

DONALD C. COOK NUCLEAR PLANT UNIT 1 CYCLE 16
CORE OPERATING LIMITS REPORT (COLR)

Revision 2

November 1997

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1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report for the Donald C. Cook Nuclear Plant Unit 1 Cycle 16 redesign has been prepared in accordance with the requirements of Technical Specification 6.9.1.9.

The Technical Specifications affected by this report are listed below:

3/4.1.1.4	Moderator Temperature Coefficient
3/4.1.3.1	Movable Control Assemblies Group Height
3/4.1.3.3	Rod Drop Time
3/4.1.3.4	Shutdown Rod Insertion Limit
3/4.1.3.5	Control Rod Insertion Limits
3/4.2.1	Axial Flux Difference
3/4.2.2	Heat Flux Hot Channel Factor
3/4.2.3	Nuclear Enthalpy Hot Channel Factor
3/4.2.6	Allowable Power Level

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 Specification 6.9.1.9.

2.1 Moderator Temperature Coefficient (Specification 3/4.1.1.4)

2.1.1 The Moderator Temperature Coefficient (MTC) limits are:

The MTC shall be less positive than the value given in Figure 1.

The ARO/RTP-MTC shall be less negative than $-4.54\text{E-}4 \Delta\text{k/k/}^\circ\text{F}$ at a vessel average temperature in the range from 553°F to 557°F.

where: ARO stands for All Rods Out

RTP stands for Rated Thermal Power

2.1.2 The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to $-3.84\text{E-}4 \Delta\text{k/k/}^\circ\text{F}$ at a vessel average temperature in the range from 553°F to 557°F.

2.2 Rod Drop Time Drop Height (Specification 3/4.1.3.3)

2.2.1 All rods shall be dropped from 225 steps.

2.3 Shutdown Rod Insertion Limit (Specification 3/4.1.3.4)

2.3.1 The shutdown rods shall be withdrawn to 225 steps.

2.4 Control Rod Insertion Limits (Specifications 3/4.1.3.5 and 3/4.1.3.1)

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

2.4.2 Successive Control Banks shall overlap by 97 steps. The sequence for Control Bank withdrawal shall be Control Bank A, Control Bank B, Control Bank C, and Control Bank D.

2.5 Axial Flux Difference (Specification 3/4.2.1)

2.5.1 The Allowable Operation Limits are provided in Figure 3.

2.5.2 The AXIAL FLUX DIFFERENCE (AFD) target band during base load operations is $\pm 3\%$. (not applicable for this cycle).

2.5.3 The AFD target band is $\pm 5\%$ for a cycle average accumulated burnup ≥ 0.0 MWD/MTU.

2.6 Heat Flux Hot Channel Factor - $F_Q(Z)$ (Specification 3.2.2)

$$F_Q(Z) \leq \frac{CF_Q}{P} * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq 2 * CF_Q * K(Z) \quad \text{for } P \leq 0.5$$

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

2.6.1 $CF_Q = 2.15$ for Westinghouse fuel

2.6.2 $K(Z)$ is provided in Figure 4 for Westinghouse fuel

2.7 Nuclear Enthalpy Rise Hot Channel Factor - $F_{\Delta H}^N$ (Specification 3/4.2.3)

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

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

2.7.1 $CF_{\Delta H} = 1.49$ for Westinghouse fuel

2.7.2 $PF_{\Delta H} = 0.3$

2.8 Allowable Power Level - APL (Specification 3.2.6)

$$APL = \min \text{ over } Z \text{ for } \frac{CF_Q * K(Z)}{F_Q(Z) * V(Z) * F_P}$$

2.8.1 $V(Z)$ is provided in Table 1 for $\pm 5\%$ AFD target band

2.8.2 CF_Q and $K(Z)$ are provided in COLR Sections 2.6.1 and 2.6.2, respectively

2.8.3 The following table shows F_P values which correspond to F_Q margin decreases that are greater than 2% per 31 Effective Full Power Days (EFPD). These values shall be used to adjust APL as per Surveillance Requirement 4.2.6.2. A 1.02 penalty factor shall be used at all cycle burnups that are outside this range.

<u>Burnup</u>	<u>Penalty Multiplier</u>
775	1.0200
900	1.0231
1025	1.0229
1150	1.0227
1275	1.0225
1400	1.0229
1525	1.0238
1650	1.0243
1775	1.0235
1900	1.0222
2025	1.0210
2150	1.0200

The burnup range only covers where F_P exceeds 1.02. Linear interpolation is adequate for intermediate cycle burnups.

FIGURE 1
MODERATOR TEMPERATURE COEFFICIENT (MTC)

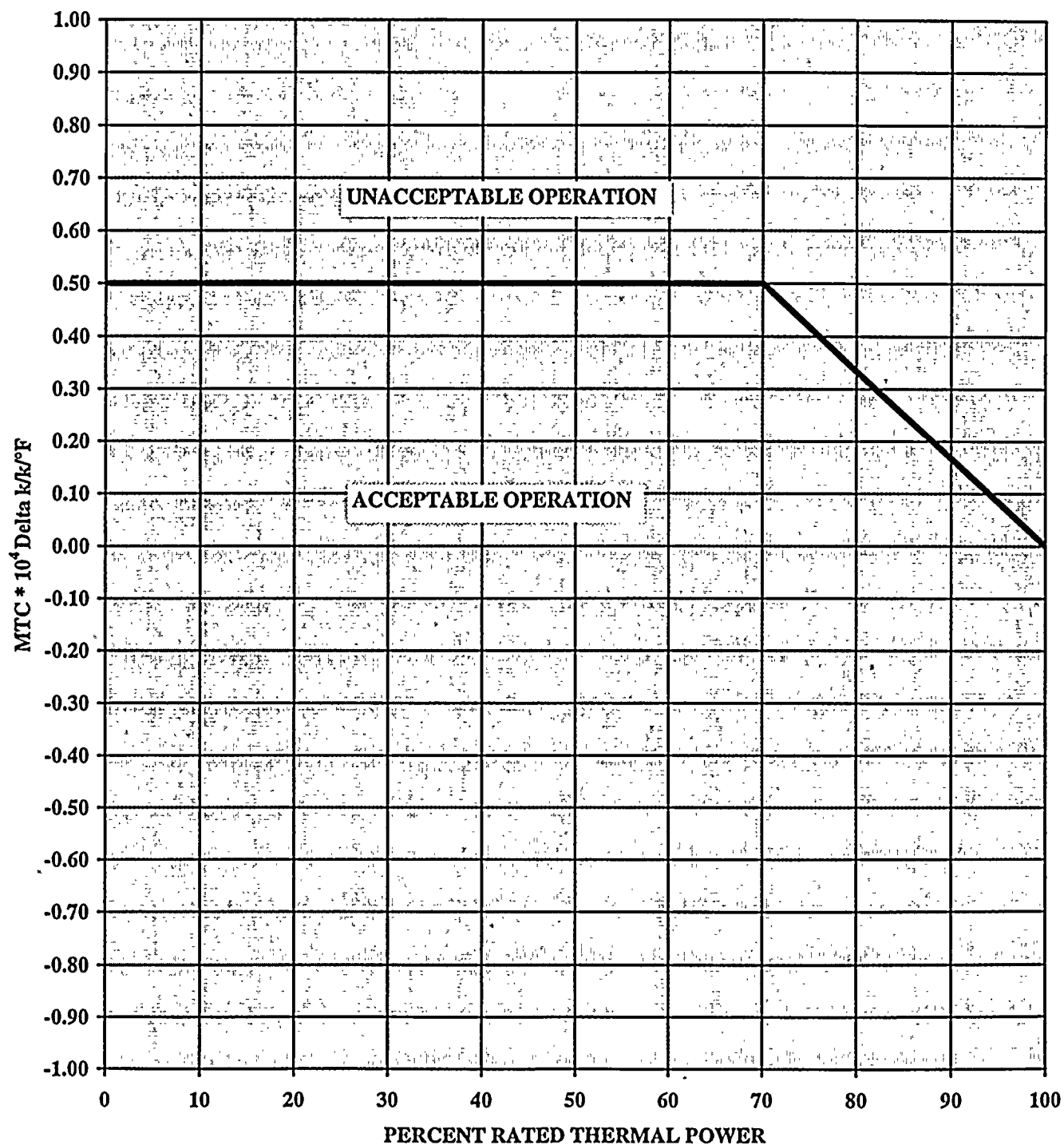


FIGURE 2
ROD BANK INSERTION LIMITS VERSUS THERMAL POWER FOUR-LOOP OPERATION

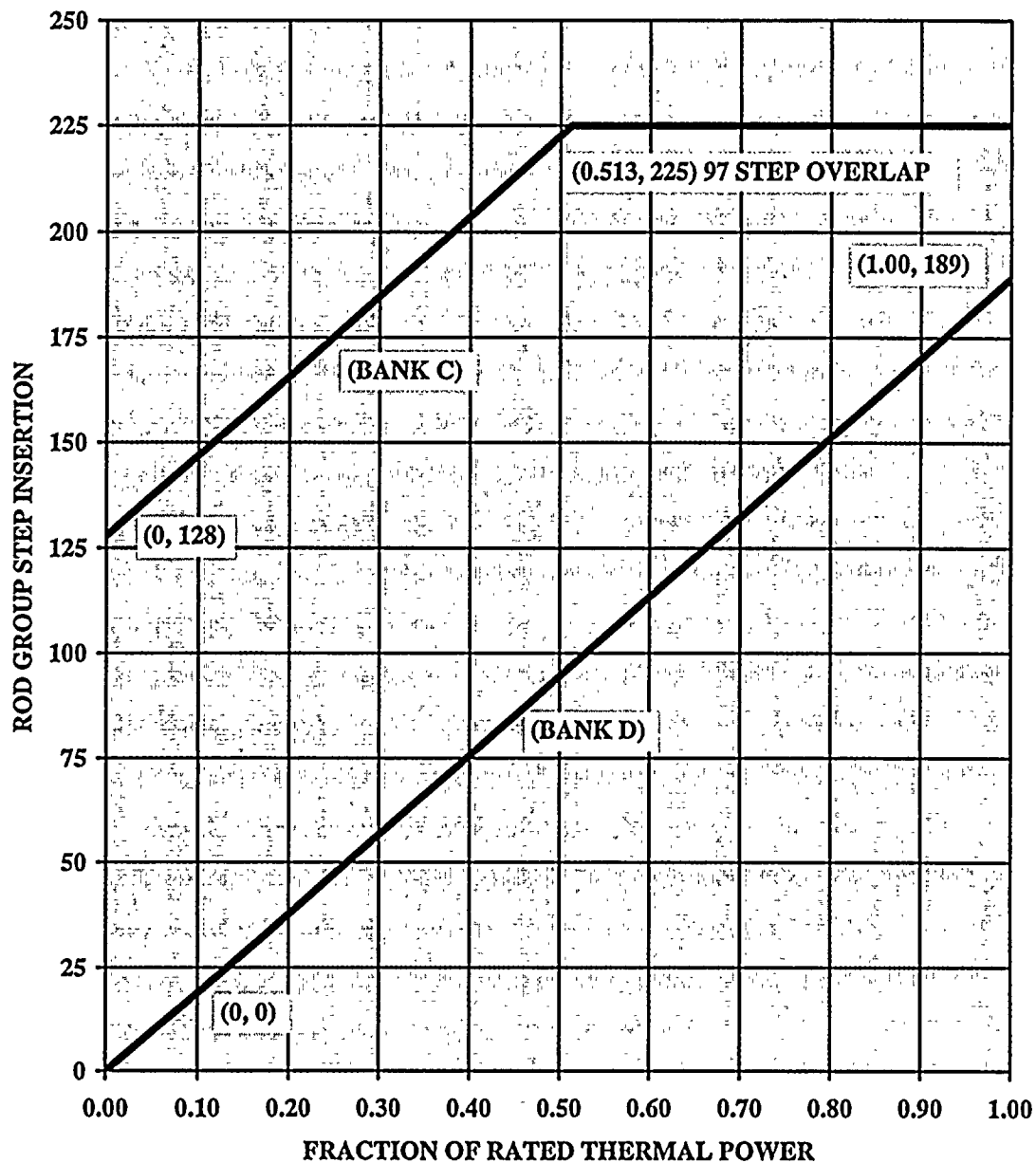


FIGURE 3
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER

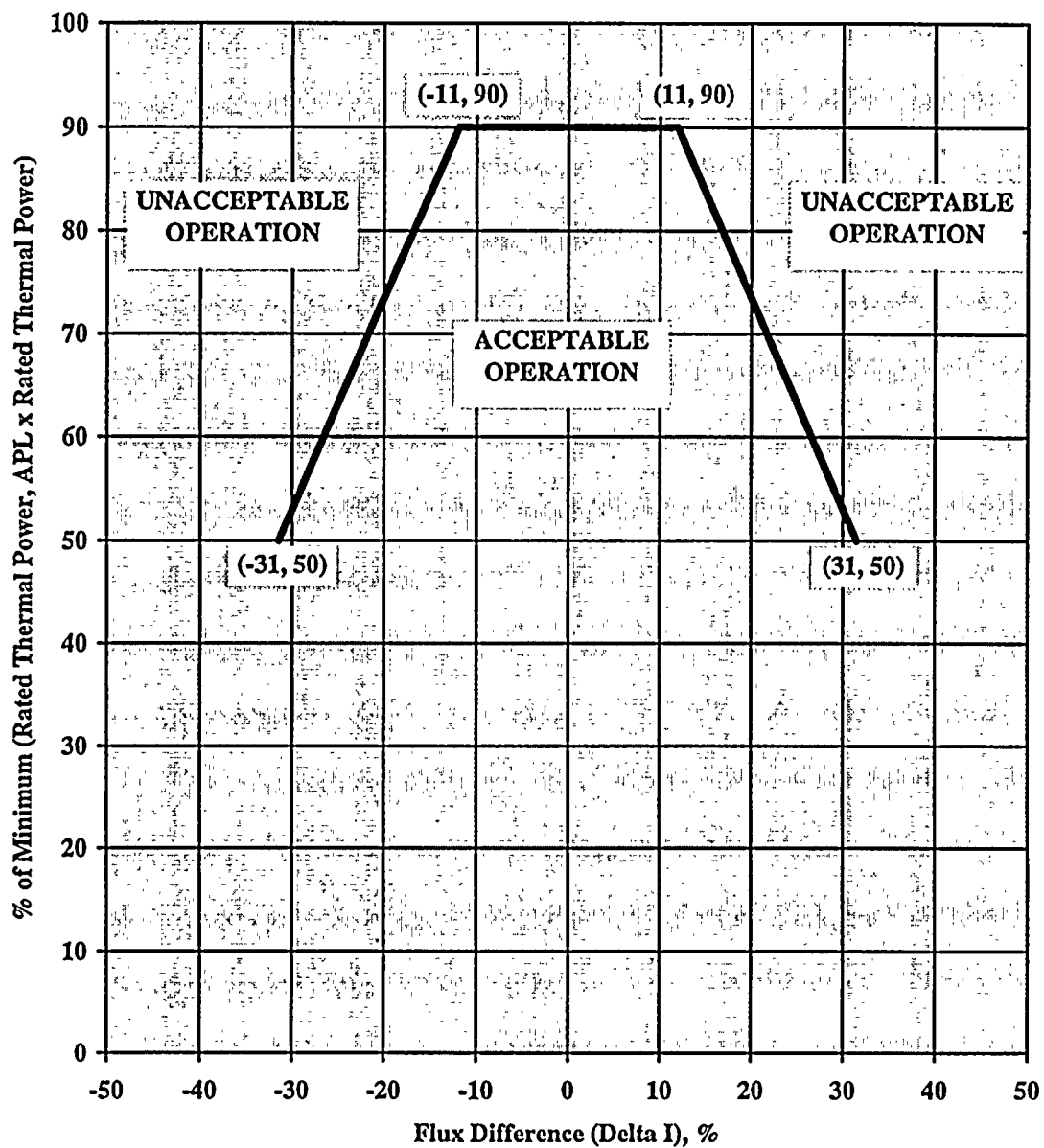
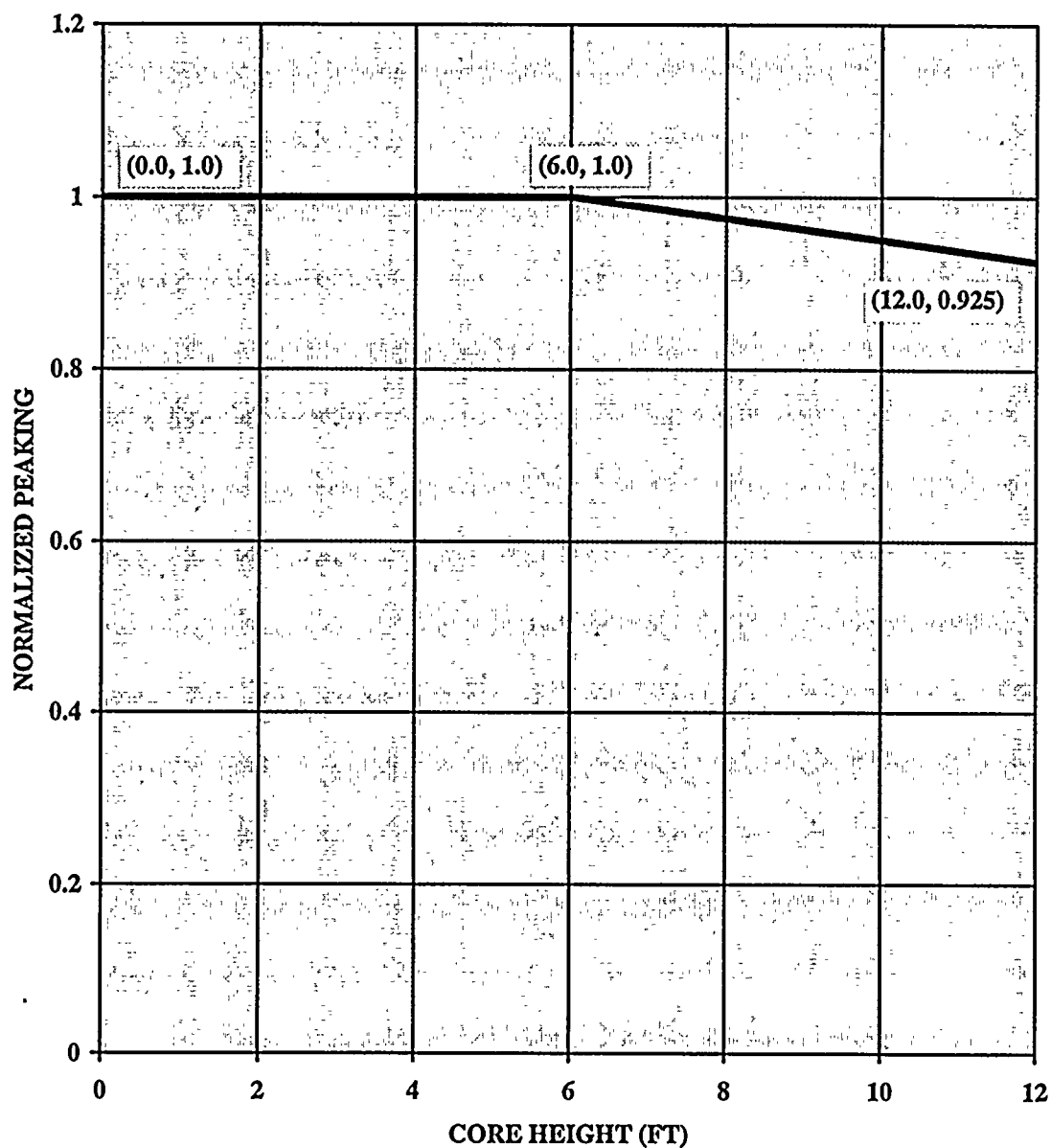


FIGURE 4
K(Z) - NORMALIZED FQ(Z) AS A FUNCTION OF CORE HEIGHT
FOR WESTINGHOUSE FUEL



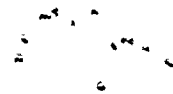


TABLE 1
DONALD C. COOK UNIT 1 CYCLE 16 REDESIGN
V(Z) FUNCTION

	HEIGHT (FT.)	BURNUP (MWD/MTU)										
		150	1000	2000	3000	4000	6000	8000	10000	12000	14000	18160
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	1.0992	1.0994	1.0999	1.1006	1.1015	1.1038	1.1070	1.1109	1.1158	1.1214	1.1324
8.	1.4	1.0988	1.0991	1.0996	1.1002	1.1011	1.1033	1.1063	1.1100	1.1145	1.1196	1.1298
9.	1.6	1.0983	1.0986	1.0991	1.0997	1.1005	1.1026	1.1053	1.1087	1.1128	1.1175	1.1268
10.	1.8	1.0977	1.0980	1.0984	1.0990	1.0997	1.1015	1.1040	1.1070	1.1106	1.1148	1.1230
11.	2.0	1.0969	1.0971	1.0975	1.0980	1.0987	1.1003	1.1024	1.1050	1.1081	1.1116	1.1186
12.	2.2	1.0959	1.0962	1.0965	1.0970	1.0975	1.0988	1.1005	1.1027	1.1051	1.1080	1.1137
13.	2.4	1.0948	1.0950	1.0953	1.0956	1.0961	1.0971	1.0984	1.1000	1.1019	1.1040	1.1082
14.	2.6	1.0934	1.0936	1.0938	1.0941	1.0944	1.0951	1.0960	1.0971	1.0983	1.0997	1.1024
15.	2.8	1.0919	1.0921	1.0922	1.0923	1.0925	1.0929	1.0933	1.0938	1.0944	1.0950	1.0962
16.	3.0	1.0902	1.0903	1.0904	1.0904	1.0905	1.0906	1.0906	1.0906	1.0905	1.0903	1.0900
17.	3.2	1.0885	1.0885	1.0885	1.0885	1.0885	1.0883	1.0880	1.0876	1.0871	1.0865	1.0854
18.	3.4	1.0875	1.0872	1.0869	1.0866	1.0864	1.0860	1.0856	1.0854	1.0853	1.0852	1.0850
19.	3.6	1.0870	1.0863	1.0856	1.0850	1.0845	1.0840	1.0840	1.0846	1.0857	1.0873	1.0903
20.	3.8	1.0864	1.0855	1.0847	1.0841	1.0837	1.0834	1.0839	1.0853	1.0875	1.0904	1.0959
21.	4.0	1.0855	1.0846	1.0839	1.0834	1.0832	1.0833	1.0844	1.0865	1.0896	1.0935	1.1011
22.	4.2	1.0851	1.0843	1.0837	1.0833	1.0832	1.0837	1.0853	1.0880	1.0917	1.0965	1.1057
23.	4.4	1.0852	1.0844	1.0837	1.0833	1.0833	1.0840	1.0859	1.0891	1.0936	1.0992	1.1100
24.	4.6	1.0853	1.0844	1.0837	1.0833	1.0833	1.0842	1.0864	1.0901	1.0952	1.1015	1.1137
25.	4.8	1.0853	1.0844	1.0837	1.0833	1.0833	1.0844	1.0869	1.0910	1.0965	1.1035	1.1169
26.	5.0	1.0852	1.0843	1.0837	1.0834	1.0835	1.0847	1.0875	1.0919	1.0977	1.1051	1.1192
27.	5.2	1.0850	1.0842	1.0836	1.0834	1.0835	1.0849	1.0879	1.0925	1.0987	1.1064	1.1211
28.	5.4	1.0846	1.0838	1.0832	1.0830	1.0832	1.0848	1.0880	1.0928	1.0992	1.1072	1.1226
29.	5.6	1.0840	1.0832	1.0826	1.0825	1.0827	1.0844	1.0876	1.0926	1.0993	1.1075	1.1233
30.	5.8	1.0831	1.0822	1.0817	1.0816	1.0818	1.0836	1.0869	1.0920	1.0988	1.1071	1.1232
31.	6.0	1.0818	1.0810	1.0805	1.0803	1.0806	1.0823	1.0857	1.0909	1.0977	1.1061	1.1224
32.	6.2	1.0803	1.0795	1.0789	1.0787	1.0790	1.0807	1.0841	1.0892	1.0960	1.1044	1.1207
33.	6.4	1.0784	1.0775	1.0769	1.0767	1.0769	1.0785	1.0818	1.0869	1.0936	1.1020	1.1181
34.	6.6	1.0761	1.0753	1.0747	1.0745	1.0748	1.0764	1.0796	1.0844	1.0909	1.0990	1.1144
35.	6.8	1.0733	1.0732	1.0732	1.0736	1.0742	1.0763	1.0795	1.0839	1.0894	1.0959	1.1087
36.	7.0	1.0701	1.0709	1.0720	1.0731	1.0744	1.0771	1.0803	1.0838	1.0877	1.0920	1.1007
37.	7.2	1.0663	1.0682	1.0704	1.0724	1.0744	1.0780	1.0813	1.0842	1.0867	1.0888	1.0936
38.	7.4	1.0640	1.0665	1.0693	1.0718	1.0742	1.0783	1.0817	1.0843	1.0861	1.0871	1.0899
39.	7.6	1.0668	1.0690	1.0714	1.0736	1.0756	1.0790	1.0816	1.0833	1.0842	1.0842	1.0850
40.	7.8	1.0695	1.0714	1.0734	1.0751	1.0767	1.0792	1.0809	1.0817	1.0817	1.0808	1.0796
41.	8.0	1.0715	1.0728	1.0741	1.0754	1.0764	1.0782	1.0795	1.0802	1.0803	1.0799	1.0795
42.	8.2	1.0734	1.0740	1.0746	1.0752	1.0757	1.0768	1.0779	1.0788	1.0797	1.0806	1.0823
43.	8.4	1.0748	1.0750	1.0753	1.0756	1.0759	1.0767	1.0776	1.0787	1.0799	1.0812	1.0839
44.	8.6	1.0757	1.0760	1.0764	1.0769	1.0774	1.0785	1.0799	1.0814	1.0832	1.0851	1.0890
45.	8.8	1.0779	1.0784	1.0790	1.0797	1.0804	1.0820	1.0837	1.0857	1.0878	1.0902	1.0949
46.	9.0	1.0818	1.0824	1.0832	1.0840	1.0848	1.0866	1.0885	1.0906	1.0929	1.0953	1.1002
47.	9.2	1.0865	1.0872	1.0880	1.0889	1.0898	1.0917	1.0936	1.0957	1.0979	1.1001	1.1047
48.	9.4	1.0910	1.0918	1.0927	1.0936	1.0946	1.0965	1.0984	1.1004	1.1025	1.1045	1.1088
49.	9.6	1.0957	1.0965	1.0974	1.0984	1.0993	1.1012	1.1030	1.1049	1.1067	1.1085	1.1123
50.	9.8	1.1003	1.1010	1.1019	1.1029	1.1038	1.1056	1.1074	1.1092	1.1110	1.1128	1.1165
51.	10.0	1.1046	1.1053	1.1061	1.1070	1.1079	1.1096	1.1114	1.1132	1.1151	1.1170	1.1209
52.	10.2	1.1087	1.1093	1.1101	1.1109	1.1117	1.1134	1.1151	1.1170	1.1189	1.1209	1.1251
53.	10.4	1.1125	1.1131	1.1138	1.1146	1.1153	1.1169	1.1186	1.1204	1.1223	1.1243	1.1284
54.	10.6	1.1159	1.1165	1.1172	1.1179	1.1186	1.1202	1.1218	1.1235	1.1252	1.1271	1.1309
55.	10.8	1.1190	1.1196	1.1202	1.1209	1.1216	1.1231	1.1246	1.1261	1.1278	1.1294	1.1329
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 as per Technical Specifications.

