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PG&E Letter DCL-12-064

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

Docket No. 50-275, OL-DPR-80
Diablo Canyon Power Plant, Unit 1
Core Operating Limits Report for Unit 1 Cycle 18

Dear Commissioners and Staff:

In accordance with Diablo Canyon Power Plant (DCPP) Technical Specification 5.6.5.d, Pacific Gas & Electric Company (PG&E) is submitting the enclosed Revision 6 of the Core Operating Limits Report (COLR) for Unit 1. PG&E revised this document for DCPP Unit 1, Cycle 18.

PG&E makes no new or revised regulatory commitments in this submittal (as defined by NEI 99-04).

If there are any questions regarding the COLR, please contact Mr. Mark Mayer at (805) 545-4674.

Sincerely,

James M. Welsch

wrl8/60034887
Enclosure
cc: Diablo Distribution
cc/enc: Elmo E. Collins, NRC Region IV
Michael S. Peck, NRC Senior Resident Inspector
Joseph M. Sebrosky, NRR Senior Project Manager

CORE OPERATING LIMITS REPORT (COLR)
DIABLO CANYON POWER PLANT UNIT 1, CYCLE 18
EFFECTIVE DATE June 13, 2012

TITLE: COLR for Diablo Canyon Unit 1

1

06/13/12
EFFECTIVE DATE

PROCEDURE CLASSIFICATION: QUALITY RELATED

1. CORE OPERATING LIMITS REPORT

1.1 This Core Operating Limits Report (COLR) for Diablo Canyon Unit 1 Cycle 18 has been prepared in accordance with the requirements of Technical Specification (TS) 5.6.5.

1.2 The Technical Specifications affected by this report are listed below:

- 3.1.1 - Shutdown Margin (MODE 2 with $k_{eff} < 1.0$, MODES 3, 4, and 5)
- 3.1.3 - Moderator Temperature Coefficient
- 3.1.4 - Rod Group Alignment Limits
- 3.1.5 - Shutdown Bank Insertion Limits
- 3.1.6 - Control Bank Insertion Limits
- 3.1.8 - PHYSICS TESTING Exceptions – MODE 2
- 3.2.1 - Heat Flux Hot Channel Factor - $F_Q(Z)$
- 3.2.2 - Nuclear Enthalpy Rise Hot Channel Factor - $F^N_{\Delta H}$
- 3.2.3 - Axial Flux Difference - (AFD)
- 3.4.1 - RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits
- 3.9.1 - Boron Concentration

2. OPERATING LIMITS

The cycle-specific parameter limits for the TS listed in Section 1 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in TS 5.6.5.

2.1 Shutdown Margin (SDM) (TS 3.1.1, 3.1.4, 3.1.5, 3.1.6, 3.1.8)

The SDM limit for MODE 1, MODE 2, MODE 3 and MODE 4 is:

2.1.1 The shutdown margin with Safety Injection enabled shall be greater than or equal to 1.6% Δk/k.

2.1.2 In MODES 3 or 4 the shutdown margin with Safety Injection blocked shall be greater than or equal to 1.6% Δk/k calculated at a temperature of 200°F.

The SDM limit for MODE 5 is:

2.1.3 The shutdown margin shall be greater than or equal to 1.0% Δk/k. However, an administrative value of 1.6 % Δk/k will be used to address concerns of NSAL-02-014.

2.2 Moderator Temperature Coefficient (MTC) (TS 3.1.3)

The MTC limit for MODES 1, 2, and 3 is:

2.2.1 The MTC shall be less negative than -3.9×10^{-4} Δk/k/°F for all rods withdrawn, end of cycle life (EOL), RATED THERMAL POWER condition.

2.2.2 The MTC 300 ppm surveillance limit is -3.0×10^{-4} Δk/k/°F (all rods withdrawn, RATED THERMAL POWER condition).

2.2.3 The MTC 60 ppm surveillance limit is -3.72×10^{-4} Δk/k/°F (all rods withdrawn, RATED THERMAL POWER condition).

2.3 Shutdown Bank Insertion Limits (TS 3.1.5)

2.3.1 Each shutdown bank shall be withdrawn to at least 225 steps.

2.4 Control Bank Insertion Limits (TS 3.1.6)

2.4.1 The control banks shall be limited in physical insertion as shown in Figure 1.

2.5 Heat Flux Hot Channel Factor – $F_Q(Z)$ (TS 3.2.1)

2.5.1 $$F_Q(Z) < \frac{F_Q^{RTP}}{P} * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) < \frac{F_Q^{RTP}}{0.5} * K(Z) \quad \text{for } P \leq 0.5$$

where: $$P = \frac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$$

$F_Q^{RTP} = 2.58$

$K(Z) = 1.0$

NOTE: The W(Z) data is appropriate for use only if the predicted axial offset is within ±3% of the measured value.

2.5.2 The W(Z) data for Relaxed Axial Offset Control (RAOC) operation, provided in Tables 2A and 2B are sufficient to determine the RAOC W(Z) versus core height for burnups through the end of full power reactivity plus a power coast down of up to 1000 MWD/MTU.

For W(Z) data at a desired burnup not listed in the table, but less than the maximum listed burnup, values at 3 or more burnup steps should be used to interpolate the W(Z) data to the desired burnup with a polynomial type fit that uses the W(Z) data for the nearest three burnup steps.

For W(Z) data at a desired burnup outside of the listed burnup steps, a linear extrapolation of the W(Z) data for the nearest two burnup steps can be used. If data are listed for only 2 burnup steps, a linear fit can be used for both interpolation and extrapolation.

The W(Z) values are generated assuming that they will be used for full power surveillance. When using a flux map instead of the Power Distribution Monitoring System (PDMS) for part power surveillance, the W(Z) values must be increased by the factor 1/P ($P > 0.5$) or 1/0.5 ($P \leq 0.5$), where P is the core relative power during the surveillance, to account for the increase in the $F_Q(Z)$ limit at reduced power levels.

Table 1 shows F_Q margin decreases that are greater than 2% per 31 Effective Full Power Days (EFPD). These values shall be used to increase $F_Q^W(Z)$ per SR 3.2.1.2. A 2% penalty factor shall be used at all cycle burnups that are outside the range of Table 1.

2.5.3 $F_Q(Z)$ shall be evaluated to determine if it is within its limits by verifying that $F_Q^C(Z)$ and $F_Q^W(Z)$ satisfy the following:

a. Using the moveable incore detectors to obtain a power distribution map in MODE 1.

b. Increasing the measured $F_Q(Z)$ component of the power distribution map by 3% to account for manufacturing tolerances and further increasing the value by 5% to account for measurement uncertainties.

c. Satisfying the following relationship:

$$F_Q^C(Z) < \frac{F_Q^{RTP} * K(Z)}{P} \quad \text{for } P > 0.5$$

$$F_Q^C(Z) \le \frac{F_Q^{RTP} * K(Z)}{0.5} \quad \text{for } P \le 0.5$$

$$F_Q^W(Z) < \frac{F_Q^{RTP}}{P} * K(Z) \quad \text{for } P > 0.5$$

$$F_Q^W(Z) \le \frac{F_Q^{RTP}}{0.5} * K(Z) \quad \text{for } P \le 0.5$$

where:

$F_Q^C(Z)$ is the measured $F_Q(Z)$ increased by the allowances for manufacturing tolerances and measurement uncertainty.

F_Q^{RTP} is the F_Q limit

$K(Z)$ is the normalized $F_Q(Z)$ as a function of core height

P is the relative THERMAL POWER, and

$F_Q^W(Z)$ is the total peaking factor, $F_Q^C(Z)$, multiplied by W(Z) which gives the maximum $F_Q(Z)$ calculated to occur in normal operation.

W(Z) is the cycle dependent function that accounts for power distribution transients encountered during normal operation.

F_Q^{RTP} and K(Z) are specified in 2.5.1 and W(Z) is specified in 2.5.2.

2.6 Nuclear Enthalpy Rise Hot Channel Factor - $F_{\Delta H}^{N}$ (TS 3.2.2)

$$F_{\Delta H}^{N} \leq F_{\Delta H}^{RTP} *[1 + PF_{\Delta H} * (1-P)]$$

where:

$$P = \frac{THERMAL\ POWER}{RATED\ THERMAL\ POWER}$$

$F_{\Delta H}^{N}$ = Measured values of $F_{\Delta H}^{N}$ obtained by using the moveable incore detectors to obtain a power distribution map.

$F_{\Delta H}^{RTP}$ = 1.586 (prior to including 4% uncertainty)

$PF_{\Delta H}$ = 0.3 = Power Factor Multiplier

2.7 Power Distribution Measurement Uncertainty (TS 3.2.1. and TS 3.2.2):

If the PDMS is OPERABLE, the uncertainty, $U_{F\Delta H}$, to be applied to the Nuclear Enthalpy Rise Hot Channel Factor, $F_{\Delta H}^{N}$, shall be calculated by the following formula:

$$U_{F\Delta H} = 1.0 + \frac{U_{\Delta H}}{100.0}$$

where: $U_{\Delta H}$ = Uncertainty for enthalpy rise as defined in equation (5-19) in Reference 6.2. However, if the uncertainty is less than 4.0, the uncertainty should be set equal to 4.0. $F_{\Delta H}^{RTP}$ = 1.65 for PDMS (in the above Section 2.6 equation).

If the PDMS is OPERABLE, the uncertainty, U_{FQ}, to be applied to the Heat Flux Hot Channel Factor, $F_Q(Z)$, shall be calculated by the following formula:

$$U_{FQ} = \left(1.0 + \frac{U_Q}{100.0}\right) * U_e$$

where: U_Q = Uncertainty for power peaking factor as defined in equation (5-19) in Reference 6.2.

U_e = Engineering uncertainty factor
= 1.03

If the PDMS is inoperable, the Nuclear Enthalpy Rise Hot Channel Factor, $F_{\Delta H}^{N}$, shall be calculated as specified in Section 2.6.

If the PDMS is inoperable, the Heat Flux Hot Channel Factor, $F_Q(Z)$, shall be calculated as specified in Section 2.5.

2.8 Axial Flux Difference (TS 3.2.3)

2.8.1 The Axial Flux Difference (AFD) Limits are provided in Figure 2.

2.9 Boron Concentration (TS 3.9.1)

The refueling boron concentration of the Reactor Coolant System, the refueling canal, and the refueling cavity shall be maintained within the more restrictive of the following limits:

2.9.1 A k_{eff} of 0.95 or less, with the most reactive control rod assembly completely withdrawn, or

2.9.2 A boron concentration of greater than or equal to 2000 ppm.

2.10 RCS Pressure and Temperature Departure from Nucleate Boiling (DNB) Limit (TS 3.4.1)

2.10.1 Pressurizer pressure is greater than or equal to 2175 psig.

2.10.2 RCS average temperature is less than or equal to 581.7°F.

NOTE: The DNB RCS T_{AVG} limit is based on the slightly lower and bounding value associated with Unit 1 in order to have the same surveillance limits for both Unit 1 and Unit 2.

3. TABLES

3.1 Table 1, "F_Q Margin Decreases in Excess of 2% Per 31 EFPD"

3.2 Table 2A, "Load Follow W(Z) Factors at 150 and 5,000 MWD/MTU as a Function of Core Height"

3.3 Table 2B, "Load Follow W(Z) Factors at 12,000 and 22,000 MWD/MTU as a Function of Core Height"

4. FIGURES

4.1 Figure 1, "Control Bank Insertion Limits Versus Rated Thermal Power"

4.2 Figure 2, "AFD Limits as a Function of Rated Thermal Power"

5. RECORDS

None

6. REFERENCES

6.1 NF-PGE-11-93, "Diablo Canyon Unit 1 Cycle 18 Reload Evaluation and Core Operating Limits Report," January 2012

6.2 WCAP-12473-A (Non-Proprietary), "BEACON Core Monitoring and Operations Support System," August 1994

Table 1: F_Q Margin Decreases in Excess of 2% Per 31 EFPD

Cycle Burnup (MWD/MTU)	Max. % Decrease in F_Q Margin
150	2.00
313	2.02
475	2.46
638	2.81
800	3.05
963	3.14
1126	3.07
1288	2.86
1451	2.54
1613	2.13
1776	2.00
6329	2.00
6491	2.01
6654	2.36
6817	2.53
6979	2.42
7142	2.31
7305	2.18
7467	2.03
7630	2.00

NOTE: All cycle burnups outside the range of this table shall use a 2% decrease in F_Q margin for compliance with SR 3.2.1.2. Linear interpolation is adequate for intermediate cycle burnups.

Table 2A: Load Follow W(Z) Factors at 150 and 5000 MWD/MTU as a Function of Core Height

HEIGHT (INCHES)	150 MWD/MTU W(Z)	HEIGHT (INCHES)	5000 MWD/MTU W(Z)
*0.0	1.4629	*0.0	1.4788
*2.4	1.4588	*2.4	1.4755
*4.8	1.4517	*4.8	1.4687
*7.2	1.4426	*7.2	1.4595
*9.7	1.4316	*9.7	1.4479
12.1	1.4173	12.1	1.4327
14.5	1.4015	14.5	1.4153
16.9	1.3841	16.9	1.3957
19.3	1.3656	19.3	1.3743
21.7	1.3461	21.7	1.3514
24.1	1.3259	24.1	1.3274
26.6	1.3049	26.6	1.3025
29.0	1.2836	29.0	1.2773
31.4	1.2608	31.4	1.2515
33.8	1.2376	33.8	1.2290
36.2	1.2227	36.2	1.2076
38.6	1.2159	38.6	1.1960
41.0	1.2112	41.0	1.1954
43.5	1.2073	43.5	1.1920
45.9	1.2032	45.9	1.1877
48.3	1.1982	48.3	1.1827
50.7	1.1916	50.7	1.1763
53.1	1.1847	53.1	1.1692
55.5	1.1790	55.5	1.1612
57.9	1.1735	57.9	1.1555
60.4	1.1671	60.4	1.1497
62.8	1.1609	62.8	1.1433
65.2	1.1588	65.2	1.1357
67.6	1.1631	67.6	1.1274
70.0	1.1668	70.0	1.1311

* Top and Bottom 8% Excluded

Table 2A: Load Follow W(Z) Factors at 150 and 5000 MWD/MTU as a Function of Core Height (Continued)

HEIGHT (INCHES)	150 MWD/MTU W(Z)	HEIGHT (INCHES)	5000 MWD/MTU W(Z)
72.4	1.1749	72.4	1.1407
74.9	1.1858	74.9	1.1504
77.3	1.1943	77.3	1.1592
79.7	1.2018	79.7	1.1669
82.1	1.2078	82.1	1.1734
84.5	1.2121	84.5	1.1783
86.9	1.2149	86.9	1.1824
89.3	1.2161	89.3	1.1869
91.8	1.2149	91.8	1.1923
94.2	1.2113	94.2	1.1958
96.6	1.2053	96.6	1.1973
99.0	1.1963	99.0	1.1970
101.4	1.1857	101.4	1.1946
103.8	1.1777	103.8	1.1901
106.2	1.1728	106.2	1.1871
108.7	1.1751	108.7	1.1858
111.1	1.1788	111.1	1.1838
113.5	1.1809	113.5	1.1845
115.9	1.1936	115.9	1.2046
118.3	1.2209	118.3	1.2232
120.7	1.2499	120.7	1.2351
123.1	1.2763	123.1	1.2438
125.6	1.3016	125.6	1.2553
128.0	1.3240	128.0	1.2692
130.4	1.3492	130.4	1.2672
132.8	1.3749	132.8	1.2775
*135.2	1.3876	*135.2	1.2902
*137.6	1.3798	*137.6	1.2820
*140.0	1.3620	*140.0	1.2747
*142.5	1.3366	*142.5	1.2669
*144.9	1.3156	*144.9	1.2592

* Top and Bottom 8% Excluded

Table 2B: Load Follow W(Z) Factors at 12000 and 22000 MWD/MTU as a Function of Core Height

HEIGHT (INCHES)	12000 MWD/MTU W(Z)	HEIGHT (INCHES)	22000 MWD/MTU W(Z)
*0.0	1.3034	*0.0	1.3483
*2.4	1.2941	*2.4	1.3352
*4.8	1.2849	*4.8	1.3219
*7.2	1.2751	*7.2	1.3079
*9.7	1.2646	*9.7	1.2926
12.1	1.2553	12.1	1.2789
14.5	1.2469	14.5	1.2668
16.9	1.2368	16.9	1.2533
19.3	1.2263	19.3	1.2398
21.7	1.2155	21.7	1.2262
24.1	1.2042	24.1	1.2131
26.6	1.1927	26.6	1.2007
29.0	1.1811	29.0	1.1883
31.4	1.1688	31.4	1.1754
33.8	1.1572	33.8	1.1674
36.2	1.1548	36.2	1.1592
38.6	1.1548	38.6	1.1603
41.0	1.1543	41.0	1.1749
43.5	1.1558	43.5	1.1889
45.9	1.1594	45.9	1.2016
48.3	1.1629	48.3	1.2129
50.7	1.1653	50.7	1.2228
53.1	1.1666	53.1	1.2301
55.5	1.1669	55.5	1.2355
57.9	1.1661	57.9	1.2397
60.4	1.1647	60.4	1.2402
62.8	1.1609	62.8	1.2469
65.2	1.1587	65.2	1.2725
67.6	1.1681	67.6	1.2931
70.0	1.1840	70.0	1.3121

* Top and Bottom 8% Excluded

Table 2B: Load Follow W(Z) Factors at 12000 and 22000 MWD/MTU as a Function of Core Height (continued)

HEIGHT (INCHES)	12000 MWD/MTU W(Z)	HEIGHT (INCHES)	22000 MWD/MTU W(Z)
72.4	1.1987	72.4	1.3280
74.9	1.2116	74.9	1.3411
77.3	1.2232	77.3	1.3515
79.7	1.2331	79.7	1.3589
82.1	1.2411	82.1	1.3632
84.5	1.2474	84.5	1.3647
86.9	1.2520	86.9	1.3631
89.3	1.2542	89.3	1.3579
91.8	1.2539	91.8	1.3483
94.2	1.2508	94.2	1.3351
96.6	1.2450	96.6	1.3180
99.0	1.2359	99.0	1.2971
101.4	1.2248	101.4	1.2720
103.8	1.2196	103.8	1.2476
106.2	1.2299	106.2	1.2466
108.7	1.2559	108.7	1.2469
111.1	1.2876	111.1	1.2450
113.5	1.3158	113.5	1.2471
115.9	1.3432	115.9	1.2643
118.3	1.3679	118.3	1.2856
120.7	1.3881	120.7	1.3058
123.1	1.4070	123.1	1.3242
125.6	1.4269	125.6	1.3415
128.0	1.4426	128.0	1.3574
130.4	1.4491	130.4	1.3714
132.8	1.4565	132.8	1.3844
*135.2	1.4566	*135.2	1.3906
*137.6	1.4394	*137.6	1.3835
*140.0	1.4131	*140.0	1.3657
*142.5	1.3801	*142.5	1.3403
*144.9	1.3509	*144.9	1.3193

* Top and Bottom 8% Excluded

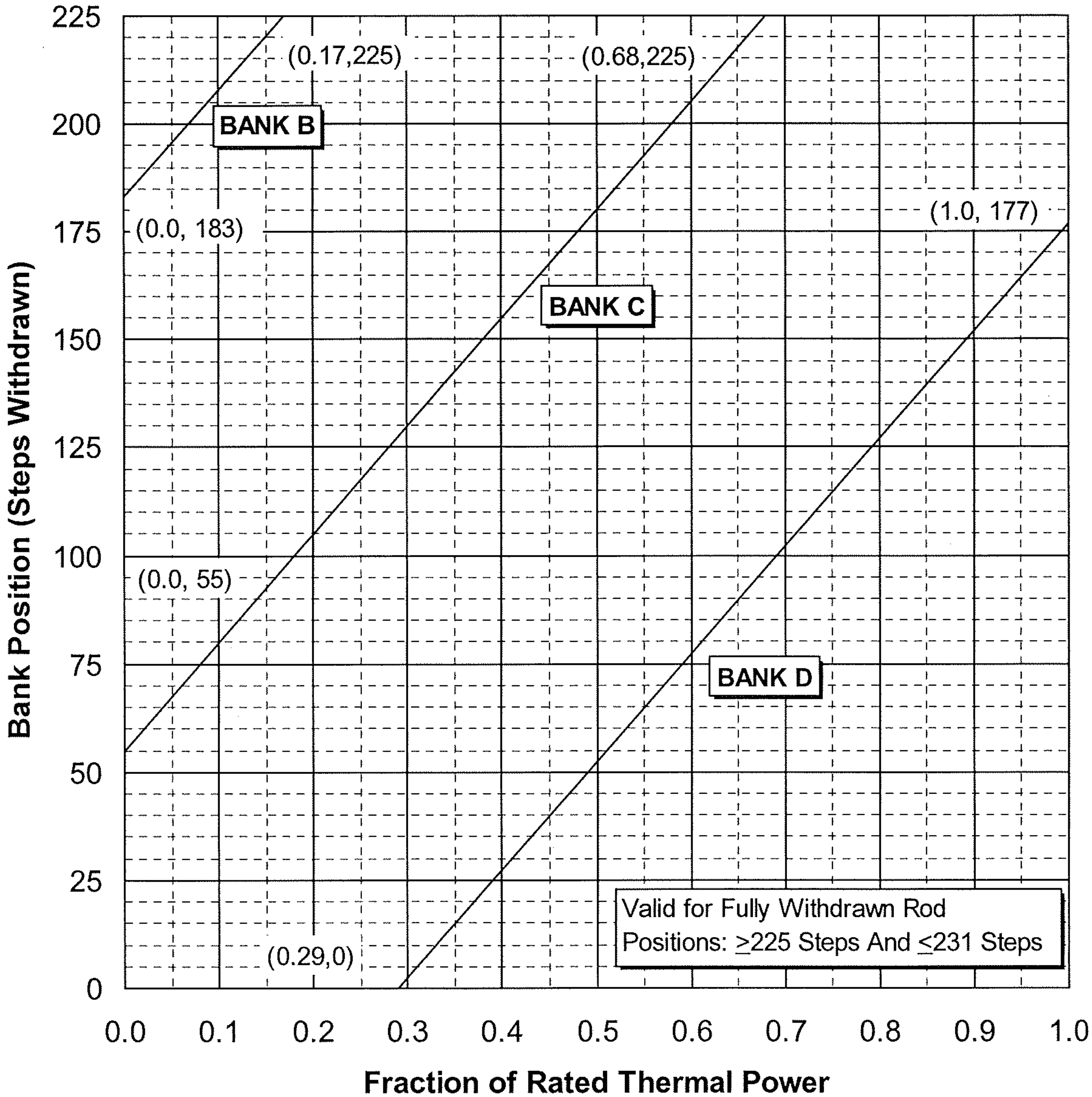

Figure 1: Control Bank Insertion Limits Versus Rated Thermal Power

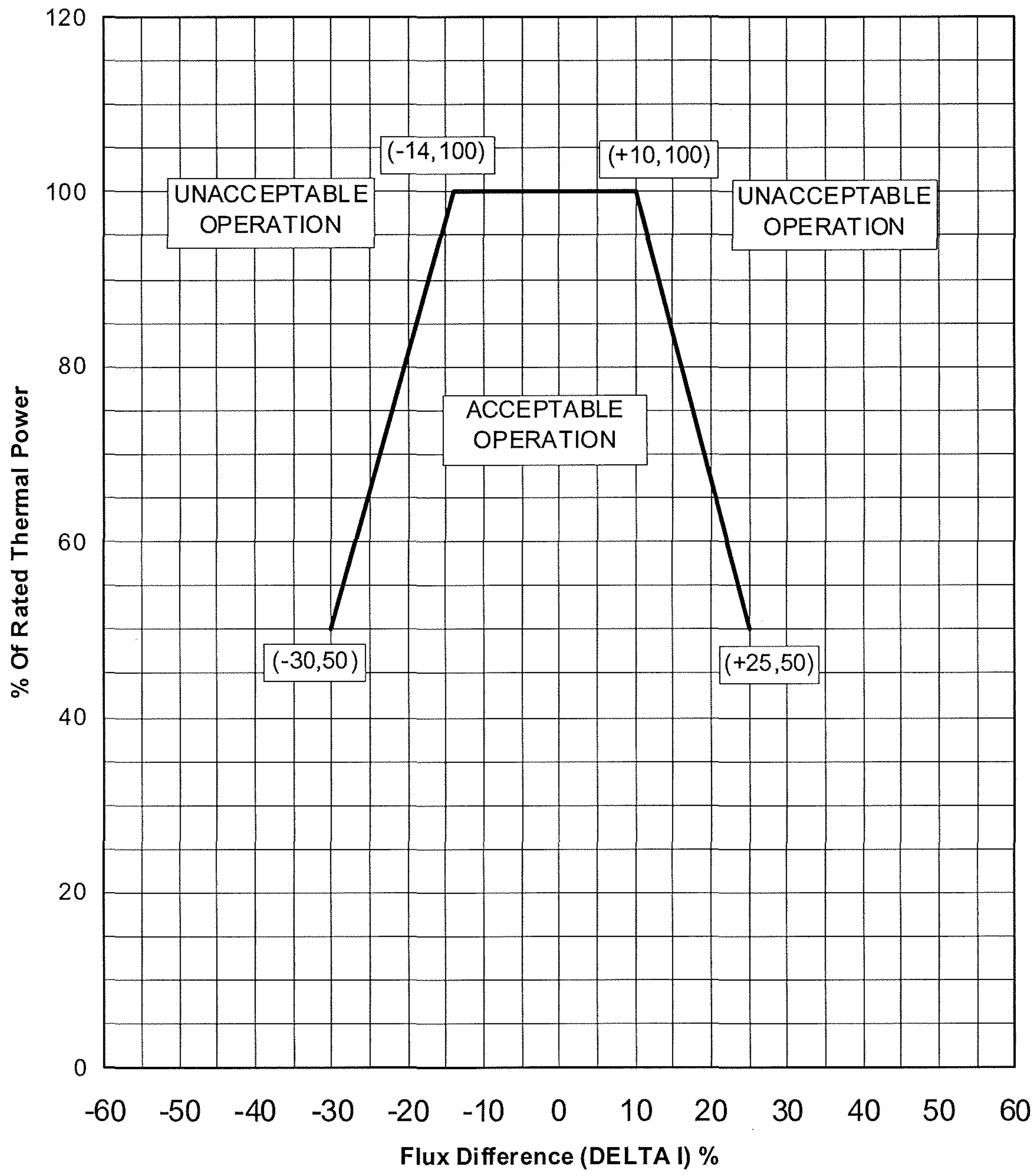

Figure 2: AFD Limits as a Function of Rated Thermal Power