CORE OPERATING LIMITS REPORT
North Anna 2 Cycle 12 Pattern CV

Revision 0

September 1996

CORE OPERATING LIMITS
N2C12 Pattern CV

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 12 has been prepared in accordance with Technical Specification 6.9.1.7. The technical specifications affected by this report are listed below:

3/4.1.1.4	Moderator Temperature Coefficient
3/4.1.3.5	Shutdown Bank Insertion Limit
3/4.1.3.6	Control Bank Insertion Limits
3/4.2.1	Axial Flux Difference
3/4.2.2	Heat Flux Hot Channel Factor
3/4.2.3	Nuclear Enthalpy Rise Hot Channel Factor and Power Factor Multiplier

The cycle-specific parameter limits for North Anna 2 Cycle 12 for the specifications listed above are provided on the following pages, and were developed using the NRC-approved methodologies specified in Technical Specification 6.9.1.7.

2.0 OPERATING LIMITS

2.1 Moderator Temperature Coefficient (Specification 3/4.1.1.4)

2.1.1 The moderator temperature coefficient (MTC) limits are:

The BOC/ARO-MTC shall be less positive than or equal to $+0.6E-4\ \Delta k/k/^{0}F$ below 70 percent of RATED THERMAL POWER.

The BOC/ARO-MTC shall be less positive than or equal to 0 (zero) $\Delta k/k/^{0}F$ at or above 70 percent of RATED THERMAL POWER.

The EOC/ARO/RTP-MTC shall be less negative than $-5.0E-4$ $\Delta k/k/^{0}F$.

2.1.2 The MTC surveillance limits are:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to $-4.0E-4\ \Delta k/k/^{0}F$.

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to $-4.7E-4\ \Delta k/k/^{0}F$.

where:
- BOC - Beginning of Cycle
- ARO - All Rods Out
- EOC - End of Cycle
- RTP - RATED THERMAL POWER

2.2 Shutdown Bank Insertion Limit (Specification 3/4.1.3.5)

2.2.1 The shutdown rods shall be withdrawn to at least 225 steps.

2.3 Control Bank Insertion Limits (Specification 3/4.1.3.6)

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

2.4 Axial Flux Difference (Specification 3/4.2.1)

2.4.1 The AXIAL FLUX DIFFERENCE Limits are provided in Figures 2a and 2b.

2.5 Heat Flux Hot Channel Factor-$F_Q(Z)$ (Specification 3/4.2.2)

2.5.1 The $F_Q(Z)$ limits are:

$$F_Q(Z) \le \frac{2.19}{P} * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \le 4.38 * K(Z) \quad \text{for } P \le 0.5$$

where: $P = \dfrac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$, and

K(Z) is provided in Figure 3

2.5.2 The $F_Q(Z)$ Surveillance limits are:

$$F_Q(Z)^M \le \frac{2.19}{P} * \frac{K(Z)}{N(Z)} \quad \text{for } P > 0.5$$

$$F_Q(Z)^M \le 4.38 * \frac{K(Z)}{N(Z)} \quad \text{for } P \le 0.5$$

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

K(Z) is provided in Figure 3, and

N(Z) is a non-equilibrium multiplier on $F_Q(Z)^M$ to account for power distribution transients during normal operation, provided in Table 1 and plotted in Figures 4 through 10. The top and bottom 15% of the core is excluded per Technical Specification 4.2.2.2.G.

2.6 Nuclear Enthalpy Rise Hot Channel Factor - $F\Delta H(N)$ and Power Factor Multiplier (Specification 3/4.2.3)

$$F\Delta H(N) \le 1.49 * \{1 + 0.3 * (1 - P)\}$$

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

Table 1

N2C12 NORMAL OPERATION N(z)'s

Node	Height (feet)	0 to 1000 MWD/MTU	1000 to 3000 MWD/MTU	3000 to 5000 MWD/MTU	5000 to 7000 MWD/MTU	7000 to 9000 MWD/MTU	9000 to 18000 MWD/MTU	18000 to EOC MWD/MTU
10	10.2	1.157	1.157	1.184	1.184	1.184	1.184	1.178
11	10.0	1.151	1.151	1.175	1.175	1.175	1.175	1.175
12	9.8	1.144	1.144	1.173	1.173	1.173	1.172	1.170
13	9.6	1.137	1.137	1.175	1.175	1.175	1.175	1.167
14	9.4	1.132	1.132	1.175	1.175	1.175	1.174	1.165
15	9.2	1.132	1.132	1.187	1.187	1.187	1.187	1.170
16	9.0	1.136	1.136	1.198	1.198	1.198	1.198	1.177
17	8.8	1.143	1.143	1.209	1.209	1.209	1.209	1.188
18	8.6	1.148	1.148	1.218	1.218	1.218	1.217	1.198
19	8.4	1.150	1.150	1.223	1.223	1.223	1.223	1.207
20	8.2	1.153	1.153	1.228	1.228	1.228	1.228	1.213
21	8.0	1.154	1.154	1.230	1.230	1.230	1.229	1.219
22	7.8	1.155	1.155	1.230	1.230	1.230	1.230	1.227
23	7.6	1.154	1.154	1.228	1.228	1.228	1.231	1.232
24	7.4	1.152	1.152	1.225	1.225	1.225	1.234	1.235
25	7.2	1.149	1.149	1.220	1.220	1.220	1.236	1.236
26	7.0	1.145	1.145	1.214	1.214	1.214	1.235	1.235
27	6.8	1.140	1.140	1.207	1.207	1.207	1.237	1.237
28	6.6	1.133	1.133	1.196	1.196	1.196	1.235	1.235
29	6.4	1.125	1.125	1.183	1.183	1.183	1.233	1.233
30	6.2	1.115	1.115	1.169	1.169	1.169	1.225	1.225
31	6.0	1.103	1.103	1.158	1.158	1.158	1.218	1.218
32	5.8	1.095	1.095	1.148	1.148	1.148	1.205	1.205
33	5.6	1.089	1.089	1.138	1.138	1.138	1.191	1.191
34	5.4	1.092	1.092	1.132	1.132	1.132	1.171	1.171
35	5.2	1.096	1.096	1.119	1.119	1.119	1.146	1.146
36	5.0	1.103	1.103	1.115	1.115	1.115	1.127	1.127
37	4.8	1.109	1.109	1.117	1.118	1.118	1.123	1.123
38	4.6	1.116	1.116	1.121	1.122	1.122	1.128	1.128
39	4.4	1.122	1.122	1.123	1.124	1.124	1.132	1.132
40	4.2	1.135	1.135	1.134	1.124	1.124	1.137	1.137
41	4.0	1.147	1.147	1.147	1.123	1.123	1.140	1.140
42	3.8	1.159	1.159	1.159	1.125	1.125	1.142	1.142
43	3.6	1.170	1.170	1.170	1.126	1.126	1.142	1.142
44	3.4	1.181	1.181	1.181	1.126	1.126	1.141	1.141
45	3.2	1.193	1.193	1.193	1.126	1.126	1.140	1.140
46	3.0	1.206	1.206	1.206	1.125	1.125	1.136	1.136
47	2.8	1.220	1.220	1.220	1.126	1.126	1.135	1.135
48	2.6	1.232	1.232	1.232	1.130	1.130	1.139	1.139
49	2.4	1.243	1.243	1.243	1.135	1.135	1.146	1.146
50	2.2	1.255	1.255	1.255	1.144	1.144	1.154	1.154
51	2.0	1.264	1.264	1.264	1.151	1.151	1.163	1.163
52	1.8	1.274	1.274	1.274	1.156	1.156	1.170	1.170

Figure 1

North Anna 2 Cycle 12
Control Rod Bank Insertion Limits

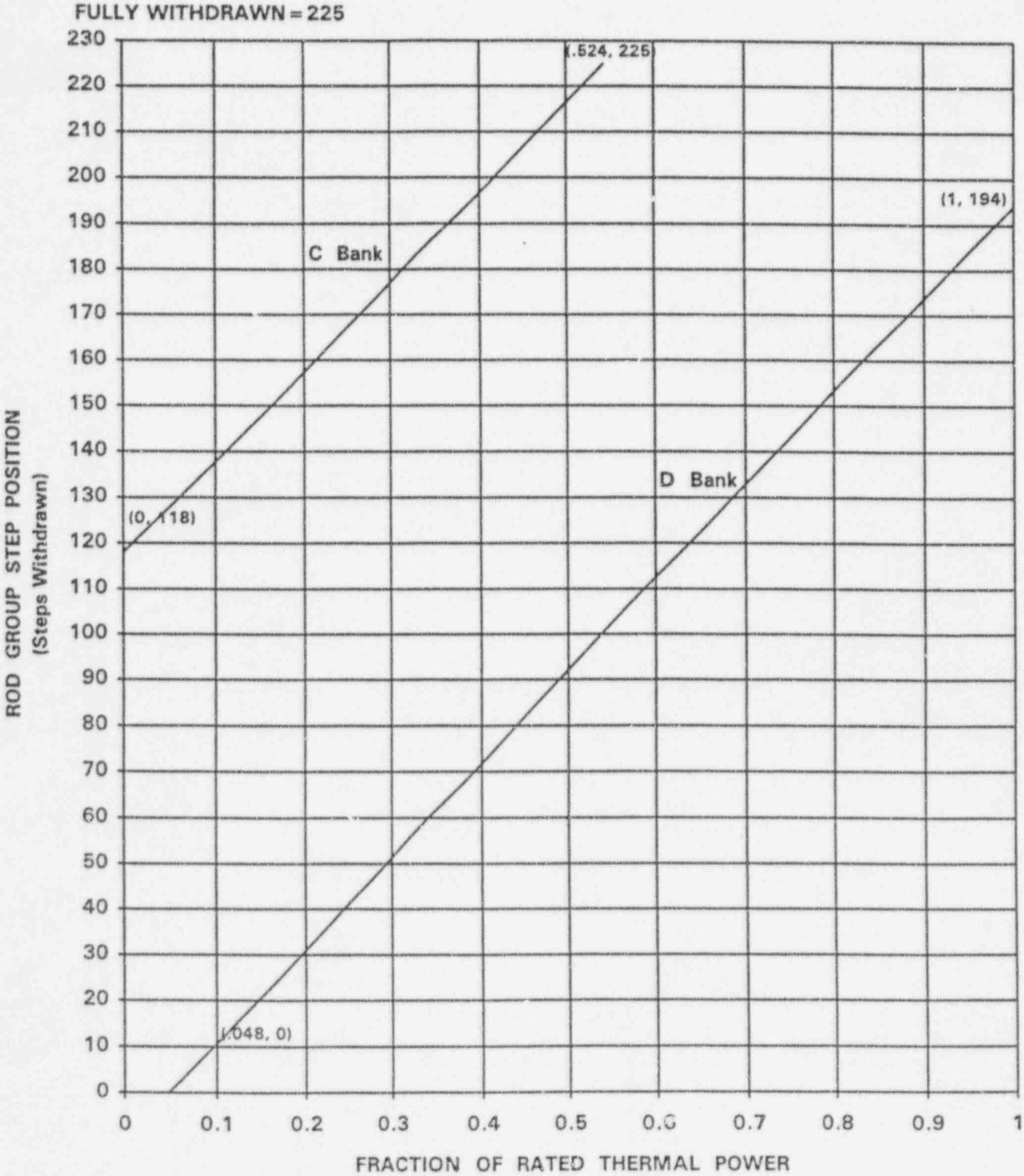


Figure 2a

N2C12 AXIAL FLUX DIFFERENCE LIMITS AS A FUNCTION OF RATED THERMAL POWER (BOC to 5000 MWD/MTU)

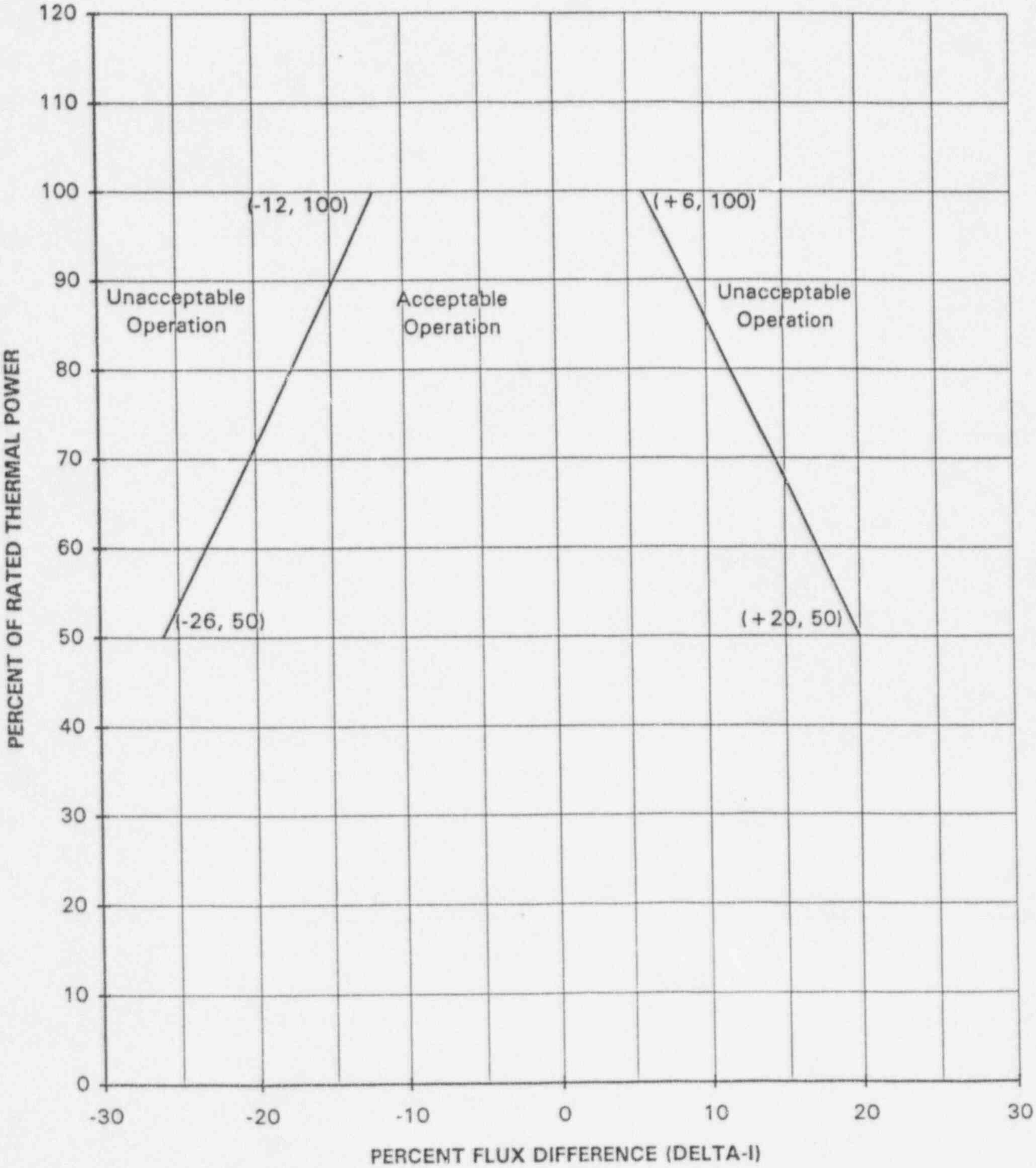


Figure 2b

N2C12 AXIAL FLUX DIFFERENCE LIMITS
AS A FUNCTION OF RATED THERMAL POWER
(5000 MWD/MTU to EOC)

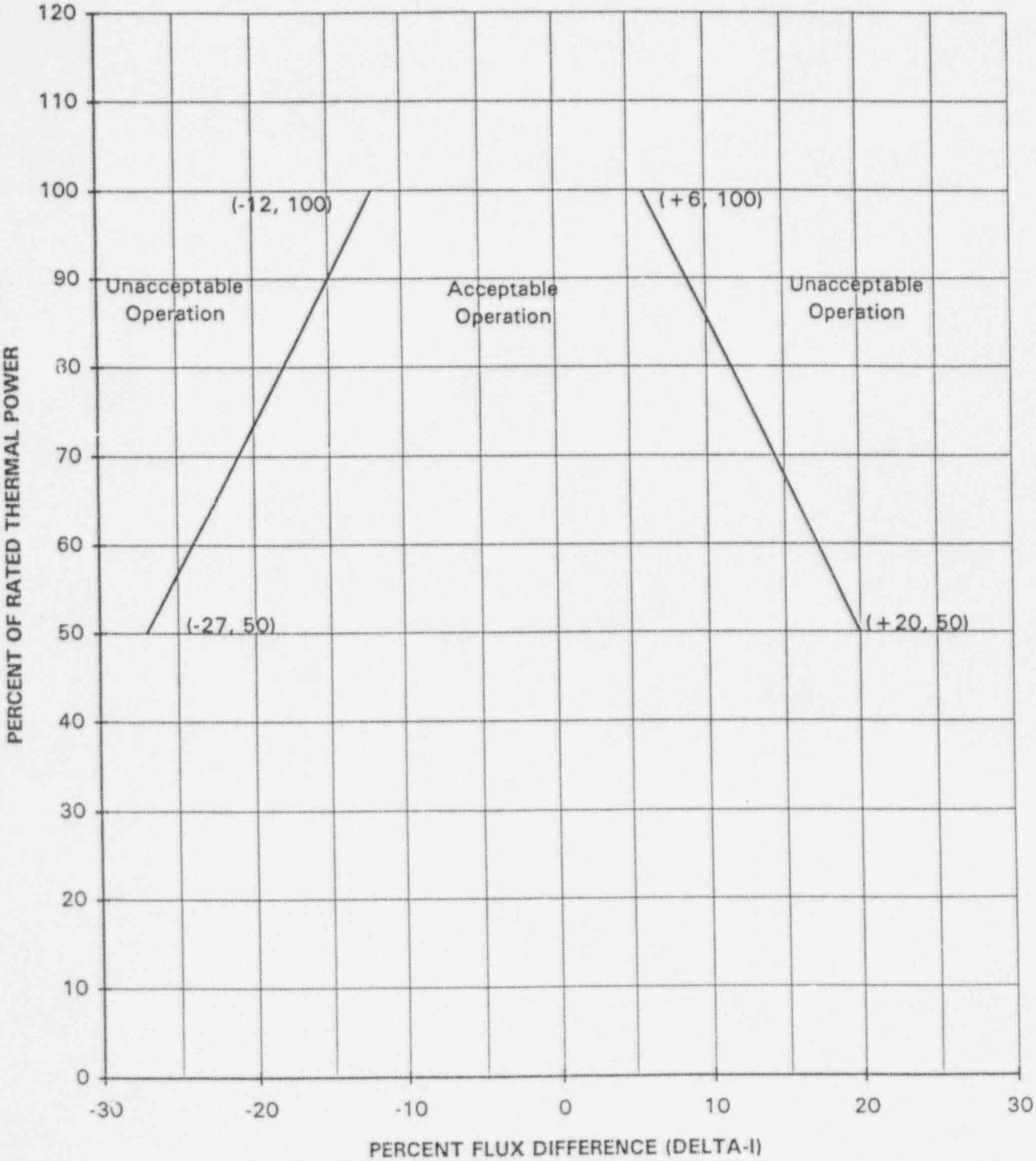


Figure 3

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

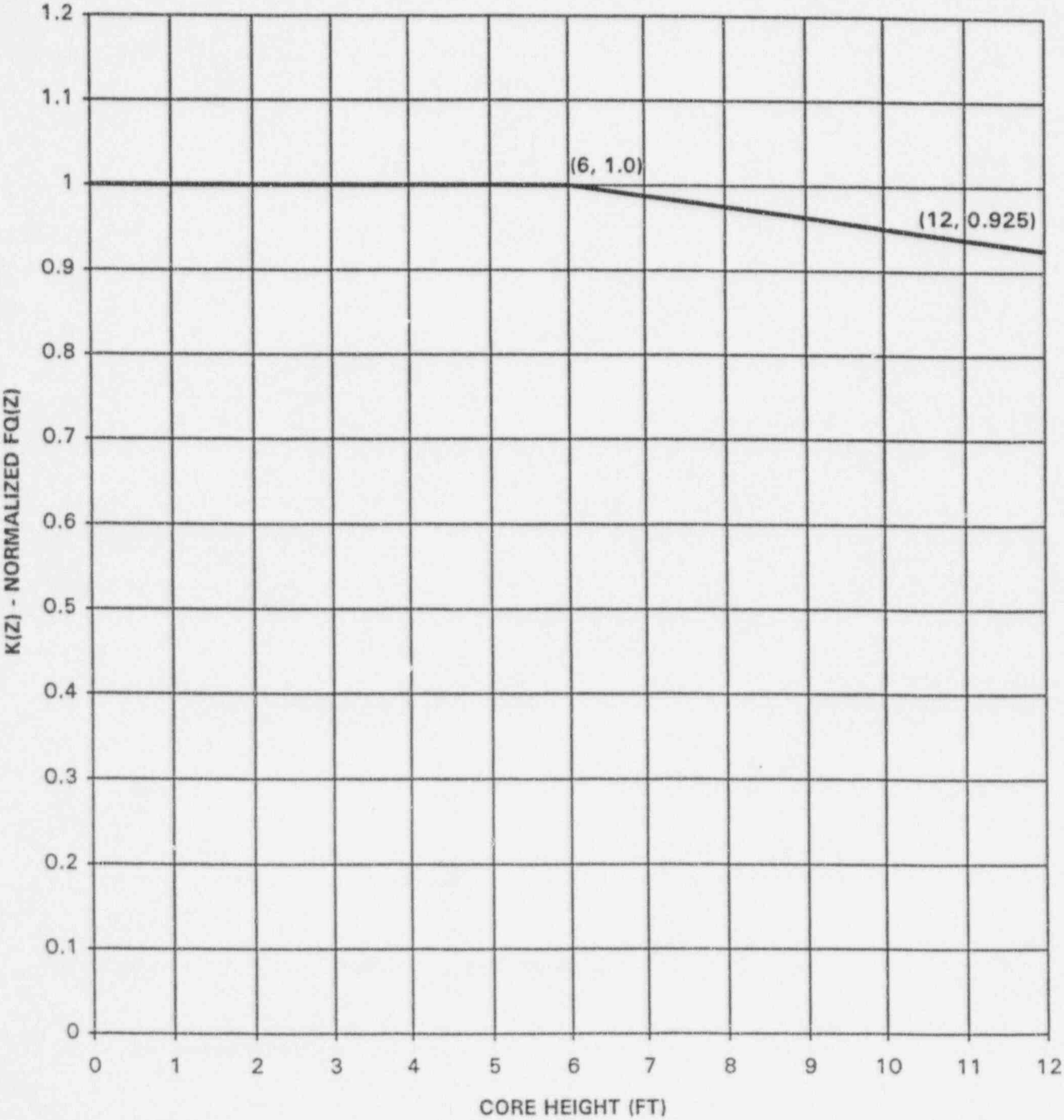


Figure 4

N2C12 NON-EQUILIBRIUM MULTIPLIER
0-1000 MWD/MTU

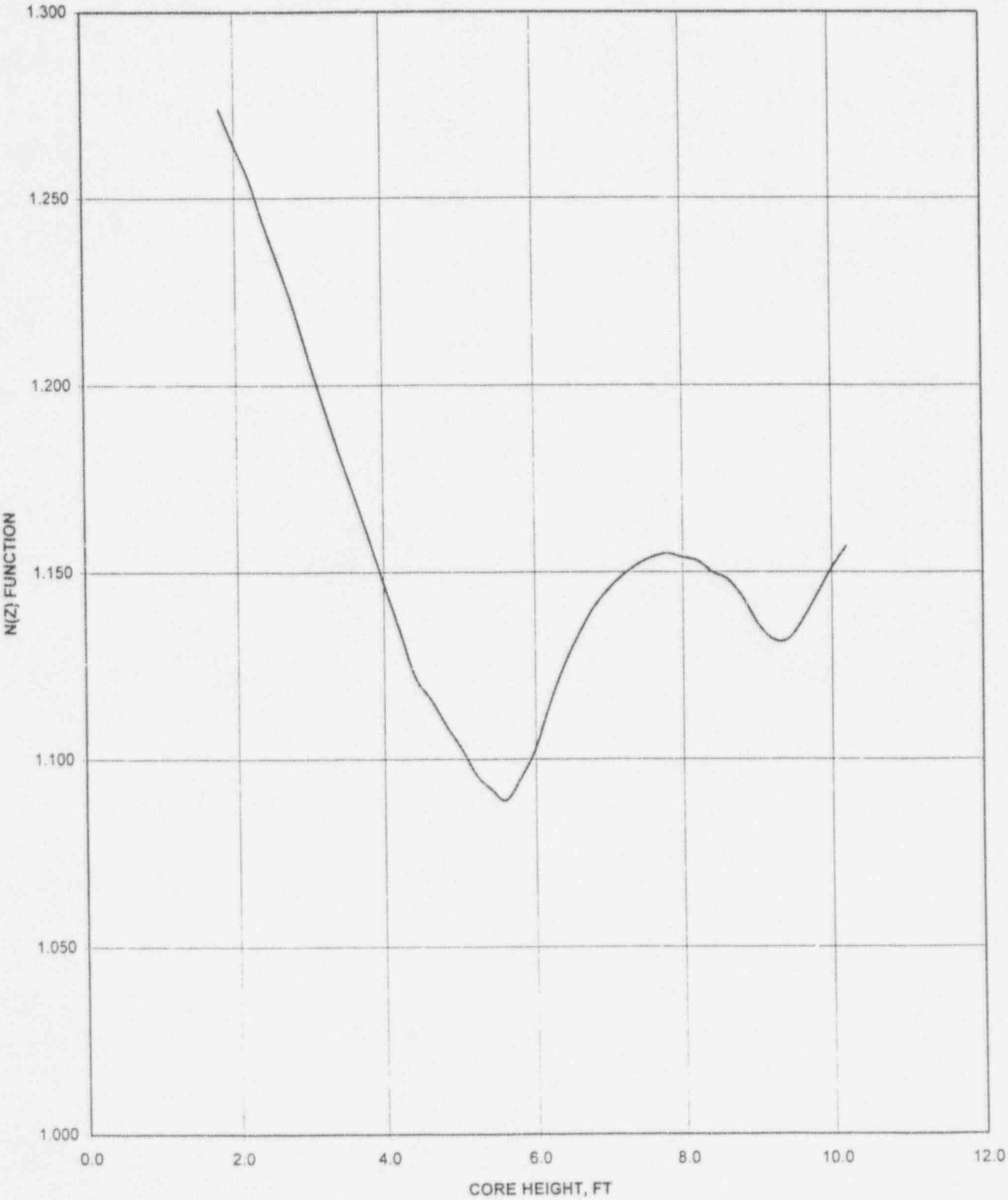


Figure 5

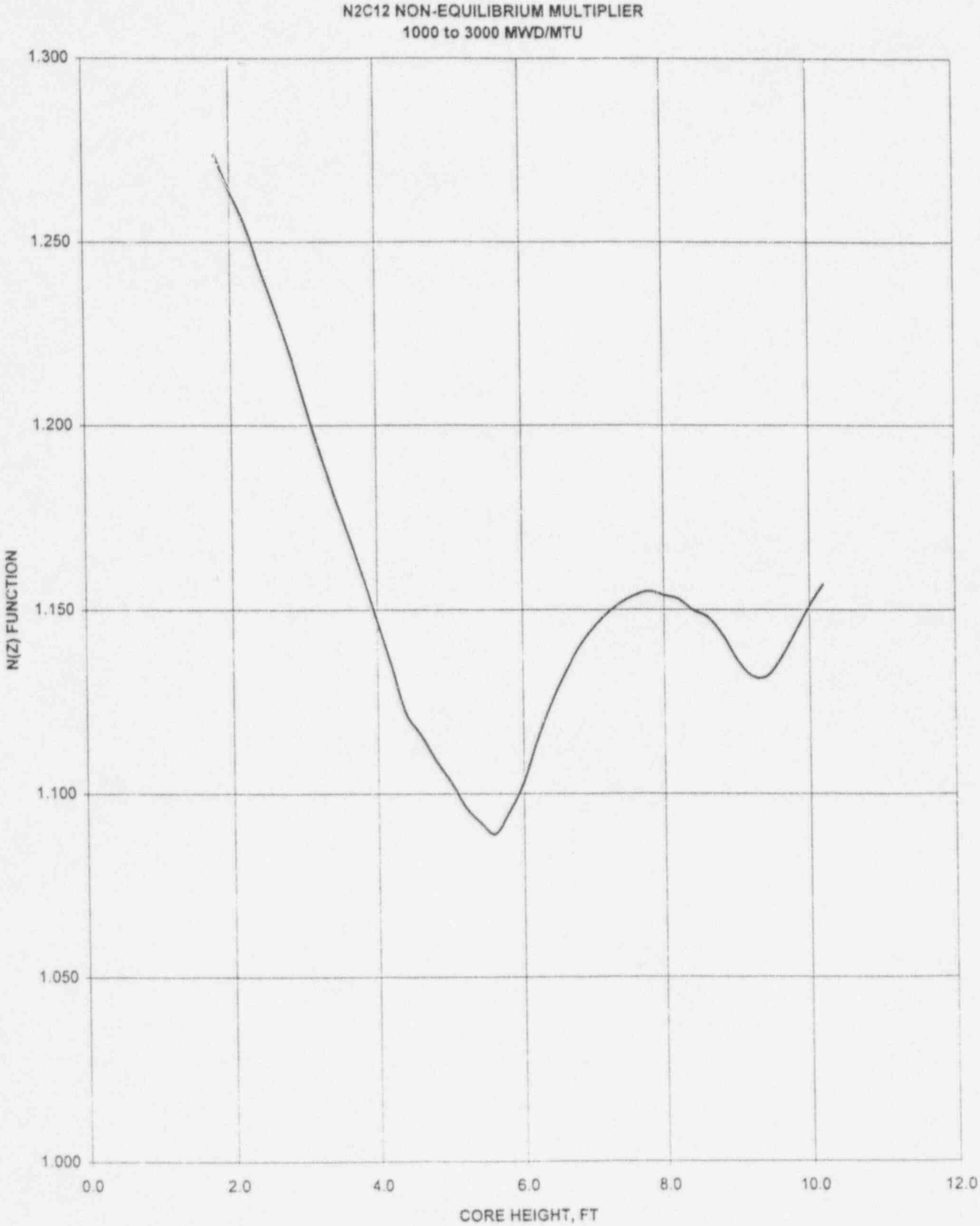
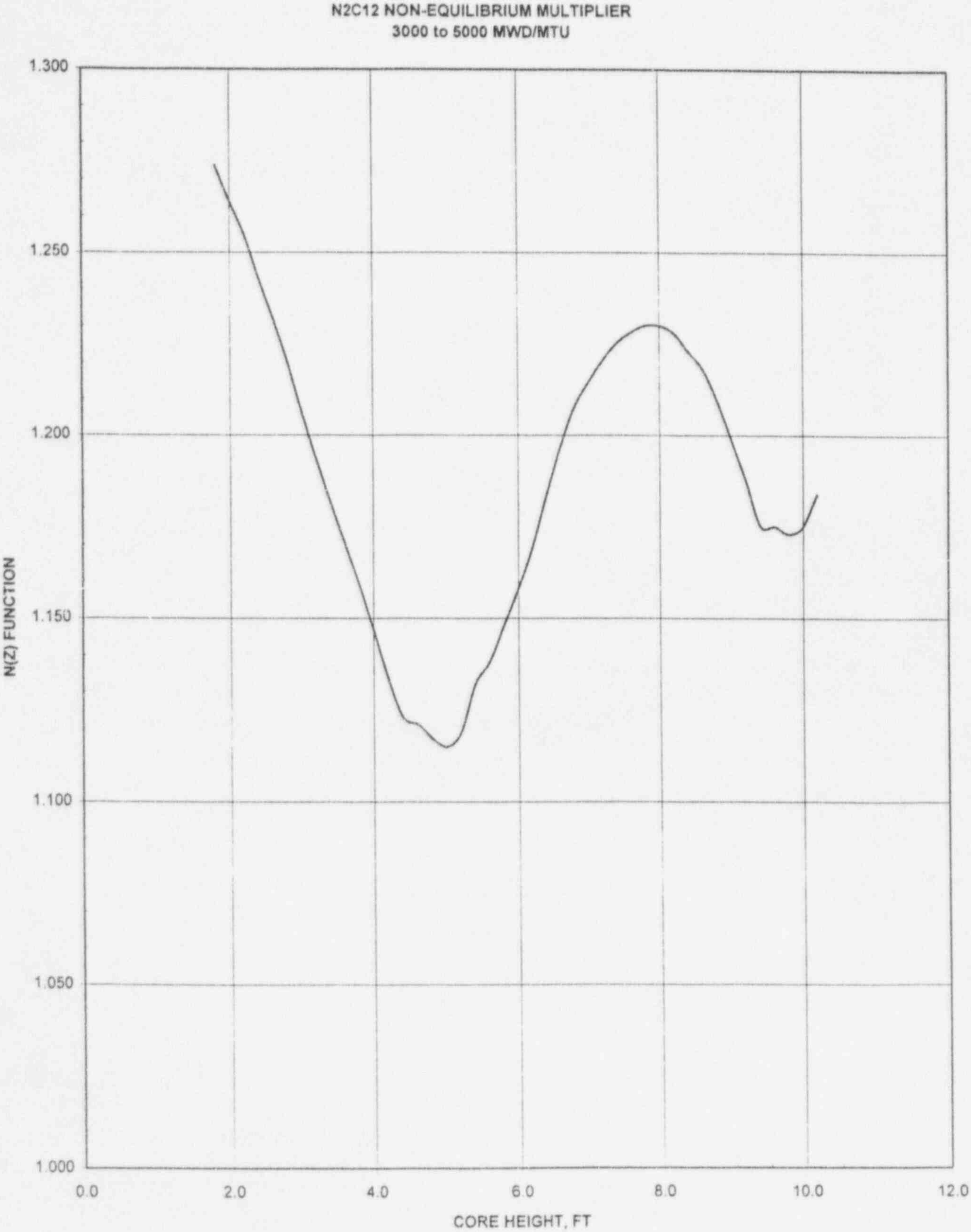

N2C12 NON-EQUILIBRIUM MULTIPLIER
1000 to 3000 MWD/MTU
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(Z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 6



N2C12 NON-EQUILIBRIUM MULTIPLIER
3000 to 5000 MWD/MTU
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(Z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 7

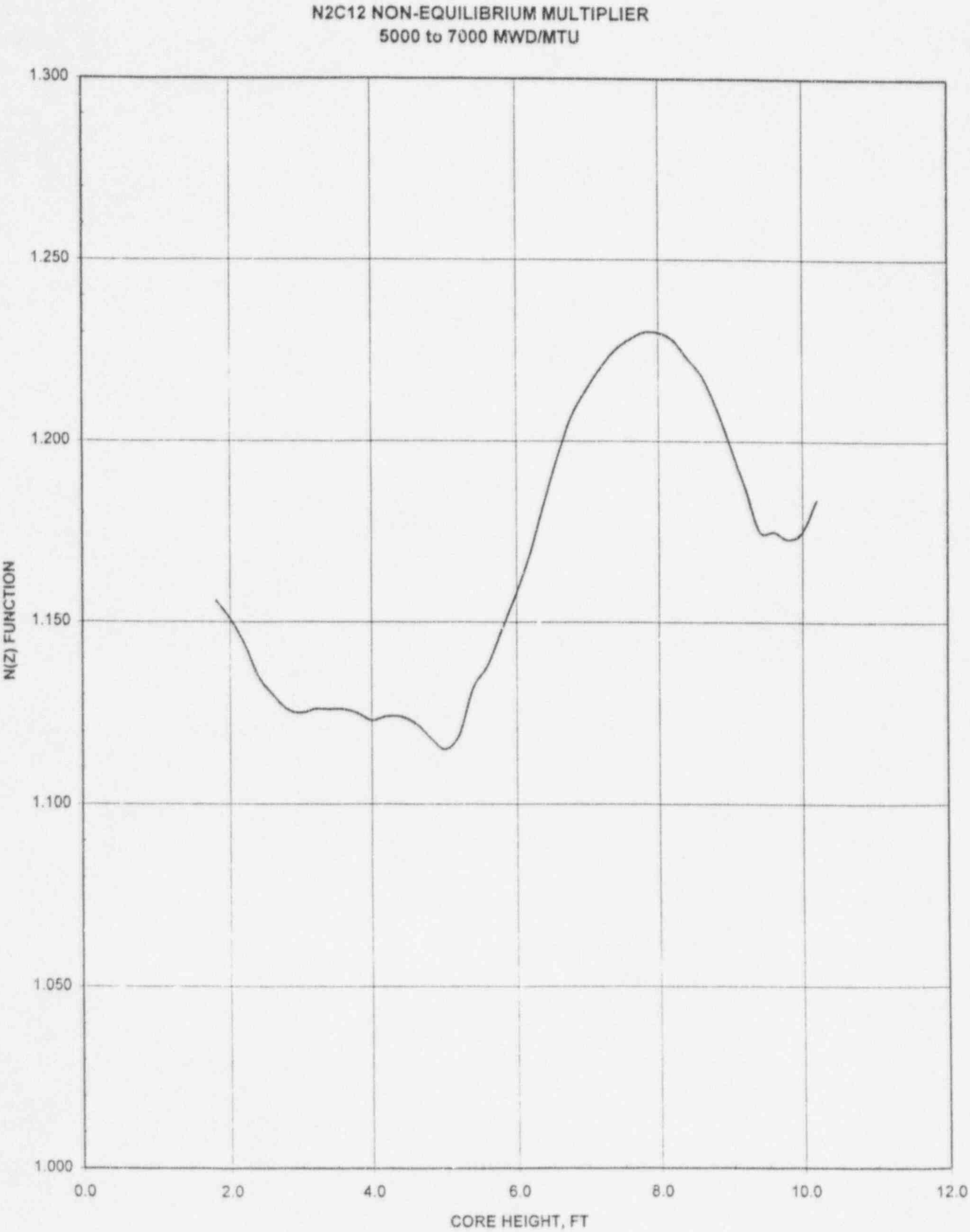

N2C12 NON-EQUILIBRIUM MULTIPLIER
5000 to 7000 MWD/MTU
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(Z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 8

N2C12 NON-EQUILIBRIUM MULTIPLIER
7000 to 9000 MWD/MTU

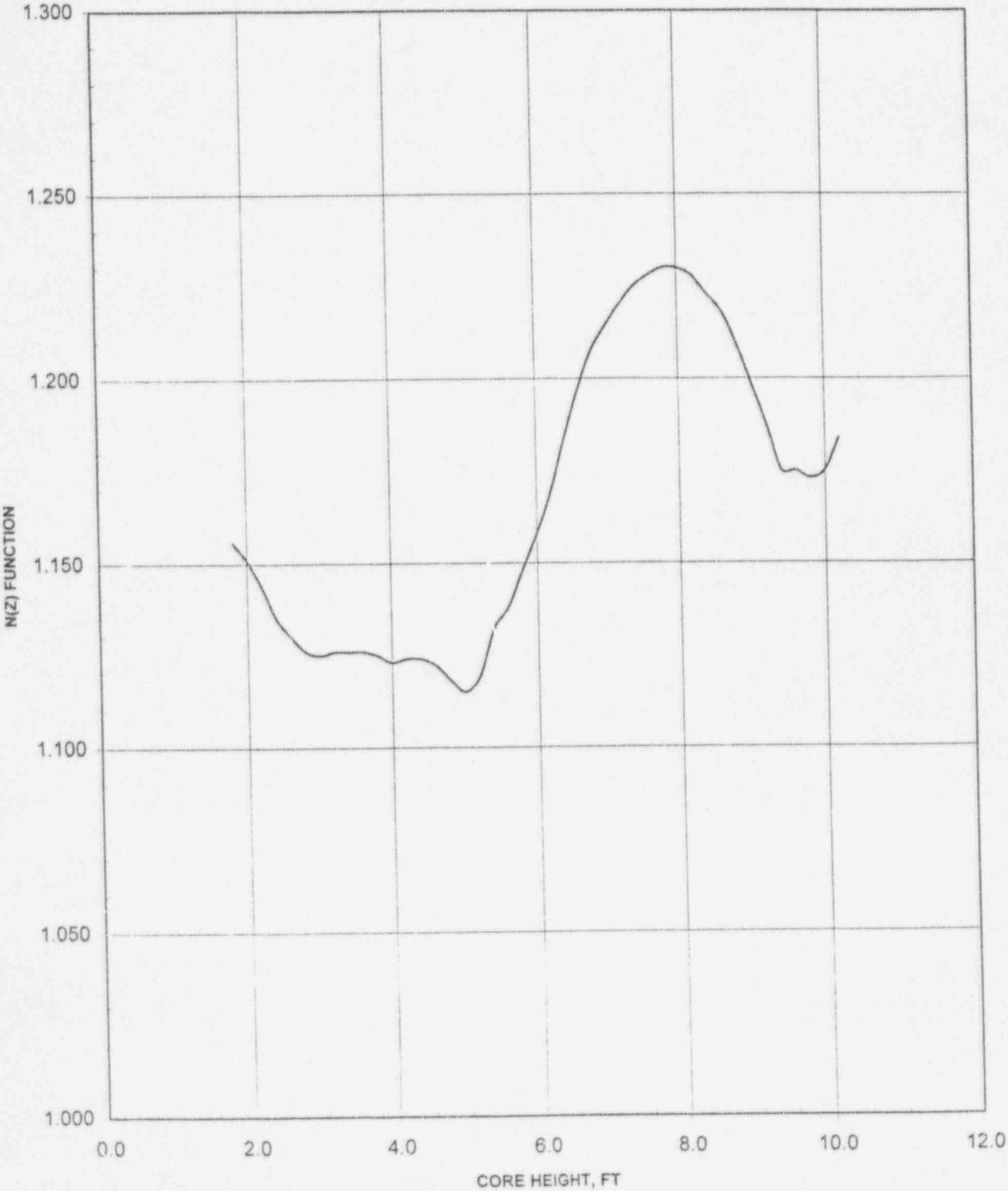


Figure 9

N2C12 NON-EQUILIBRIUM MULTIPLIER
9000 to 18000 MWD/MTU

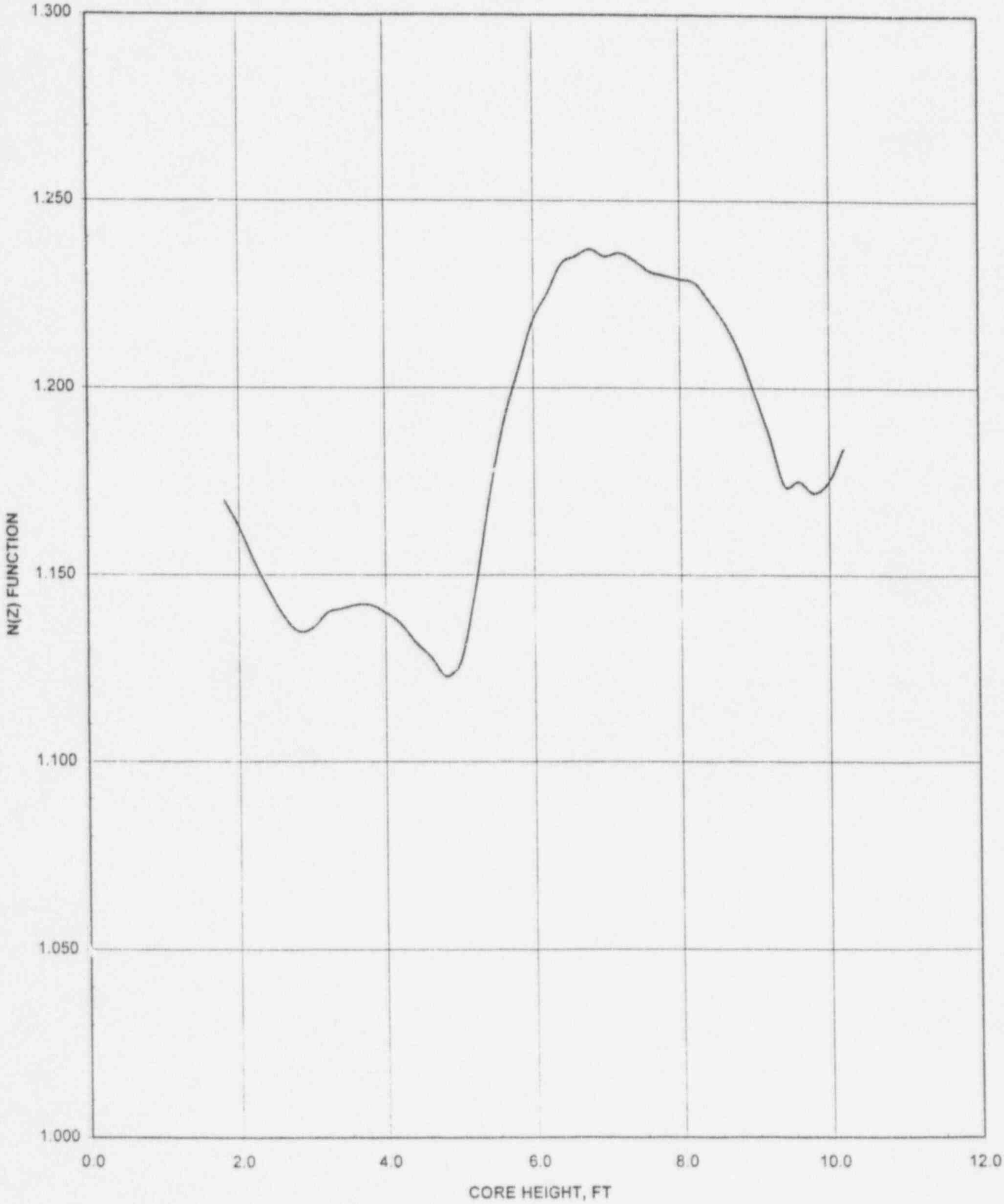


Figure 10

N2C12 NON-EQUILIBRIUM MULTIPLIER
18000 to EOC MWD/MTU