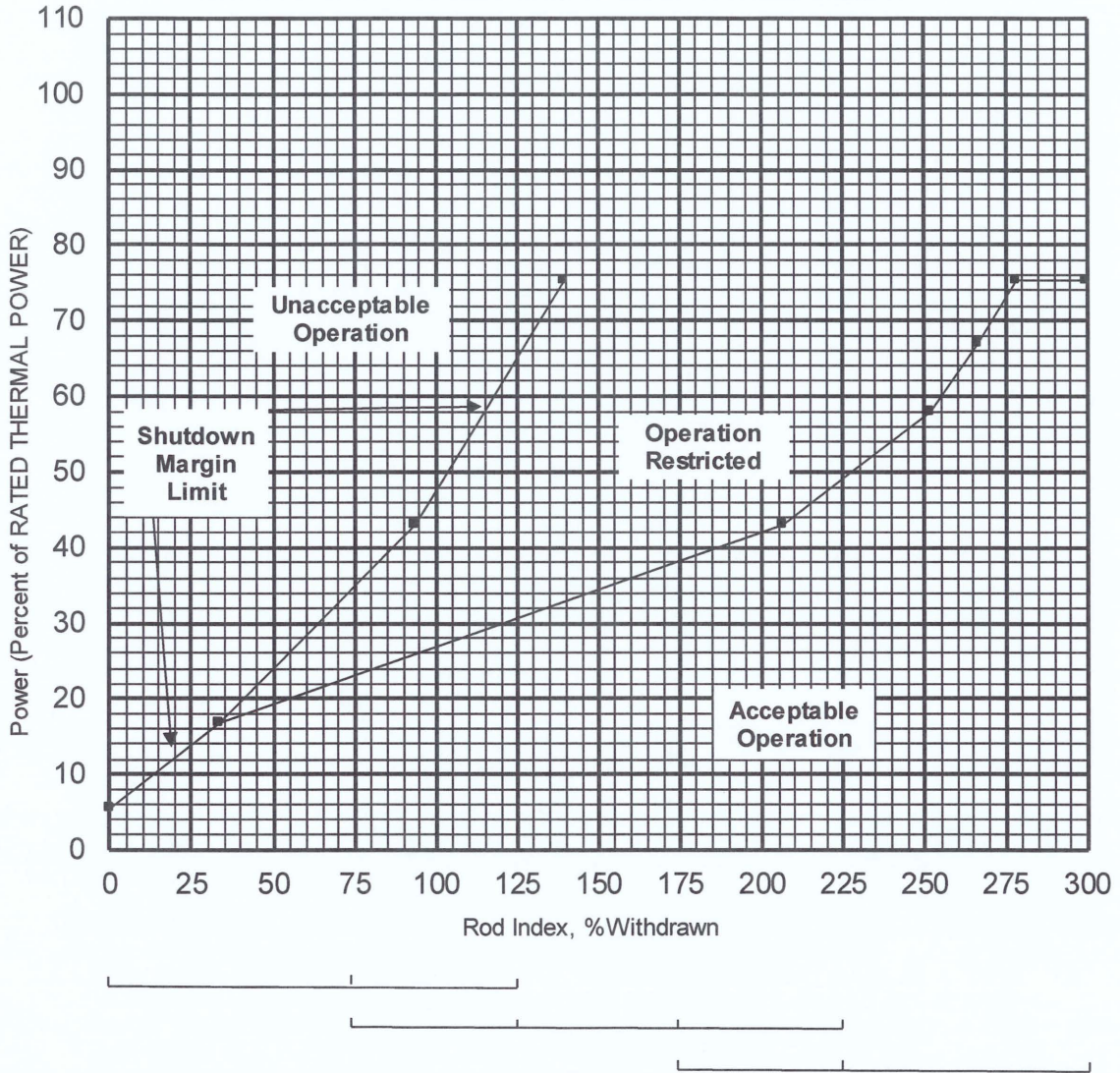
Note 3: Maximum plotted power level is 100.37 %RTP.

SDM Limit	
Power	RI
100.37	230.10
58.00	174.50
23.00	141.50
2.80	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	141.50
2.80	0.00

Figure 2c Regulating Group Position Operating Limits  
 0 to 300 ±10 EFPD, Three RC Pumps  
 Davis-Besse 1, Cycle 22

This Figure is referred to by Technical Specifications 3.2.1



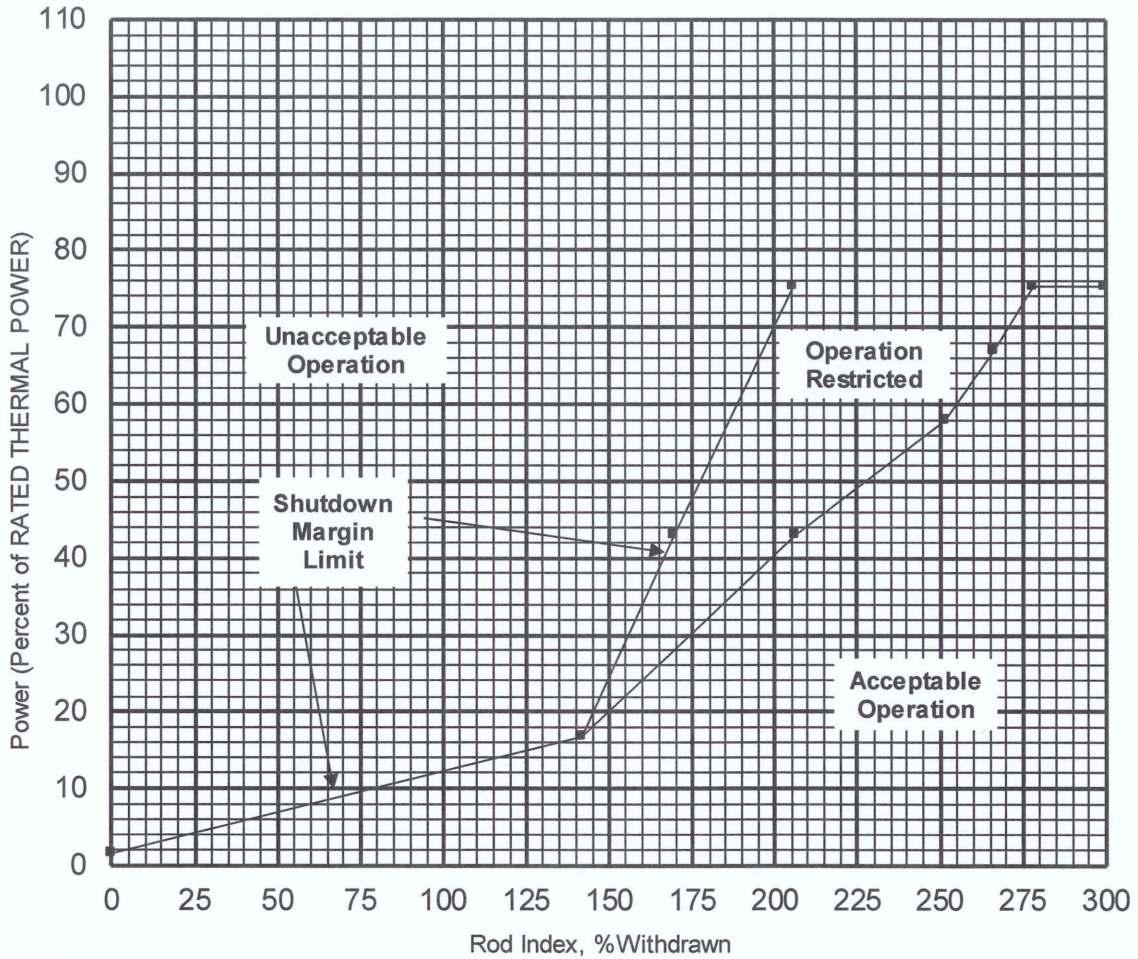
Note 1: A Rod Group overlap of 25 +/- 5% between sequential withdrawn groups 5 and 6, and 6 and 7, shall be maintained.  
 Note 2: Instrument error is accounted for in these Operating Limits.  
 Note 3: Maximum plotted power level is 75.37 %RTP.

SDM Limit	
Power	RI
75.37	139.30
43.10	93.50
16.80	33.50
5.40	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	33.50
5.40	0.00

Figure 2d Regulating Group Position Operating Limits  
 After  $300 \pm 10$  EFPD, Three RC Pumps  
 Davis-Besse 1, Cycle 22

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	205.70
43.10	169.50
16.80	141.50
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	141.50
1.60	0.00

Figure 3 APSR Position Operating Limits for Davis-Besse, Cycle 22

This Figure is referred to by Technical Specifications 3.2.2

**Before APSR Pull: 0 EFPD to  $648 \pm 10$  EFPD,  
Three or Four RC pumps operation\***

Lower Limit: 0 %WD

Upper Limit: 100 %WD

**After APSR Pull:  $648 \pm 10$  EFPD to End-of-Cycle  
Three or Four RC pumps operation\***

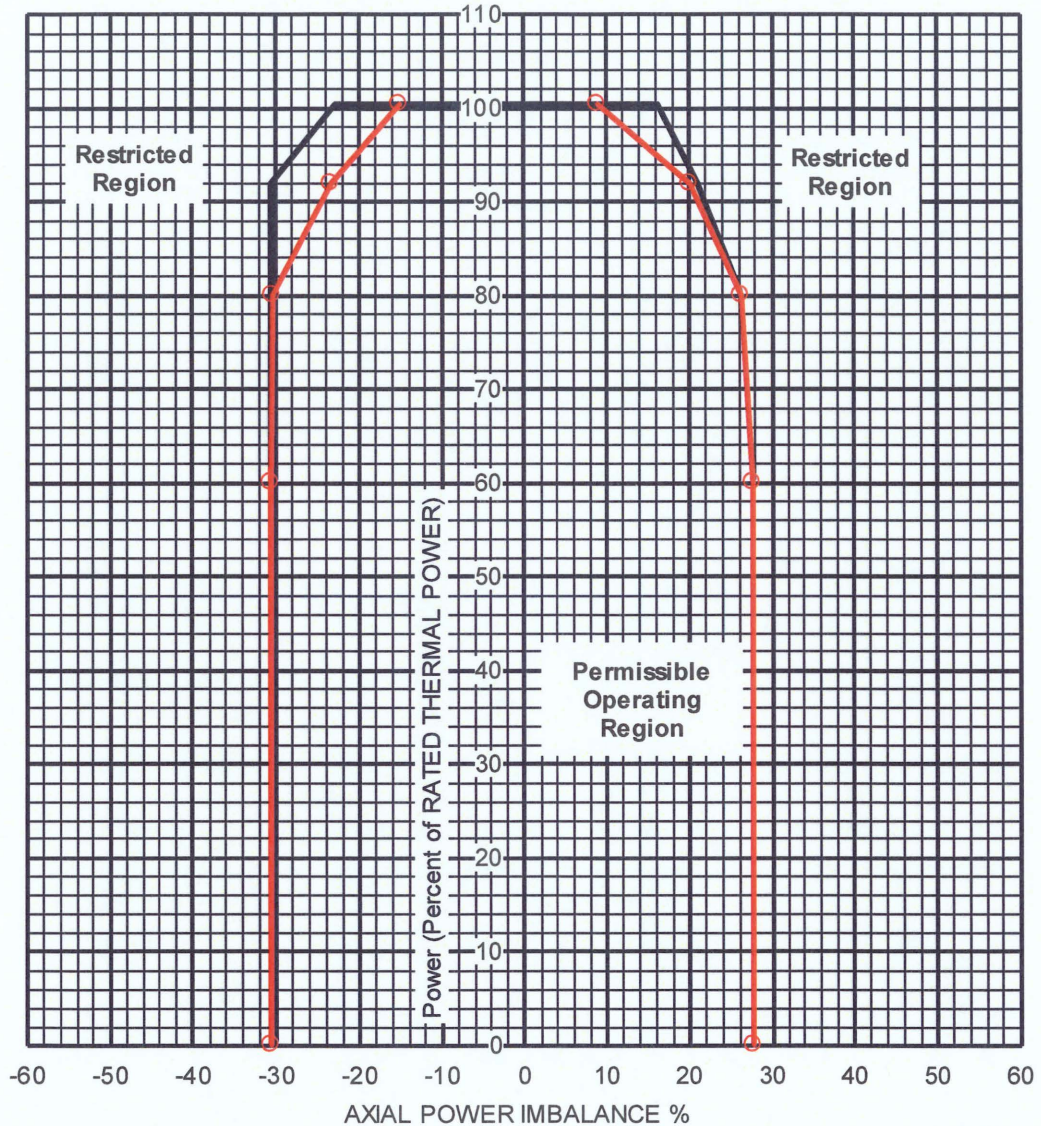
Insertion Prohibited (maintain  $\geq 99\%$ WD) \*\*

\* 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 EFPD to EOC, Four RC Pumps  
 Davis-Besse 1, Cycle 22

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 Excure 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.

LEGEND  
FULL INCORE

EXCURE



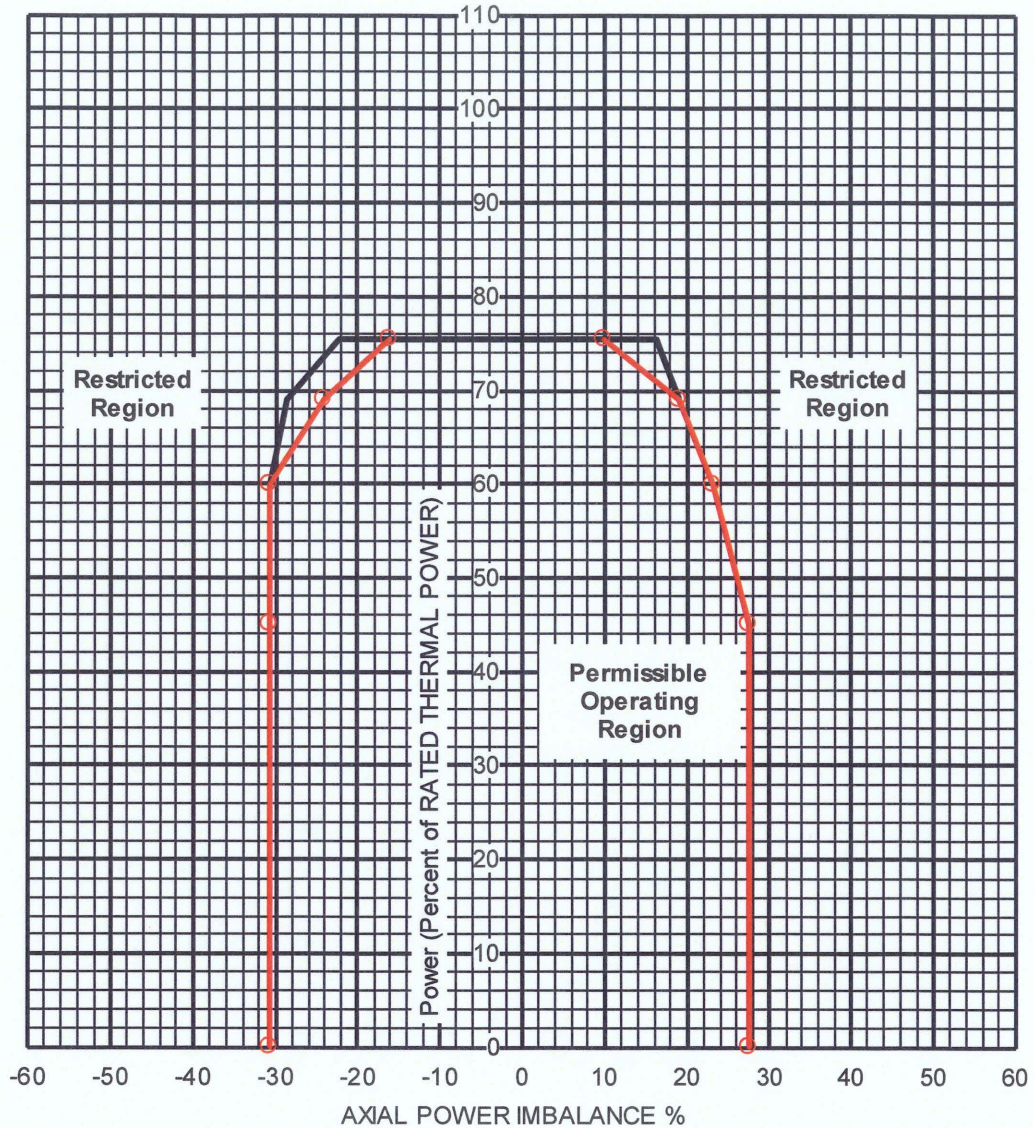
Full Incore		
Power	Negative Imbalance	Positive Imbalance
100.37	-22.84	16.21
92.00	-30.60	21.04
80.00	-30.60	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60

Excure		
Power	Negative Imbalance	Positive Imbalance
100.37	-15.17	8.95
92.00	-23.29	20.12
80.00	-30.28	26.32
60.00	-30.60	27.60
0.00	-30.60	27.60



Figure 4b AXIAL POWER IMBALANCE Operating Limits  
 0 EFPD to EOC, Three RC Pumps  
 Davis-Besse 1, Cycle 22

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.

LEGEND  
FULL INCORE

EXCORE



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	-16.09	9.87
69.00	-24.10	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 22

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 $\leq$ 60% (%)	Steady-state Limit for THERMAL POWER $>$ 60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	5.60	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 $\leq$ 60% (%)	Steady-state Limit for THERMAL POWER $>$ 60% (%)	Transient Limit (%)	Maximum Limit (%)
Symmetric Incore Detector System	7.90	4.32	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 22.

Table 5 Power Peaking Factors -  $F_Q$  for Davis-Besse, Cycle 22

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:

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

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

$LHR^{avg}$  = 6.4265 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  $F_Q$  values are augmented by the required uncertainties.

UO<sub>2</sub> Fuel (Mark-B-HTP) – All Batches except Batch 23A LHR<sup>ALLOW</sup> kW/ft<sup>(a)</sup>

	0	30,000	62,000
<u>Core Elevation (ft)</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>
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

UO<sub>2</sub> Fuel (Mark-B-HTP) – Batch 23A LHR<sup>ALLOW</sup> kW/ft<sup>(a)</sup>

	0	30,000	45,000
<u>Core Elevation (ft)</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>
0	17.6	17.6	15.4
2.506	17.6	17.6	15.4
4.264	17.4	17.4	15.2
6.021	16.8	16.8	14.9
7.779	16.8	16.8	14.9
9.536	16.2	16.2	14.6
12.000	15.4	15.4	13.9

<sup>(a)</sup> Linear interpolation for allowable LHR between specified burnup points is valid for these tables.

Table 5 (continued)

4 wt% Gad Fuel (Mark-B-HTP) – All Batches LHR<sup>ALLOW</sup> kW/ft<sup>(a)</sup>

	0	30,000	55,000
<u>Core Elevation (ft)</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>
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<sup>ALLOW</sup> kW/ft<sup>(a)</sup>

	0	30,000	55,000
<u>Core Elevation (ft)</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>
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<sup>ALLOW</sup> kW/ft<sup>(a)</sup>

	0	30,000	55,000
<u>Core Elevation (ft)</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>	<u>MWd/mtU</u>
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

<sup>(a)</sup> Linear interpolation for allowable LHR between specified burnup points is valid for these tables.

Table 6 Power Peaking Factors -  $F_{\Delta H}^N$  for Davis-Besse, Cycle 22

This Table is referred to by Technical Specifications 3.2.5

Enthalpy Rise Hot Channel Factors -  $F_{\Delta H}^N$

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

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

P = THERMAL POWER / RATED THERMAL POWER and  $P \leq 1.0$

$P_m$  = 1.00 for 4-RCP operation

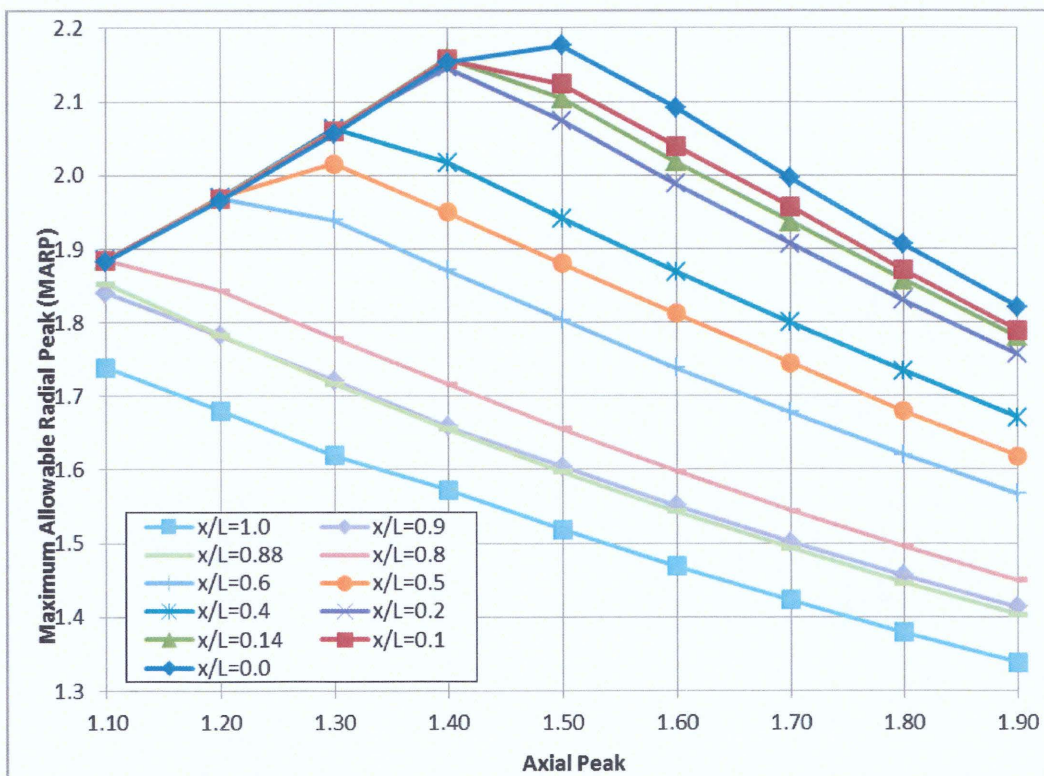
$P_m$  = 0.75 for 3-RCP operation

1/RH = 0.3

RH = 3.333

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

Figure 5 Maximum Allowable Radial Peak for  $F_{\Delta H}^N$  for Davis-Besse, Cycle 22 \*



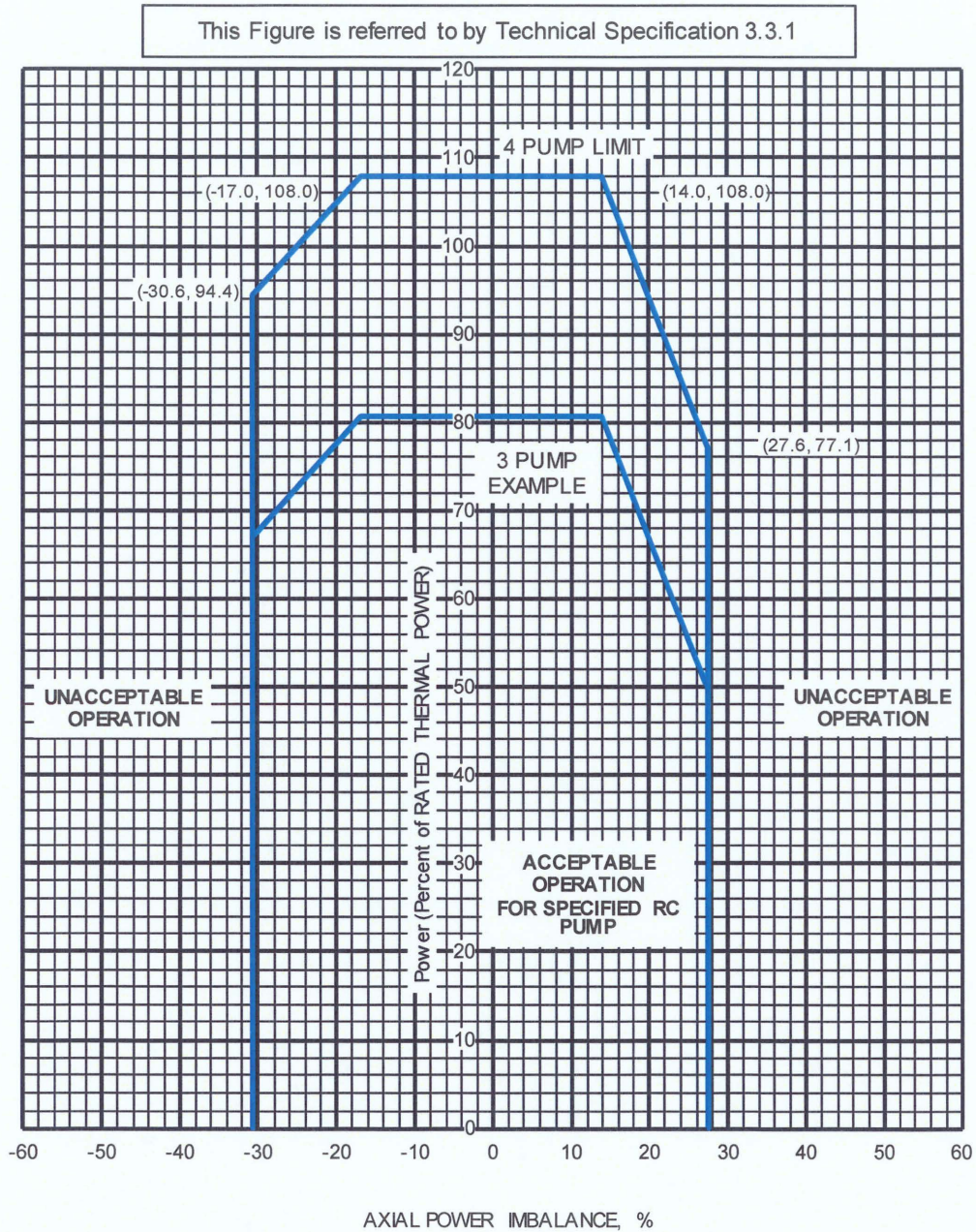
\* Linear interpolation is acceptable.

Table 7 Maximum Allowable Radial Peak for  $F_{\Delta H}^N$  for Davis-Besse, Cycle 22

Axial Peak	x/L	Axial Height (inches)	MARP Limit	Axial Peak	x/L	Axial Height (inches)	MARP Limit
1.1	0.0	0.00	1.88299	1.6	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
	0.5	71.50	1.88439		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		
1.2	0.0	0.00	1.96511	1.7	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
	0.5	71.50	1.96984		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		
1.3	0.0	0.00	2.05580	1.8	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
	0.5	71.50	2.01583		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		
1.4	0.0	0.00	2.15314	1.9	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
	0.5	71.50	1.95015		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		
1.5	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				
	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- $\Delta$ Flux-Flow  
 (or Power/Imbalance/Flow)  
 Allowable Values  
 Davis-Besse 1, Cycle 22



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 reactor coolant system 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 22 limits.

Table 8 Refueling Boron Concentration Limit for Davis-Besse, Cycle 22

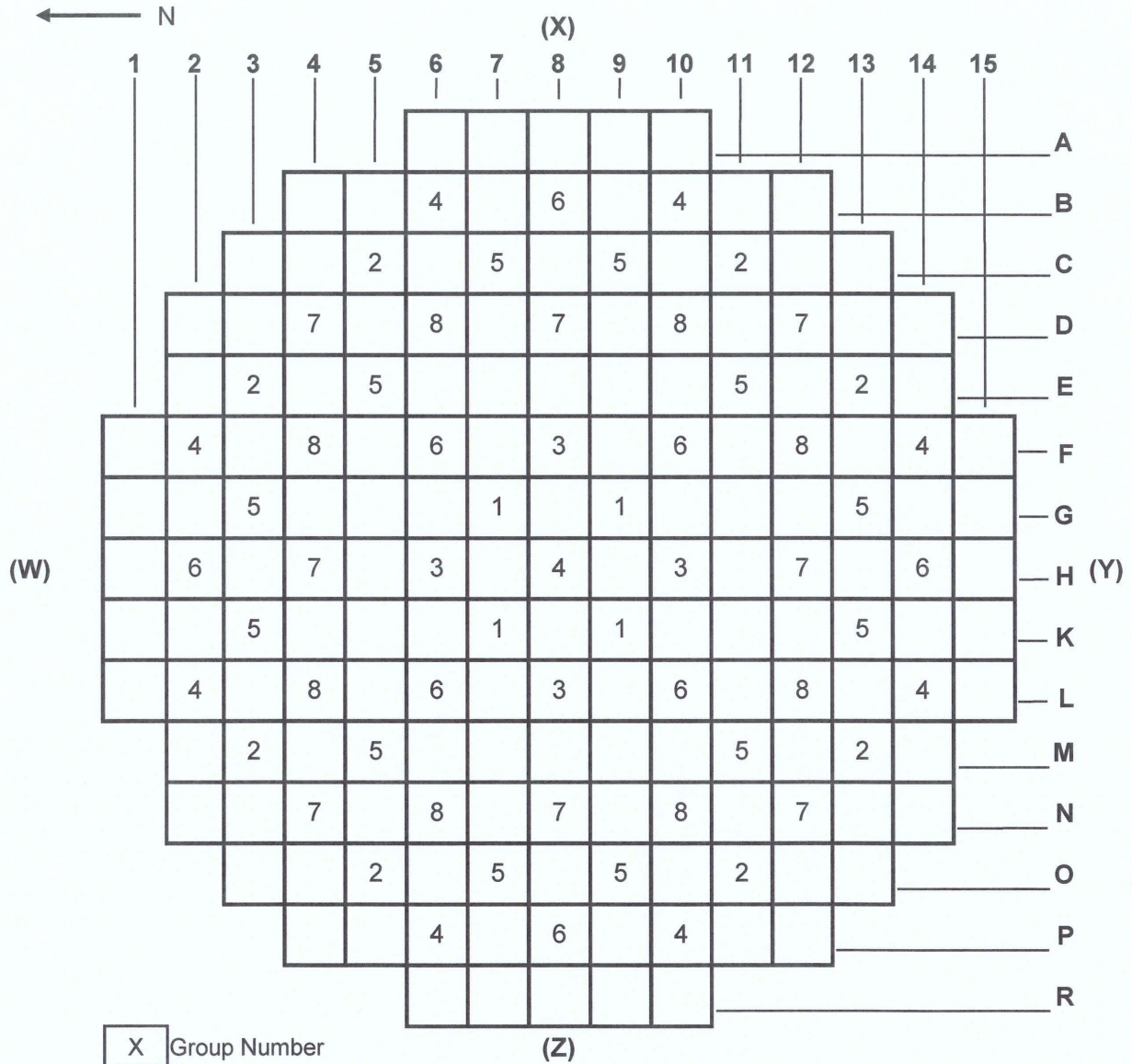
This limit is referred to by Technical Specifications 3.9.1

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 22

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	