CORE OPERATING LIMITS REPORT
North Anna 2 Cycle 11 Pattern UM

Revision 0

May 1995

CORE OPERATING LIMITS
N2C11 Pattern UM

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 2 Cycle 11 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 11 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-04 $\Delta k/k/^{0}F$.

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2.2.1 The shutdown rods shall be withdrawn to at least 225 steps.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-FQ(Z) (Specification 3/4.2.2)

2.5.1 The $F_Q(Z)$ limits are:

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

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

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

K(Z) is provided in Figure 3

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

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

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

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

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 - FΔH(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

N2C11 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 17600 MWD/MTU	17600 to EOC MWD/MTU
10	10.2	1.173	1.173	1.181	1.181	1.181	1.181	1.177
11	10.0	1.166	1.166	1.175	1.175	1.175	1.175	1.175
12	9.8	1.158	1.158	1.172	1.172	1.172	1.172	1.170
13	9.6	1.151	1.151	1.176	1.176	1.176	1.176	1.168
14	9.4	1.146	1.146	1.181	1.181	1.181	1.181	1.168
15	9.2	1.145	1.145	1.187	1.187	1.187	1.187	1.174
16	9.0	1.143	1.143	1.194	1.194	1.194	1.194	1.183
17	8.8	1.141	1.141	1.205	1.205	1.205	1.205	1.194
18	8.6	1.137	1.137	1.214	1.214	1.214	1.213	1.204
19	8.4	1.140	1.140	1.219	1.219	1.219	1.219	1.212
20	8.2	1.144	1.144	1.224	1.224	1.224	1.223	1.219
21	8.0	1.149	1.149	1.225	1.225	1.225	1.225	1.223
22	7.8	1.156	1.156	1.225	1.225	1.225	1.228	1.227
23	7.6	1.160	1.160	1.223	1.223	1.223	1.230	1.230
24	7.4	1.160	1.160	1.220	1.220	1.220	1.233	1.233
25	7.2	1.158	1.158	1.218	1.218	1.218	1.234	1.234
26	7.0	1.153	1.153	1.212	1.212	1.212	1.233	1.233
27	6.8	1.146	1.146	1.206	1.206	1.206	1.235	1.235
28	6.6	1.136	1.136	1.195	1.195	1.195	1.233	1.233
29	6.4	1.126	1.126	1.182	1.182	1.182	1.231	1.231
30	6.2	1.116	1.116	1.168	1.168	1.168	1.223	1.223
31	6.0	1.105	1.105	1.157	1.157	1.157	1.216	1.216
32	5.8	1.097	1.097	1.148	1.148	1.148	1.202	1.202
33	5.6	1.090	1.090	1.137	1.137	1.137	1.189	1.189
34	5.4	1.092	1.092	1.129	1.129	1.129	1.169	1.169
35	5.2	1.093	1.093	1.119	1.119	1.119	1.143	1.143
36	5.0	1.099	1.099	1.116	1.117	1.117	1.126	1.124
37	4.8	1.108	1.108	1.119	1.120	1.120	1.123	1.123
38	4.6	1.119	1.119	1.124	1.125	1.125	1.127	1.127
39	4.4	1.128	1.128	1.129	1.126	1.126	1.132	1.132
40	4.2	1.136	1.136	1.135	1.127	1.127	1.136	1.136
41	4.0	1.144	1.144	1.143	1.126	1.126	1.138	1.138
42	3.8	1.152	1.152	1.151	1.124	1.124	1.139	1.139
43	3.6	1.160	1.160	1.160	1.123	1.123	1.139	1.139
44	3.4	1.170	1.170	1.170	1.124	1.124	1.136	1.136
45	3.2	1.180	1.180	1.180	1.124	1.124	1.136	1.136
46	3.0	1.190	1.190	1.190	1.122	1.122	1.140	1.140
47	2.8	1.197	1.197	1.197	1.123	1.123	1.148	1.148
48	2.6	1.205	1.205	1.205	1.129	1.129	1.156	1.156
49	2.4	1.211	1.211	1.211	1.138	1.138	1.165	1.165
50	2.2	1.220	1.220	1.220	1.146	1.146	1.173	1.173
51	2.0	1.229	1.229	1.229	1.152	1.152	1.179	1.179
52	1.8	1.238	1.238	1.238	1.157	1.157	1.184	1.184

Figure 1

North Anna Unit 2 Cycle 11
CONTROL ROD BANK INSERTION LIMITS

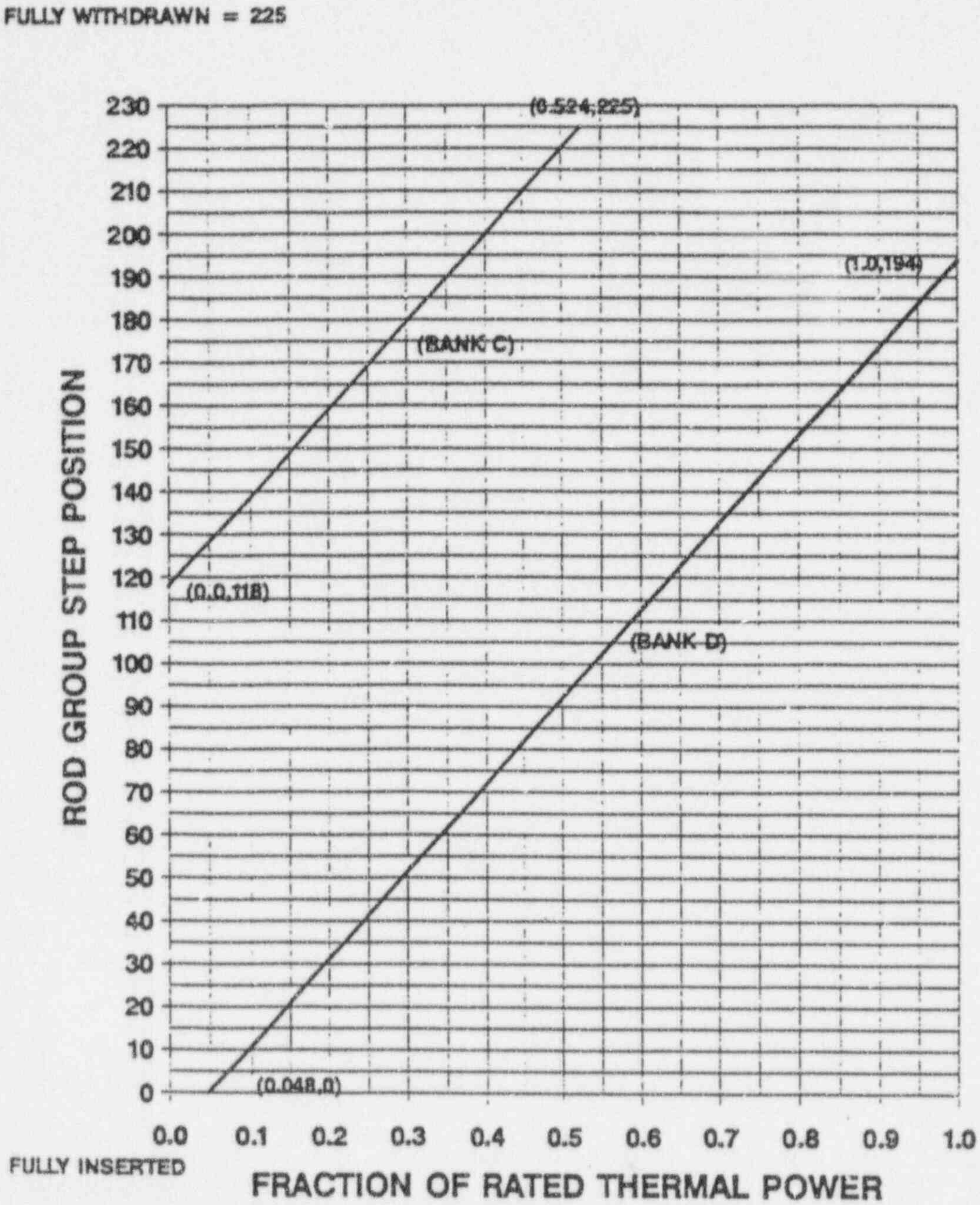


Figure 2a

N2C11 AXIAL FLUX DIFFERENCE LIMITS
AS A FUNCTION OF RATED THERMAL POWER
(BOC to 5000 MWD/MTU)

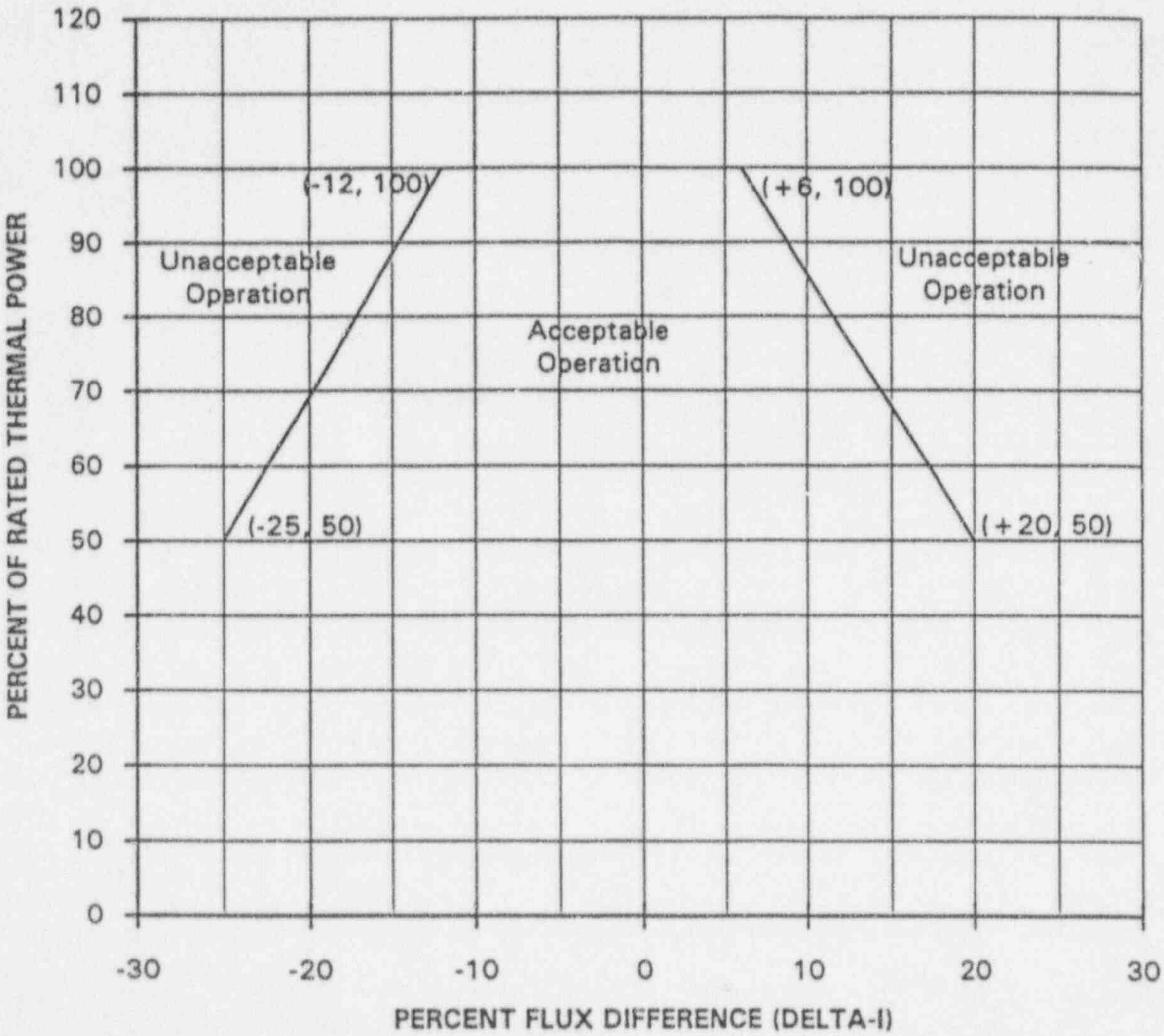


Figure 2b

N2C11 AXIAL FLUX DIFFERENCE LIMITS
AS A FUNCTION OF RATED THERMAL POWER
(5000 MWD/MTU to EOC)

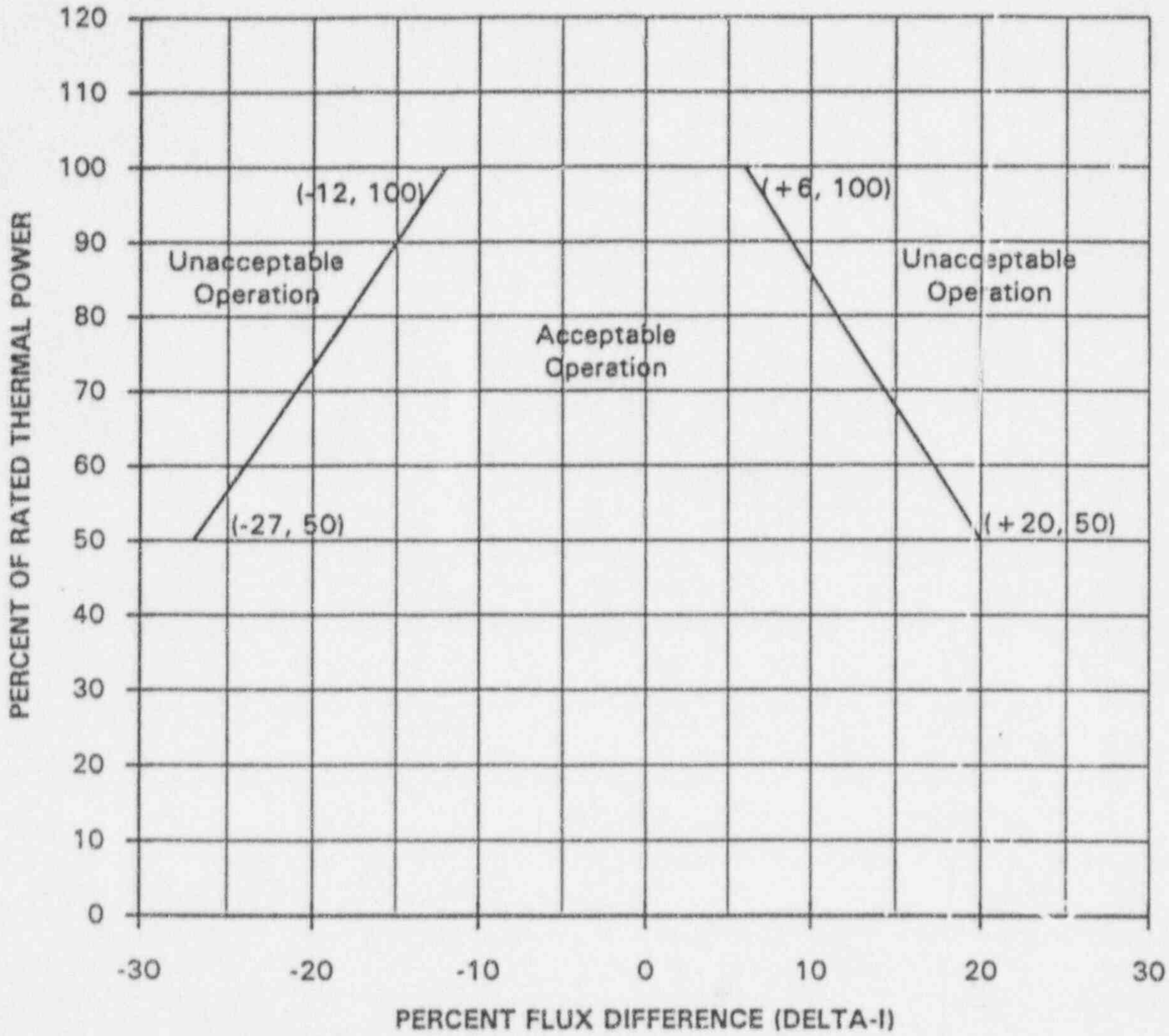


Figure 3

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

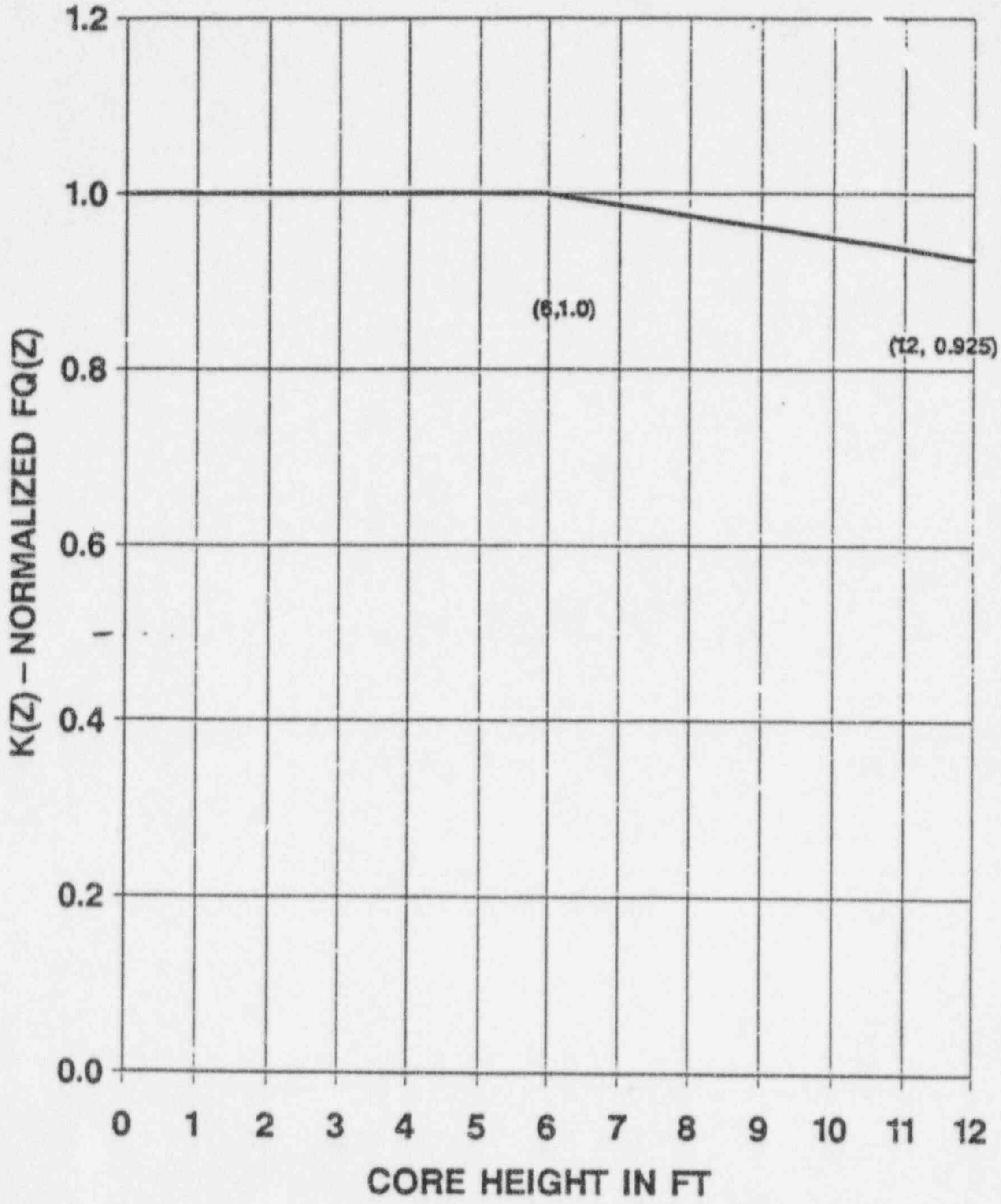


Figure 4

N2C11 NON-EQUILIBRIUM MULTIPLIER

0 - 1000 MWD/MTU BURNUP

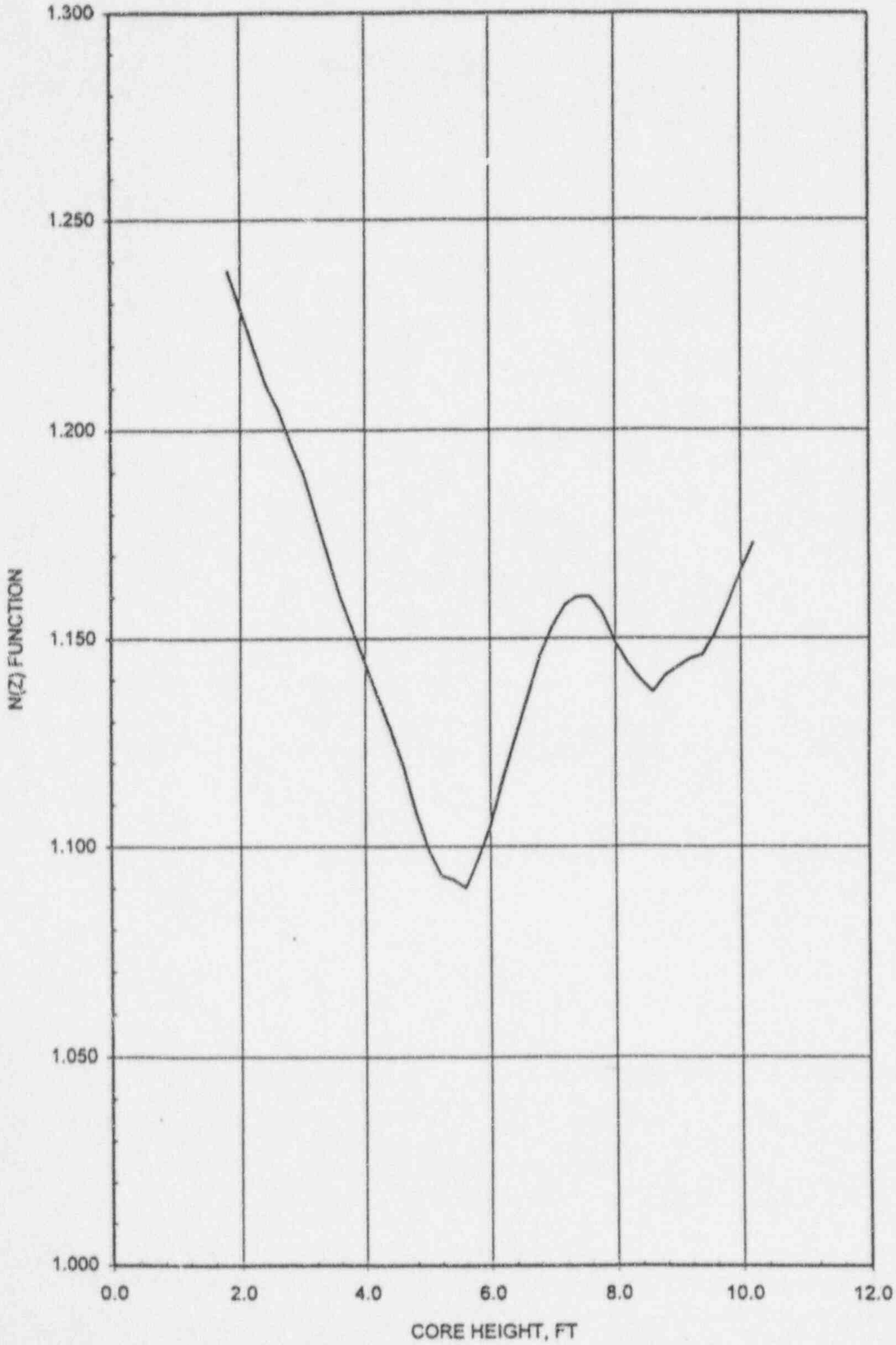


Figure 5

N2C11 NON-EQUILIBRIUM MULTIPLIER

1000 - 3000 MWD/MTU BURNUP

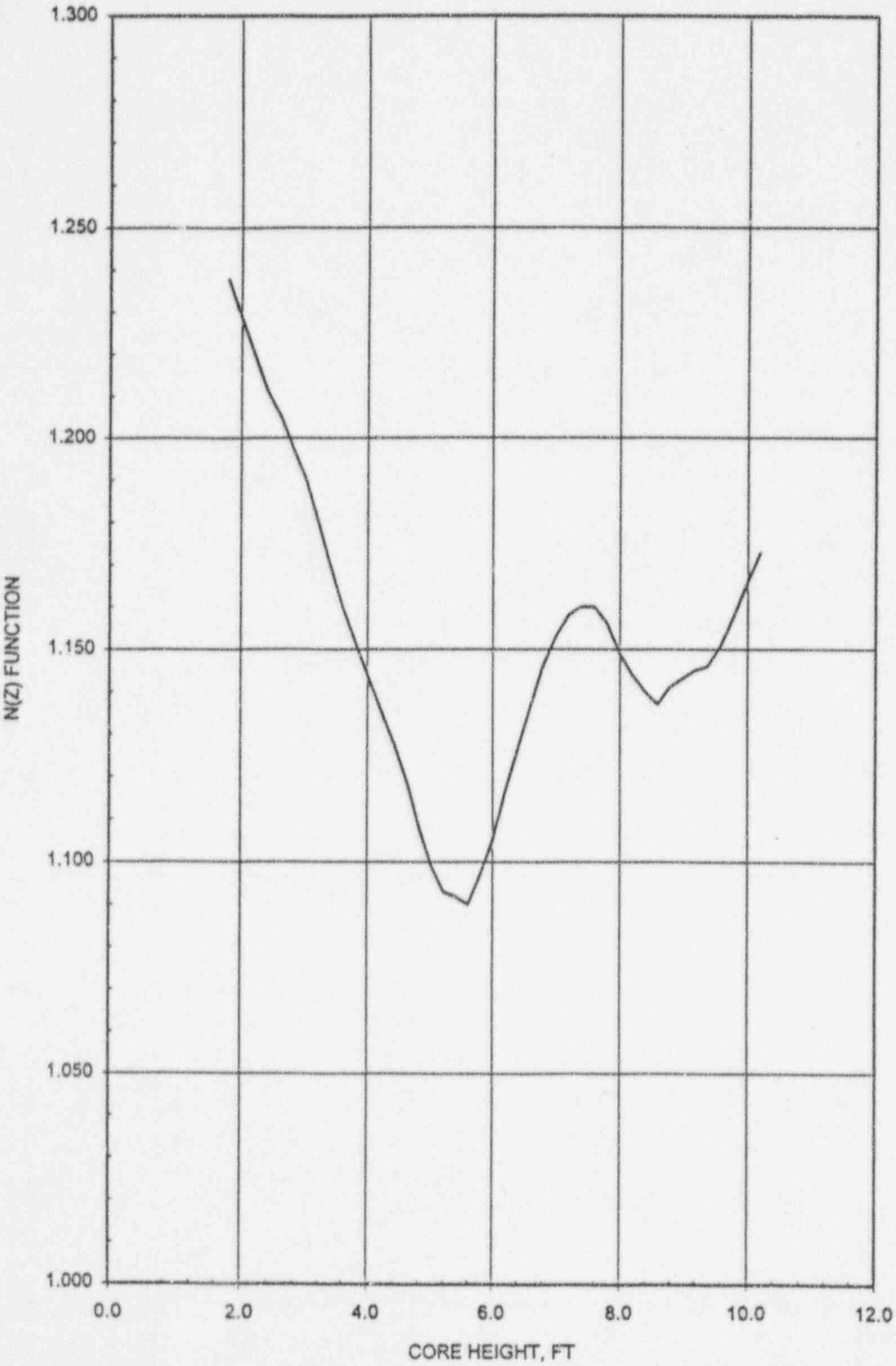


Figure 6

N2C11 NON-EQUILIBRIUM MULTIPLIER

3000 - 5000 MWD/MTU BURNUP

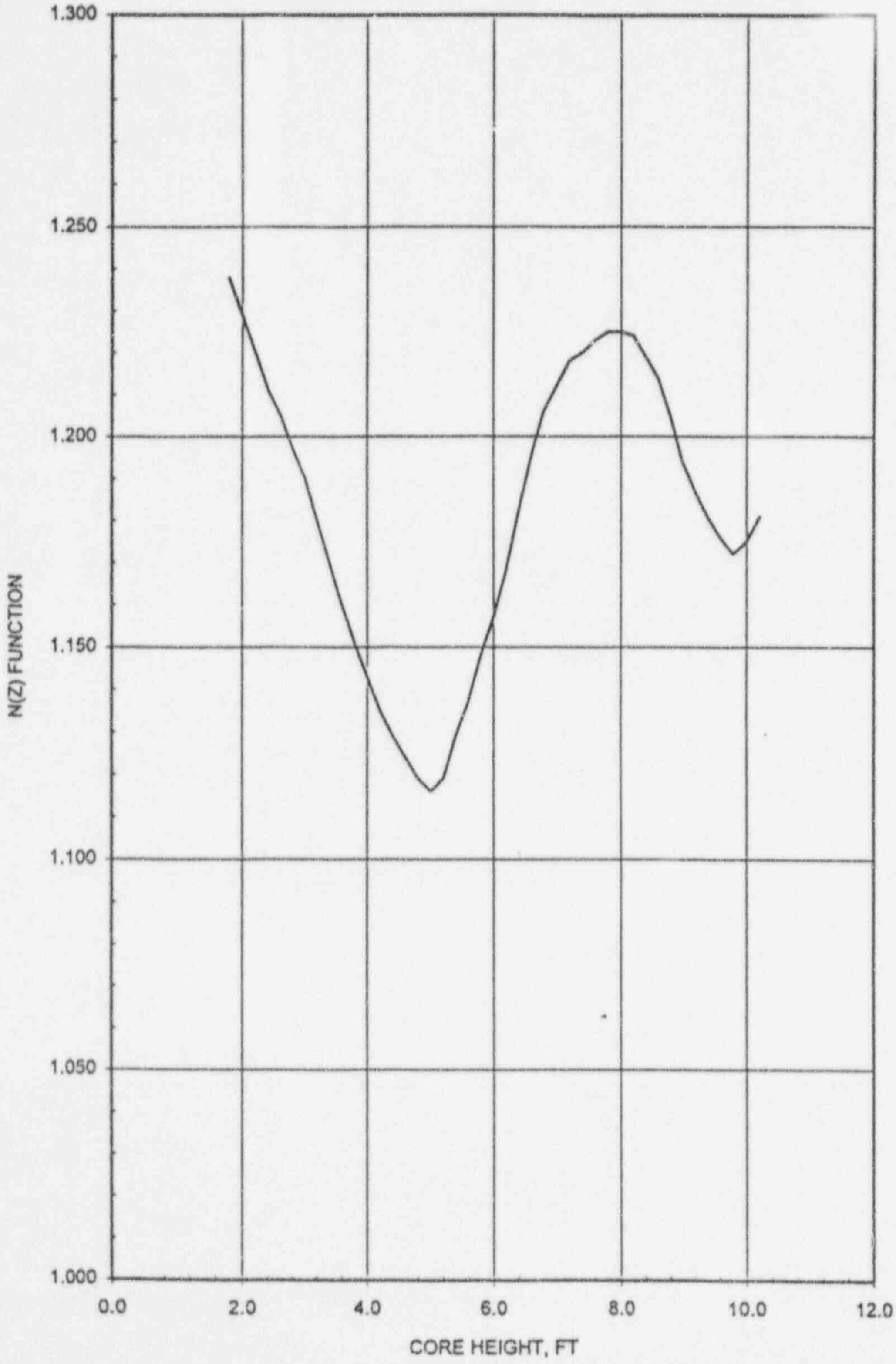


Figure 7

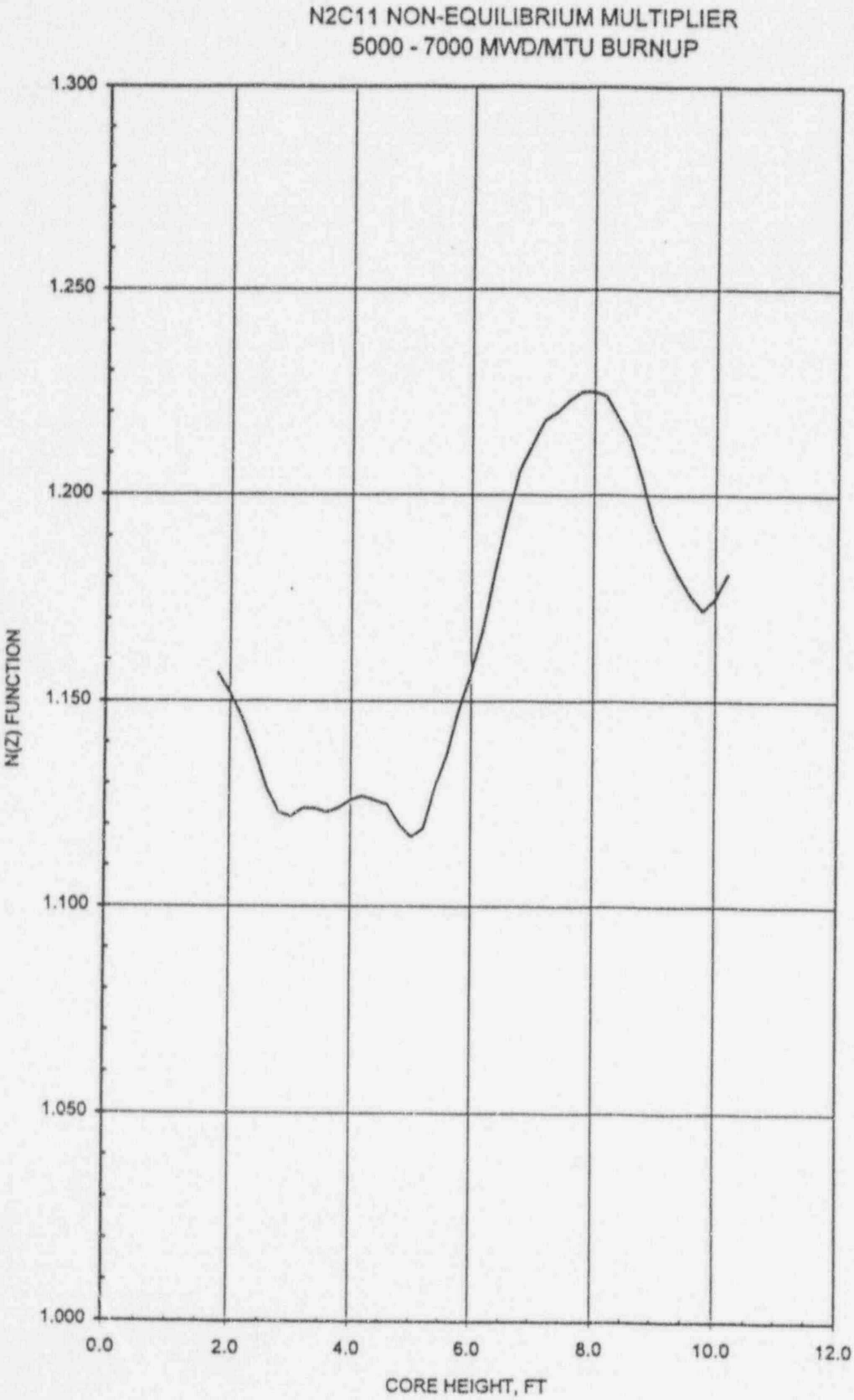
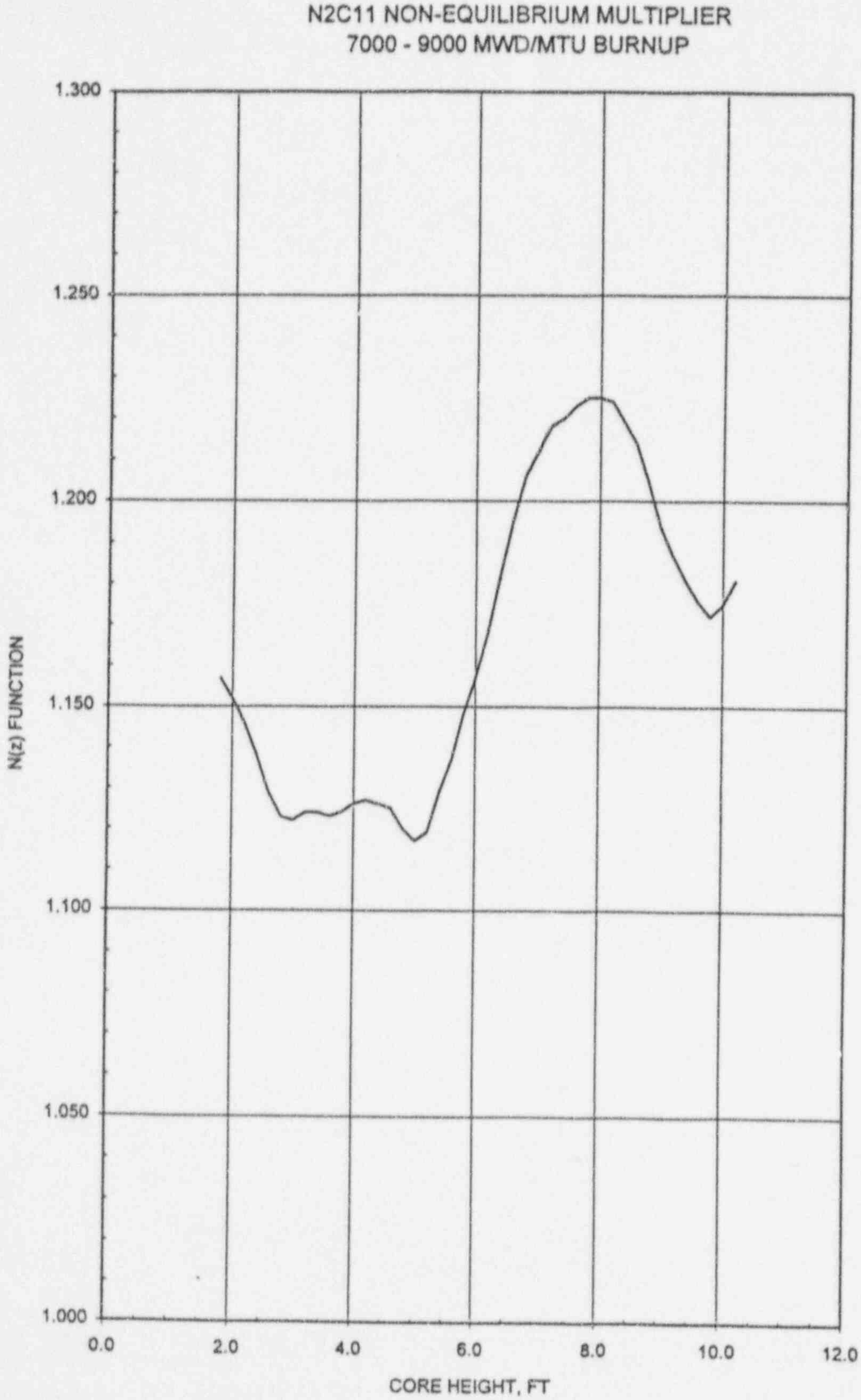

N2C11 NON-EQUILIBRIUM MULTIPLIER
5000 - 7000 MWD/MTU BURNUP
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(Z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 8



N2C11 NON-EQUILIBRIUM MULTIPLIER
7000 - 9000 MWD/MTU BURNUP
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 9

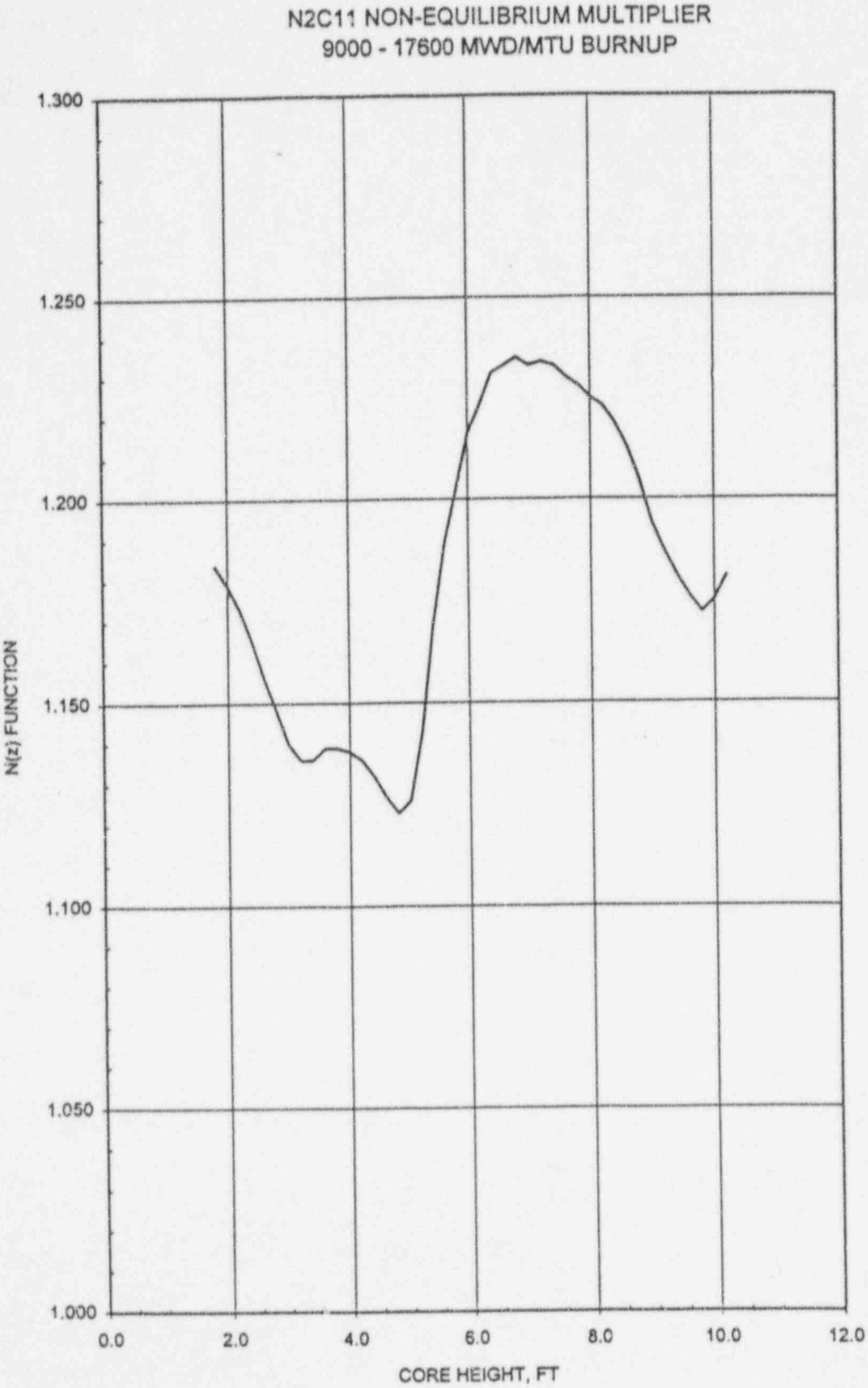
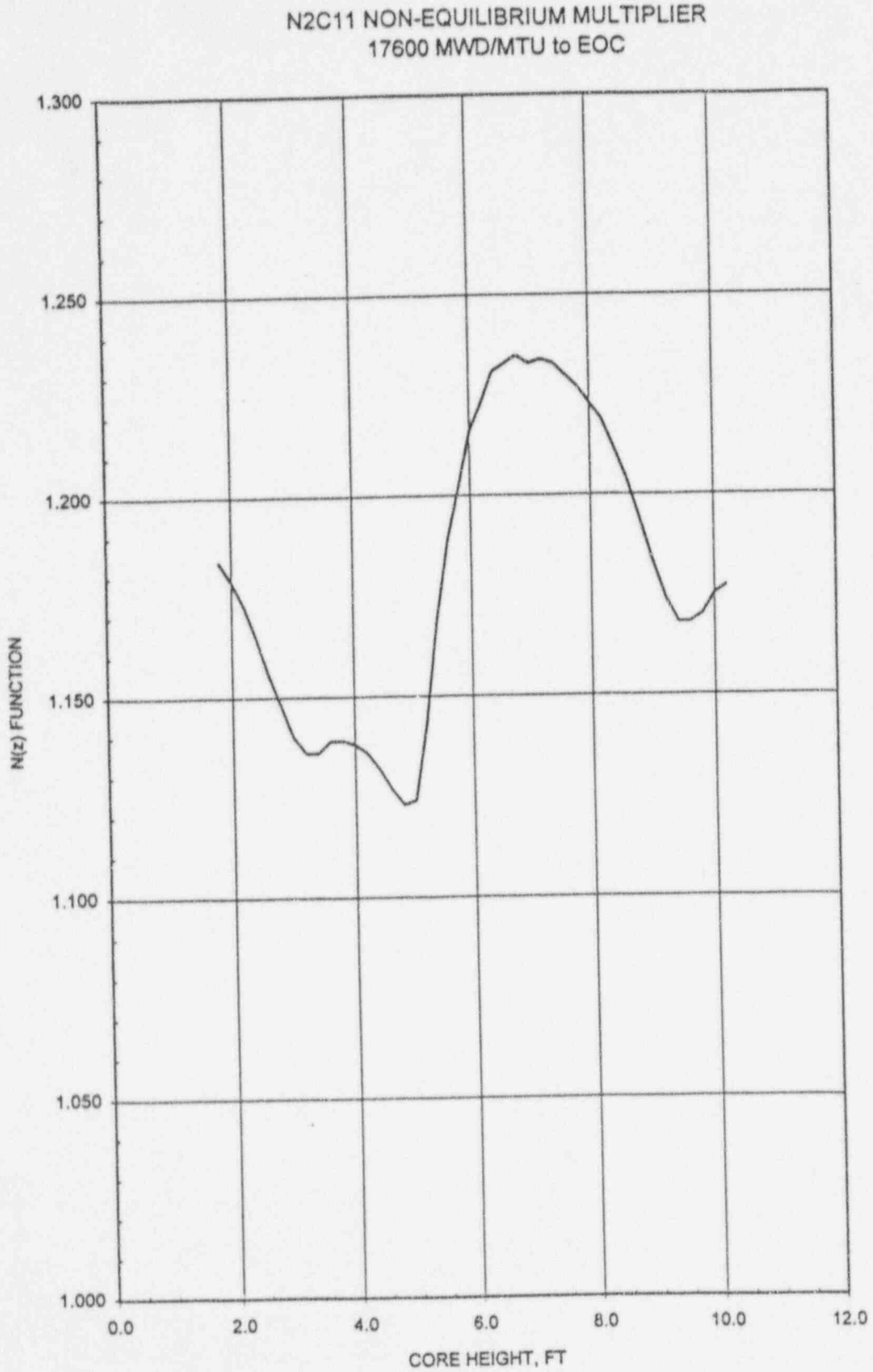

N2C11 NON-EQUILIBRIUM MULTIPLIER
9000 - 17600 MWD/MTU BURNUP
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 10


N2C11 NON-EQUILIBRIUM MULTIPLIER
17600 MWD/MTU to EOC
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