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U. S. Nuclear Regulatory Commission
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Mail Stop O-P1-17
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Donald C. Cook Nuclear Plant Units 1 and 2
CORE OPERATING LIMITS REPORT

Indiana Michigan Power Company, the licensee for Donald C. Cook Nuclear Plant Units 1 and 2, is submitting two revisions to the Core Operating Limits Report (COLR) for Unit 1 Cycle 20 and Unit 2 Cycle 15 in accordance with Technical Specification 5.6.5.d. Revision 1 of the Unit 1 and Unit 2 COLR implemented Improved Technical Specifications and a license amendment allowing conditional exemption from the near-end of life Moderator Temperature Coefficient measurement. Soon after issuance of Revision 1 of the COLRs for each unit, some administrative quality control issues with the documents were identified. Revision 2 of the Unit 1 and Unit 2 COLR has been issued to correct these issues.

Revisions 1 and 2 of the Unit 1 Cycle 20 COLR are provided as Attachments 1 and 2, respectively. Revisions 1 and 2 of the Unit 2 Cycle 15 COLR are provided as Attachments 3 and 4, respectively.

There are no new commitments in this letter. Should you have any questions, please contact Mr. John A. Zwolinski, Director of Safety Assurance, at (269) 466-2428.

Sincerely,

Joseph N. Jensen
Site Vice President

Attachments

KAS/rdw

A001

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K. D. Curry – AEP Ft. Wayne, w/o attachments
J. T. King – MPSC, w/o attachments
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NRC Resident Inspector
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ATTACHMENT 1 TO AEP:NRC:5691-04

DONALD C. COOK NUCLEAR PLANT (CNP) UNIT 1
CYCLE 20 CORE OPERATING LIMITS REPORT
REVISION 1

Donald C. Cook Nuclear Plant
Unit 1 Cycle 20

Core Operating Limits Report
Revision 1

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Donald C. Cook Nuclear Plant Unit 1 Cycle 20 design has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC in:

a. WCAP-9272-P-A, Westinghouse Reload Safety Evaluation Methodology, July 1985

b. WCAP-8385, Power Distribution Control and Load Following Procedures – Topical Report, September 1974

c. WCAP-10216-P-A, Rev. 1A, Relaxation of Constant Axial Offset Control/F_Q Surveillance Technical Specification, February 1994

d. WCAP-10266-P-A, Rev.2, The 1981 Version of Westinghouse Evaluation Mode Using BASH Code, March 1987

e. WCAP-12610-P-A, VANTAGE+ Fuel Assembly Reference Core Report, July 1991

f. WCAP-8745-P-A, Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions, September 1986

g. WCAP-13749-P-A, Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement, March 1997

The Technical Specifications affected by this report are listed below:

2.1.1	Safety Limits
3.1.1	Shutdown Margin (SDM)
3.1.3	Moderator Temperature Coefficient (MTC)
3.1.5	Shutdown Bank Insertion Limit
3.1.6	Control Bank Insertion Limits
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)
3.3.1	Reactor Trip System (RTS) Instrumentation
3.4.1	RCS Pressure, Temperature and Flow Departure from Nucleate Boiling (DNB) Limits
3.9.1	Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specifications 5.6.5.

2.1 SAFETY LIMITS

2.1.1 Safety Limits (Specification 2.1.1)

In Modes 1 and 2, the combination of thermal power, pressurizer pressure, and the highest operating loop coolant average temperature (T_{avg}) shall not exceed the limits as shown in Figure 6 for 4 loop operation.

2.2 REACTIVITY CONTROL

2.2.1 Shutdown Margin (Specification 3.1.1)

Shutdown margin shall be greater than or equal to 1.3% Δk/k for $T_{avg} > 200°F$
Shutdown margin shall be greater than or equal to 1.0% Δk/k for $T_{avg} \leq 200°F$

2.2.2 Moderator Temperature Coefficient (Specification 3.1.3)

a. The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO-MTC shall be less positive than the value given in Figure 1.

The EOL/ARO/RTP-MTC shall be less negative than –4.54E-4 Δk/k/°F.

This limit is based on a T_{avg} program with HFP T_{avg} of 554.0 - 558.0 °F.

Where: ARO stands for All Rods Out
BOL stands for Beginning of Cycle Life
EOL stands for End of Cycle Life
RTP stands for Rated Thermal Power
HFP stands for Hot Full Thermal Power

b. The MTC Surveillance limit is:
The 300 ppm/ARO/RTP-MTC should be less negative than or equal to –3.84E-4 Δk/k/°F at a vessel average temperature of 554.0 – 558.0 °F.

c. The Revised Predicted near-EOL 300 ppm MTC shall be calculated using Figure 7 and the following algorithm:

Revised Predicted MTC = Predicted MTC + AFD Correction + Predicted Correction*

* Predicted Correction is -0.30E-4 Δk/k/°F.

If the Revised Predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 2.2.2.b) and all of the benchmark data contained in the surveillance procedure are met, then a MTC measurement in accordance with SR 3.1.3.2 is not required.

d. The MTC Surveillance limit is:
The 60 ppm/ARO/RTP-MTC should be less negative or equal to -4.41E-4 Δk/k/°F at a HFP vessel T_{avg} of 554 - 558 °F

2.2.3 Shutdown Rod Insertion Limit (Specification 3.1.5)

The shutdown rods shall be withdrawn to 228 steps.

2.2.4 Control Bank Insertion Limits (Specifications 3.1.6)

a. The control rod banks shall be limited in physical insertion as shown in Figure 2.

b. Successive Control Banks shall overlap by 100 steps. The sequence for Control Bank withdrawal shall be Control Bank A, Control Bank B, Control Bank C and Control Bank D.

2.3 POWER DISTRIBUTION LIMITS

2.3.1 Axial Flux Difference (AFD) (Specification 3.2.3)

a. The Allowable Operation Limits are provided in Figure 3.

b. The AFD target band during base load operations is +3%, -3% (not applicable for this cycle).

c. The AFD target band is +5%, -5% for a cycle average accumulated burnup ≥0.0 MWD/MTU.

2.3.2 Heat Flux Hot Channel Factor - $F_Q(Z)$ (Specification 3.2.1)

$$F_Q^C(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^C(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

$$F_Q^W(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^W(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_Q = 2.15$ for Westinghouse Fuel.

b. $K(Z)$ is provided in Figure 4 for Westinghouse Fuel.

c. $F_Q^C(Z)$ is the measured hot channel factor including a 3% manufacturing tolerance uncertainty and a 5% measurement uncertainty.

d. $W(Z)$ is provided in Table 1 for ±5% AFD target band

e. For Cycle 20, when applicable, $F_P = 1.02$ for all burnups.

f. $F_Q^W(Z) = F_Q^C(Z) \times W(Z) \times F_P$

2.3.3 Nuclear Enthalpy Hot Channel Factor - $F^N_{\Delta H}$ (Specification 3.2.2)

$$F^N_{\Delta H} \le CF_{\Delta H} * (1 + PF_{\Delta H} * (1-P))$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_{\Delta H} = 1.49$ for Westinghouse Fuel.

b. $PF_{\Delta H} = 0.3$

2.4 INSTRUMENTATION

2.4.1 Reactor Trip System Instrumentation (Specification 3.3.1)

The Overtemperature ΔT and Overpower ΔT setpoints are as shown in Figure 5.

2.5 REACTOR COOLANT SYSTEM

2.5.1 RCS Pressure, Temperature and Flow Departure from Nucleate Boiling (DNB) Limits (Specification 3.4.1)

a. Reactor Coolant System T_{AVG} shall be $\leq$ 581.4°F [+]

b. Pressurizer Pressure shall be $\geq$ 2018 psig [+]

c. Reactor Coolant System Total Flow Rate shall be $\geq$ 341,100 gpm

2.6 REFUELING OPERATIONS

2.6.1 Boron Concentration (Specification 3.9.1)

The boron concentration of all filled portions of the Reactor Coolant System, the refueling canal and the refueling cavity shall be greater than or equal to 2400 ppm[++].

[+] These are Safety Analysis values. With readability allowance, the corresponding values are 579.1°F for T_{avg}, and 2050 psig for Pressurizer Pressure.

[++] This concentration bounds the condition of $K_{eff} \leq 0.95$ which includes a 1% $\Delta k/k$ conservative allowance for uncertainties. The boron concentration of 2400 ppm includes a 50 ppm conservative allowance for uncertainties.

FIGURE 1

MODERATOR TEMPERATURE COEFFICIENT (MTC)

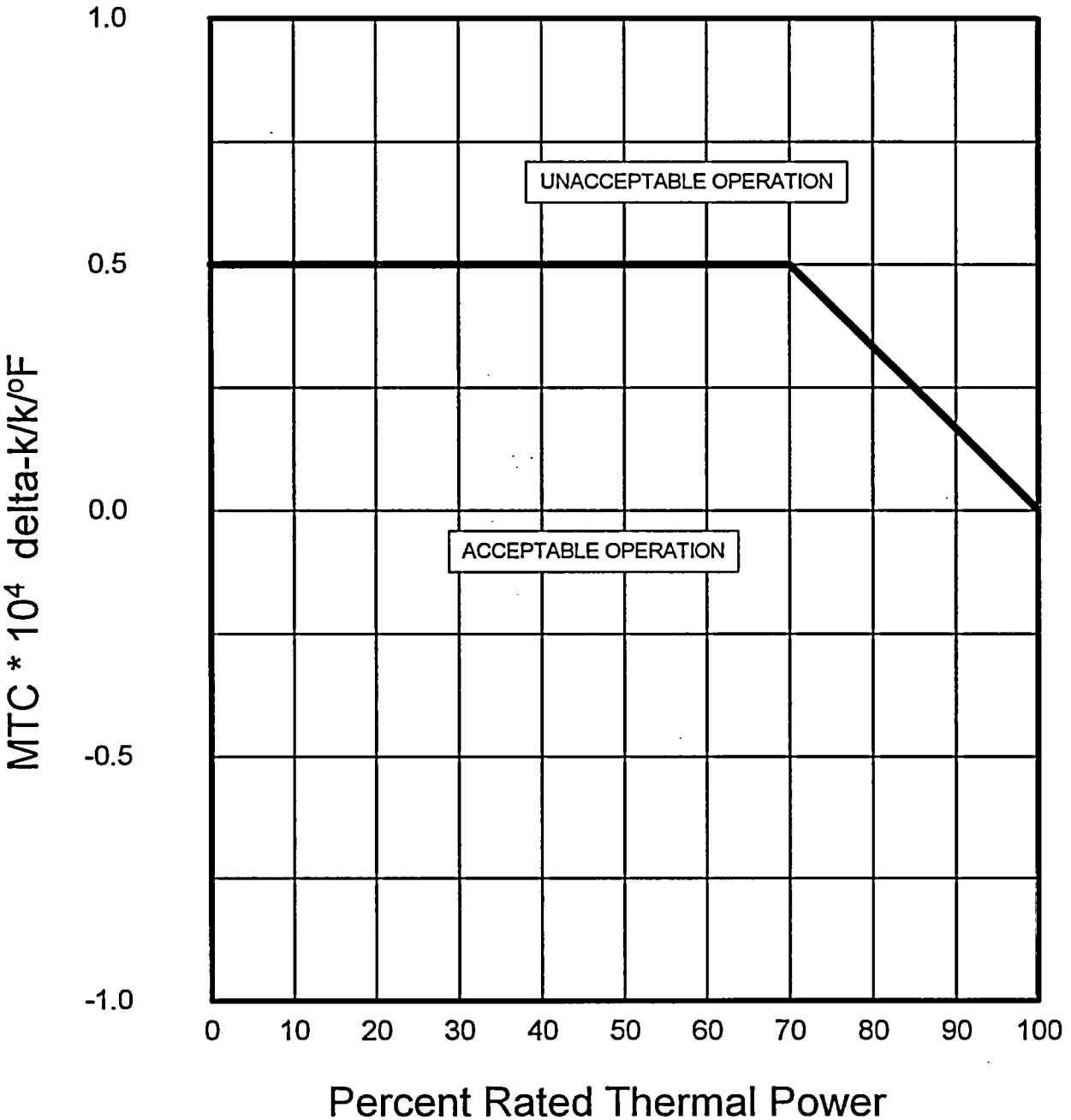


FIGURE 2

ROD BANK INSERTION LIMITS VERSUS THERMAL POWER

(FOUR LOOP OPERATION)

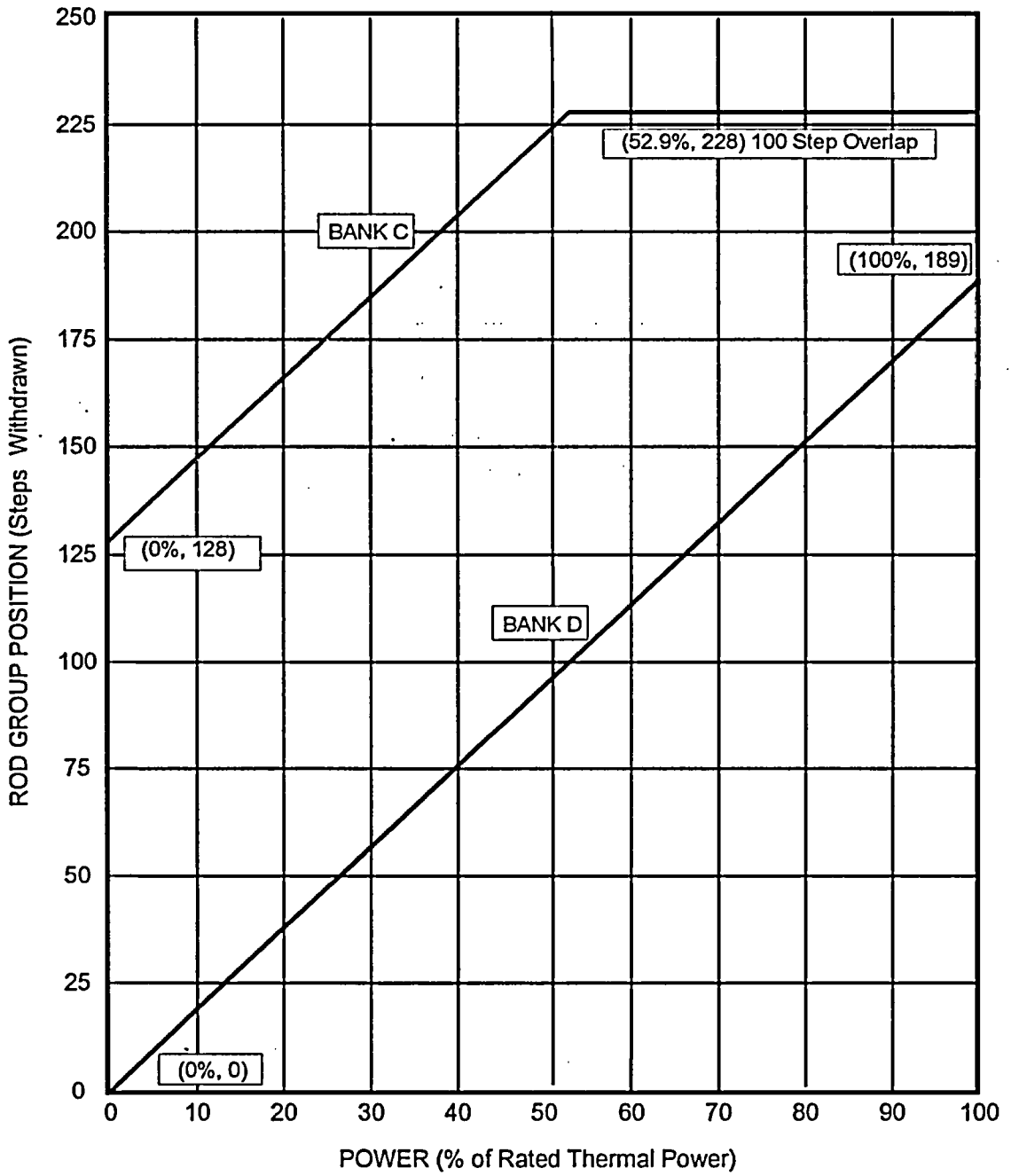


FIGURE 3

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER (RTP)

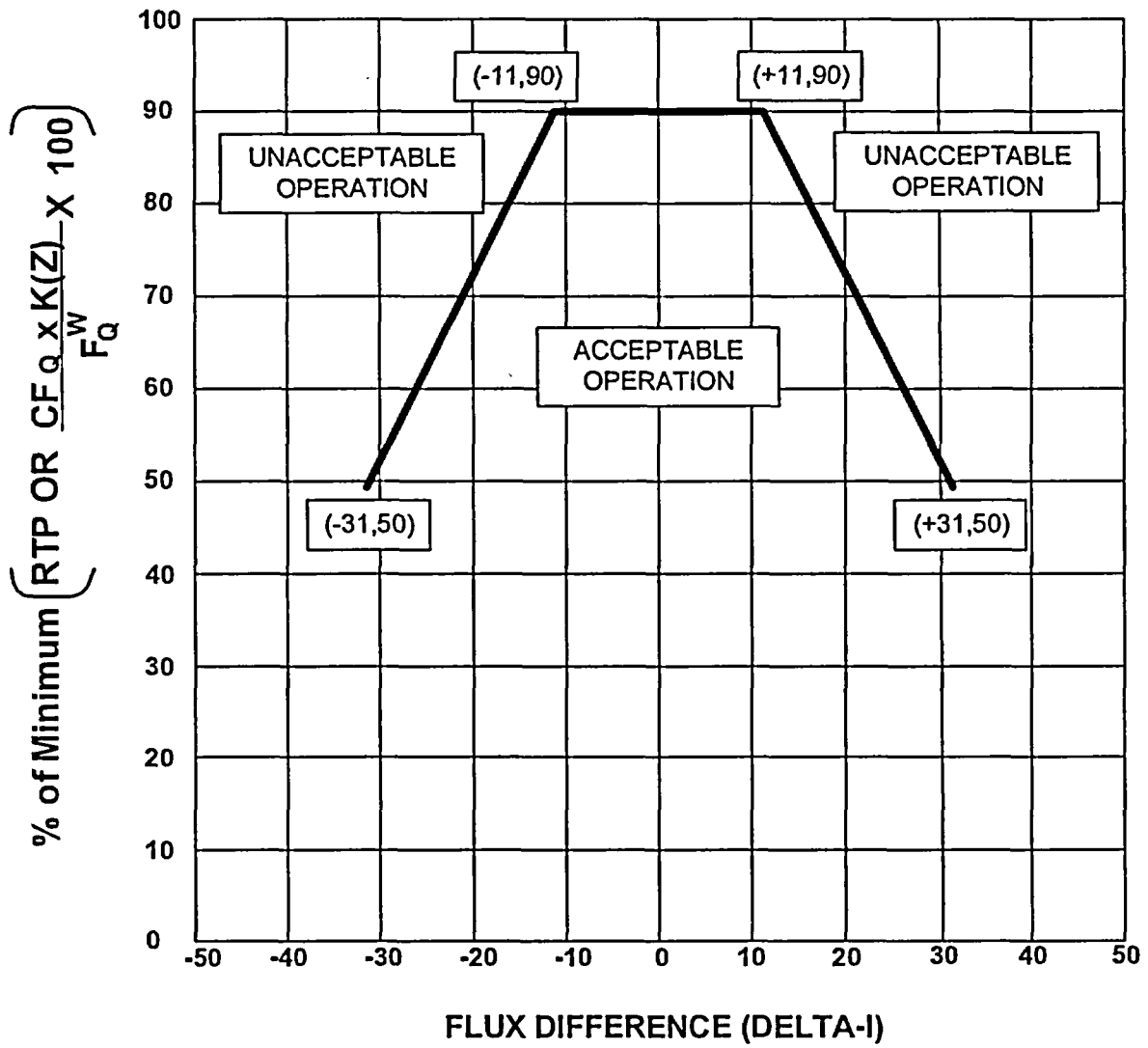


FIGURE 4

K(Z) – NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

(FOR WESTINGHOUSE FUEL)

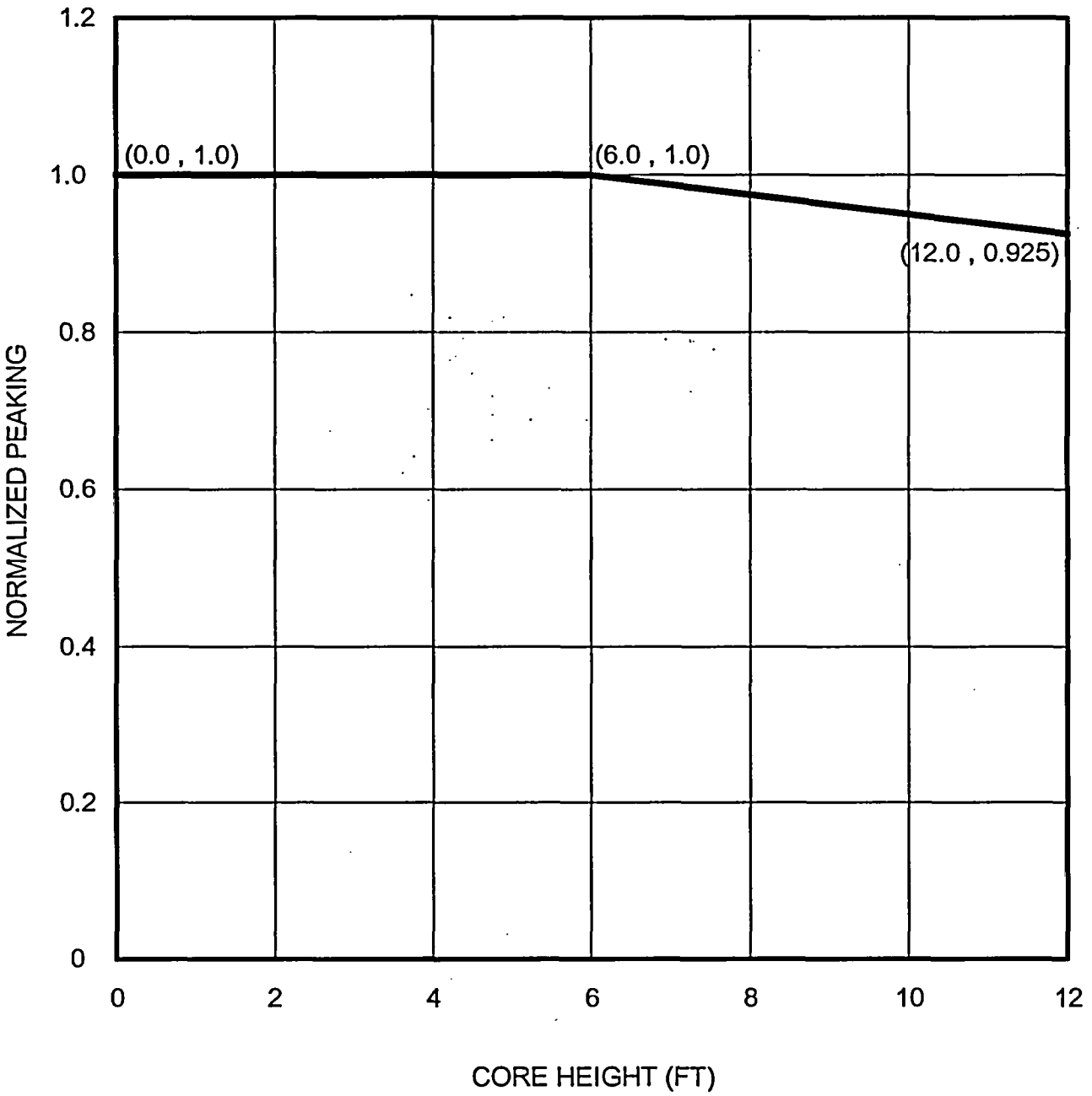


FIGURE 5
(Page 1 of 2)

Reactor Trip System Instrumentation
Overtemperature ΔT Trip Setpoint

$$\text{Overtemperature } \Delta T \le \Delta T_o \left[K_1 - K_2 \left[\frac{1+\tau_1 S}{1+\tau_2 S}\right] (T-T') + K_3 (P-P') - f_1(\Delta I)\right]$$

Where:	ΔT_o	=	Indicated ΔT at RATED THERMAL POWER °F
	T	=	Average temperature, °F
	T'	=	Nominal T_{avg} at RATED THERMAL POWER (≤ 574.0 °F)
	P	=	Pressurizer pressure, psig
	P'	=	Indicated RCS nominal operating pressure (2085 psig)
	$\frac{1+\tau_1 S}{1+\tau_2 S}$	=	The function generated by the lead-lag controller for T_{avg} dynamic compensation
	τ_1, τ_2	=	Time constants utilized in the lead-lag controller for T_{avg} $\tau_1 \ge 22$ secs. $\tau_2 \le 4$ secs.
	S	=	Laplace transform operator, sec^{-1}
	K_1	≤	1.35 *
	K_2	≥	0.0230
	K_3	≥	0.00110

and $f_1(\Delta I)$ is a function of the indicated difference between top and bottom detectors of the power-range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

(i) for $q_t - q_b$ between -37 percent and +3 percent, $f_1(\Delta I)=0$ (where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) For each percent that the magnitude of $(q_t - q_b)$ exceeds -37 percent, the ΔT trip setpoint shall be automatically reduced by 0.33 percent of its value at RATED THERMAL POWER.

(iii) For each percent that the magnitude of $(q_t - q_b)$ exceeds +3 percent, the ΔT trip setpoint shall be automatically reduced by 2.34 percent of its value at RATED THERMAL POWER.

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 5

(Page 2 of 2)

Overpower ΔT Setpoint

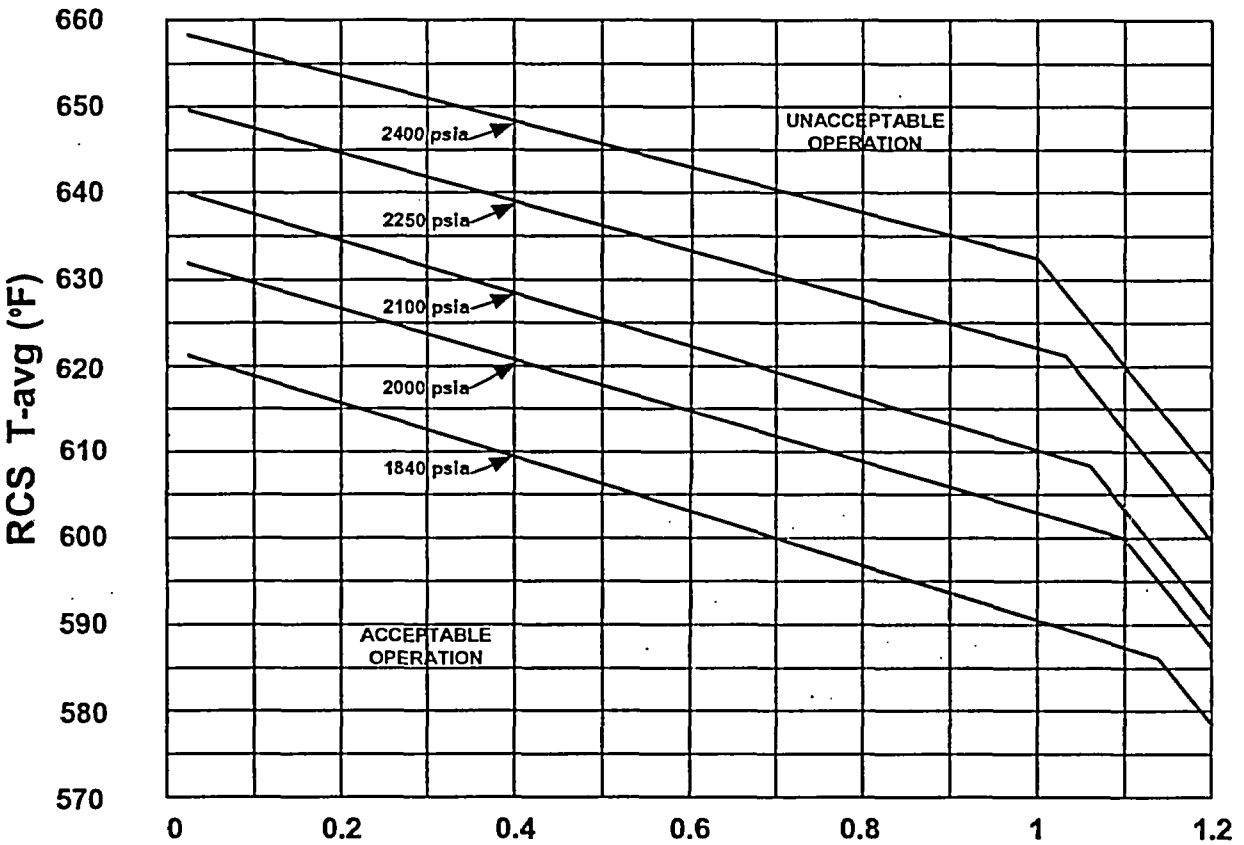
$$\text{Overpower } \Delta T \leq \Delta T_o \left[K_4 - K_5 \left[\frac{\tau_3 S}{1+\tau_3 S}\right] T - K_6 (T - T'') - f_2(\Delta I)\right]$$

Where:	ΔT_o	=	Indicated ΔT at RATED THERMAL POWER, °F
	T	=	Average temperature, °F
	T''	=	Nominal T_{avg} at RATED THERMAL POWER (≤ 562.1 °F)
	K_4	≤	1.172 *
	K_5	≥	0.0177/°F for increasing average temperature ; K_5 = 0 for decreasing average temperature
	K_6	≥	0.0015/°F for T > T'' ; K_6 = 0 for T ≤ T''
	$\frac{\tau_3 S}{1+\tau_3 S}$	=	The function generated by the rate lag controller for T_{avg} dynamic compensation
	τ_3	=	Time constant utilized in the rate lag controller for T_{avg} $\tau_3 \geq$ 10 secs.
	S	=	Laplace transform operator
	$f_2(\Delta I)$	=	0

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 6

Reactor Core Safety Limits

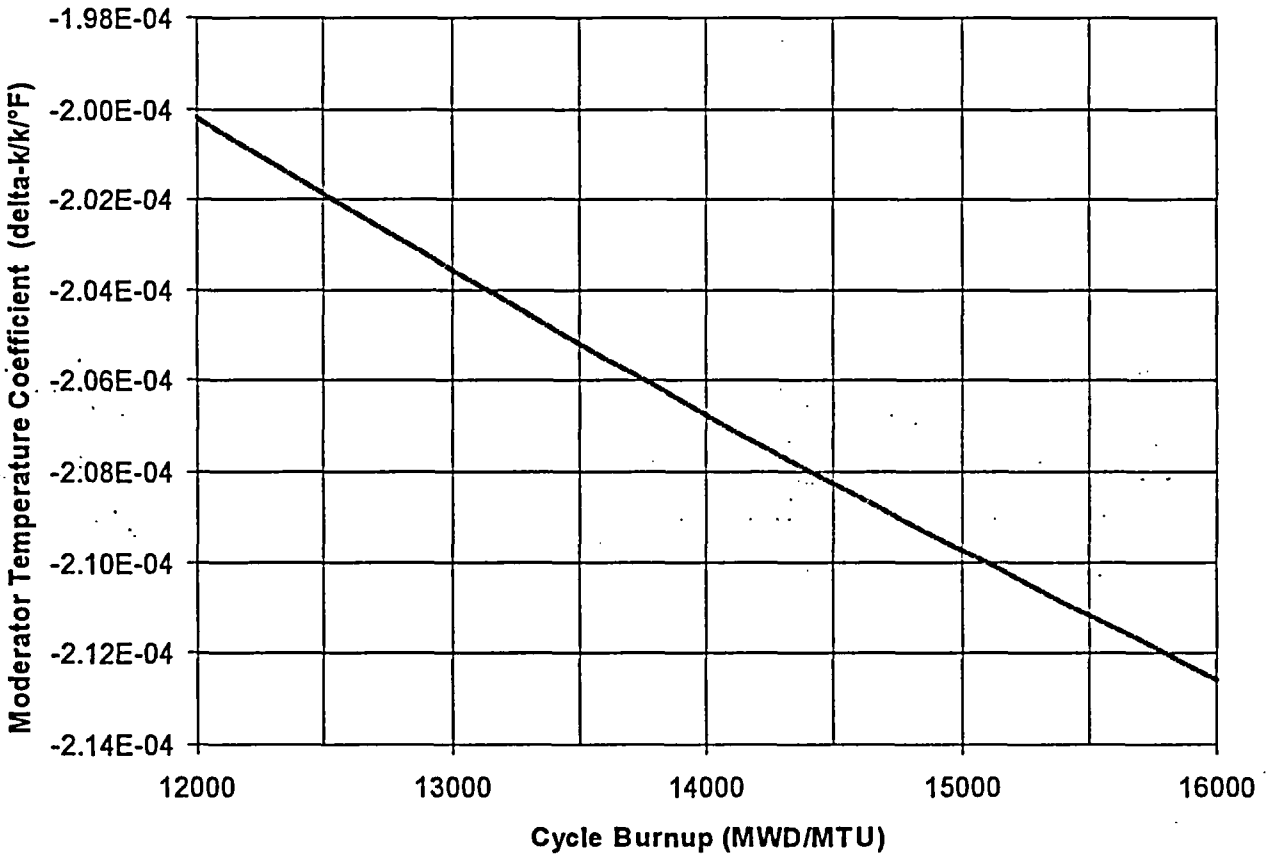


DESCRIPTION OF SAFETY LIMITS

PRESSURE (PSIA)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)
1840	0.02	620.86	1.136	586.17	1.2	577.94
2000	0.02	632.79	1.094	600.31	1.2	586.52
2100	0.02	639.85	1.068	608.72	1.2	591.77
2250	0.02	649.96	1.031	620.83	1.2	599.40
2400	0.02	659.52	0.996	632.42	1.2	606.63

UNIT 1 Reactor Core Safety Limits

FIGURE 7
Unit 1 Cycle 20 Predicted HFP ARO 300 PPM MTC Versus Burnup



Burnup (MWD/MTU)	MTC (Δk/k/°F)
12000	-2.0020E-4
13320	-2.0458E-4
14320	-2.0770E-4
15320	-2.1064E-4
16000	-2.1256E-4

TABLE 1
DONALD C. COOK UNIT 1 CYCLE 20
W(Z) FUNCTION

Node No.	Height (feet)	Burnup (MWD/MTU) 150	1000	2000	4000	6000	8000	10000	12000	14000	16000	17970
1	0.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.2	1.0985	1.0993	1.1003	1.1026	1.1052	1.1081	1.1114	1.1151	1.1191	1.1231	1.1268
8	1.4	1.0987	1.0994	1.1004	1.1025	1.1050	1.1078	1.1109	1.1143	1.1181	1.1219	1.1254
9	1.6	1.0986	1.0993	1.1002	1.1022	1.1045	1.1071	1.1100	1.1132	1.1167	1.1202	1.1235
10	1.8	1.0983	1.0989	1.0997	1.1016	1.1037	1.1060	1.1087	1.1116	1.1147	1.1179	1.1209
11	2.0	1.0977	1.0983	1.0990	1.1006	1.1025	1.1046	1.1069	1.1094	1.1122	1.1151	1.1177
12	2.2	1.0969	1.0974	1.0980	1.0994	1.1010	1.1027	1.1047	1.1069	1.1093	1.1117	1.1139
13	2.4	1.0959	1.0963	1.0968	1.0978	1.0991	1.1006	1.1022	1.1040	1.1060	1.1080	1.1099
14	2.6	1.0947	1.0949	1.0952	1.0960	1.0969	1.0980	1.0993	1.1008	1.1025	1.1042	1.1057
15	2.8	1.0932	1.0933	1.0934	1.0938	1.0944	1.0951	1.0961	1.0973	1.0986	1.1000	1.1011
16	3.0	1.0916	1.0915	1.0915	1.0915	1.0917	1.0921	1.0926	1.0934	1.0943	1.0952	1.0960
17	3.2	1.0901	1.0899	1.0897	1.0894	1.0892	1.0892	1.0893	1.0895	1.0899	1.0903	1.0906
18	3.4	1.0888	1.0885	1.0882	1.0876	1.0871	1.0868	1.0865	1.0864	1.0864	1.0865	1.0864
19	3.6	1.0880	1.0875	1.0870	1.0862	1.0856	1.0852	1.0849	1.0849	1.0851	1.0853	1.0852
20	3.8	1.0875	1.0867	1.0860	1.0848	1.0840	1.0837	1.0839	1.0845	1.0855	1.0866	1.0874
21	4.0	1.0869	1.0859	1.0849	1.0835	1.0828	1.0828	1.0836	1.0851	1.0874	1.0899	1.0917
22	4.2	1.0862	1.0851	1.0841	1.0828	1.0824	1.0828	1.0842	1.0864	1.0896	1.0930	1.0955
23	4.4	1.0854	1.0844	1.0835	1.0825	1.0824	1.0832	1.0851	1.0880	1.0916	1.0958	1.0989
24	4.6	1.0845	1.0836	1.0828	1.0820	1.0822	1.0835	1.0858	1.0893	1.0937	1.0984	1.1021
25	4.8	1.0833	1.0825	1.0818	1.0813	1.0819	1.0836	1.0864	1.0903	1.0953	1.1006	1.1048
26	5.0	1.0823	1.0816	1.0810	1.0807	1.0815	1.0835	1.0867	1.0911	1.0966	1.1025	1.1071
27	5.2	1.0818	1.0810	1.0804	1.0800	1.0809	1.0830	1.0866	1.0914	1.0974	1.1038	1.1090
28	5.4	1.0813	1.0804	1.0797	1.0792	1.0801	1.0824	1.0862	1.0913	1.0978	1.1047	1.1102
29	5.6	1.0805	1.0798	1.0793	1.0791	1.0803	1.0827	1.0865	1.0916	1.0981	1.1049	1.1103
30	5.8	1.0795	1.0791	1.0789	1.0793	1.0807	1.0833	1.0871	1.0920	1.0980	1.1043	1.1095
31	6.0	1.0782	1.0781	1.0782	1.0791	1.0809	1.0836	1.0873	1.0919	1.0974	1.1031	1.1079
32	6.2	1.0766	1.0768	1.0772	1.0786	1.0807	1.0835	1.0870	1.0912	1.0961	1.1012	1.1056
33	6.4	1.0746	1.0751	1.0759	1.0777	1.0800	1.0828	1.0861	1.0899	1.0941	1.0986	1.1025
34	6.6	1.0722	1.0730	1.0740	1.0763	1.0788	1.0815	1.0846	1.0879	1.0915	1.0951	1.0985
35	6.8	1.0696	1.0706	1.0718	1.0743	1.0768	1.0795	1.0823	1.0852	1.0883	1.0913	1.0942
36	7.0	1.0671	1.0682	1.0695	1.0721	1.0747	1.0775	1.0803	1.0831	1.0861	1.0890	1.0919
37	7.2	1.0646	1.0660	1.0678	1.0711	1.0743	1.0775	1.0805	1.0833	1.0861	1.0889	1.0917
38	7.4	1.0630	1.0655	1.0682	1.0731	1.0773	1.0809	1.0837	1.0859	1.0874	1.0887	1.0906
39	7.6	1.0654	1.0681	1.0711	1.0763	1.0806	1.0840	1.0863	1.0876	1.0879	1.0880	1.0890
40	7.8	1.0702	1.0727	1.0755	1.0801	1.0838	1.0864	1.0879	1.0883	1.0877	1.0868	1.0869
41	8.0	1.0750	1.0773	1.0798	1.0838	1.0868	1.0886	1.0891	1.0885	1.0867	1.0846	1.0837
42	8.2	1.0796	1.0816	1.0837	1.0871	1.0892	1.0902	1.0899	1.0884	1.0858	1.0828	1.0809
43	8.4	1.0840	1.0855	1.0871	1.0895	1.0909	1.0914	1.0909	1.0895	1.0870	1.0844	1.0826
44	8.6	1.0881	1.0891	1.0900	1.0914	1.0921	1.0921	1.0914	1.0900	1.0879	1.0856	1.0840
45	8.8	1.0921	1.0923	1.0926	1.0928	1.0928	1.0924	1.0917	1.0907	1.0894	1.0879	1.0868
46	9.0	1.0957	1.0952	1.0947	1.0939	1.0932	1.0927	1.0924	1.0923	1.0924	1.0926	1.0925
47	9.2	1.0990	1.0978	1.0966	1.0946	1.0934	1.0929	1.0933	1.0943	1.0961	1.0981	1.0994
48	9.4	1.1020	1.1000	1.0980	1.0950	1.0932	1.0928	1.0937	1.0959	1.0994	1.1033	1.1059
49	9.6	1.1045	1.1021	1.0997	1.0961	1.0942	1.0938	1.0952	1.0983	1.1029	1.1081	1.1116
50	9.8	1.1069	1.1043	1.1017	1.0978	1.0958	1.0956	1.0973	1.1009	1.1064	1.1124	1.1165
51	10.0	1.1093	1.1065	1.1036	1.0994	1.0972	1.0971	1.0991	1.1033	1.1094	1.1162	1.1209
52	10.2	1.1112	1.1083	1.1054	1.1012	1.0990	1.0991	1.1013	1.1057	1.1122	1.1194	1.1244
53	10.4	1.1125	1.1099	1.1072	1.1034	1.1016	1.1018	1.1042	1.1086	1.1150	1.1219	1.1269
54	10.6	1.1136	1.1111	1.1087	1.1053	1.1037	1.1041	1.1065	1.1108	1.1170	1.1238	1.1286
55	10.8	1.1150	1.1126	1.1103	1.1070	1.1056	1.1060	1.1083	1.1125	1.1185	1.1251	1.1298
56	11.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
61	12.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Top and bottom 10% of core excluded.

ATTACHMENT 2 TO AEP:NRC:5691-04

DONALD C. COOK NUCLEAR PLANT (CNP) UNIT 1
CYCLE 20 CORE OPERATING LIMITS REPORT
REVISION 2

Donald C. Cook Nuclear Plant
Unit 1 Cycle 20

Core Operating Limits Report
Revision 2

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Donald C. Cook Nuclear Plant Unit 1 Cycle 20 design has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC in:

a. WCAP-9272-P-A, Westinghouse Reload Safety Evaluation Methodology

b. WCAP-8385, Power Distribution Control and Load Following Procedures – Topical Report

c. WCAP-10216-P-A, Relaxation of Constant Axial Offset Control/F_Q Surveillance Technical Specification

d. WCAP-10266-P-A, The 1981 Version of Westinghouse Evaluation Mode Using BASH Code

e. WCAP-12610-P-A, VANTAGE+ Fuel Assembly Reference Core Report

f. WCAP-8745-P-A, Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions

g. WCAP-13749-P-A, Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement

The Technical Specifications affected by this report are listed below:

2.1.1	Reactor Core Safety Limits
3.1.1	SHUTDOWN MARGIN (SDM)
3.1.3	Moderator Temperature Coefficient (MTC)
3.1.5	Shutdown Bank Insertion Limits
3.1.6	Control Bank Insertion Limits
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)
3.3.1	Reactor Trip System (RTS) Instrumentation
3.4.1	RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits
3.9.1	Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specifications 5.6.5.

2.1 SAFETY LIMITS

2.1.1 Reactor Core Safety Limits (Specification 2.1.1)

In Modes 1 and 2, the combination of thermal power, pressurizer pressure, and the highest loop average temperature (T_{avg}) shall not exceed the limits as shown in Figure 6 for 4 loop operation.

2.2 REACTIVITY CONTROL

2.2.1 SHUTDOWN MARGIN (SDM) (Specification 3.1.1)

Shutdown margin shall be greater than or equal to 1.3% Δk/k for $T_{avg} > 200°F$
Shutdown margin shall be greater than or equal to 1.0% Δk/k for $T_{avg} \leq 200°F$

2.2.2 Moderator Temperature Coefficient (MTC) (Specification 3.1.3)

a. The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO-MTC shall be less positive or equal to the value given in Figure 1.

The EOL/ARO/RTP-MTC shall be less negative or equal to –4.54E-4 Δk/k/°F.

This limit is based on a T_{avg} program with HFP vessel T_{avg} of 554.0 to 558.0 °F.

Where: ARO stands for All Rods Out
BOL stands for Beginning of Cycle Life
EOL stands for End of Cycle Life
RTP stands for Rated Thermal Power
HFP stands for Hot Full Thermal Power

b. The MTC Surveillance limit is:
The 300 ppm/ARO/RTP-MTC should be less negative or equal to –3.84E-4 Δk/k/°F at a HFP vessel T_{avg} of 554.0 to 558.0 °F.

c. The Revised Predicted near-EOL 300 ppm MTC shall be calculated using Figure 7 and the following algorithm:

Revised Predicted MTC = Predicted MTC + AFD Correction + Predicted Correction*

* Predicted Correction is -0.30E-4 Δk/k/°F.

If the Revised Predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 2.2.2.b) and all of the benchmark data contained in the surveillance procedure are met, then a MTC measurement in accordance with SR 3.1.3.2 is not required.

d. The MTC Surveillance limit is:
The 60 ppm/ARO/RTP-MTC should be less negative or equal to -4.41E-4 Δk/k/°F at a HFP vessel T_{avg} of 554.0 to 558.0 °F

2.2.3 Shutdown Bank Insertion Limits (Specification 3.1.5)

The shutdown rods shall be withdrawn to at least 228 steps.

2.2.4 Control Bank Insertion Limits (Specifications 3.1.6)

a. The control rod banks shall be limited in physical insertion as shown in Figure 2.

b. Successive Control Banks shall overlap by 100 steps. The sequence for Control Bank withdrawal shall be Control Bank A, Control Bank B, Control Bank C and Control Bank D.

2.3 POWER DISTRIBUTION LIMITS

2.3.1 AXIAL FLUX DIFFERENCE (AFD) (Specification 3.2.3)

a. The Allowable Operation Limits are provided in Figure 3.

b. The AFD target band is ±5% for a cycle average accumulated burnup ≥0.0 MWD/MTU.

2.3.2 Heat Flux Hot Channel Factor ($F_Q(Z)$) (Specification 3.2.1)

$$F_Q^C(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^C(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

$$F_Q^W(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^W(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_Q = 2.15$

b. **K(Z)** is provided in Figure 4.

c. $F_Q^C(Z)$ is the measured hot channel factor including a 3% manufacturing tolerance uncertainty and a 5% measurement uncertainty.

d. **W(Z)** is provided in Table 1 for ±5% AFD target band.

e. $F_Q^W(Z) = F_Q^C(Z) \times W(Z) \times F_P$

f. For Cycle 20, when $F^c_Q(Z)/K(Z)$ is increasing, $F_P = 1.02$ for all burnups. When no penalty is required, $F_P = 1.00$.

2.3.3 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$) (Specification 3.2.2)

$F^N_{\Delta H} \le CF_{\Delta H} * (1 + PF_{\Delta H} * (1-P))$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_{\Delta H} = 1.49$

b. $PF_{\Delta H} = 0.3$

2.4 INSTRUMENTATION

2.4.1 Reactor Trip System (RTS) Instrumentation (Specification 3.3.1)

The Overtemperature ΔT and Overpower ΔT setpoints are as shown in Figure 5.

2.5 REACTOR COOLANT SYSTEM

2.5.1 RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits (Specification 3.4.1)

a. Pressurizer Pressure shall be $\geq$ 2018 psig [+]

b. Reactor Coolant System T_{AVG} shall be $\leq$ 581.4°F [+]

c. Reactor Coolant System Total Flow Rate shall be $\geq$ 341,100 gpm

2.6 REFUELING OPERATIONS

2.6.1 Boron Concentration (Specification 3.9.1)

The boron concentration of all filled portions of the Reactor Coolant System, the refueling canal and the refueling cavity shall be greater than or equal to 2400 ppm[++].

[+] These are Safety Analysis values. With readability allowance, the corresponding values are 579.1°F for T_{avg}, and 2050 psig for Pressurizer Pressure.

[++] This concentration bounds the condition of $K_{eff} \leq 0.95$ which includes a 1% $\Delta k/k$ conservative allowance for uncertainties. The boron concentration of 2400 ppm includes a 50 ppm conservative allowance for uncertainties.

FIGURE 1

MODERATOR TEMPERATURE COEFFICIENT (MTC) LIMITS

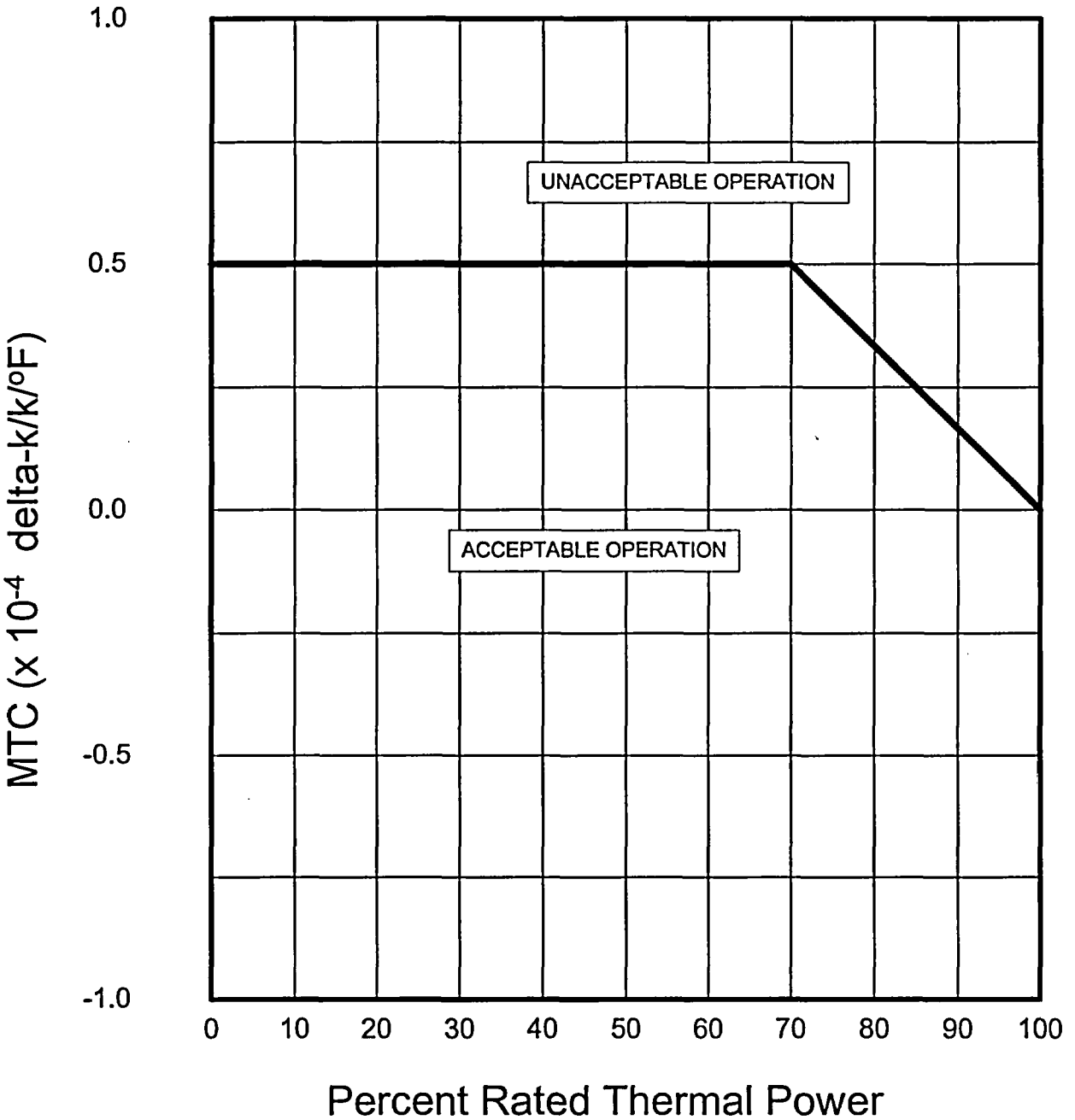


FIGURE 2

ROD BANK INSERTION LIMITS VERSUS THERMAL POWER

(FOUR-LOOP OPERATION)

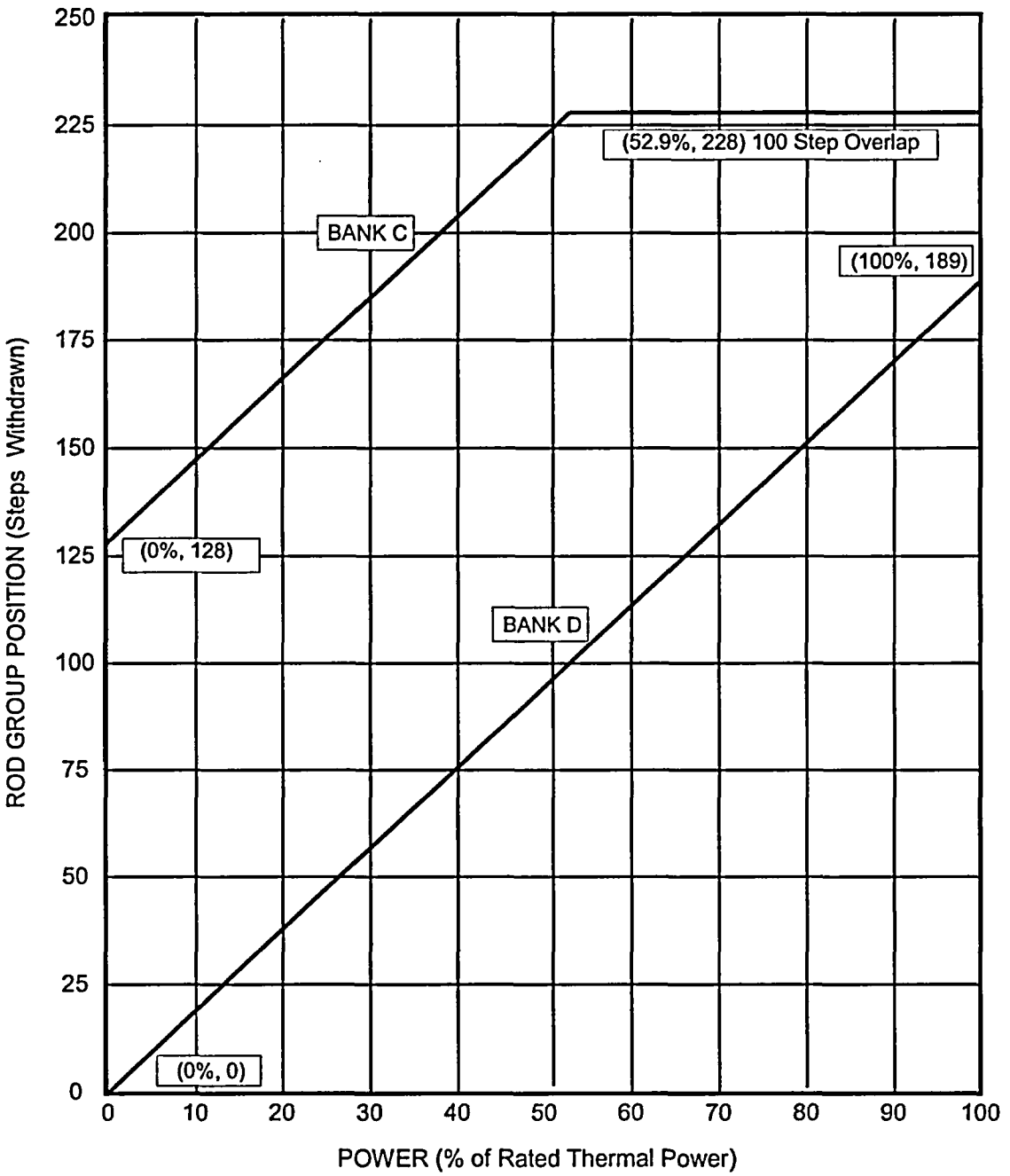


FIGURE 3

AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER (RTP)

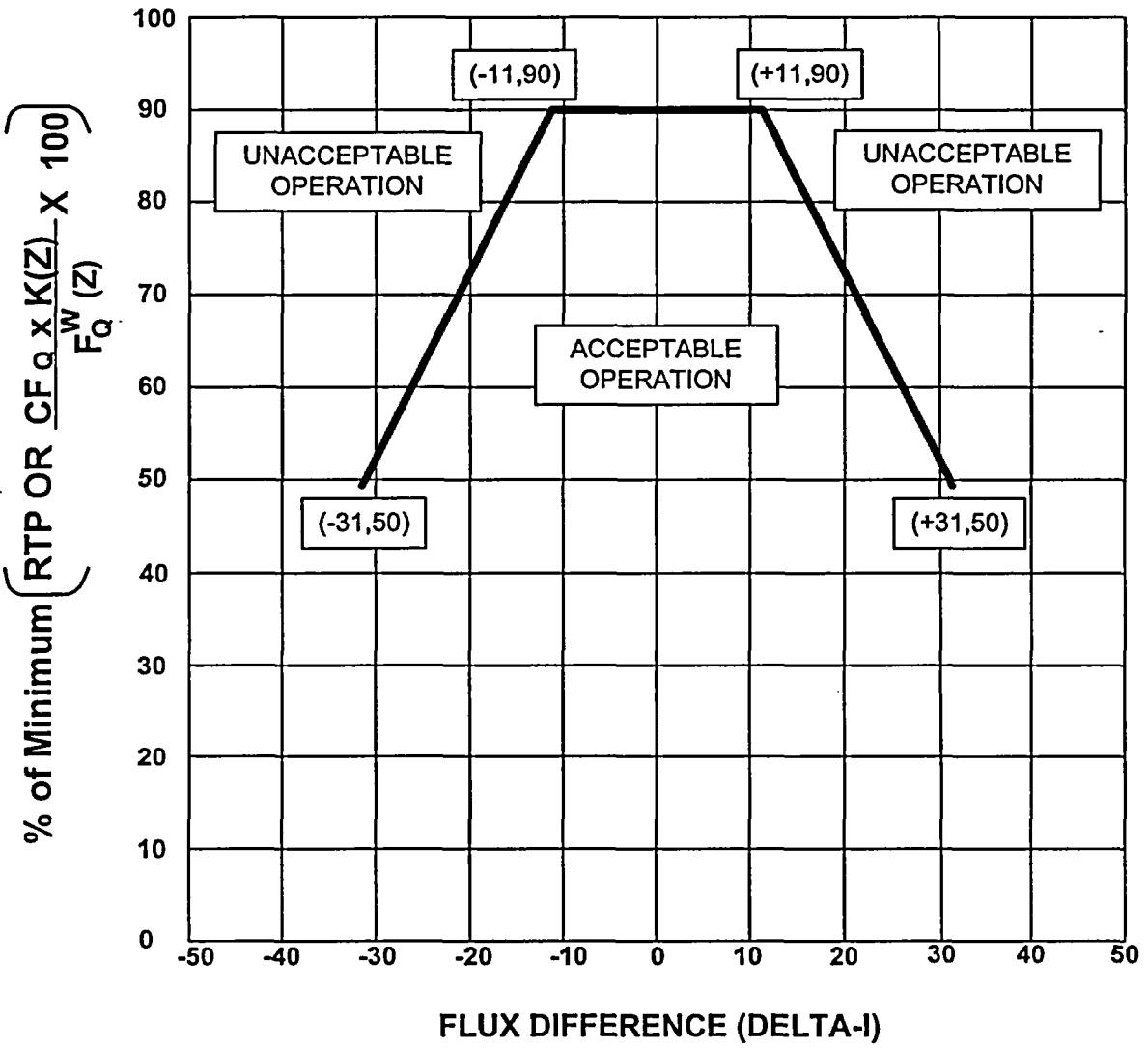


FIGURE 4

K(Z) – NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

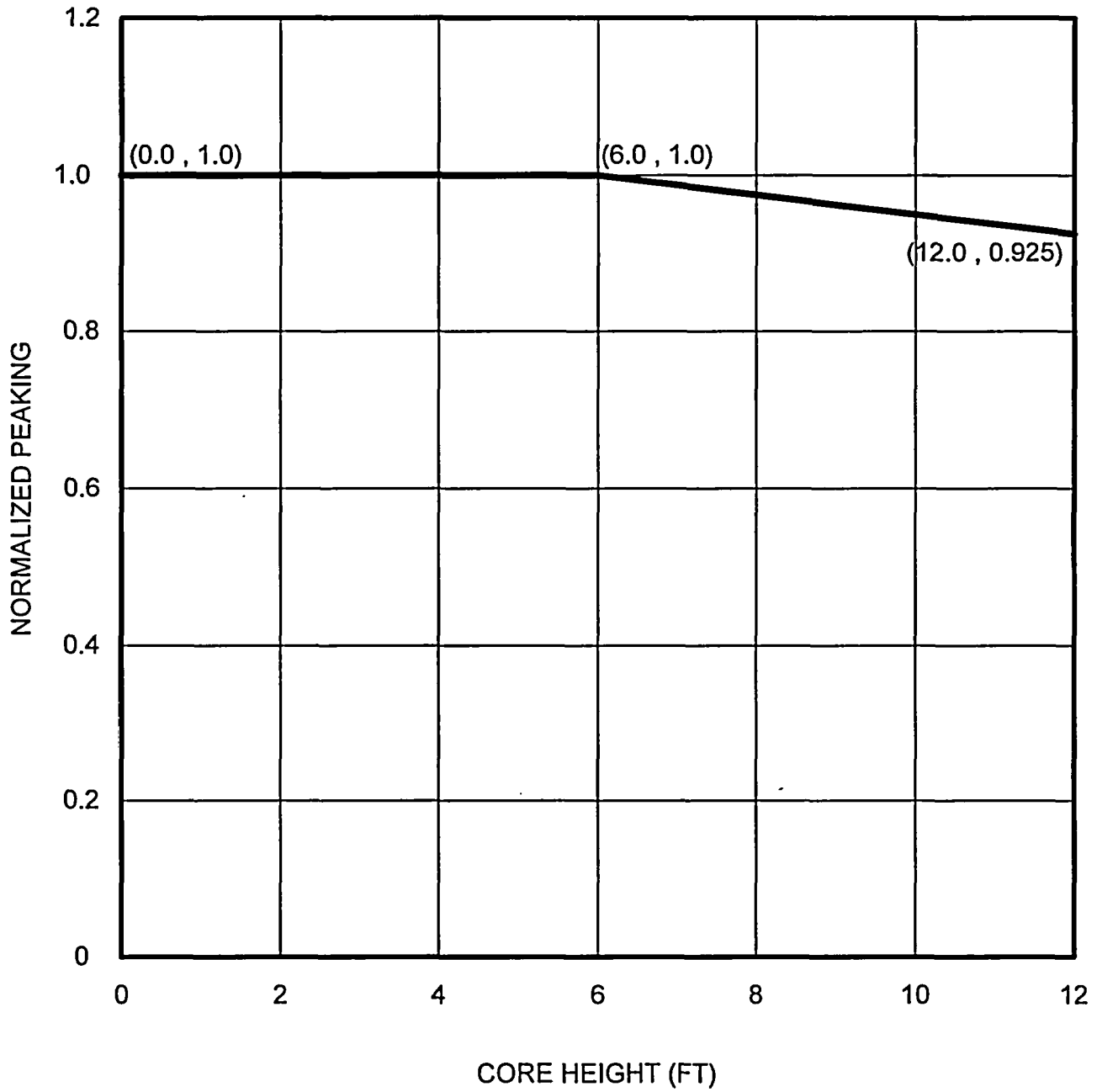


FIGURE 5
(Page 1 of 2)
Reactor Trip System Instrumentation Trip Setpoints
Overtemperature ΔT Trip Setpoint

$$\text{Overtemperature } \Delta T \le \Delta T_o \left[K_1 - K_2 \left[\frac{1+\tau_1 S}{1+\tau_2 S}\right] (T-T') + K_3 (P-P') - f_1(\Delta I)\right]$$

Where:

ΔT	=	Measured RCS ΔT, °F
ΔT_o	=	Indicated ΔT at RATED THERMAL POWER °F
T	=	Average temperature, °F
T'	=	Nominal T_{avg} at RATED THERMAL POWER (≤ 574.0 °F)
P	=	Pressurizer pressure, psig
P'	=	Nominal RCS operating pressure (2085 psig)
$\frac{1+\tau_1 S}{1+\tau_2 S}$	=	The function generated by the lead-lag controller for T_{avg} dynamic compensation
τ_1, τ_2	=	Time constants utilized in the lead-lag controller for T_{avg} $\tau_1 \ge 22$ secs. $\tau_2 \le 4$ secs.
S	=	Laplace transform operator, sec^{-1}
K_1	≤	1.35 *
K_2	≥	0.0230/°F
K_3	≥	0.00110/psig
$f_1(\Delta I)$	=	$0.33\{37 + (q_t - q_b)\}$ when $q_t - q_b \le -37\%$ RTP 0% of RTP when -37% RTP $< q_t - q_b \le 3\%$ RTP $-2.34\{(q_t - q_b) - 3\}$ when $q_t - q_b > 3\%$ RTP

where q_t and q_b are percent RATED THERMAL POWER in the upper and lower halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent RATED THERMAL POWER.

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

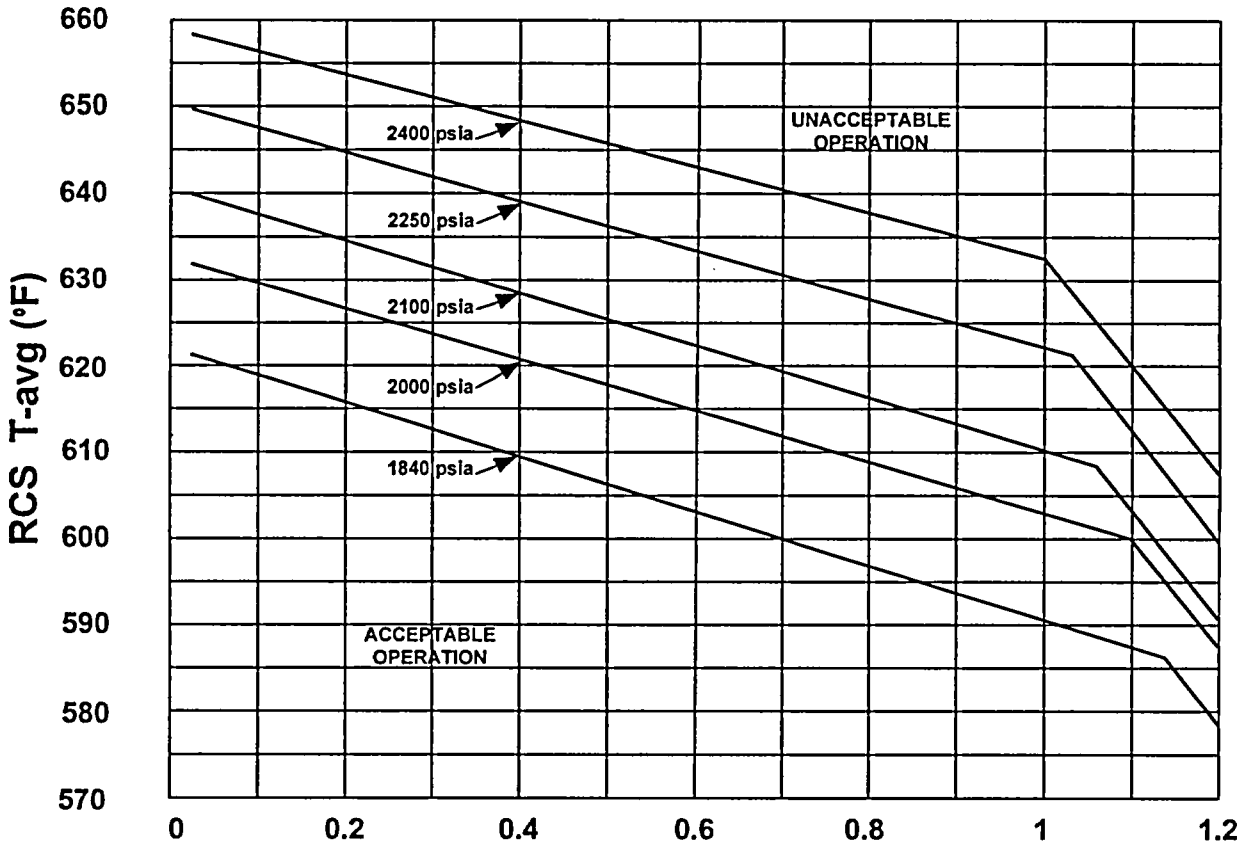
FIGURE 5
(Page 2 of 2)
Overpower ΔT Trip Setpoint

$$\text{Overpower } \Delta T \le \Delta T_o \left[K_4 - K_5 \left[\frac{\tau_3 S}{1+\tau_3 S}\right] T - K_6 (T - T'') - f_2(\Delta I)\right]$$

Where:	ΔT	=	Measured RCS ΔT, °F
	ΔT_o	=	Indicated ΔT at RATED THERMAL POWER, °F
	T	=	Average temperature, °F
	T''	=	Nominal T_{avg} at RATED THERMAL POWER ($\le$ 562.1 °F)
	K_4	$\le$	1.172 *
	K_5	$\ge$	0.0177/°F for increasing average temperature ; K_5 = 0 for decreasing average temperature
	K_6	$\ge$	0.0015/°F for T greater than T'' ; K_6 = 0 for T less than or equal to T''
	$\frac{\tau_3 S}{1+\tau_3 S}$	=	The function generated by the rate lag controller for T_{avg} dynamic compensation
	τ_3	=	Time constant utilized in the rate lag controller for T_{avg} $\tau_3 \ge$ 10 secs.
	S	=	Laplace transform operator, sec^{-1}
	$f_2(\Delta I)$	=	0.0

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 6
Reactor Core Safety Limits



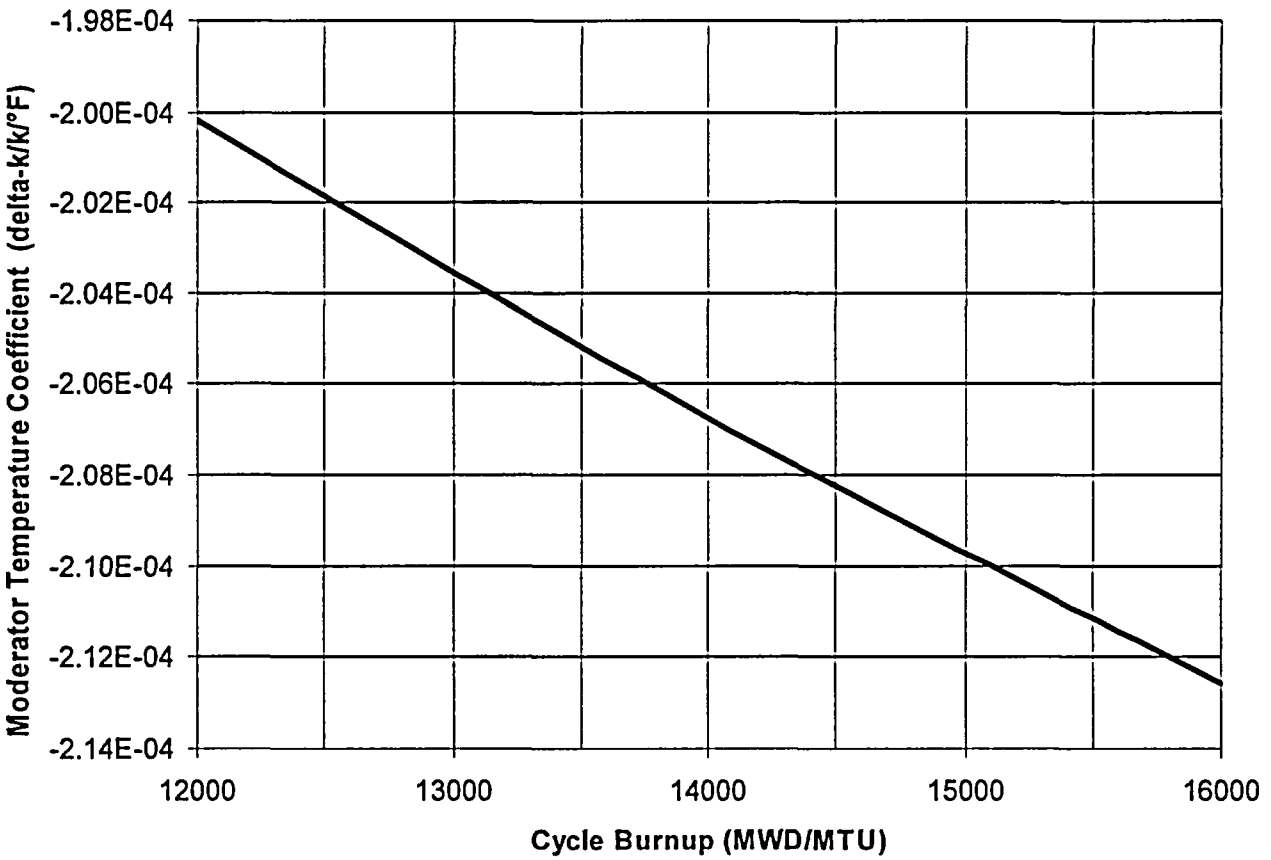
DESCRIPTION OF SAFETY LIMITS

PRESSURE (PSIA)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)
1840	0.02	620.86	1.136	586.17	1.2	577.94
2000	0.02	632.79	1.094	600.31	1.2	586.52
2100	0.02	639.85	1.068	608.72	1.2	591.77
2250	0.02	649.96	1.031	620.83	1.2	599.40
2400	0.02	659.52	0.996	632.42	1.2	606.63

UNIT 1 **Reactor Core Safety Limits**

FIGURE 7

Unit 1 Cycle 20 Predicted HFP ARO 300 PPM MTC Versus Burnup



Burnup (MWD/MTU)	MTC (Δk/k/°F)
12000	-2.0020E-4
13320	-2.0458E-4
14320	-2.0770E-4
15320	-2.1064E-4
16000	-2.1256E-4

TABLE 1
DONALD C. COOK UNIT 1 CYCLE 20
W(Z) FUNCTION

Node	Height	Burnup (MWD/MTU)										
No.	(feet)	150	1000	2000	4000	6000	8000	10000	12000	14000	16000	17970
1	0.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.2	1.0985	1.0993	1.1003	1.1026	1.1052	1.1081	1.1114	1.1151	1.1191	1.1231	1.1268
8	1.4	1.0987	1.0994	1.1004	1.1025	1.1050	1.1078	1.1109	1.1143	1.1181	1.1219	1.1254
9	1.6	1.0986	1.0993	1.1002	1.1022	1.1045	1.1071	1.1100	1.1132	1.1167	1.1202	1.1235
10	1.8	1.0983	1.0989	1.0997	1.1016	1.1037	1.1060	1.1087	1.1116	1.1147	1.1179	1.1209
11	2.0	1.0977	1.0983	1.0990	1.1006	1.1025	1.1046	1.1069	1.1094	1.1122	1.1151	1.1177
12	2.2	1.0969	1.0974	1.0980	1.0994	1.1010	1.1027	1.1047	1.1069	1.1093	1.1117	1.1139
13	2.4	1.0959	1.0963	1.0968	1.0978	1.0991	1.1006	1.1022	1.1040	1.1060	1.1080	1.1099
14	2.6	1.0947	1.0949	1.0952	1.0960	1.0969	1.0980	1.0993	1.1008	1.1025	1.1042	1.1057
15	2.8	1.0932	1.0933	1.0934	1.0938	1.0944	1.0951	1.0961	1.0973	1.0986	1.1000	1.1011
16	3.0	1.0916	1.0915	1.0915	1.0915	1.0917	1.0921	1.0926	1.0934	1.0943	1.0952	1.0960
17	3.2	1.0901	1.0899	1.0897	1.0894	1.0892	1.0892	1.0893	1.0895	1.0899	1.0903	1.0906
18	3.4	1.0888	1.0885	1.0882	1.0876	1.0871	1.0868	1.0865	1.0864	1.0864	1.0865	1.0864
19	3.6	1.0880	1.0875	1.0870	1.0862	1.0856	1.0852	1.0849	1.0849	1.0851	1.0853	1.0853
20	3.8	1.0875	1.0867	1.0860	1.0848	1.0840	1.0837	1.0839	1.0845	1.0855	1.0866	1.0874
21	4.0	1.0869	1.0859	1.0849	1.0835	1.0828	1.0828	1.0836	1.0851	1.0874	1.0899	1.0917
22	4.2	1.0862	1.0851	1.0841	1.0828	1.0824	1.0828	1.0842	1.0864	1.0896	1.0930	1.0955
23	4.4	1.0854	1.0844	1.0835	1.0825	1.0824	1.0832	1.0851	1.0880	1.0918	1.0958	1.0989
24	4.6	1.0845	1.0836	1.0828	1.0820	1.0822	1.0835	1.0858	1.0893	1.0937	1.0984	1.1021
25	4.8	1.0833	1.0825	1.0818	1.0813	1.0819	1.0836	1.0864	1.0903	1.0953	1.1006	1.1048
26	5.0	1.0823	1.0816	1.0810	1.0807	1.0815	1.0835	1.0867	1.0911	1.0966	1.1025	1.1071
27	5.2	1.0818	1.0810	1.0804	1.0800	1.0809	1.0830	1.0866	1.0914	1.0974	1.1038	1.1090
28	5.4	1.0813	1.0804	1.0797	1.0792	1.0801	1.0824	1.0862	1.0913	1.0978	1.1047	1.1102
29	5.6	1.0805	1.0798	1.0793	1.0791	1.0803	1.0827	1.0865	1.0916	1.0981	1.1049	1.1103
30	5.8	1.0795	1.0791	1.0789	1.0793	1.0807	1.0833	1.0871	1.0920	1.0980	1.1043	1.1095
31	6.0	1.0782	1.0781	1.0782	1.0791	1.0809	1.0836	1.0873	1.0919	1.0974	1.1031	1.1079
32	6.2	1.0766	1.0768	1.0772	1.0786	1.0807	1.0835	1.0870	1.0912	1.0961	1.1012	1.1056
33	6.4	1.0746	1.0751	1.0759	1.0777	1.0800	1.0828	1.0861	1.0899	1.0941	1.0986	1.1025
34	6.6	1.0722	1.0730	1.0740	1.0763	1.0788	1.0815	1.0846	1.0879	1.0915	1.0951	1.0985
35	6.8	1.0696	1.0706	1.0718	1.0743	1.0768	1.0795	1.0823	1.0852	1.0883	1.0913	1.0942
36	7.0	1.0671	1.0682	1.0695	1.0721	1.0747	1.0775	1.0803	1.0831	1.0861	1.0890	1.0919
37	7.2	1.0646	1.0660	1.0678	1.0711	1.0743	1.0775	1.0805	1.0833	1.0861	1.0889	1.0917
38	7.4	1.0630	1.0655	1.0682	1.0731	1.0773	1.0809	1.0837	1.0859	1.0874	1.0887	1.0906
39	7.6	1.0654	1.0681	1.0711	1.0763	1.0806	1.0840	1.0863	1.0876	1.0879	1.0880	1.0890
40	7.8	1.0702	1.0727	1.0755	1.0801	1.0838	1.0864	1.0879	1.0883	1.0877	1.0868	1.0869
41	8.0	1.0750	1.0773	1.0798	1.0838	1.0868	1.0886	1.0891	1.0885	1.0867	1.0846	1.0837
42	8.2	1.0796	1.0816	1.0837	1.0871	1.0892	1.0902	1.0899	1.0884	1.0858	1.0828	1.0809
43	8.4	1.0840	1.0855	1.0871	1.0895	1.0909	1.0914	1.0909	1.0895	1.0870	1.0844	1.0826
44	8.6	1.0881	1.0891	1.0900	1.0914	1.0921	1.0921	1.0914	1.0900	1.0879	1.0856	1.0840
45	8.8	1.0921	1.0923	1.0926	1.0928	1.0928	1.0924	1.0917	1.0907	1.0894	1.0879	1.0868
46	9.0	1.0957	1.0952	1.0947	1.0939	1.0932	1.0927	1.0924	1.0923	1.0924	1.0926	1.0925
47	9.2	1.0990	1.0978	1.0966	1.0946	1.0934	1.0929	1.0933	1.0943	1.0961	1.0981	1.0994
48	9.4	1.1020	1.1000	1.0980	1.0950	1.0932	1.0928	1.0937	1.0959	1.0994	1.1033	1.1059
49	9.6	1.1045	1.1021	1.0997	1.0961	1.0942	1.0938	1.0952	1.0983	1.1029	1.1081	1.1116
50	9.8	1.1069	1.1043	1.1017	1.0978	1.0958	1.0956	1.0973	1.1009	1.1064	1.1124	1.1165
51	10.0	1.1093	1.1065	1.1036	1.0994	1.0972	1.0971	1.0991	1.1033	1.1094	1.1162	1.1209
52	10.2	1.1112	1.1083	1.1054	1.1012	1.0990	1.0991	1.1013	1.1057	1.1122	1.1194	1.1244
53	10.4	1.1125	1.1099	1.1072	1.1034	1.1016	1.1018	1.1042	1.1086	1.1150	1.1219	1.1269
54	10.6	1.1136	1.1111	1.1087	1.1053	1.1037	1.1041	1.1065	1.1108	1.1170	1.1238	1.1286
55	10.8	1.1150	1.1126	1.1103	1.1070	1.1056	1.1060	1.1083	1.1125	1.1185	1.1251	1.1298
56	11.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
61	12.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Top and bottom 10% of core excluded.

ATTACHMENT 3 TO AEP:NRC:5691-04

DONALD C. COOK NUCLEAR PLANT (CNP) UNIT 2
CYCLE 15 CORE OPERATING LIMITS REPORT
REVISION 1

Donald C. Cook Nuclear Plant

Unit 2 Cycle 15

Core Operating Limits Report

Revision 1

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report for the Donald C. Cook Nuclear Plant Unit 2 Cycle 15 has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC in:

a. WCAP-9272-P-A, Westinghouse Reload Safety Evaluation Methodology, July 1985

b. WCAP-8385, Power Distribution Control and Load Following Procedures – Topical Report, September 1974

c. WCAP-10216-P-A, Rev. 1A, Relaxation of Constant Axial Offset Control/F_Q Surveillance Technical Specification, February 1994

d. WCAP-10266-P-A, Rev. 2, The 1981 Version of Westinghouse Evaluation Mode Using BASH Code, March 1987

e. WCAP-12610-P-A, VANTAGE+ Fuel Assembly Reference Core Report, July 1991

f. WCAP-8745-P-A, Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions, September 1986

g. WCAP-13749-P-A, Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement, March 1997

The Technical Specifications affected by this report are listed below:

2.1.1	Safety Limits
3.1.1	Shutdown Margin (SDM)
3.1.3	Moderator Temperature Coefficient (MTC)
3.1.5	Shutdown Bank Insertion Limit
3.1.6	Control Bank Insertion Limits
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)
3.3.1	Reactor Trip System (RTS) Instrumentation
3.4.1	RCS Pressure, Temperature and Flow Departure from Nucleate Boiling (DNB) Limits
3.9.1	Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits listed in Section 1.0 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

2.1 SAFETY LIMITS

2.1.1 Safety Limits (Specification 2.1.1)

In Modes 1 and 2, the combination of thermal power, pressurizer pressure, and the highest operating loop coolant average temperature (T_{avg}) shall not exceed the limits as shown in Figure 6 for 4 loop operation.

2.2 REACTIVITY CONTROL

2.2.1 Shutdown Margin (Specification 3.1.1)

Shutdown margin shall be greater than or equal to 1.3% Δk/k for $T_{avg} > 200°F$
Shutdown margin shall be greater than or equal to 1.0% Δk/k for $T_{avg} \leq 200°F$

2.2.2 Moderator Temperature Coefficient (Specification 3.1.3)

a. The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO-MTC shall be less positive than or equal to the value given in Figure 1.

The EOL/ARO/RTP-MTC shall be less negative than or equal to -4.10E-4 Δk/k/°F.

This limit is based on a T_{avg} program with HFP vessel T_{avg} of 571 to 576 °F

Where: ARO stands for All Rods Out
BOL stands for Beginning of Cycle Life
EOL stands for End of Cycle Life
RTP stands for Rated Thermal Power
HFP stands for Hot Full Thermal Power

b. The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative or equal to -3.20E-4 Δk/k/°F at a HFP vessel T_{avg} of 571 to 576 °F

c. The Revised Predicted near-EOL 300 ppm MTC shall be calculated using Figure 7 and the following algorithm:

Revised Predicted MTC = Predicted MTC + AFD Correction + Predicted Correction*

* Predicted Correction is -0.30E-4 Δk/k/°F.

If the Revised Predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 2.2.2.b) and all of the benchmark data contained in the surveillance procedure are met, then a MTC measurement in accordance with SR 3.1.3.2 is not required.

d. The MTC Surveillance limit is:
The 60 ppm/ARO/RTP-MTC should be less negative or equal to -3.90E-4 Δk/k/°F at a HFP vessel T_{avg} of 571 to 576 °F

2.2.3 Shutdown Rod Insertion Limit (Specification 3.1.5)

The shutdown rods shall be withdrawn to at least 228 steps.

2.2.4 Control Bank Insertion Limits (Specifications 3.1.6)

a. The control rod banks shall be limited in physical insertion as shown in Figure 2.

b. Successive Control Banks shall overlap by 100 steps. The sequence for Control Bank withdrawal shall be Control Bank A, Control Bank B, Control Bank C, and Control
Bank D.

2.3 POWER DISTRIBUTION LIMITS

2.3.1 Axial Flux Difference (AFD) (Specification 3.2.3)

a. The Allowable Operation Limits are provided in Figure 3.

b. The AFD target band is ±5% for a cycle average accumulated burnup ≥0.0 MWD/MTU

2.3.2 Heat Flux Hot Channel Factor - $F_Q(Z)$ (Specification 3.2.1)

$$F_Q^C(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^C(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

$$F_Q^W(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^W(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_Q = 2.335$

b. **K(Z)** is provided in Figure 4.

c. $F_Q^C(Z)$ is the measured hot channel factor including a 3% manufacturing tolerance uncertainty and a 5% measurement uncertainty.

d. **W(Z)** is provided in Tables 1 for AFD target band of ±5%.

e. $F_Q^W(Z) = F_Q^C(Z) \times W(Z) \times F_P$

f. For Cycle 15, when applicable, $F_P = 1.02$ all burnups.

2.3.3 Nuclear Enthalpy Rise Hot Channel Factor – $F^N_{\Delta H}$ (Specification 3.2.2)

$$F^N_{\Delta H} \leq CF_{\Delta H} * (1 + PF_{\Delta H} * (1-P))$$

Where: $$P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$$

a. $CF_{\Delta H} = 1.58$

b. $PF_{\Delta H} = 0.3$

2.4 INSTRUMENTATION

2.4.1 Reactor Trip System Instrumentation (Specification 3.3.1)

The Overtemperature ΔT and Overpower ΔT setpoints are as shown in Figure 5.

2.5 REACTOR COOLANT SYSTEM

2.5.1 RCS Pressure, Temperature and Flow Departure from Nucleate Boiling (DNB) Limits (Specification 3.4.1)

a. Reactor Coolant System T_{avg} shall be $\leq$ 580.1 °F [+]

b. Pressurizer Pressure shall be $\geq$ 2172 psig [+]

c. Reactor Coolant System Total Flow Rate shall be $\geq$ 366,400 gpm

[+] These are Safety Analysis values. With readability allowance, the corresponding values are 577.8°F for T_{avg}, and 2200 psig for Pressurizer Pressure.

2.6 REFUELING OPERATIONS

2.6.1 Boron Concentration (Specification 3.9.1)

The boron concentration of all filled portions of the Reactor Coolant System, the refueling canal and the refueling cavity shall be greater than or equal to 2400 ppm[++].

[++] This concentration bounds the condition of $K_{eff} \leq 0.95$ which includes a 1% $\Delta k/k$ conservative allowance for uncertainties. The boron concentration of 2400 ppm includes a 50 ppm conservative allowance for uncertainties.

FIGURE 1
MODERATOR TEMPERATURE COEFFICIENT (MTC) LIMITS

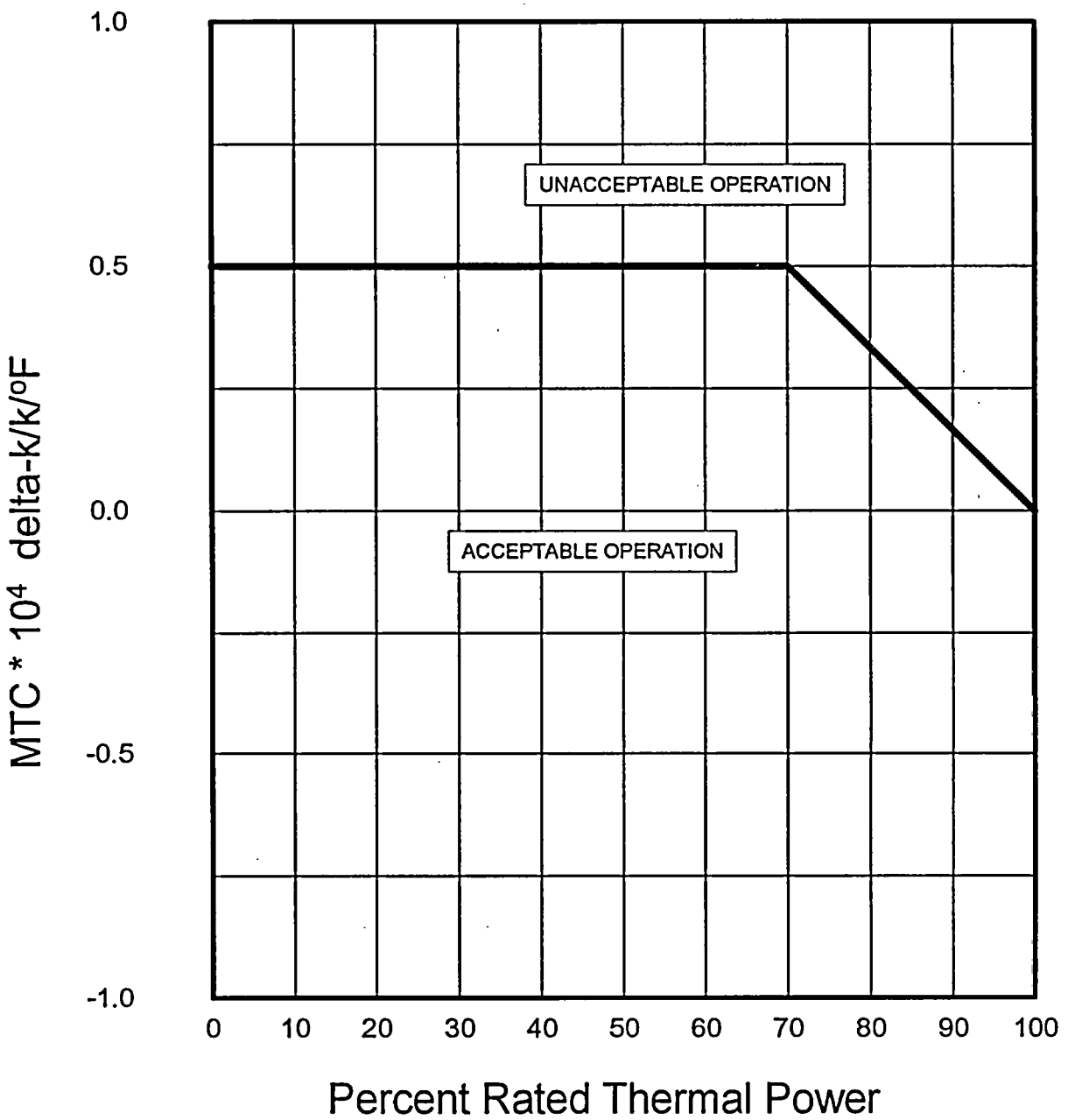


FIGURE 2
ROD BANK INSERTION LIMITS VERSUS THERMAL POWER
(FOUR-LOOP OPERATION)

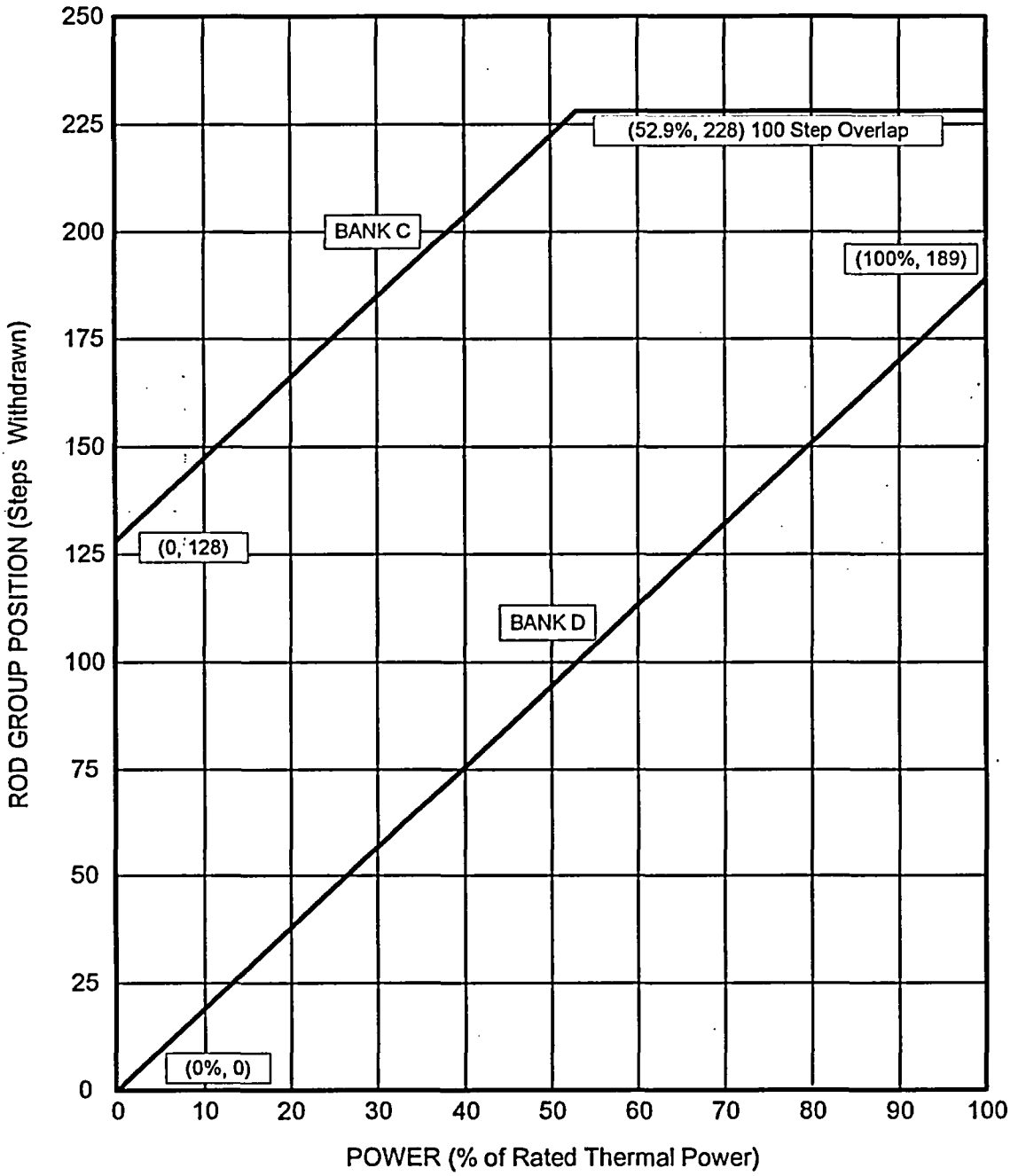


FIGURE 3
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER (RTP)

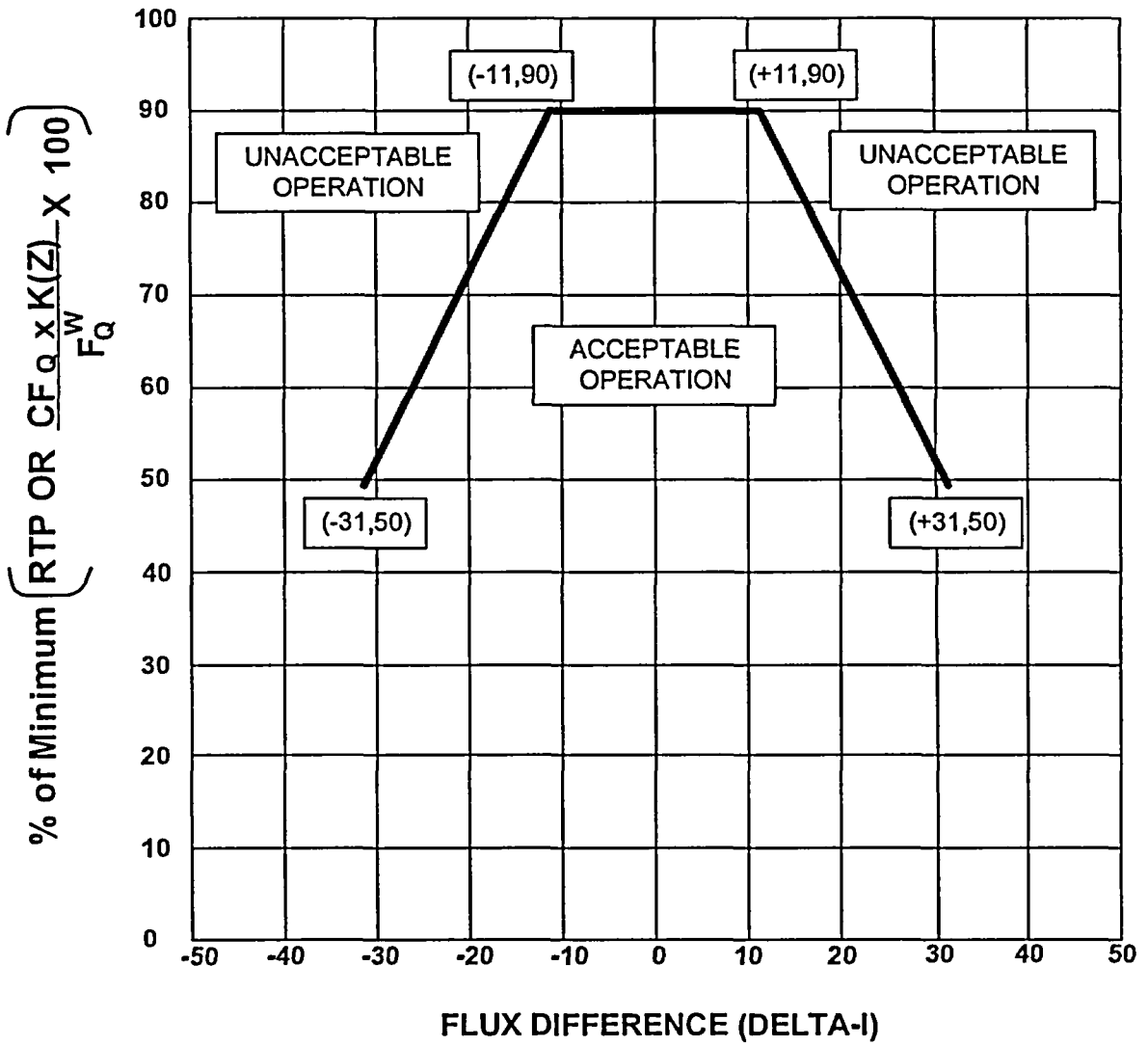


FIGURE 4
K(Z) - NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

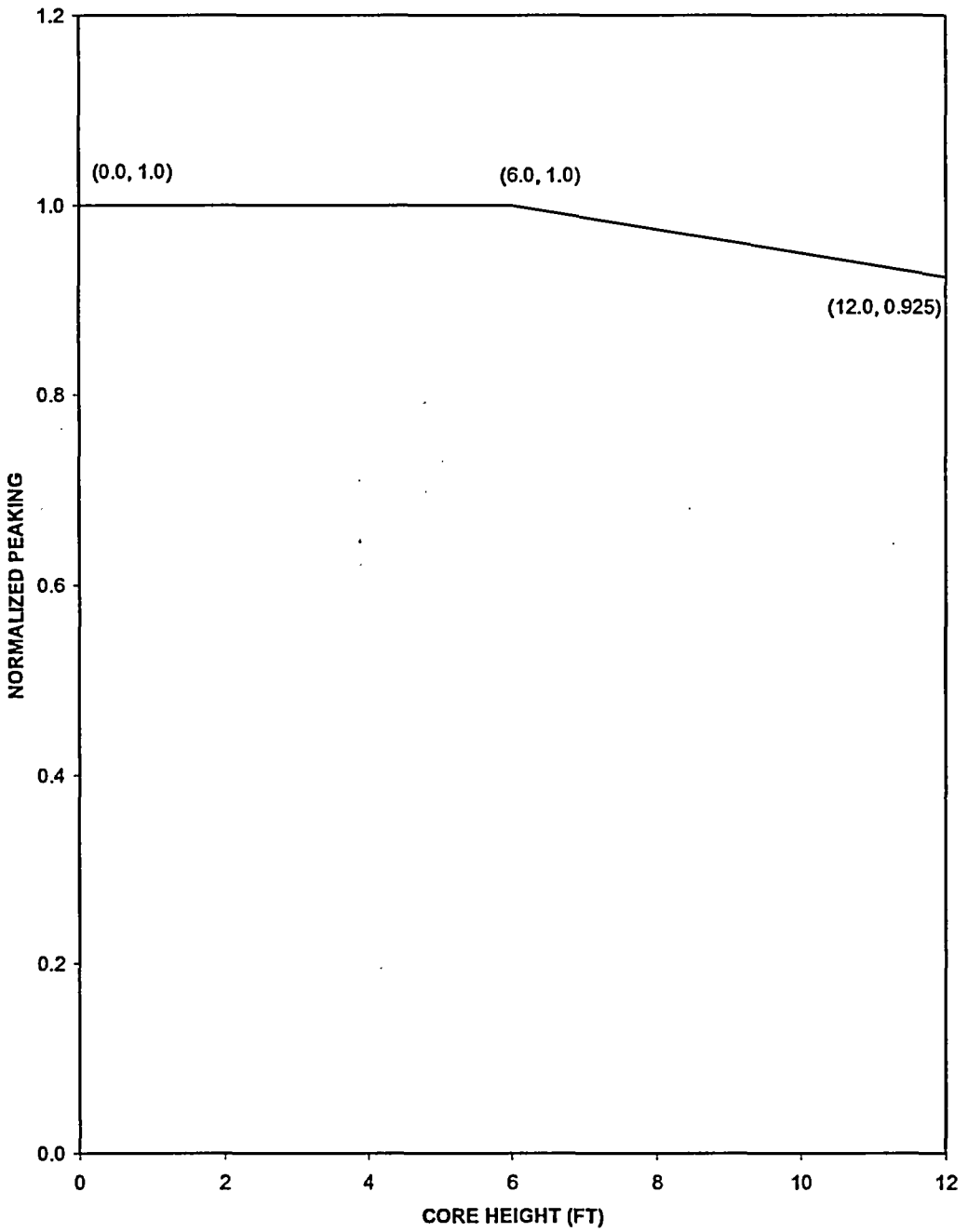


FIGURE 5
(Page 1 of 3)

Reactor Trip System Instrumentation Trip Setpoints

Overtemperature ΔT Trip Setpoint

$$\text{Overtemperature } \Delta T \leq \Delta T_o \{K_1 - K_2 \left[\frac{1+\tau_1 S}{1+\tau_2 S}\right] (T-T') + K_3 (P-P') - f_1(\Delta I)\}$$

Where:

ΔT_o = Indicated ΔT at RATED THERMAL POWER, °F

T = Average temperature, °F

T' = Nominal T_{avg} at RATED THERMAL POWER, ≤ 576.0°F

P = Pressurizer Pressure, psig

P' = 2235 psig (indicated RCS nominal operating pressure)

$\frac{1+\tau_1 S}{1+\tau_2 S}$ = The function generated by the lead-lag controller for T_{avg} dynamic compensation

τ_1, τ_2 = Time constants utilized in the lead-lag controller for T_{avg}; $\tau_1 \geq 28$ secs, $\tau_2 \leq 4$ secs.

S = Laplace transform operator, sec^{-1}

FIGURE 5
(Page 2 of 3)

4 Loops in Operation

$K_1 \leq 1.19$ *

$K_2 \geq 0.01331/°F$

$K_3 \geq 0.00058/psig$

and $f_1(\Delta I)$ is a function of the indicated difference between top and bottom detectors of the power-range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

(i) For $q_t - q_b$ between -33 percent and +6 percent, $f_1(\Delta I)=0$ (where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) For each percent that the magnitude of $(q_t - q_b)$ exceeds -33 percent, the ΔT trip setpoint shall be automatically reduced by 3.5 percent of its value at RATED THERMAL POWER.

(iii) For each percent that the magnitude of $(q_t - q_b)$ exceeds +6 percent, the ΔT trip setpoint shall be automatically reduced by 1.0 percent of its value at RATED THERMAL POWER.

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 5

(Page 3 of 3)

Overpower ΔT Setpoint

$$\text{Overpower } \Delta T \leq \Delta T_o \left[K_4 - K_5 \left[\frac{\tau_3 S}{1+\tau_3 S}\right] T - K_6 [T - T''] - f_2(\Delta I)\right]$$

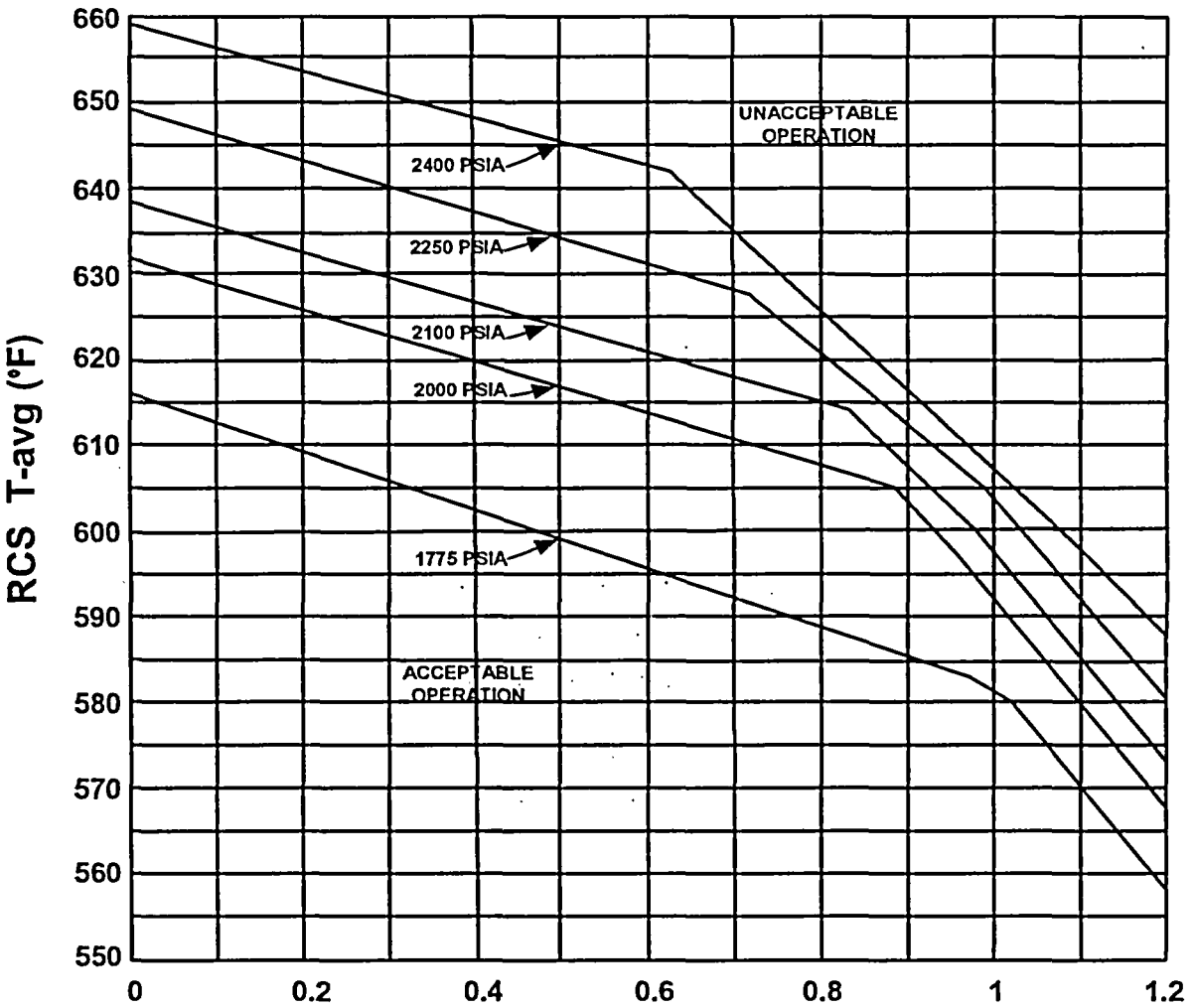
Where:

ΔT_o	=	Indicated ΔT at rated power
T	=	Average temperature, °F
T''	=	Nominal T_{avg} at RATED THERMAL POWER, ≤ 576.0 °F
K_4	≤	1.16 *
K_5	≥	0.02/°F for increasing average temperature and 0 for decreasing average temperature
K_6	≥	0.00197/°F for T greater than T'' ; K_6=0 for T less than or equal to T''
$\frac{\tau_3 S}{1+\tau_3 S}$	=	The function generated by the rate lag controller for T_{avg} dynamic compensation
τ_3	=	Time constant utilized in the rate lag controller for T_{avg}; $\tau_3 \geq 10$ secs.
S	=	Laplace transform operator, sec^{-1}
$f_2(\Delta I)$	=	0.0

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 6

Reactor Core Safety Limits



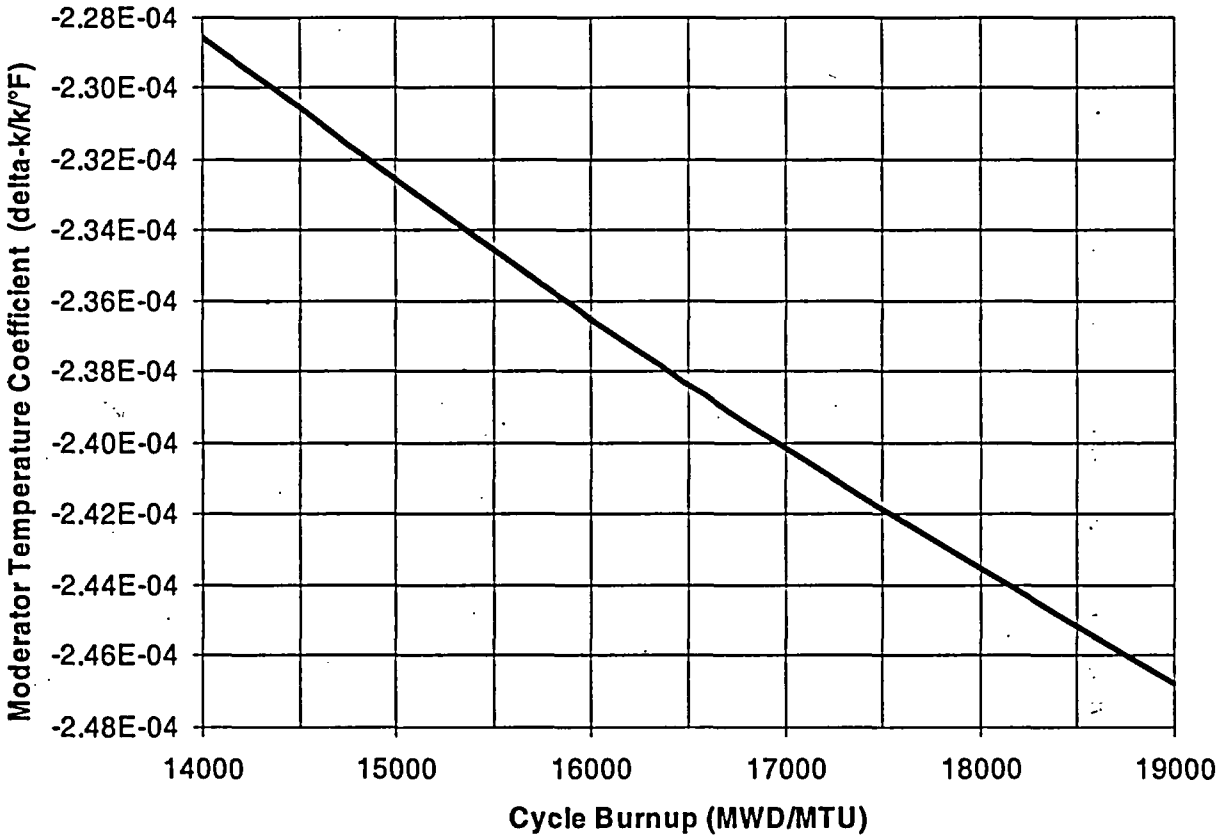
DESCRIPTION OF SAFETY LIMITS

PRESSURE (psia)	Power (frac)	Tavg (° F)	Power (frac)	Tavg (° F)	Power (frac)	Tavg (° F)	Power (frac)	Tavg (° F)
1775	0.00	615.4	0.98	583.8	1.02	580.9	1.2	558.1
2000	0.00	631.8	0.86	605.8	0.96	597.5	1.2	568.5
2100	0.00	639.1	0.82	614.0	0.96	601.6	1.2	573.1
2250	0.00	649.2	0.72	628.6	0.98	605.2	1.2	580.4
2400	0.00	659.0	0.62	642.0	1.1	599.0	1.2	588.1

UNIT 2 Reactor Core Safety Limits

FIGURE 7

Unit 2 Cycle 15 Predicted HFP ARO 300 PPM MTC Versus Burnup



Burnup (MWD/MTU)	MTC (Δk/k/°F)
14000	-2.2855E-4
15916	-2.3615E-4
16916	-2.3984E-4
17916	-2.4325E-4
19000	-2.4679E-4

TABLE 1
D. C. Cook Unit 2, Cycle 15
W(Z) Function

Node	Height	Burnup (MWD/MTU)												
PT	(Ft.)	150	1000	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	20650
1	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.4000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.6000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.2000	1.1012	1.1007	1.1005	1.1015	1.1046	1.1097	1.1159	1.1221	1.1281	1.1342	1.1405	1.1466	1.1486
8	1.4000	1.1013	1.1009	1.1008	1.1018	1.1047	1.1095	1.1153	1.1210	1.1266	1.1322	1.1379	1.1435	1.1454
9	1.6000	1.1012	1.1008	1.1008	1.1018	1.1045	1.1090	1.1143	1.1195	1.1246	1.1297	1.1348	1.1400	1.1417
10	1.8000	1.1008	1.1005	1.1005	1.1014	1.1039	1.1080	1.1128	1.1175	1.1220	1.1265	1.1311	1.1356	1.1371
11	2.0000	1.1001	1.0999	1.0999	1.1008	1.1030	1.1066	1.1108	1.1149	1.1188	1.1226	1.1265	1.1304	1.1317
12	2.2000	1.0991	1.0990	1.0990	1.0998	1.1017	1.1048	1.1084	1.1118	1.1151	1.1182	1.1213	1.1246	1.1256
13	2.4000	1.0978	1.0977	1.0978	1.0985	1.1001	1.1027	1.1056	1.1083	1.1108	1.1132	1.1155	1.1180	1.1188
14	2.6000	1.0963	1.0962	1.0963	1.0969	1.0982	1.1002	1.1024	1.1043	1.1060	1.1076	1.1091	1.1107	1.1113
15	2.8000	1.0945	1.0945	1.0946	1.0950	1.0959	1.0972	1.0987	1.0999	1.1008	1.1016	1.1023	1.1031	1.1034
16	3.0000	1.0923	1.0924	1.0924	1.0928	1.0934	1.0942	1.0950	1.0955	1.0956	1.0955	1.0952	1.0953	1.0953
17	3.2000	1.0901	1.0902	1.0903	1.0905	1.0908	1.0911	1.0913	1.0911	1.0905	1.0897	1.0886	1.0880	1.0878
18	3.4000	1.0886	1.0887	1.0888	1.0888	1.0886	1.0881	1.0876	1.0872	1.0868	1.0865	1.0862	1.0858	1.0857
19	3.6000	1.0880	1.0880	1.0880	1.0879	1.0873	1.0863	1.0856	1.0861	1.0876	1.0900	1.0928	1.0946	1.0952
20	3.8000	1.0873	1.0870	1.0868	1.0863	1.0857	1.0851	1.0852	1.0869	1.0902	1.0949	1.1003	1.1041	1.1054
21	4.0000	1.0864	1.0859	1.0854	1.0848	1.0845	1.0845	1.0856	1.0886	1.0933	1.0996	1.1069	1.1122	1.1139
22	4.2000	1.0853	1.0848	1.0844	1.0840	1.0844	1.0854	1.0877	1.0918	1.0976	1.1049	1.1132	1.1196	1.1216
23	4.4000	1.0843	1.0838	1.0836	1.0838	1.0849	1.0870	1.0903	1.0954	1.1020	1.1100	1.1189	1.1261	1.1284
24	4.6000	1.0839	1.0834	1.0831	1.0835	1.0851	1.0882	1.0927	1.0987	1.1060	1.1147	1.1241	1.1319	1.1345
25	4.8000	1.0839	1.0832	1.0827	1.0830	1.0852	1.0893	1.0949	1.1017	1.1097	1.1188	1.1286	1.1370	1.1397
26	5.0000	1.0837	1.0828	1.0821	1.0825	1.0851	1.0901	1.0967	1.1044	1.1128	1.1222	1.1323	1.1412	1.1440
27	5.2000	1.0833	1.0822	1.0813	1.0816	1.0846	1.0905	1.0982	1.1065	1.1154	1.1250	1.1351	1.1443	1.1473
28	5.4000	1.0827	1.0813	1.0803	1.0805	1.0839	1.0907	1.0992	1.1081	1.1173	1.1269	1.1370	1.1464	1.1495
29	5.6000	1.0817	1.0803	1.0793	1.0796	1.0833	1.0906	1.0997	1.1090	1.1183	1.1279	1.1378	1.1474	1.1505
30	5.8000	1.0805	1.0790	1.0780	1.0783	1.0823	1.0900	1.0996	1.1092	1.1185	1.1279	1.1376	1.1471	1.1502
31	6.0000	1.0791	1.0776	1.0765	1.0768	1.0809	1.0890	1.0990	1.1086	1.1178	1.1269	1.1363	1.1456	1.1487
32	6.2000	1.0777	1.0760	1.0748	1.0749	1.0791	1.0874	1.0976	1.1072	1.1162	1.1249	1.1338	1.1429	1.1458
33	6.4000	1.0758	1.0740	1.0727	1.0728	1.0770	1.0853	1.0955	1.1049	1.1136	1.1218	1.1302	1.1388	1.1416
34	6.6000	1.0734	1.0720	1.0709	1.0713	1.0753	1.0832	1.0927	1.1016	1.1097	1.1176	1.1255	1.1336	1.1363
35	6.8000	1.0704	1.0691	1.0682	1.0686	1.0724	1.0798	1.0886	1.0968	1.1043	1.1115	1.1187	1.1262	1.1287
36	7.0000	1.0677	1.0672	1.0671	1.0685	1.0723	1.0787	1.0861	1.0933	1.1002	1.1070	1.1138	1.1208	1.1230
37	7.2000	1.0678	1.0686	1.0698	1.0727	1.0763	1.0808	1.0860	1.0919	1.0983	1.1053	1.1127	1.1194	1.1216
38	7.4000	1.0715	1.0721	1.0731	1.0757	1.0793	1.0840	1.0892	1.0945	1.0999	1.1054	1.1111	1.1166	1.1184
39	7.6000	1.0749	1.0753	1.0761	1.0784	1.0819	1.0866	1.0918	1.0966	1.1012	1.1056	1.1100	1.1146	1.1161
40	7.8000	1.0777	1.0780	1.0787	1.0808	1.0841	1.0888	1.0937	1.0981	1.1019	1.1053	1.1085	1.1122	1.1134
41	8.0000	1.0803	1.0804	1.0809	1.0827	1.0858	1.0904	1.0953	1.0992	1.1021	1.1043	1.1061	1.1088	1.1097
42	8.2000	1.0824	1.0824	1.0826	1.0841	1.0871	1.0916	1.0963	1.0997	1.1017	1.1027	1.1032	1.1049	1.1055
43	8.4000	1.0841	1.0839	1.0839	1.0850	1.0877	1.0922	1.0968	1.0996	1.1007	1.1005	1.0997	1.1004	1.1007
44	8.6000	1.0852	1.0848	1.0847	1.0854	1.0879	1.0923	1.0967	1.0989	1.0990	1.0973	1.0949	1.0944	1.0943
45	8.8000	1.0861	1.0855	1.0852	1.0855	1.0877	1.0918	1.0959	1.0981	1.0986	1.0977	1.0960	1.0961	1.0961
46	9.0000	1.0866	1.0861	1.0858	1.0862	1.0882	1.0919	1.0959	1.0987	1.1004	1.1011	1.1015	1.1029	1.1033
47	9.2000	1.0878	1.0878	1.0881	1.0893	1.0916	1.0951	1.0987	1.1015	1.1034	1.1047	1.1056	1.1074	1.1079
48	9.4000	1.0911	1.0915	1.0920	1.0936	1.0963	1.1000	1.1037	1.1064	1.1081	1.1090	1.1096	1.1110	1.1115
49	9.6000	1.0954	1.0957	1.0963	1.0980	1.1008	1.1046	1.1083	1.1110	1.1126	1.1134	1.1137	1.1151	1.1155
50	9.8000	1.0996	1.0999	1.1005	1.1022	1.1049	1.1087	1.1125	1.1151	1.1166	1.1172	1.1173	1.1185	1.1189
51	10.0000	1.1035	1.1038	1.1044	1.1061	1.1088	1.1126	1.1163	1.1189	1.1202	1.1207	1.1207	1.1218	1.1221
52	10.2000	1.1071	1.1075	1.1081	1.1097	1.1124	1.1160	1.1196	1.1221	1.1236	1.1242	1.1244	1.1256	1.1260
53	10.4000	1.1104	1.1108	1.1113	1.1130	1.1155	1.1189	1.1223	1.1248	1.1263	1.1270	1.1274	1.1287	1.1291
54	10.6000	1.1132	1.1134	1.1139	1.1154	1.1179	1.1215	1.1250	1.1275	1.1289	1.1295	1.1297	1.1309	1.1313
55	10.8000	1.1154	1.1156	1.1160	1.1175	1.1200	1.1235	1.1271	1.1295	1.1309	1.1314	1.1315	1.1326	1.1329
56	11.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.4000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.6000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.8000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
61	12.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

ATTACHMENT 4 TO AEP:NRC:5691-04

DONALD C. COOK NUCLEAR PLANT (CNP) UNIT 2
CYCLE 15 CORE OPERATING LIMITS REPORT
REVISION 2

Donald C. Cook Nuclear Plant

Unit 2 Cycle 15

Core Operating Limits Report

Revision 2

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report for the Donald C. Cook Nuclear Plant Unit 2 Cycle 15 has been prepared in accordance with the requirements of Technical Specification 5.6.5.

The analytical methods used to determine the core operating limits shall be those previously reviewed and approved by the NRC in:

a. WCAP-9272-P-A, Westinghouse Reload Safety Evaluation Methodology

b. WCAP-8385, Power Distribution Control and Load Following Procedures – Topical Report

c. WCAP-10216-P-A, Relaxation of Constant Axial Offset Control/F_Q Surveillance Technical Specification

d. WCAP-10266-P-A, The 1981 Version of Westinghouse Evaluation Mode Using BASH Code

e. WCAP-12610-P-A, VANTAGE+ Fuel Assembly Reference Core Report

f. WCAP-8745-P-A, Design Bases for the Thermal Overpower ΔT and Thermal Overtemperature ΔT Trip Functions

g. WCAP-13749-P-A, Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement

The Technical Specifications affected by this report are listed below:

2.1.1	Reactor Core Safety Limits
3.1.1	SHUTDOWN MARGIN (SDM)
3.1.3	Moderator Temperature Coefficient (MTC)
3.1.5	Shutdown Bank Insertion Limits
3.1.6	Control Bank Insertion Limits
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)
3.3.1	Reactor Trip System (RTS) Instrumentation
3.4.1	RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits
3.9.1	Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits listed in Section 1.0 are presented in the following subsections. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

2.1 SAFETY LIMITS

2.1.1 Reactor Core Safety Limits (Specification 2.1.1)

In Modes 1 and 2, the combination of thermal power, pressurizer pressure, and the highest loop average temperature (T_{avg}) shall not exceed the limits as shown in Figure 6 for 4 loop operation.

2.2 REACTIVITY CONTROL

2.2.1 SHUTDOWN MARGIN (SDM) (Specification 3.1.1)

Shutdown margin shall be greater than or equal to 1.3% Δk/k for $T_{avg} > 200°F$
Shutdown margin shall be greater than or equal to 1.0% Δk/k for $T_{avg} \leq 200°F$

2.2.2 Moderator Temperature Coefficient (MTC) (Specification 3.1.3)

a. The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO-MTC shall be less positive or equal to the value given in Figure 1.

The EOL/ARO/RTP-MTC shall be less negative or equal to -4.10E-4 Δk/k/°F.

This limit is based on a T_{avg} program with HFP vessel T_{avg} of 571.0 to 576.0 °F

Where: ARO stands for All Rods Out
BOL stands for Beginning of Cycle Life
EOL stands for End of Cycle Life
RTP stands for Rated Thermal Power
HFP stands for Hot Full Thermal Power

b. The MTC Surveillance limit is:
The 300 ppm/ARO/RTP-MTC should be less negative or equal to -3.20E-4 Δk/k/°F at a HFP vessel T_{avg} of 571.0 to 576.0 °F

c. The Revised Predicted near-EOL 300 ppm MTC shall be calculated using Figure 7 and the following algorithm:

Revised Predicted MTC = Predicted MTC + AFD Correction + Predicted Correction*

* Predicted Correction is -0.30E-4 Δk/k/°F.

If the Revised Predicted MTC is less negative than the SR 3.1.3.2 limit (COLR 2.2.2.b) and all of the benchmark data contained in the surveillance procedure are met, then a MTC measurement in accordance with SR 3.1.3.2 is not required.

d. The MTC Surveillance limit is:
The 60 ppm/ARO/RTP-MTC should be less negative or equal to -3.90E-4 Δk/k/°F at a HFP vessel T_{avg} of 571.0 to 576.0 °F

2.2.3 Shutdown Bank Insertion Limits (Specification 3.1.5)

The shutdown rods shall be withdrawn to at least 228 steps.

2.2.4 Control Bank Insertion Limits (Specifications 3.1.6)

a. The control rod banks shall be limited in physical insertion as shown in Figure 2.

b. Successive Control Banks shall overlap by 100 steps. The sequence for Control Bank withdrawal shall be Control Bank A, Control Bank B, Control Bank C, and Control Bank D.

2.3 POWER DISTRIBUTION LIMITS

2.3.1 AXIAL FLUX DIFFERENCE (AFD) (Specification 3.2.3)

a. The Allowable Operation Limits are provided in Figure 3.

b. The AFD target band is ±5% for a cycle average accumulated burnup ≥0.0 MWD/MTU.

2.3.2 Heat Flux Hot Channel Factor ($F_Q(Z)$) (Specification 3.2.1)

$$F_Q^C(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^C(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

$$F_Q^W(Z) \le \frac{CF_Q}{P} * K(Z) \qquad for\ P > 0.5$$

$$F_Q^W(Z) \le 2 * CF_Q * K(Z) \qquad for\ P \le 0.5$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_Q = 2.335$

b. **K(Z)** is provided in Figure 4.

c. $F_Q^C(Z)$ is the measured hot channel factor including a 3% manufacturing tolerance uncertainty and a 5% measurement uncertainty.

d. **W(Z)** is provided in Table 1 for ±5% AFD target band.

e. $F_Q^W(Z) = F_Q^C(Z) \times W(Z) \times F_P$

f. For Cycle 15, when $F^c_Q(Z)/K(Z)$ is increasing, $F_P = 1.02$ for all burnups. When no penalty is required, $F_P = 1.00$.

2.3.3 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$) (Specification 3.2.2)

$$F^N_{\Delta H} \le CF_{\Delta H} * (1 + PF_{\Delta H} * (1-P))$$

Where: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$

a. $CF_{\Delta H} = 1.58$

b. $PF_{\Delta H} = 0.3$

2.4 INSTRUMENTATION

2.4.1 Reactor Trip System (RTS) Instrumentation (Specification 3.3.1)

The Overtemperature ΔT and Overpower ΔT setpoints are as shown in Figure 5.

2.5 REACTOR COOLANT SYSTEM

2.5.1 RCS Pressure, Temperature, and Flow Departure from Nucleate Boiling (DNB) Limits (Specification 3.4.1)

a. Pressurizer Pressure shall be $\geq$ 2172 psig [+]

b. Reactor Coolant System T_{avg} shall be $\leq$ 580.1 °F [+]

c. Reactor Coolant System Total Flow Rate shall be $\geq$ 366,400 gpm

2.6 REFUELING OPERATIONS

2.6.1 Boron Concentration (Specification 3.9.1)

The boron concentration of all filled portions of the Reactor Coolant System, the refueling canal and the refueling cavity shall be greater than or equal to 2400 ppm[++].

[+] These are Safety Analysis values. With readability allowance, the corresponding values are 577.8°F for T_{avg}, and 2200 psig for Pressurizer Pressure.

[++] This concentration bounds the condition of $K_{eff} \leq 0.95$ which includes a 1% $\Delta k/k$ conservative allowance for uncertainties. The boron concentration of 2400 ppm includes a 50 ppm conservative allowance for uncertainties.

FIGURE 1
MODERATOR TEMPERATURE COEFFICIENT (MTC) LIMITS

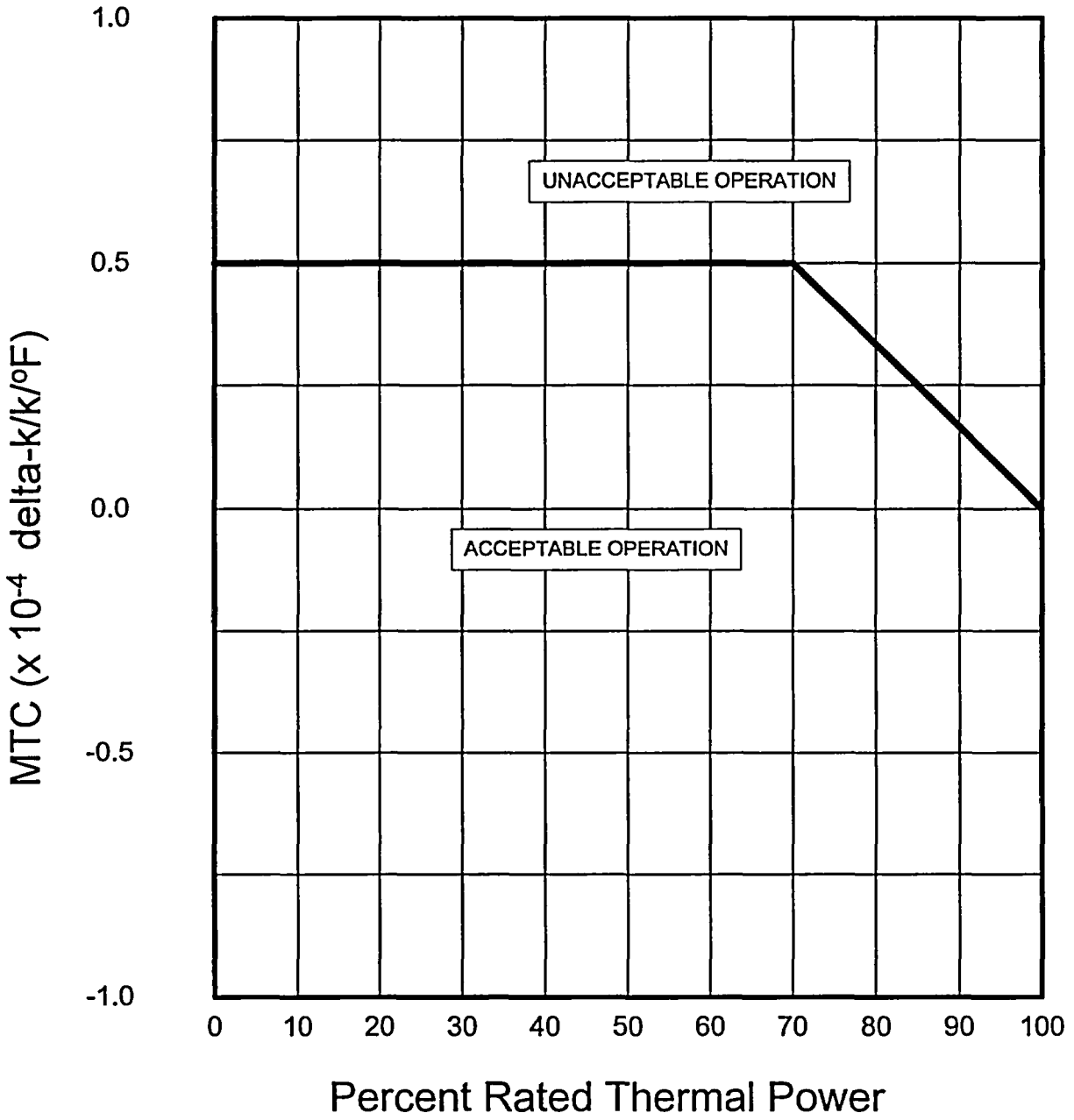


FIGURE 2
ROD BANK INSERTION LIMITS VERSUS THERMAL POWER
(FOUR-LOOP OPERATION)

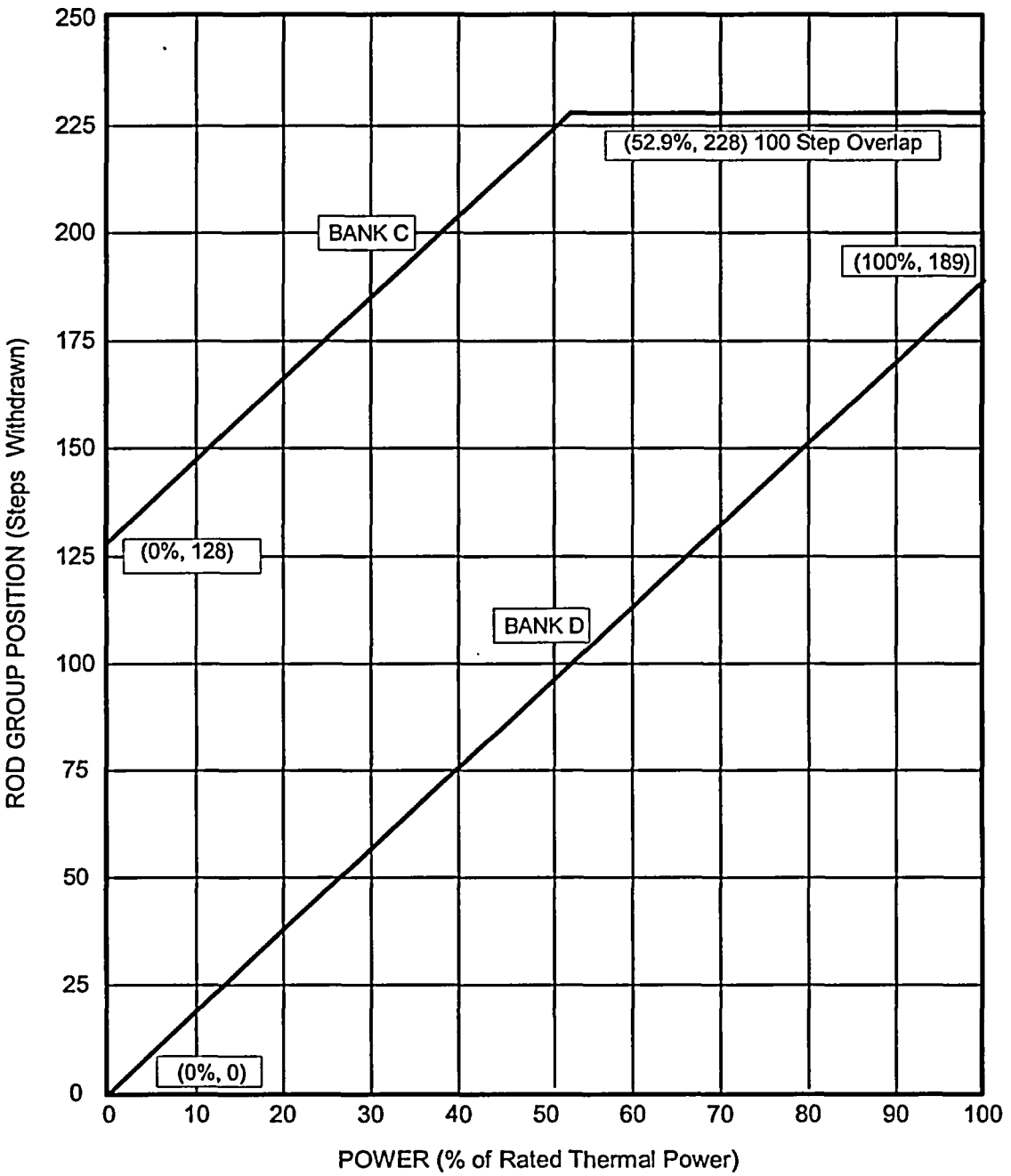


FIGURE 3
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER (RTP)

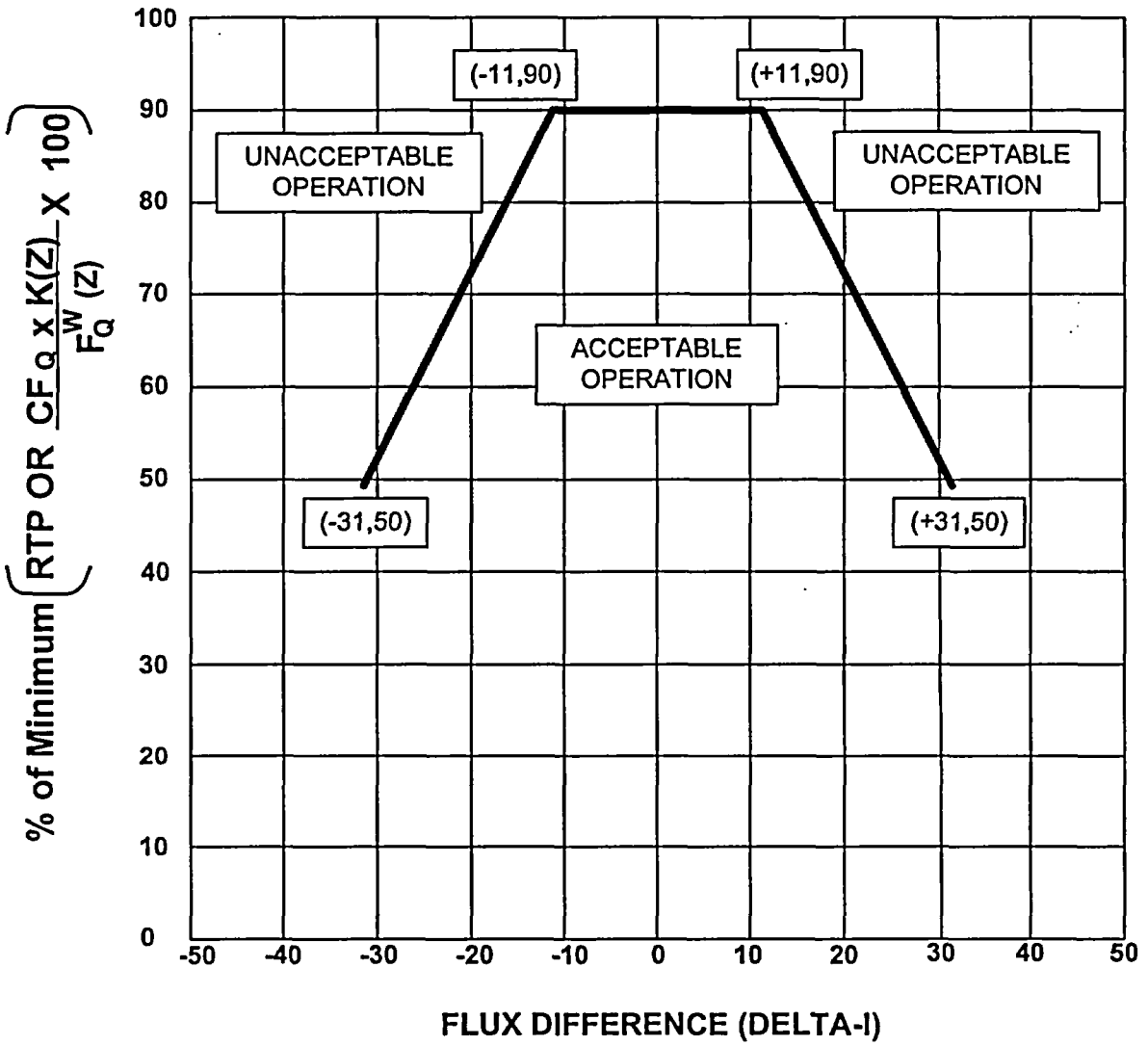


FIGURE 4
K(Z) - NORMALIZED $F_Q(Z)$ AS A FUNCTION OF CORE HEIGHT

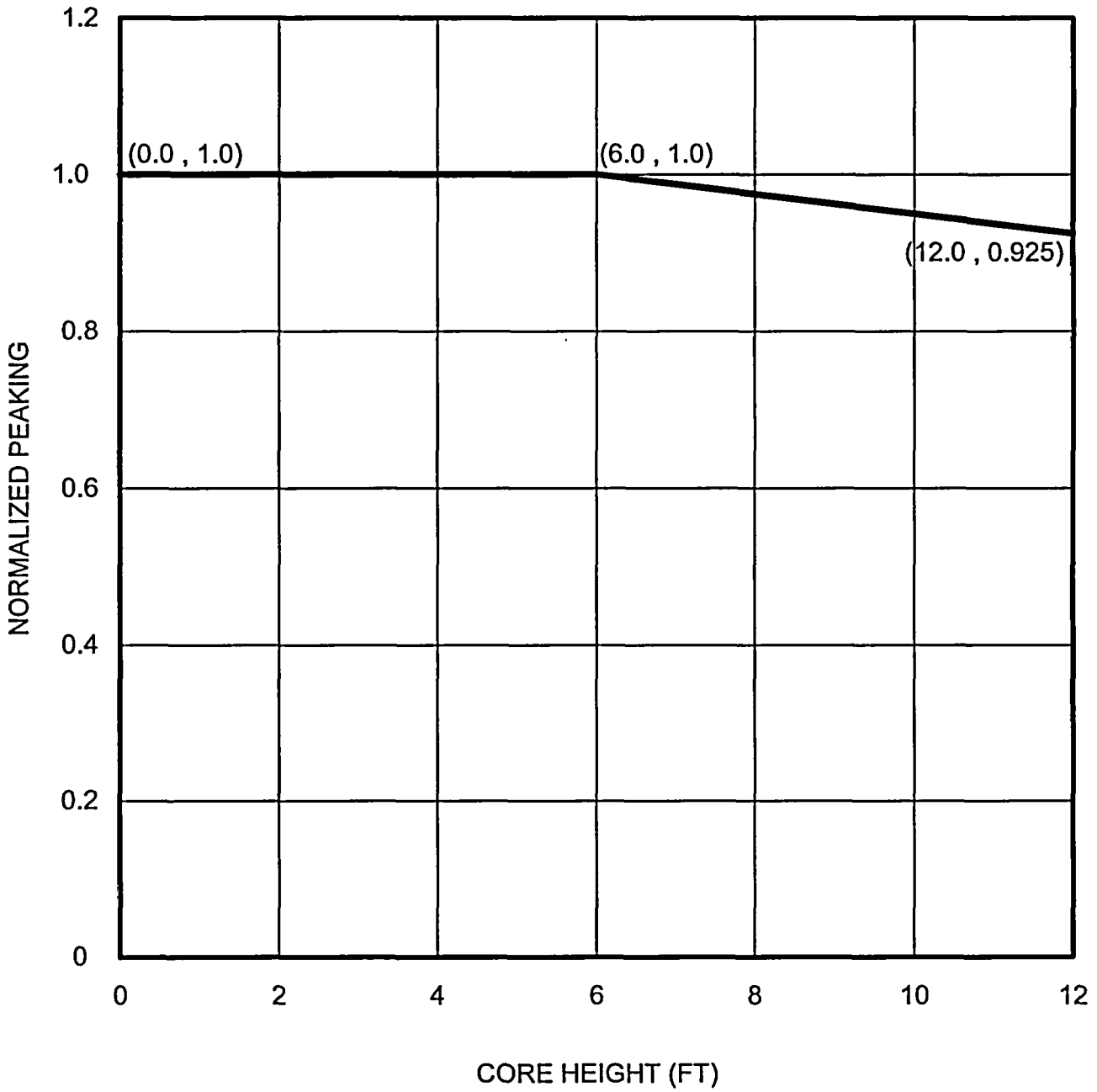


FIGURE 5

(Page 1 of 2)

Reactor Trip System Instrumentation Trip Setpoints

Overtemperature ΔT Trip Setpoint

$$\text{Overtemperature } \Delta T \le \Delta T_o \left[K_1 - K_2 \left[\frac{1+\tau_1 S}{1+\tau_2 S}\right] (T-T') + K_3 (P-P') - f_1(\Delta I)\right]$$

Where:

ΔT	=	Measured RCS ΔT, °F
ΔT_o	=	Indicated ΔT at RATED THERMAL POWER, °F
T	=	Average temperature, °F
T'	=	Nominal T_{avg} at RATED THERMAL POWER, ($\le$ 576.0°F)
P	=	Pressurizer Pressure, psig
P'	=	Nominal RCS operating pressure (2235 psig)
$\frac{1+\tau_1 S}{1+\tau_2 S}$	=	The function generated by the lead-lag controller for T_{avg} dynamic compensation
τ_1, τ_2	=	Time constants utilized in the lead-lag controller for T_{avg} $\tau_1 \ge 28$ secs. $\tau_2 \le 4$ secs.
S	=	Laplace transform operator, sec^{-1}
K_1	$\le$	1.19 *
K_2	$\ge$	0.01331/°F
K_3	$\ge$	0.00058/psig
$f_1(\Delta I)$	=	$3.5\{33 + (q_t - q_b)\}$ when $q_t - q_b \le -33\%$ RTP 0% of RTP when -33% RTP $< q_t - q_b \le 6\%$ RTP $-1.0\{(q_t - q_b) - 6\}$ when $q_t - q_b > 6\%$ RTP

where q_t and q_b are percent RATED THERMAL POWER in the upper and lower halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent RATED THERMAL POWER.

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 5

(Page 2 of 2)

Overpower ΔT Trip Setpoint

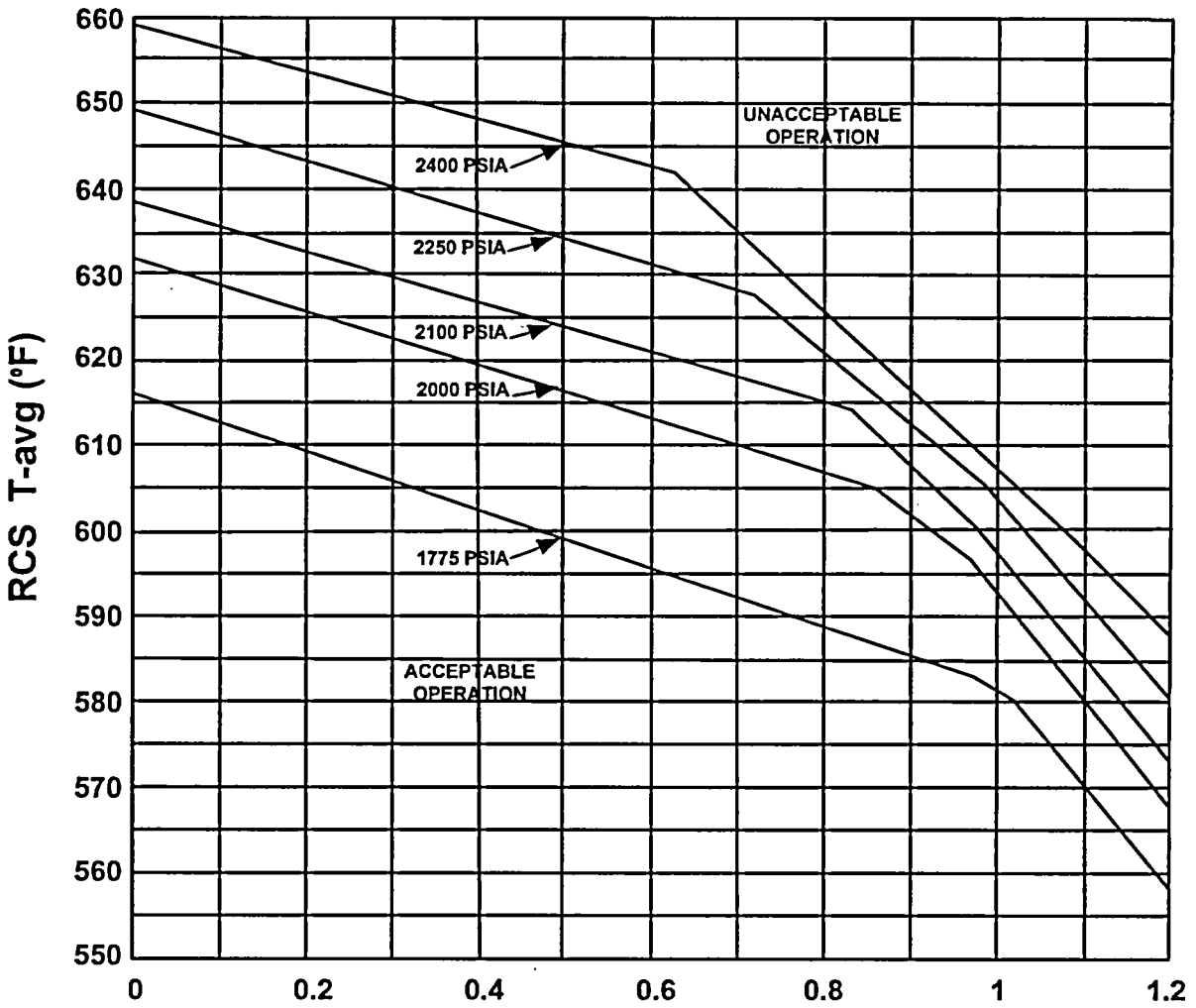
$$\text{Overpower } \Delta T \leq \Delta T_o \left[K_4 - K_5 \left[\frac{\tau_3 S}{1+\tau_3 S}\right] T - K_6 (T - T'') - f_2(\Delta I)\right]$$

Where:	ΔT	=	Measured RCS ΔT, °F
	ΔT_o	=	Indicated ΔT at RATED THERMAL POWER, °F
	T	=	Average temperature, °F
	T''	=	Nominal T_{avg} at RATED THERMAL POWER, ($\leq$ 576.0 °F)
	K_4	$\leq$	1.16 *
	K_5	$\geq$	0.02/°F for increasing average temperature; $K_5 = 0$ for decreasing average temperature
	K_6	$\geq$	0.00197/°F for T greater than T" ; K_6=0 for T less than or equal to T"
	$\frac{\tau_3 S}{1+\tau_3 S}$	=	The function generated by the rate lag controller for T_{avg} dynamic compensation
	τ_3	=	Time constant utilized in the rate lag controller for T_{avg}; $\tau_3 \geq 10$ secs.
	S	=	Laplace transform operator, sec^{-1}
	$f_2(\Delta I)$	=	0.0

* This is a Safety Analysis value. Refer to Technical Requirements Manual for nominal value of this coefficient used in programming the trip setpoint.

FIGURE 6

Reactor Core Safety Limits



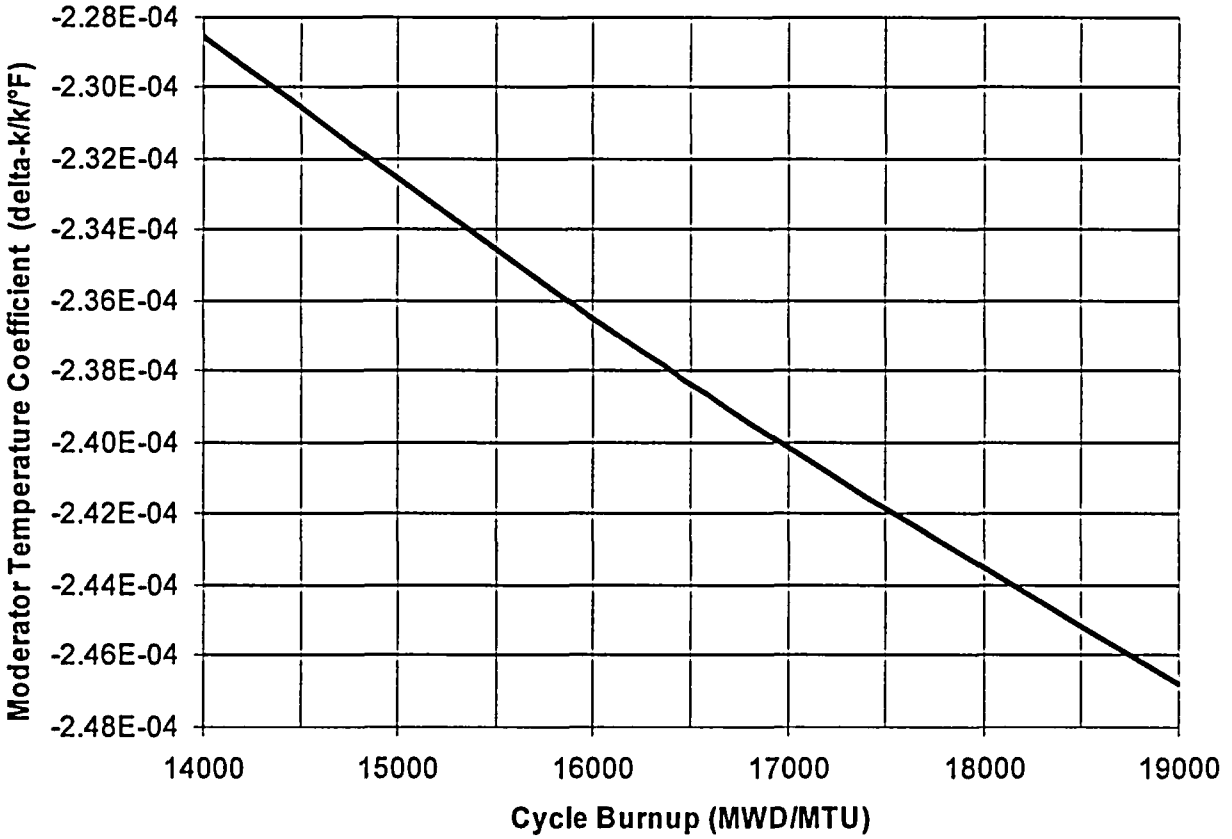
DESCRIPTION OF SAFETY LIMITS

PRESSURE (psia)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)	Power (frac)	Tavg (°F)
1775	0.00	615.4	0.98	583.8	1.02	580.9	1.2	558.1
2000	0.00	631.8	0.86	605.8	0.96	597.5	1.2	568.5
2100	0.00	639.1	0.82	614.0	0.96	601.6	1.2	573.1
2250	0.00	649.2	0.72	628.6	0.98	605.2	1.2	580.4
2400	0.00	659.0	0.62	642.0	1.1	599.0	1.2	588.1

UNIT 2 Reactor Core Safety Limits

FIGURE 7

Unit 2 Cycle 15 Predicted HFP ARO 300 PPM MTC Versus Burnup



Burnup (MWD/MTU)	MTC (Δk/k/°F)
14000	-2.2855E-4
15916	-2.3615E-4
16916	-2.3984E-4
17916	-2.4325E-4
19000	-2.4679E-4

TABLE 1
D. C. Cook Unit 2 Cycle 15
W(Z) Function

Node	Height	Burnup (MWD/MTU)												
PT	(Ft.)	150	1000	2000	4000	6000	8000	10000	12000	14000	16000	18000	20000	20650
1	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.4000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.6000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.8000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.2000	1.1012	1.1007	1.1005	1.1015	1.1046	1.1097	1.1159	1.1221	1.1281	1.1342	1.1405	1.1466	1.1486
8	1.4000	1.1013	1.1009	1.1008	1.1018	1.1047	1.1095	1.1153	1.1210	1.1266	1.1322	1.1379	1.1435	1.1454
9	1.6000	1.1012	1.1008	1.1008	1.1018	1.1045	1.1090	1.1143	1.1195	1.1246	1.1297	1.1348	1.1400	1.1417
10	1.8000	1.1008	1.1005	1.1005	1.1014	1.1039	1.1080	1.1128	1.1175	1.1220	1.1265	1.1311	1.1356	1.1371
11	2.0000	1.1001	1.0999	1.0999	1.1008	1.1030	1.1066	1.1108	1.1149	1.1188	1.1226	1.1265	1.1304	1.1317
12	2.2000	1.0991	1.0990	1.0990	1.0998	1.1017	1.1048	1.1084	1.1118	1.1151	1.1182	1.1213	1.1246	1.1256
13	2.4000	1.0978	1.0977	1.0978	1.0985	1.1001	1.1027	1.1056	1.1083	1.1108	1.1132	1.1155	1.1180	1.1188
14	2.6000	1.0963	1.0962	1.0963	1.0969	1.0982	1.1002	1.1024	1.1043	1.1060	1.1076	1.1091	1.1107	1.1113
15	2.8000	1.0945	1.0945	1.0946	1.0950	1.0959	1.0972	1.0987	1.0999	1.1008	1.1016	1.1023	1.1031	1.1034
16	3.0000	1.0923	1.0924	1.0924	1.0928	1.0934	1.0942	1.0950	1.0955	1.0956	1.0955	1.0952	1.0953	1.0953
17	3.2000	1.0901	1.0902	1.0903	1.0905	1.0908	1.0911	1.0913	1.0911	1.0905	1.0897	1.0886	1.0880	1.0878
18	3.4000	1.0886	1.0887	1.0888	1.0888	1.0886	1.0881	1.0876	1.0872	1.0868	1.0865	1.0862	1.0858	1.0857
19	3.6000	1.0880	1.0880	1.0880	1.0879	1.0873	1.0863	1.0856	1.0861	1.0876	1.0900	1.0928	1.0946	1.0952
20	3.8000	1.0873	1.0870	1.0868	1.0863	1.0857	1.0851	1.0852	1.0869	1.0902	1.0949	1.1003	1.1041	1.1054
21	4.0000	1.0864	1.0859	1.0854	1.0848	1.0845	1.0845	1.0856	1.0886	1.0933	1.0996	1.1069	1.1122	1.1139
22	4.2000	1.0853	1.0848	1.0844	1.0840	1.0844	1.0854	1.0877	1.0918	1.0976	1.1049	1.1132	1.1196	1.1216
23	4.4000	1.0843	1.0838	1.0836	1.0838	1.0849	1.0870	1.0903	1.0954	1.1020	1.1100	1.1189	1.1261	1.1284
24	4.6000	1.0839	1.0834	1.0831	1.0835	1.0851	1.0882	1.0927	1.0987	1.1060	1.1147	1.1241	1.1319	1.1345
25	4.8000	1.0839	1.0832	1.0827	1.0830	1.0852	1.0893	1.0949	1.1017	1.1097	1.1188	1.1286	1.1370	1.1397
26	5.0000	1.0837	1.0828	1.0821	1.0825	1.0851	1.0901	1.0967	1.1044	1.1128	1.1222	1.1323	1.1412	1.1440
27	5.2000	1.0833	1.0822	1.0813	1.0816	1.0846	1.0905	1.0982	1.1065	1.1154	1.1250	1.1351	1.1443	1.1473
28	5.4000	1.0827	1.0813	1.0803	1.0805	1.0839	1.0907	1.0992	1.1081	1.1173	1.1269	1.1370	1.1464	1.1495
29	5.6000	1.0817	1.0803	1.0793	1.0796	1.0833	1.0906	1.0997	1.1090	1.1183	1.1279	1.1378	1.1474	1.1505
30	5.8000	1.0805	1.0790	1.0780	1.0783	1.0823	1.0900	1.0996	1.1092	1.1185	1.1279	1.1376	1.1471	1.1502
31	6.0000	1.0791	1.0776	1.0765	1.0768	1.0809	1.0890	1.0990	1.1086	1.1178	1.1269	1.1363	1.1456	1.1487
32	6.2000	1.0777	1.0760	1.0748	1.0749	1.0791	1.0874	1.0976	1.1072	1.1162	1.1249	1.1338	1.1429	1.1458
33	6.4000	1.0758	1.0740	1.0727	1.0728	1.0770	1.0853	1.0955	1.1049	1.1136	1.1218	1.1302	1.1388	1.1416
34	6.6000	1.0734	1.0720	1.0709	1.0713	1.0753	1.0832	1.0927	1.1016	1.1097	1.1176	1.1255	1.1336	1.1363
35	6.8000	1.0704	1.0691	1.0682	1.0686	1.0724	1.0798	1.0886	1.0968	1.1043	1.1115	1.1187	1.1262	1.1287
36	7.0000	1.0677	1.0672	1.0671	1.0685	1.0723	1.0787	1.0861	1.0933	1.1002	1.1070	1.1138	1.1208	1.1230
37	7.2000	1.0678	1.0686	1.0698	1.0727	1.0763	1.0808	1.0860	1.0919	1.0983	1.1053	1.1127	1.1194	1.1216
38	7.4000	1.0715	1.0721	1.0731	1.0757	1.0793	1.0840	1.0892	1.0945	1.0999	1.1054	1.1111	1.1166	1.1184
39	7.6000	1.0749	1.0753	1.0761	1.0784	1.0819	1.0866	1.0918	1.0966	1.1012	1.1056	1.1100	1.1146	1.1161
40	7.8000	1.0777	1.0780	1.0787	1.0808	1.0841	1.0888	1.0937	1.0981	1.1019	1.1053	1.1085	1.1122	1.1134
41	8.0000	1.0803	1.0804	1.0809	1.0827	1.0858	1.0904	1.0953	1.0992	1.1021	1.1043	1.1061	1.1088	1.1097
42	8.2000	1.0824	1.0824	1.0826	1.0841	1.0871	1.0916	1.0963	1.0997	1.1017	1.1027	1.1032	1.1049	1.1055
43	8.4000	1.0841	1.0839	1.0839	1.0850	1.0877	1.0922	1.0968	1.0996	1.1007	1.1005	1.0997	1.1004	1.1007
44	8.6000	1.0852	1.0848	1.0847	1.0854	1.0879	1.0923	1.0967	1.0989	1.0990	1.0973	1.0949	1.0944	1.0943
45	8.8000	1.0861	1.0855	1.0852	1.0855	1.0877	1.0918	1.0959	1.0981	1.0986	1.0977	1.0960	1.0961	1.0961
46	9.0000	1.0866	1.0861	1.0858	1.0862	1.0882	1.0919	1.0959	1.0987	1.1004	1.1011	1.1015	1.1029	1.1033
47	9.2000	1.0878	1.0878	1.0881	1.0893	1.0916	1.0951	1.0987	1.1015	1.1034	1.1047	1.1056	1.1074	1.1079
48	9.4000	1.0911	1.0915	1.0920	1.0936	1.0963	1.1000	1.1037	1.1064	1.1081	1.1090	1.1096	1.1110	1.1115
49	9.6000	1.0954	1.0957	1.0963	1.0980	1.1008	1.1046	1.1083	1.1110	1.1126	1.1134	1.1137	1.1151	1.1155
50	9.8000	1.0996	1.0999	1.1005	1.1022	1.1049	1.1087	1.1125	1.1151	1.1166	1.1172	1.1173	1.1185	1.1189
51	10.0000	1.1035	1.1038	1.1044	1.1061	1.1088	1.1126	1.1163	1.1189	1.1202	1.1207	1.1207	1.1218	1.1221
52	10.2000	1.1071	1.1075	1.1081	1.1097	1.1124	1.1160	1.1196	1.1221	1.1236	1.1242	1.1244	1.1256	1.1260
53	10.4000	1.1104	1.1108	1.1113	1.1130	1.1155	1.1189	1.1223	1.1248	1.1263	1.1270	1.1274	1.1287	1.1291
54	10.6000	1.1132	1.1134	1.1139	1.1154	1.1179	1.1215	1.1250	1.1275	1.1289	1.1295	1.1297	1.1309	1.1313
55	10.8000	1.1154	1.1156	1.1160	1.1175	1.1200	1.1235	1.1271	1.1295	1.1309	1.1314	1.1315	1.1326	1.1329
56	11.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
57	11.2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
58	11.4000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
59	11.6000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
60	11.8000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
61	12.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Top and bottom 10% of core excluded.