

ATTACHMENT TO AEP:NRC:1077Z  
CORE OPERATING LIMITS REPORT, REVISION 1

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DONALD C. COOK NUCLEAR PLANT UNIT 2 CYCLE 12  
CORE OPERATING LIMITS REPORT (COLR)

Revision 1  
December 1997

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report for the Donald C. Cook Nuclear Plant Unit 2 Cycle 12 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
3/4.1.3.4	Rod Drop Time
3/4.1.3.5	Shutdown Rod Insertion Limit
3/4.1.3.6	Control Rod Insertion Limits
3/4.2.1	Axial Flux Difference (AFD)
3/4.2.2	Heat Flux Hot Channel Factor - $F_Q(Z)$
3/4.2.3	Nuclear Enthalpy Hot Channel Factor - $F_{N\Delta H}$
3/4.2.6	Allowable Power Level (APL)



## 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 or equal to the value given in Figure 1.

The EOL/ARO/RTP-MTC shall be less negative than or equal to  $-4.37\text{E-}4 \Delta\text{k/k/}^{\circ}\text{F}$ .

This limit is based on a  $T_{\text{avg}}$  program with HFP vessel  $T_{\text{avg}}$  of 571.5°F to 576.5°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

#### 2.1.2 The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to  $-3.57\text{E-}4 \Delta\text{k/k/}^{\circ}\text{F}$  at a HFP vessel  $T_{\text{avg}}$  of 571.5°F to 576.5°F.

2.2 Rod Drop Time Drop Height (Specification 3/4.1.3.4)

2.2.1 All rods shall be dropped from 225 steps.

2.3 Shutdown Rod Insertion Limit (Specification 3/4.1.3.5)

2.3.1 The shutdown rods shall be withdrawn to at least 225 steps.

2.4 Control Rod Insertion Limits (Specifications 3/4.1.3.6 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 +3%, -3% (not applicable for this cycle).

2.5.3 The AFD target band is +5%, -5% for a cycle average accumulated burnup  $\geq 0.0$  MWD/MTU.

2.6 Heat Flux Hot Channel Factor -F<sub>Q</sub>(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  $CF_Q = 2.335$

2.6.2  $K(Z)$  is provided in Figure 4

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  $CF_{\Delta H} = 1.56$

2.7.2  $PF_{\Delta H} = 0.3$



2.8 Allowable Power Level - APL (Specification 3.2.6)

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

2.8.1  $V(Z)$  is provided in Table 1 for  $\pm 5\%$  AFD target band2.8.2  $CF_Q$  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.

Cycle Burnup (MWD/MTU)	$F_P$ Penalty Multiplier
0	1.0340
150	1.0340
311	1.0418
472	1.0483
633	1.0535
795	1.0527
956	1.0515
1117	1.0499
1278	1.0476
1439	1.0446
1600	1.0411
1761	1.0369
1922	1.0322
2084	1.0272
2245	1.0221
2406	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)

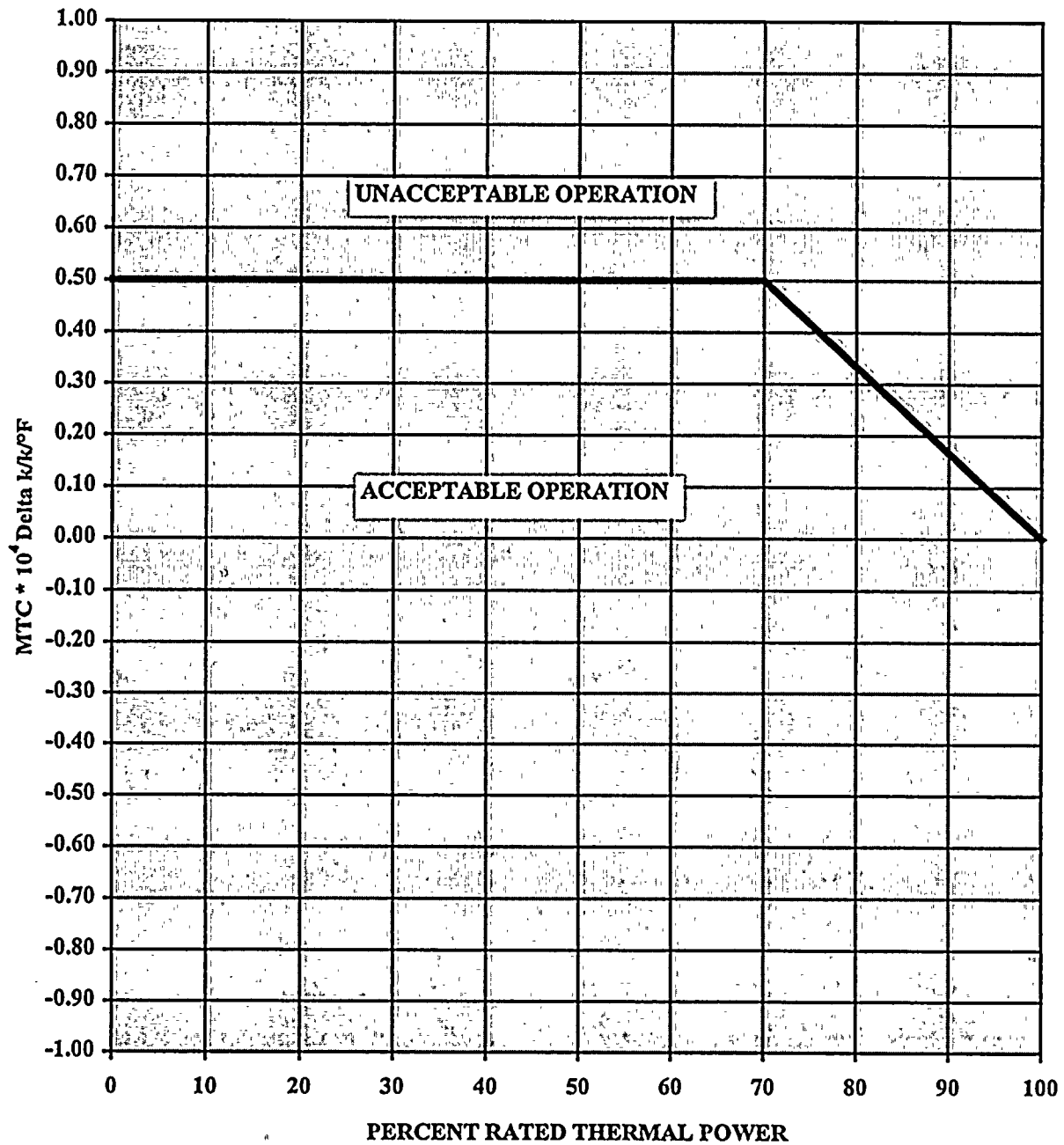


FIGURE 2  
ROD BANK INSERTION LIMITS VERSUS THERMAL POWER FOUR-LOOP OPERATION

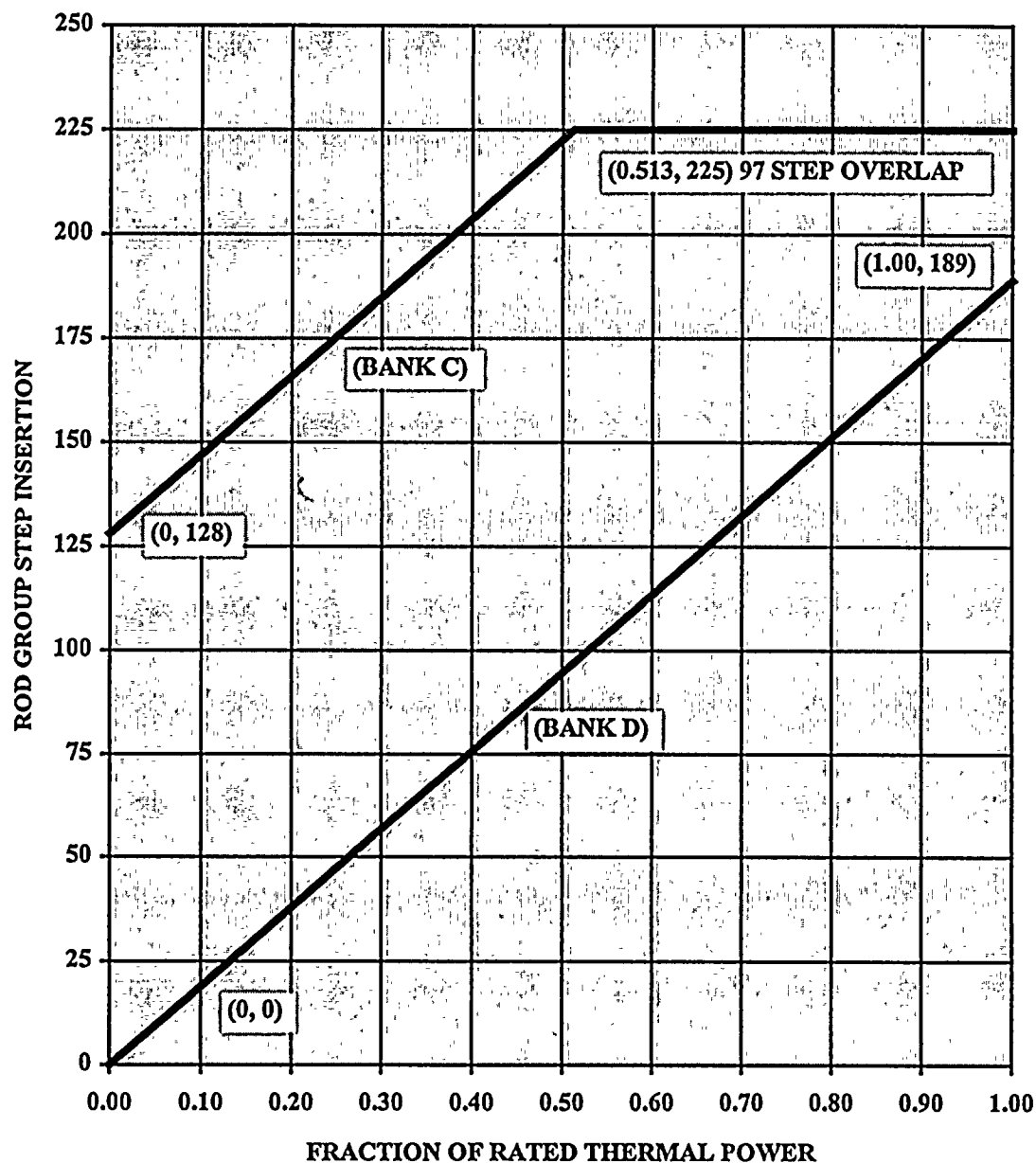




FIGURE 3  
AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER

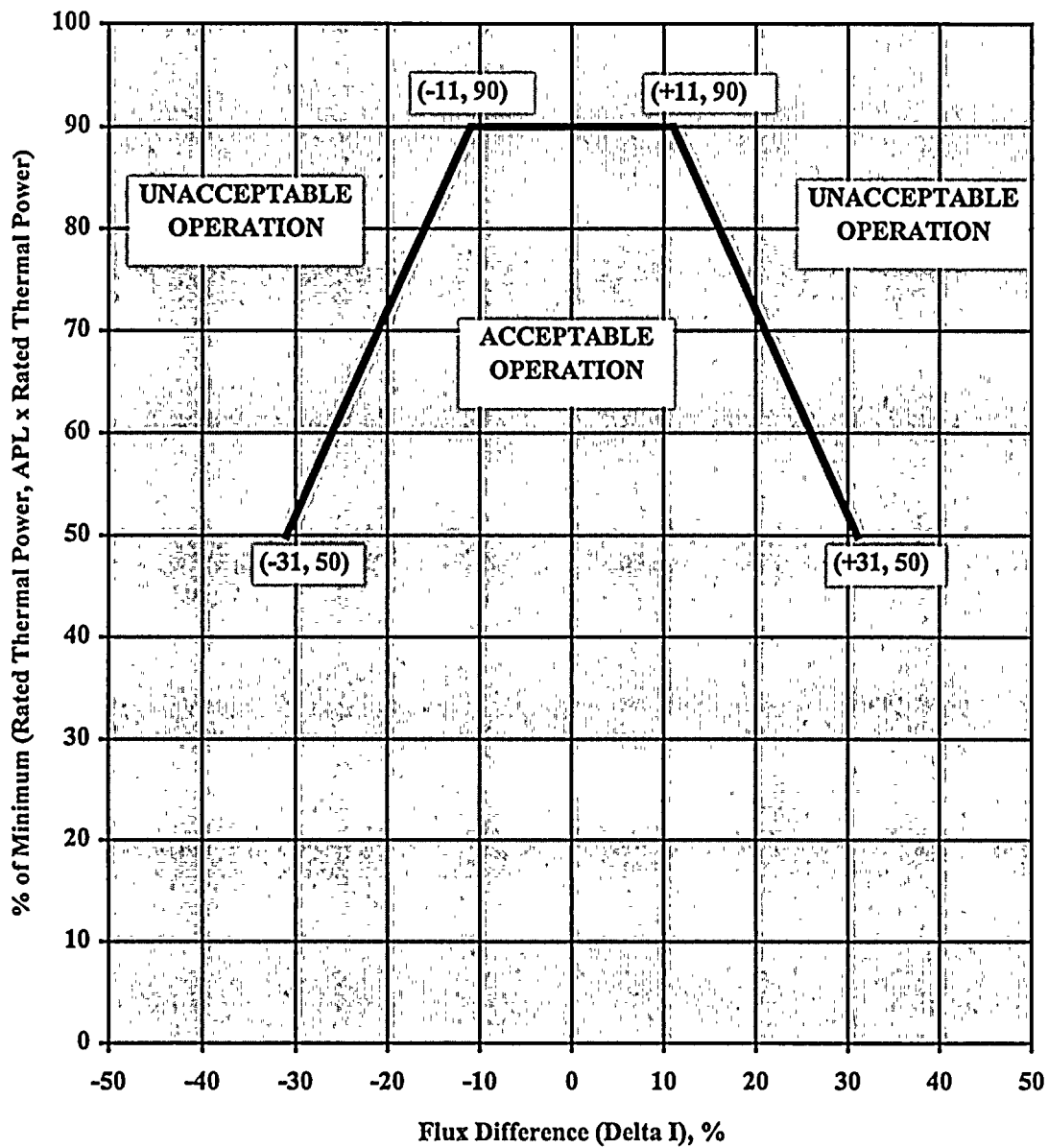




FIGURE 4  
K(Z) - NORMALIZED FQ(Z) AS A FUNCTION OF CORE HEIGHT

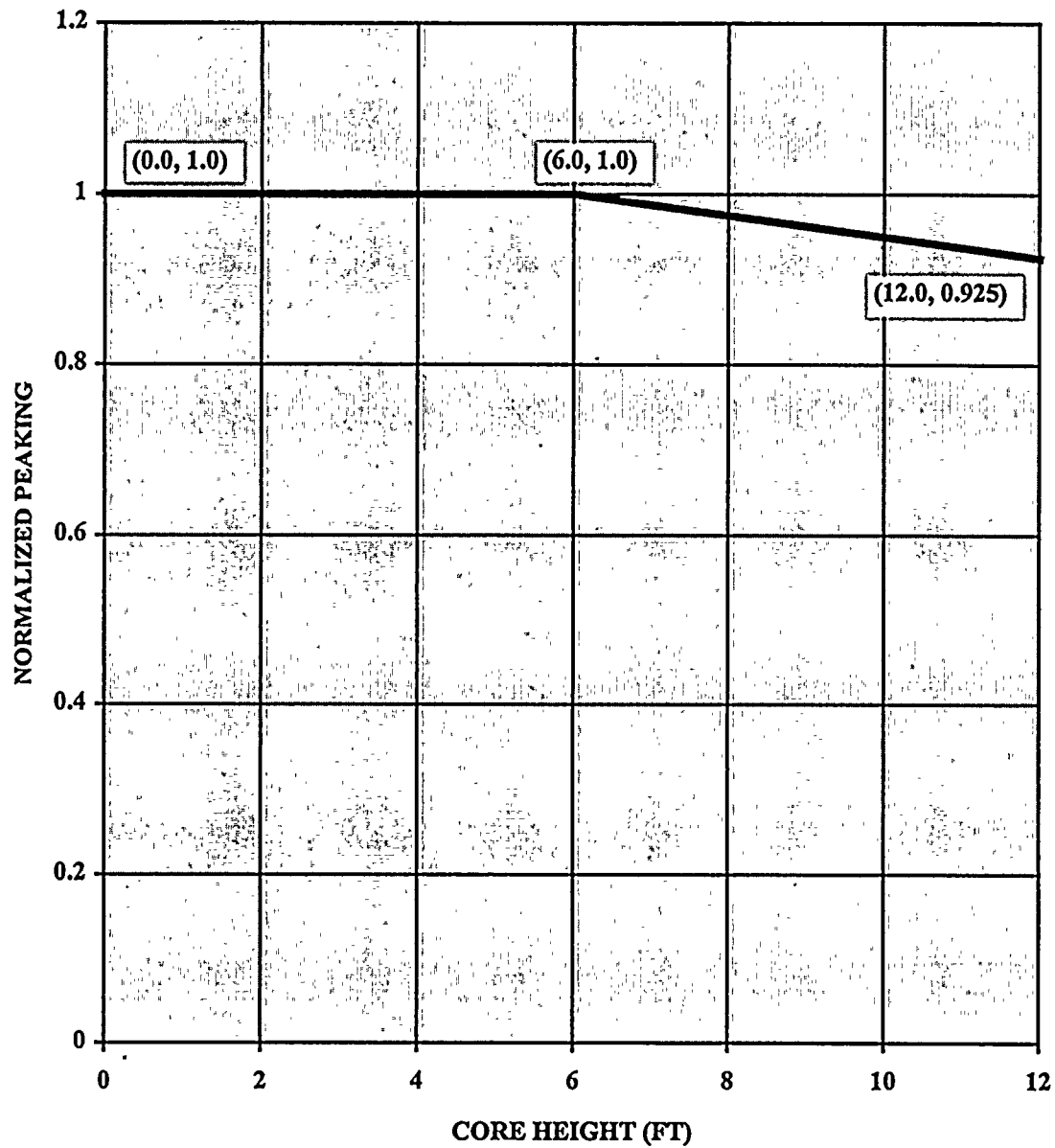


TABLE 1  
V(Z) FUNCTION

PT	HT. (FT)	BURNUP (MWD/MTU)												
		150	1000	2000	3000	4000	6000	8000	10000	12000	14000	16000	18000	22860
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	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	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	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	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	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	1.0000	1.0000
7	1.2	1.1049	1.0964	1.0885	1.0835	1.0819	1.0865	1.0971	1.1087	1.1177	1.1246	1.1307	1.1371	1.1543
8	1.4	1.1042	1.0965	1.0894	1.0848	1.0834	1.0878	1.0976	1.1084	1.1168	1.1232	1.1289	1.1349	1.1510
9	1.6	1.1034	1.0965	1.0901	1.0860	1.0848	1.0889	1.0979	1.1078	1.1155	1.1214	1.1265	1.1320	1.1467
10	1.8	1.1022	1.0962	1.0906	1.0871	1.0861	1.0899	1.0979	1.1068	1.1136	1.1189	1.1234	1.1283	1.1413
11	2.0	1.1007	1.0956	1.0909	1.0880	1.0872	1.0906	1.0976	1.1053	1.1112	1.1158	1.1197	1.1238	1.1351
12	2.2	1.0990	1.0949	1.0911	1.0888	1.0882	1.0911	1.0971	1.1035	1.1085	1.1122	1.1154	1.1187	1.1280
13	2.4	1.0970	1.0939	1.0910	1.0893	1.0890	1.0915	1.0964	1.1015	1.1054	1.1082	1.1106	1.1130	1.1199
14	2.6	1.0948	1.0927	1.0907	1.0897	1.0896	1.0916	1.0953	1.0991	1.1019	1.1038	1.1053	1.1066	1.1112
15	2.8	1.0923	1.0912	1.0902	1.0898	1.0899	1.0915	1.0940	1.0965	1.0982	1.0993	1.1000	1.1005	1.1030
16	3.0	1.0896	1.0895	1.0895	1.0896	1.0899	1.0911	1.0924	1.0936	1.0942	1.0943	1.0941	1.0936	1.0936
17	3.2	1.0870	1.0878	1.0886	1.0893	1.0898	1.0904	1.0905	1.0905	1.0905	1.0904	1.0902	1.0898	1.0893
18	3.4	1.0848	1.0864	1.0879	1.0890	1.0895	1.0893	1.0884	1.0876	1.0875	1.0881	1.0892	1.0904	1.0921
19	3.6	1.0837	1.0855	1.0873	1.0884	1.0888	1.0879	1.0862	1.0852	1.0863	1.0891	1.0932	1.0982	1.1061
20	3.8	1.0840	1.0855	1.0870	1.0878	1.0879	1.0865	1.0847	1.0842	1.0864	1.0912	1.0978	1.1060	1.1193
21	4.0	1.0849	1.0858	1.0866	1.0870	1.0869	1.0855	1.0841	1.0845	1.0879	1.0942	1.1027	1.1132	1.1307
22	4.2	1.0858	1.0859	1.0861	1.0860	1.0857	1.0847	1.0843	1.0859	1.0906	1.0982	1.1081	1.1201	1.1409
23	4.4	1.0865	1.0859	1.0855	1.0851	1.0847	1.0842	1.0850	1.0878	1.0937	1.1023	1.1132	1.1265	1.1500
24	4.6	1.0870	1.0859	1.0849	1.0841	1.0837	1.0838	1.0856	1.0896	1.0966	1.1061	1.1179	1.1322	1.1580
25	4.8	1.0874	1.0856	1.0841	1.0831	1.0827	1.0833	1.0861	1.0912	1.0991	1.1094	1.1220	1.1370	1.1649
26	5.0	1.0875	1.0854	1.0835	1.0823	1.0819	1.0830	1.0865	1.0926	1.1012	1.1121	1.1254	1.1411	1.1705
27	5.2	1.0873	1.0850	1.0829	1.0816	1.0812	1.0827	1.0868	1.0935	1.1027	1.1142	1.1279	1.1441	1.1748
28	5.4	1.0869	1.0843	1.0820	1.0806	1.0802	1.0820	1.0868	1.0941	1.1038	1.1156	1.1296	1.1461	1.1776
29	5.6	1.0861	1.0833	1.0808	1.0793	1.0790	1.0812	1.0865	1.0943	1.1043	1.1163	1.1304	1.1469	1.1798
30	5.8	1.0851	1.0821	1.0794	1.0778	1.0774	1.0799	1.0857	1.0939	1.1041	1.1161	1.1302	1.1465	1.1785
31	6.0	1.0838	1.0805	1.0776	1.0759	1.0755	1.0783	1.0844	1.0930	1.1033	1.1152	1.1289	1.1449	1.1765
32	6.2	1.0820	1.0785	1.0754	1.0737	1.0733	1.0762	1.0827	1.0914	1.1017	1.1133	1.1266	1.1421	1.1728
33	6.4	1.0797	1.0761	1.0729	1.0710	1.0706	1.0737	1.0804	1.0893	1.0993	1.1105	1.1233	1.1379	1.1675
34	6.6	1.0770	1.0732	1.0698	1.0679	1.0675	1.0707	1.0776	1.0864	1.0961	1.1068	1.1188	1.1325	1.1605
35	6.8	1.0733	1.0699	1.0668	1.0650	1.0647	1.0678	1.0741	1.0824	1.0916	1.1016	1.1129	1.1259	1.1524
36	7.0	1.0727	1.0682	1.0641	1.0616	1.0611	1.0645	1.0717	1.0805	1.0892	1.0978	1.1071	1.1175	1.1400
37	7.2	1.0741	1.0686	1.0635	1.0604	1.0596	1.0635	1.0716	1.0808	1.0887	1.0956	1.1023	1.1097	1.1273
38	7.4	1.0771	1.0710	1.0653	1.0619	1.0611	1.0655	1.0744	1.0840	1.0913	1.0967	1.1013	1.1060	1.1193
39	7.6	1.0797	1.0735	1.0678	1.0644	1.0636	1.0681	1.0770	1.0864	1.0932	1.0979	1.1016	1.1052	1.1166
40	7.8	1.0818	1.0757	1.0700	1.0666	1.0658	1.0703	1.0791	1.0882	1.0946	1.0986	1.1014	1.1039	1.1134
41	8.0	1.0836	1.0775	1.0718	1.0684	1.0676	1.0721	1.0808	1.0897	1.0955	1.0987	1.1005	1.1018	1.1092
42	8.2	1.0849	1.0789	1.0733	1.0699	1.0691	1.0735	1.0820	1.0905	1.0958	1.0983	1.0993	1.0996	1.1050
43	8.4	1.0858	1.0798	1.0742	1.0708	1.0700	1.0744	1.0828	1.0909	1.0956	1.0973	1.0972	1.0963	1.0995
44	8.6	1.0861	1.0801	1.0746	1.0712	1.0704	1.0748	1.0830	1.0908	1.0949	1.0956	1.0944	1.0921	1.0928
45	8.8	1.0861	1.0803	1.0748	1.0715	1.0708	1.0750	1.0831	1.0909	1.0953	1.0967	1.0964	1.0951	1.0977
46	9.0	1.0861	1.0802	1.0747	1.0715	1.0709	1.0758	1.0848	1.0936	1.0987	1.1009	1.1011	1.1006	1.1049
47	9.2	1.0875	1.0806	1.0744	1.0708	1.0704	1.0771	1.0866	1.0954	1.1055	1.1074	1.1068	1.1047	1.1079
48	9.4	1.0913	1.0824	1.0742	1.0694	1.0688	1.0768	1.0910	1.1043	1.1116	1.1136	1.1122	1.1092	1.1121
49	9.6	1.0955	1.0841	1.0736	1.0674	1.0663	1.0757	1.0929	1.1091	1.1178	1.1199	1.1181	1.1141	1.1171
50	9.8	1.0995	1.0851	1.0717	1.0637	1.0620	1.0731	1.0939	1.1136	1.1240	1.1266	1.1243	1.1194	1.1230
51	10.0	1.1033	1.0870	1.0719	1.0627	1.0607	1.0728	1.0958	1.1176	1.1293	1.1322	1.1297	1.1246	1.1288
52	10.2	1.1068	1.0899	1.0742	1.0647	1.0626	1.0751	1.0987	1.1213	1.1334	1.1365	1.1340	1.1288	1.1333
53	10.4	1.1099	1.0925	1.0764	1.0665	1.0643	1.0771	1.1013	1.1245	1.1370	1.1402	1.1378	1.1326	1.1375
54	10.6	1.1125	1.0947	1.0782	1.0681	1.0658	1.0787	1.1034	1.1270	1.1399	1.1434	1.1412	1.1362	1.1417
55	10.8	1.1146	1.0965	1.0797	1.0694	1.0671	1.0801	1.1052	1.1291	1.1420	1.1454	1.1429	1.1376	1.1427
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	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	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	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	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	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	1.0000	1.0000

The top and bottom 10% of the core are excluded per the Technical Specifications.