Core Operating Limits Report (COLR)

North Anna Unit 1 Cycle 13 Pattern OG

Virginia Electric and Power Company

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 1 Cycle 13 has been prepared in accordance with Technical Specification (TS) 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 1 Cycle 13 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 (TS 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 (TS 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2.2.1 The shutdown rods shall be withdrawn to at least 225 steps.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 (TS 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 (TS 3/4.2.1)

2.4.1 The AXIAL FLUX DIFFERENCE limits are provided in Figure 2.

2.5 Heat Flux Hot Channel Factor-FQ(Z) (TS 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: $P = \frac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$, and

K(Z) is provided in Figure 3.

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

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

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

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

where: P = THERMAL POWER / 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 TS 4.2.2.2.G.

2.6 Nuclear Enthalpy Rise Hot Channel Factor - FΔH(N) and Power Factor Multiplier (TS 3/4.2.3)

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

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

Table 1
N1C13 NORMAL OPERATION N(z)

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 18100 MWD/MTU	18100 to EOC MWD/MTU
10	10.2	1.078	1.078	1.157	1.157	1.157	1.157	1.139
11	10.0	1.086	1.086	1.157	1.157	1.157	1.157	1.141
12	9.8	1.094	1.094	1.156	1.156	1.156	1.156	1.142
13	9.6	1.102	1.102	1.155	1.155	1.155	1.155	1.144
14	9.4	1.109	1.109	1.154	1.154	1.154	1.154	1.145
15	9.2	1.113	1.113	1.157	1.157	1.157	1.157	1.147
16	9.0	1.117	1.117	1.160	1.160	1.160	1.160	1.153
17	8.8	1.120	1.120	1.167	1.167	1.167	1.167	1.160
18	8.6	1.120	1.120	1.175	1.175	1.175	1.175	1.165
19	8.4	1.124	1.124	1.184	1.184	1.184	1.184	1.169
20	8.2	1.134	1.134	1.191	1.191	1.191	1.191	1.174
21	8.0	1.145	1.145	1.197	1.197	1.197	1.197	1.180
22	7.8	1.155	1.155	1.205	1.205	1.205	1.205	1.187
23	7.6	1.162	1.162	1.209	1.209	1.209	1.209	1.192
24	7.4	1.167	1.167	1.211	1.211	1.211	1.211	1.194
25	7.2	1.169	1.169	1.211	1.211	1.211	1.211	1.194
26	7.0	1.168	1.168	1.208	1.208	1.208	1.208	1.192
27	6.8	1.165	1.165	1.206	1.206	1.206	1.206	1.190
28	6.6	1.160	1.160	1.201	1.201	1.201	1.200	1.186
29	6.4	1.157	1.157	1.194	1.194	1.194	1.193	1.180
30	6.2	1.154	1.154	1.183	1.183	1.183	1.183	1.172
31	6.0	1.150	1.150	1.173	1.173	1.173	1.172	1.165
32	5.8	1.145	1.145	1.161	1.161	1.161	1.161	1.158
33	5.6	1.138	1.138	1.147	1.148	1.148	1.155	1.155
34	5.4	1.129	1.129	1.134	1.134	1.134	1.149	1.149
35	5.2	1.114	1.114	1.117	1.119	1.119	1.139	1.139
36	5.0	1.110	1.110	1.112	1.111	1.111	1.130	1.130
37	4.8	1.118	1.118	1.118	1.109	1.109	1.123	1.123
38	4.6	1.128	1.128	1.128	1.110	1.110	1.122	1.122
39	4.4	1.136	1.136	1.136	1.112	1.112	1.126	1.126
40	4.2	1.143	1.143	1.143	1.116	1.116	1.129	1.130
41	4.0	1.149	1.149	1.149	1.122	1.122	1.131	1.131
42	3.8	1.155	1.155	1.155	1.127	1.127	1.131	1.130
43	3.6	1.163	1.163	1.163	1.131	1.131	1.131	1.129
44	3.4	1.175	1.175	1.175	1.132	1.132	1.132	1.128
45	3.2	1.190	1.190	1.190	1.135	1.135	1.135	1.131
46	3.0	1.203	1.203	1.203	1.141	1.141	1.141	1.136
47	2.8	1.217	1.217	1.217	1.150	1.150	1.150	1.146
48	2.6	1.229	1.229	1.229	1.160	1.160	1.160	1.155
49	2.4	1.241	1.241	1.241	1.170	1.170	1.170	1.163
50	2.2	1.252	1.252	1.252	1.179	1.179	1.179	1.171
51	2.0	1.262	1.262	1.262	1.188	1.188	1.188	1.179
52	1.8	1.271	1.271	1.271	1.196	1.196	1.196	1.186

Figure 1
Control Rod Bank Insertion Limits

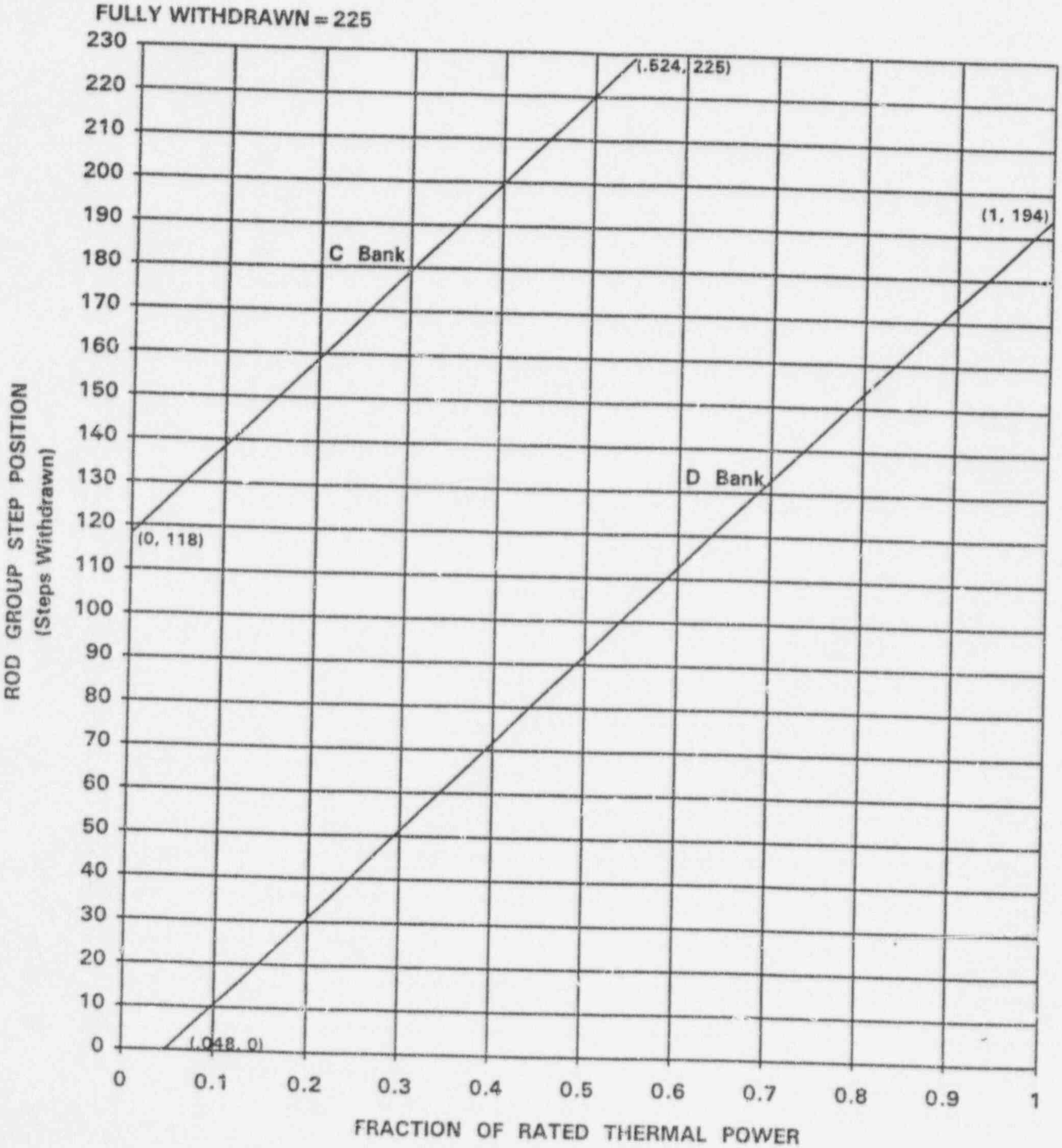


Figure 2
N1C13 Axial Flux Difference Limits

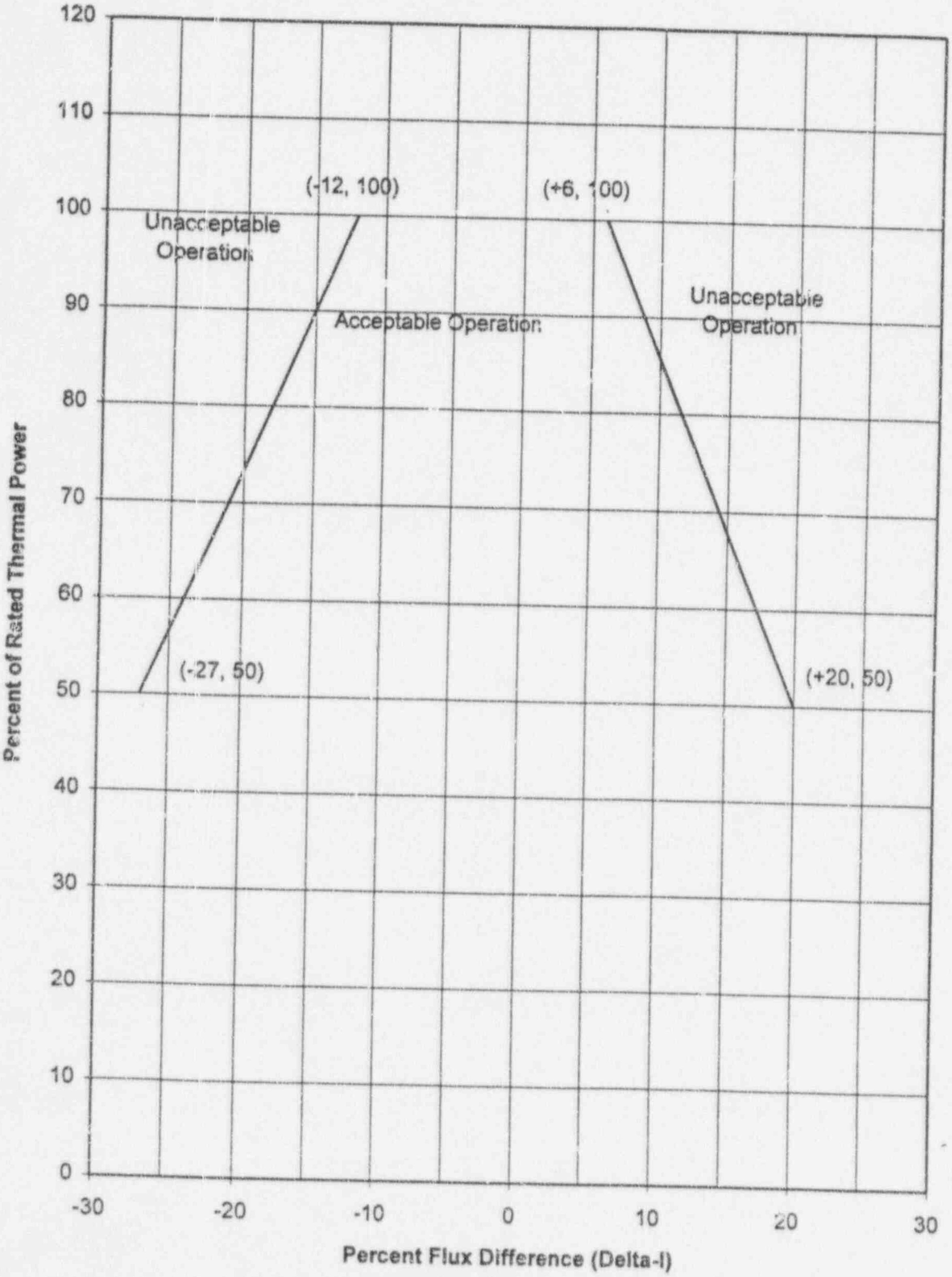


Figure 3

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

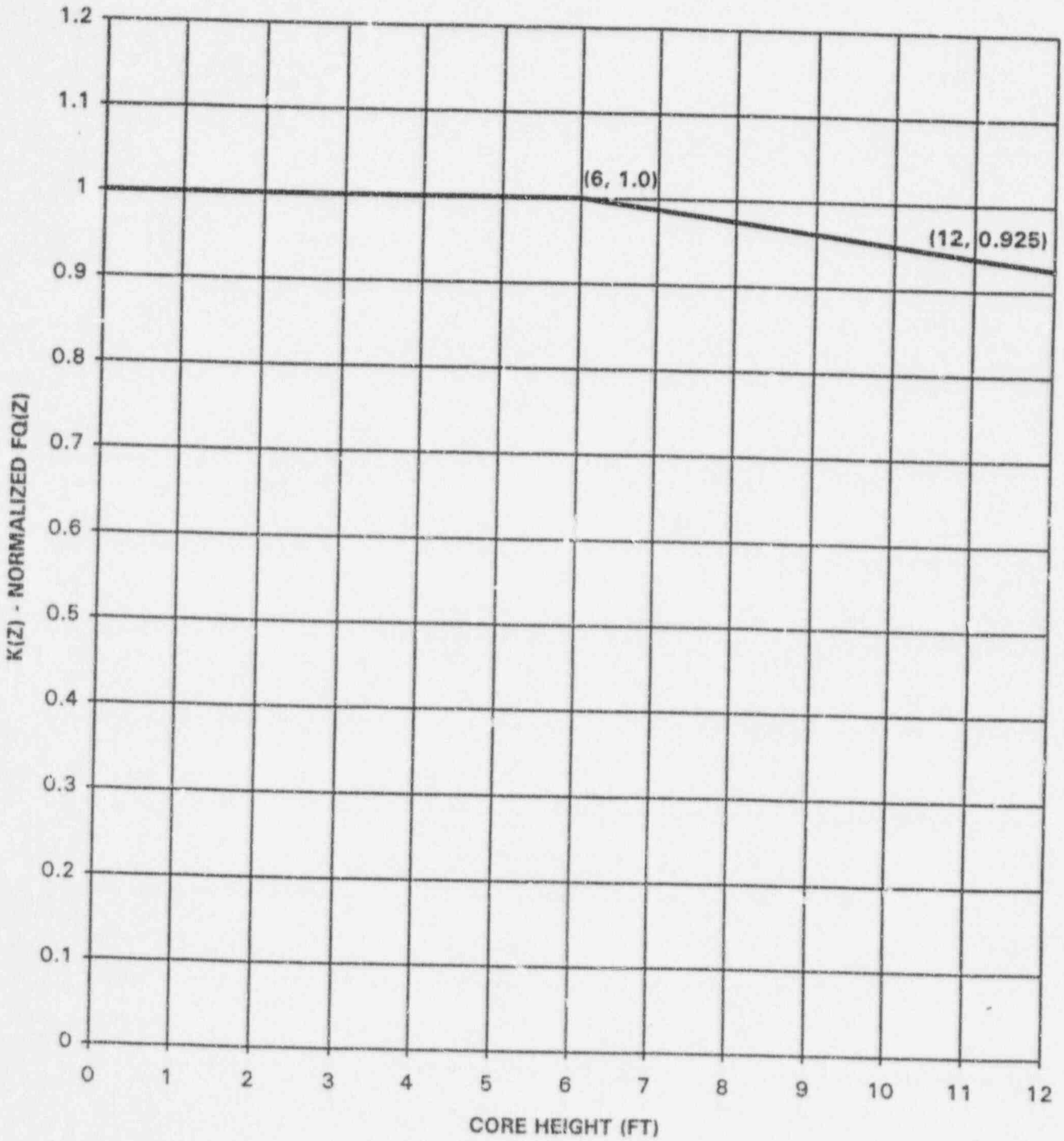


Figure 4

N1C13 NON-EQUILIBRIUM MULTIPLIER
0 - 1000 MWD/MTU BURNUP

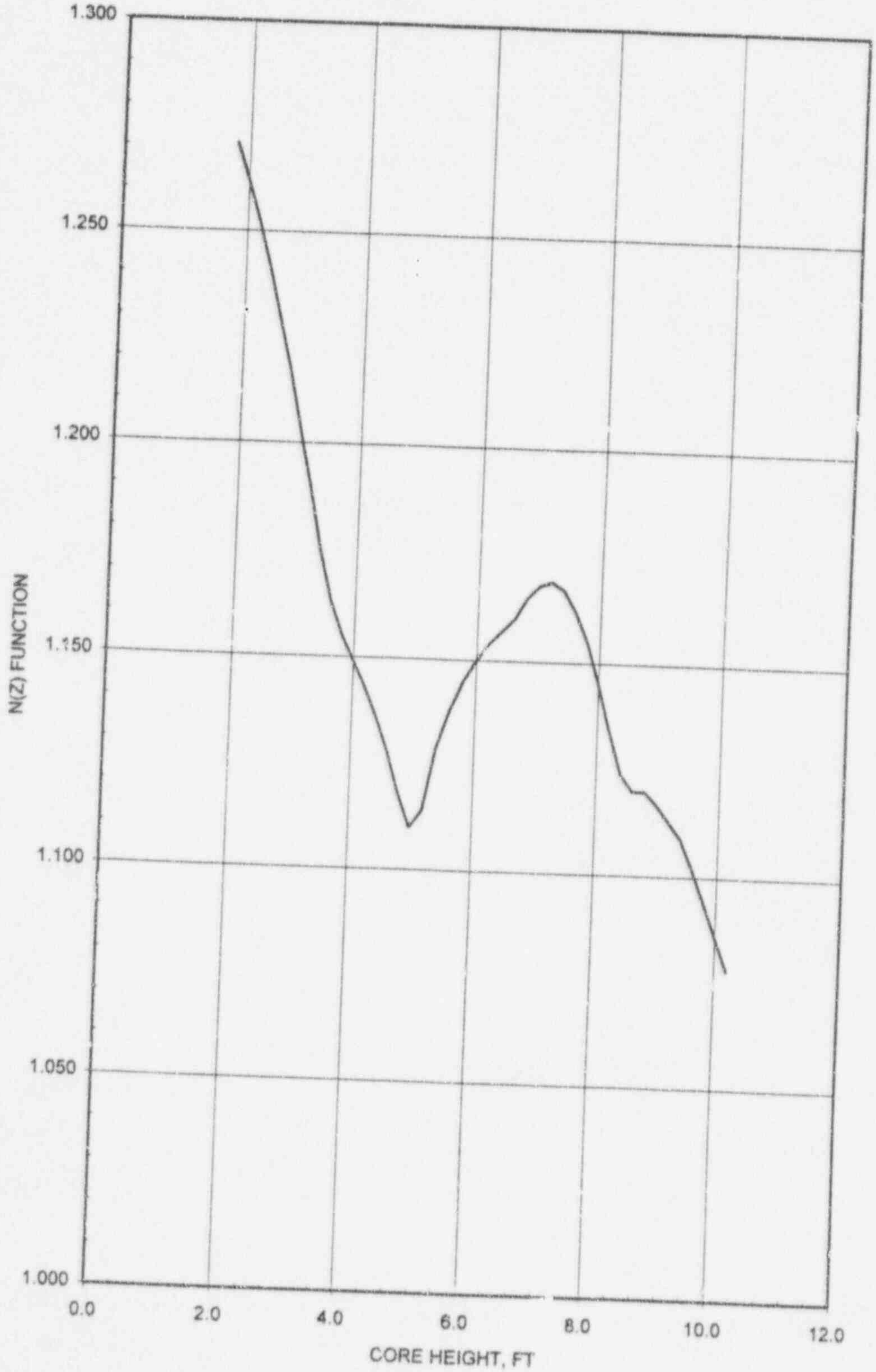


Figure 5

N1C13 NON-EQUILIBRIUM MULTIPLIER
1000 - 3000 MWD/MTU BURNUP

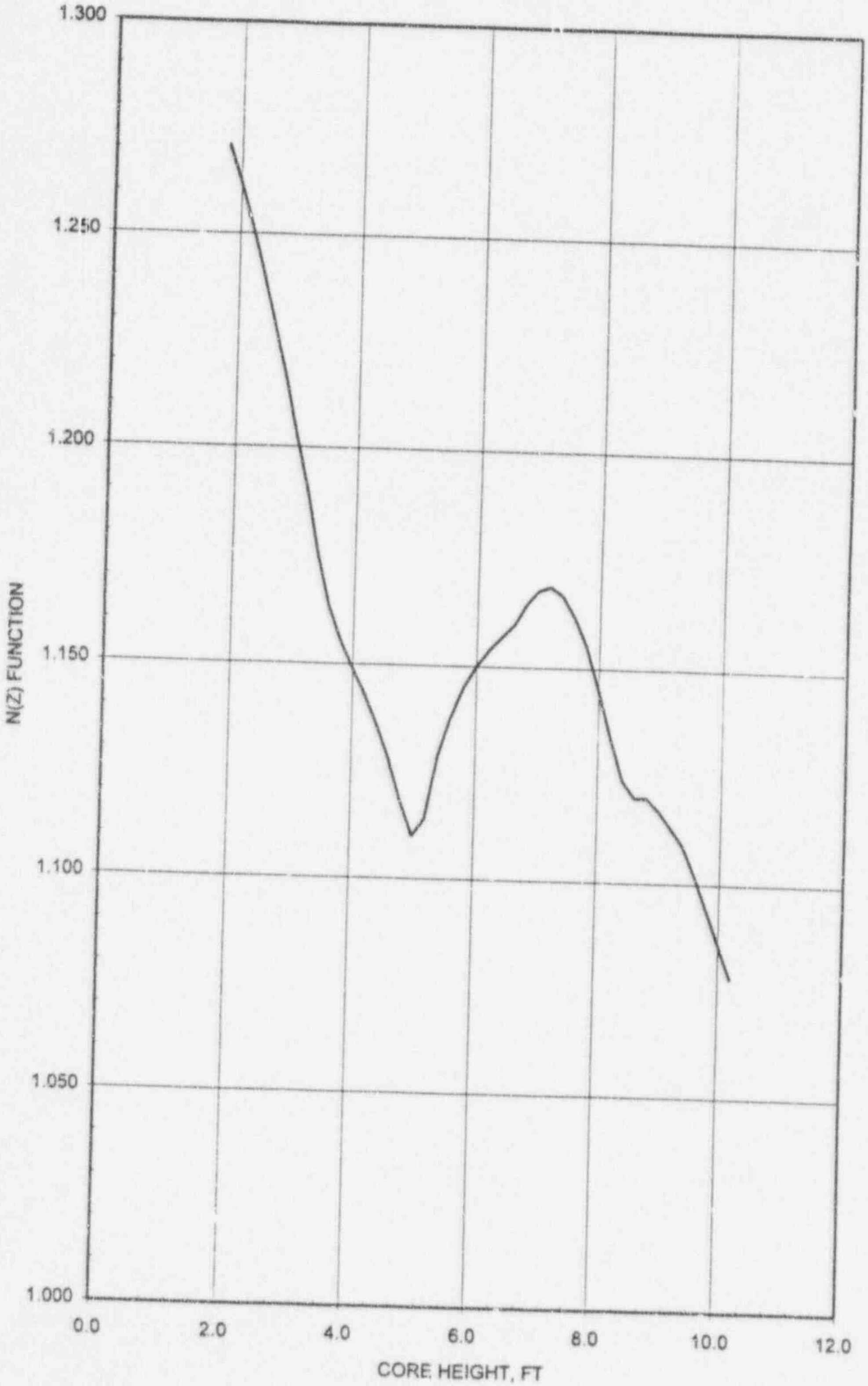


Figure 6

N1C13 NON-EQUILIBRIUM MULTIPLIER
3000 - 5000 MWD/MTU BURNUP

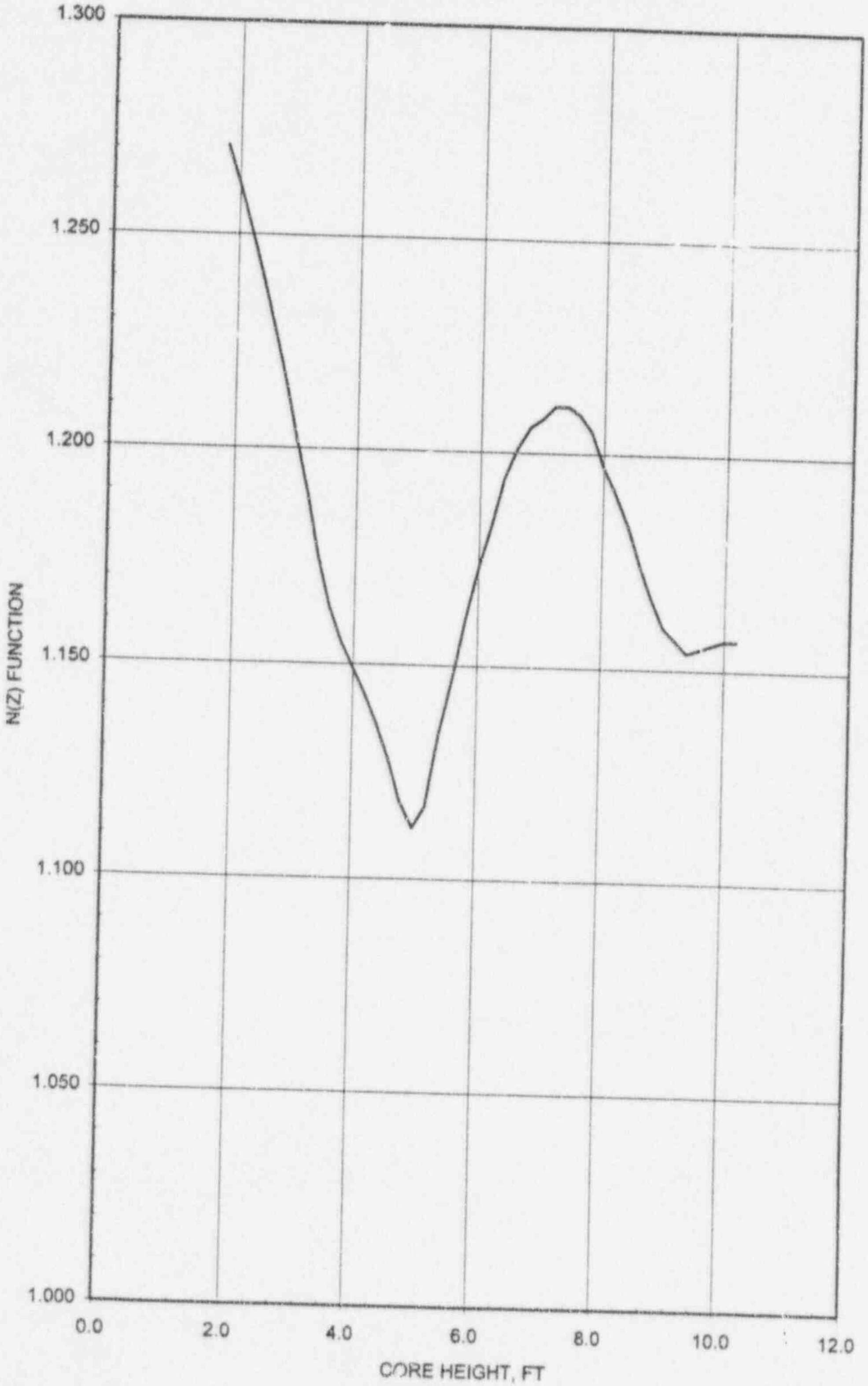


Figure 7

N1C13 NON-EQUILIBRIUM MULT:PLIER
5000 - 7000 MWD/MTU BURNUP

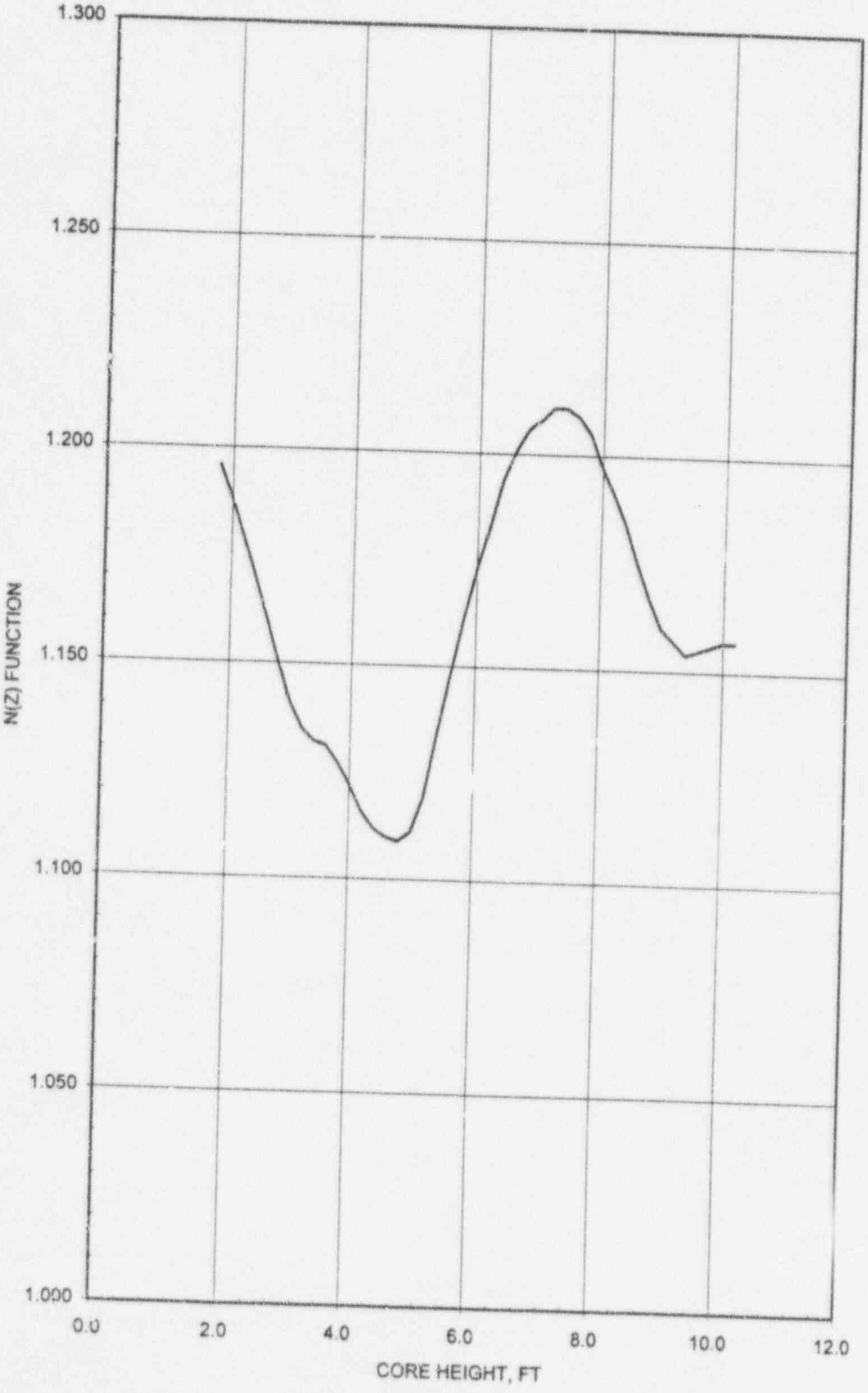
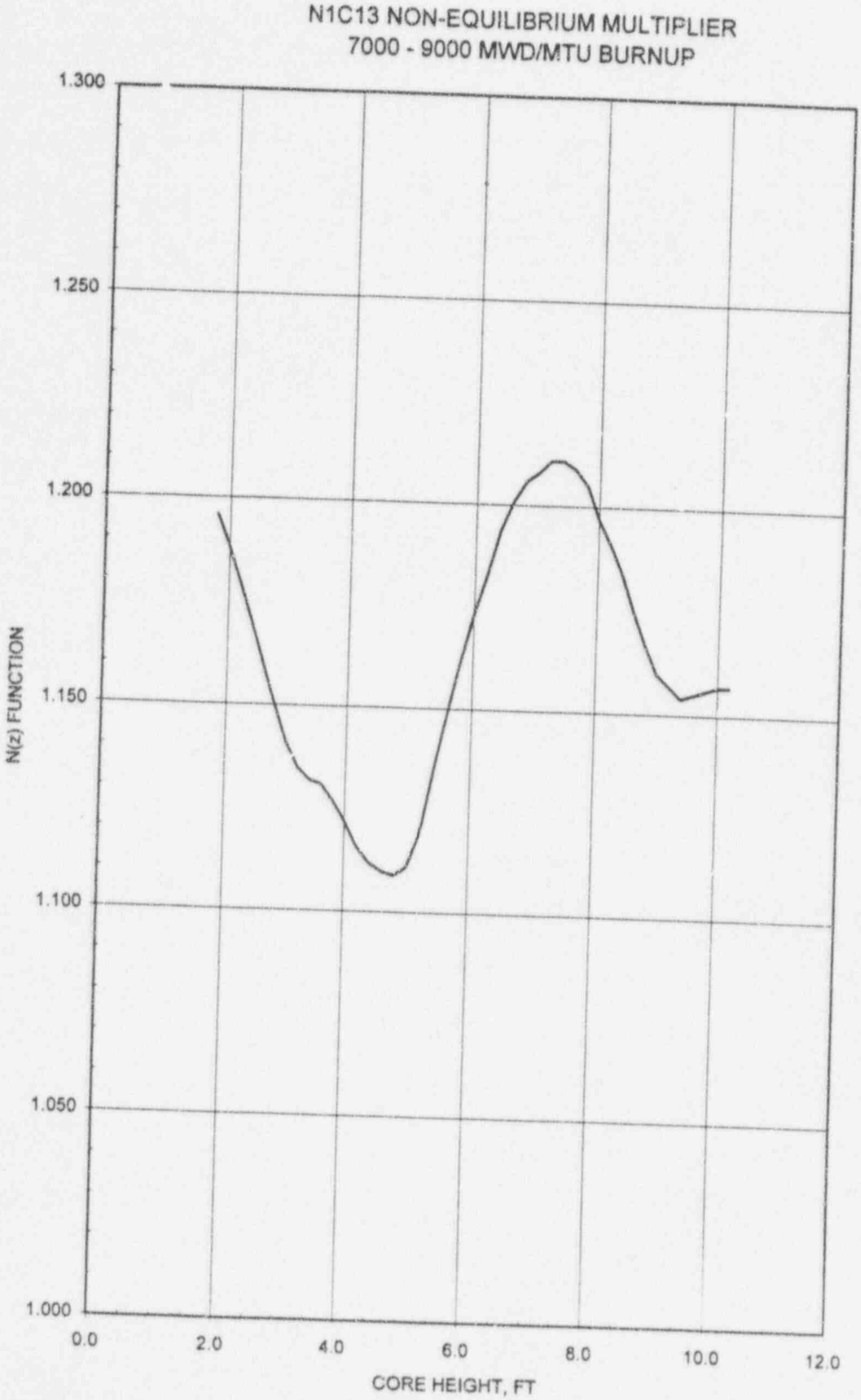


Figure 8



N1C13 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

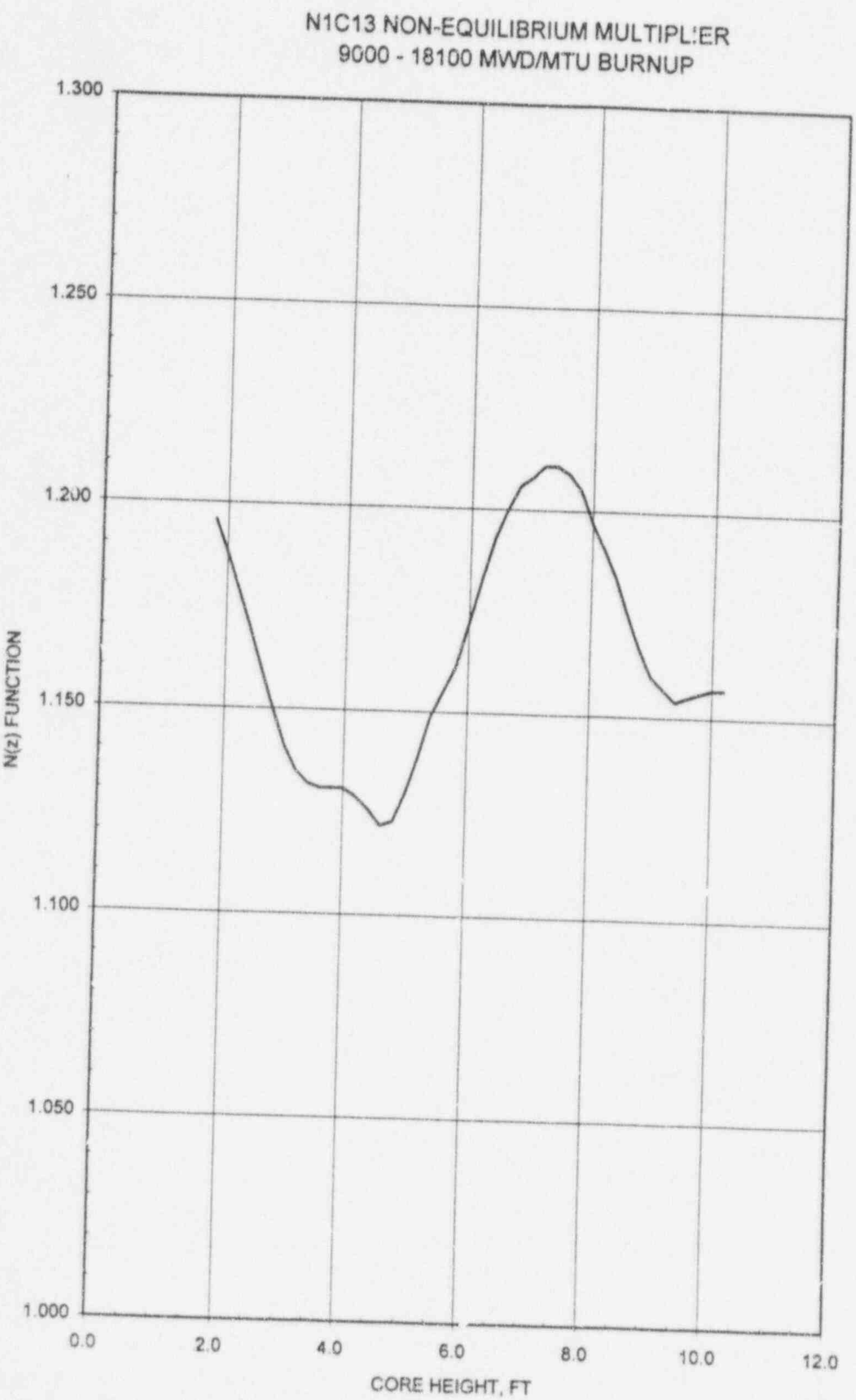

N1C13 NON-EQUILIBRIUM MULTIPL!ER
9000 - 18100 MWD/MTU BURNUP
1.300
1.250
1.200
1.150
1.100
1.050
1.000
N(z) FUNCTION
0.0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT, FT

Figure 10

N1C13 NON-EQUILIBRIUM MULTIPLIER
18100 MWD/MTU to EOC