CORE OPERATING LIMITS REPORT

North Anna 1 Cycle 12 Pattern BL

Revision 0

February 1996

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 1 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 1 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 $\Delta k/k/^0F$ below 70 percent of RATED THERMAL POWER.

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

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

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 $\Delta k/k/^0F$.

The 60 ppm/ARO/RTP-MTC should be less negative than or equal to -4.7E-04 $\Delta k/k/^0F$.

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2.2.1 The shutdown rods shall be withdrawn to at least 225 steps.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

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

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

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

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. Values for N(Z) are provided in Table 1 and plotted in Figures 4 through 10. Values of N(Z) for the top and bottom 15% of the core are 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

N1C12 Normal Operation N(z) Curves

NODE	HEIGHT (FEET)	0 MWD/T to 1000 MWD/T	1000 MWD/T to 3000 MWD/T	3000 MWD/T to 5000 MWD/T	5000 MWD/T to 7000 MWD/T	7000 MWD/T to 9000 MWD/T	9000 MWD/T to 17800 MWD/T	17800 MWD/T and beyond
10	10.2	1.159	1.159	1.177	1.177	1.177	1.177	1.175
11	10.0	1.152	1.152	1.173	1.173	1.173	1.173	1.172
12	9.8	1.143	1.143	1.168	1.168	1.168	1.168	1.167
13	9.6	1.136	1.136	1.173	1.173	1.173	1.173	1.165
14	9.4	1.132	1.132	1.177	1.177	1.177	1.177	1.164
15	9.2	1.131	1.131	1.188	1.188	1.188	1.188	1.171
16	9.0	1.131	1.131	1.199	1.199	1.199	1.199	1.179
17	8.8	1.137	1.137	1.208	1.208	1.208	1.208	1.190
18	8.6	1.142	1.142	1.217	1.217	1.217	1.217	1.200
19	8.4	1.145	1.145	1.222	1.222	1.222	1.221	1.208
20	8.2	1.147	1.147	1.226	1.226	1.226	1.225	1.214
21	8.0	1.148	1.148	1.227	1.227	1.227	1.227	1.219
22	7.8	1.149	1.149	1.227	1.227	1.227	1.228	1.226
23	7.6	1.148	1.148	1.224	1.224	1.224	1.230	1.231
24	7.4	1.146	1.146	1.220	1.220	1.220	1.233	1.233
25	7.2	1.144	1.144	1.215	1.215	1.215	1.234	1.234
26	7.0	1.140	1.140	1.210	1.210	1.210	1.235	1.235
27	6.8	1.135	1.135	1.203	1.203	1.203	1.236	1.236
28	6.6	1.128	1.128	1.192	1.192	1.192	1.234	1.234
29	6.4	1.120	1.120	1.179	1.179	1.179	1.231	1.231
30	6.2	1.111	1.111	1.165	1.165	1.165	1.223	1.223
31	6.0	1.100	1.100	1.154	1.154	1.154	1.216	1.216
32	5.8	1.091	1.091	1.146	1.146	1.146	1.202	1.202
33	5.6	1.085	1.085	1.135	1.135	1.135	1.188	1.188
34	5.4	1.087	1.087	1.125	1.126	1.126	1.167	1.168
35	5.2	1.090	1.090	1.116	1.116	1.116	1.142	1.142
36	5.0	1.097	1.097	1.113	1.114	1.114	1.125	1.124
37	4.8	1.107	1.107	1.116	1.117	1.117	1.121	1.121
38	4.6	1.119	1.119	1.122	1.122	1.122	1.125	1.125
39	4.4	1.129	1.129	1.129	1.124	1.124	1.129	1.129
40	4.2	1.138	1.138	1.137	1.124	1.124	1.134	1.134
41	4.0	1.147	1.147	1.147	1.124	1.124	1.136	1.136
42	3.8	1.157	1.157	1.157	1.122	1.122	1.138	1.138
43	3.6	1.167	1.167	1.167	1.124	1.124	1.138	1.138
44	3.4	1.179	1.179	1.179	1.125	1.125	1.137	1.137
45	3.2	1.191	1.191	1.191	1.126	1.126	1.135	1.135
46	3.0	1.202	1.202	1.202	1.125	1.125	1.132	1.132
47	2.8	1.212	1.212	1.212	1.126	1.126	1.131	1.131
48	2.6	1.221	1.221	1.221	1.130	1.130	1.136	1.136
49	2.4	1.229	1.229	1.229	1.136	1.136	1.145	1.145
50	2.2	1.237	1.237	1.237	1.143	1.143	1.153	1.153
51	2.0	1.244	1.244	1.244	1.150	1.150	1.162	1.162
52	1.8	1.250	1.250	1.250	1.155	1.155	1.169	1.169

FIGURE 1

North Anna 1 Cycle 12
Control Rod Bank Insertion Limits

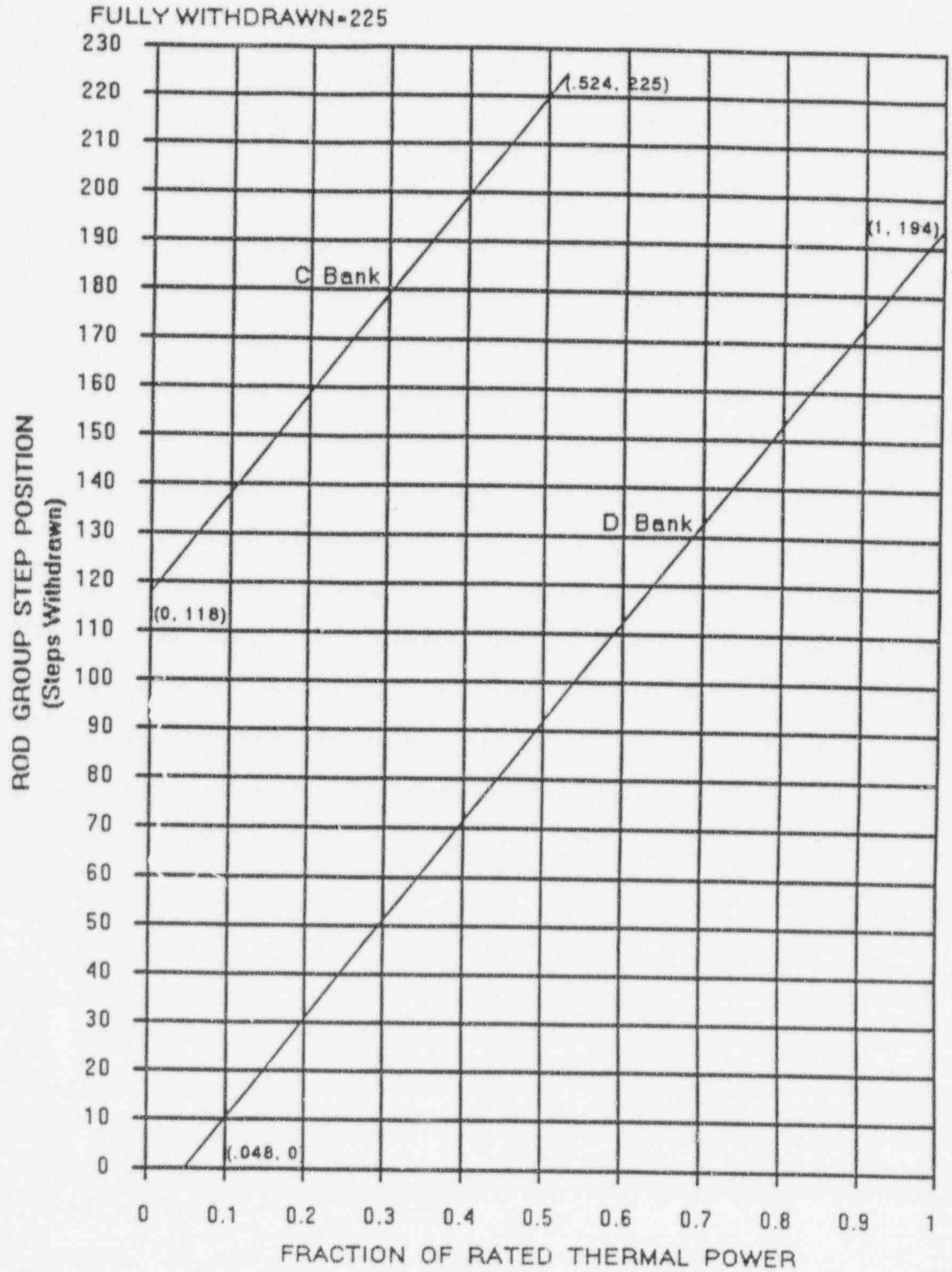

FIGURE 2a
N1C12 AXIAL FLUX DIFFERENCE LIMITS
AS A FUNCTION OF RATED THERMAL POWER
(BOC to 5000 MWD/MTU)

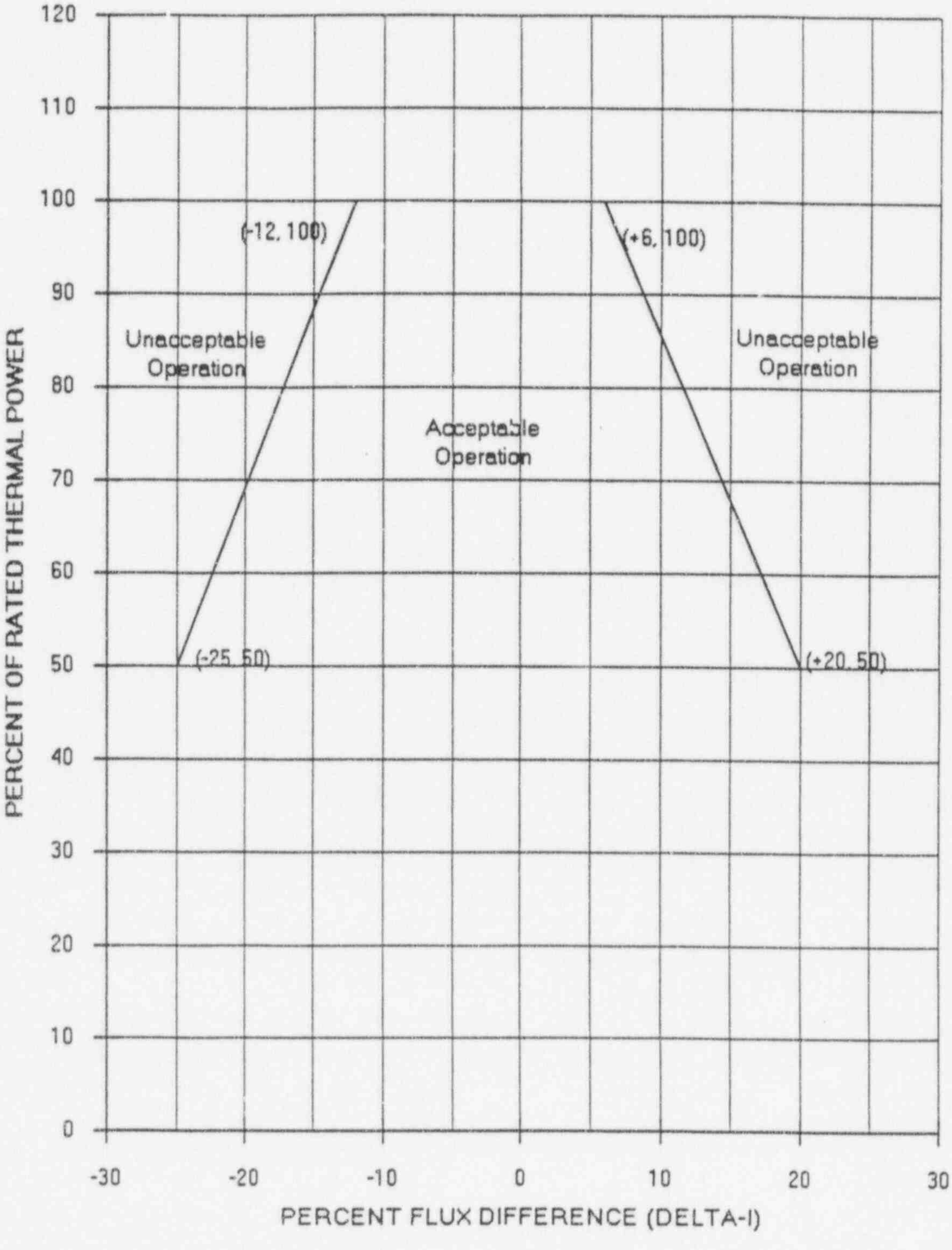

FIGURE 2b
N1C12 AXIAL FLUX DIFFERENCE LIMITS
AS A FUNCTION OF RATED THERMAL POWER
(5000 MWD/MTU to EOC)

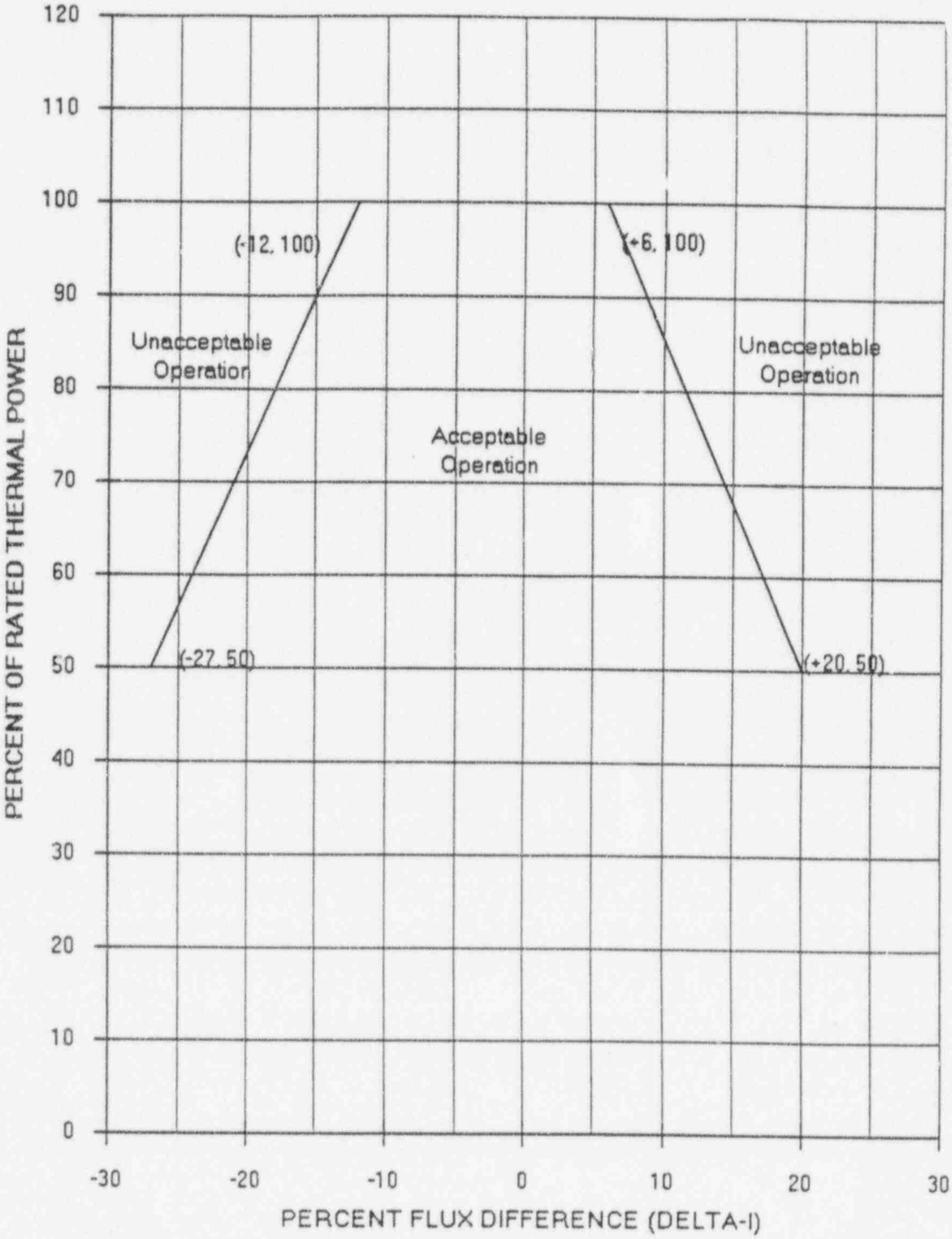

FIGURE 3

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

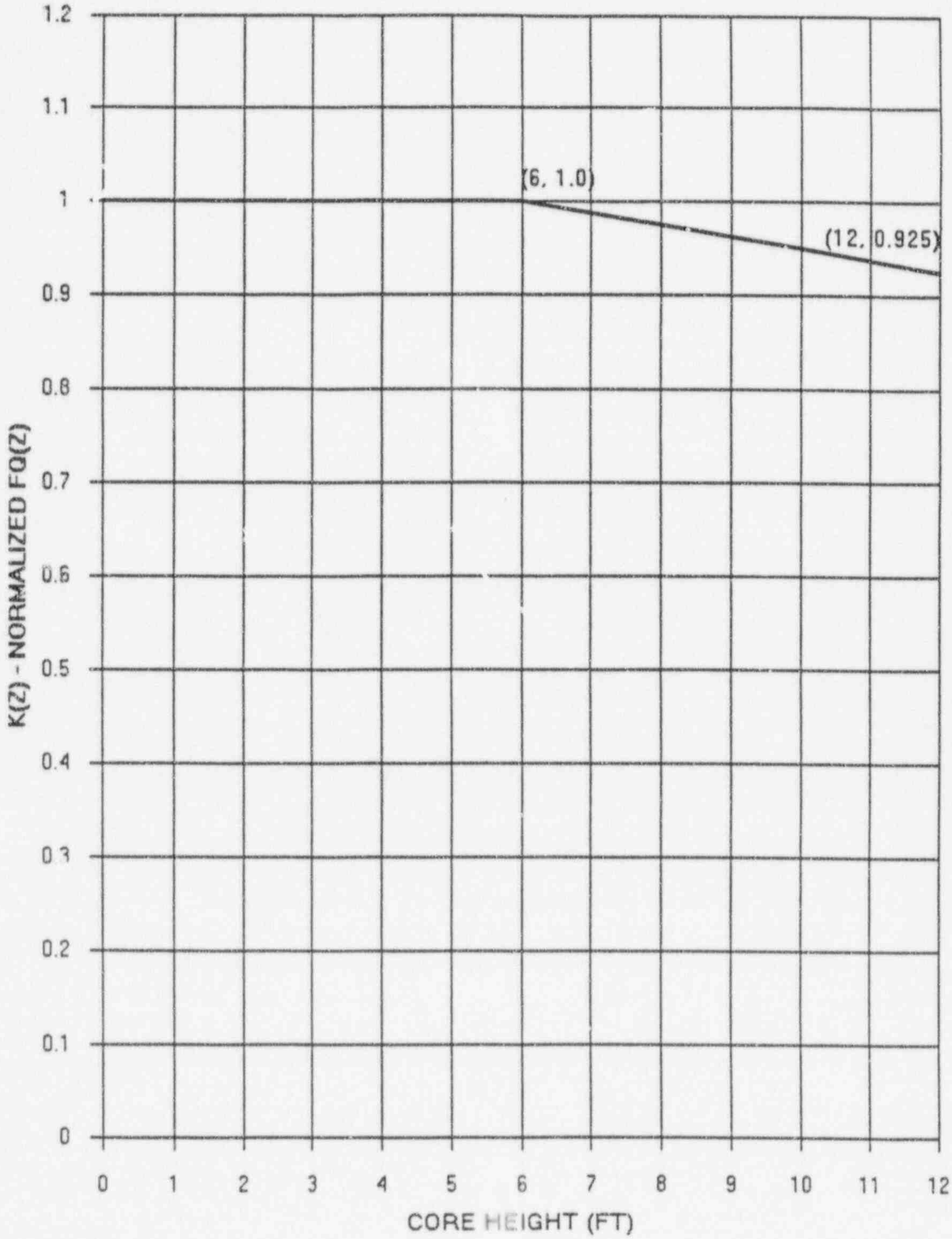

FIGURE 4
N1C12 NON-EQUILIBRIUM MULTIPLIER
0 - 1000 MWD/MTU BURNUP

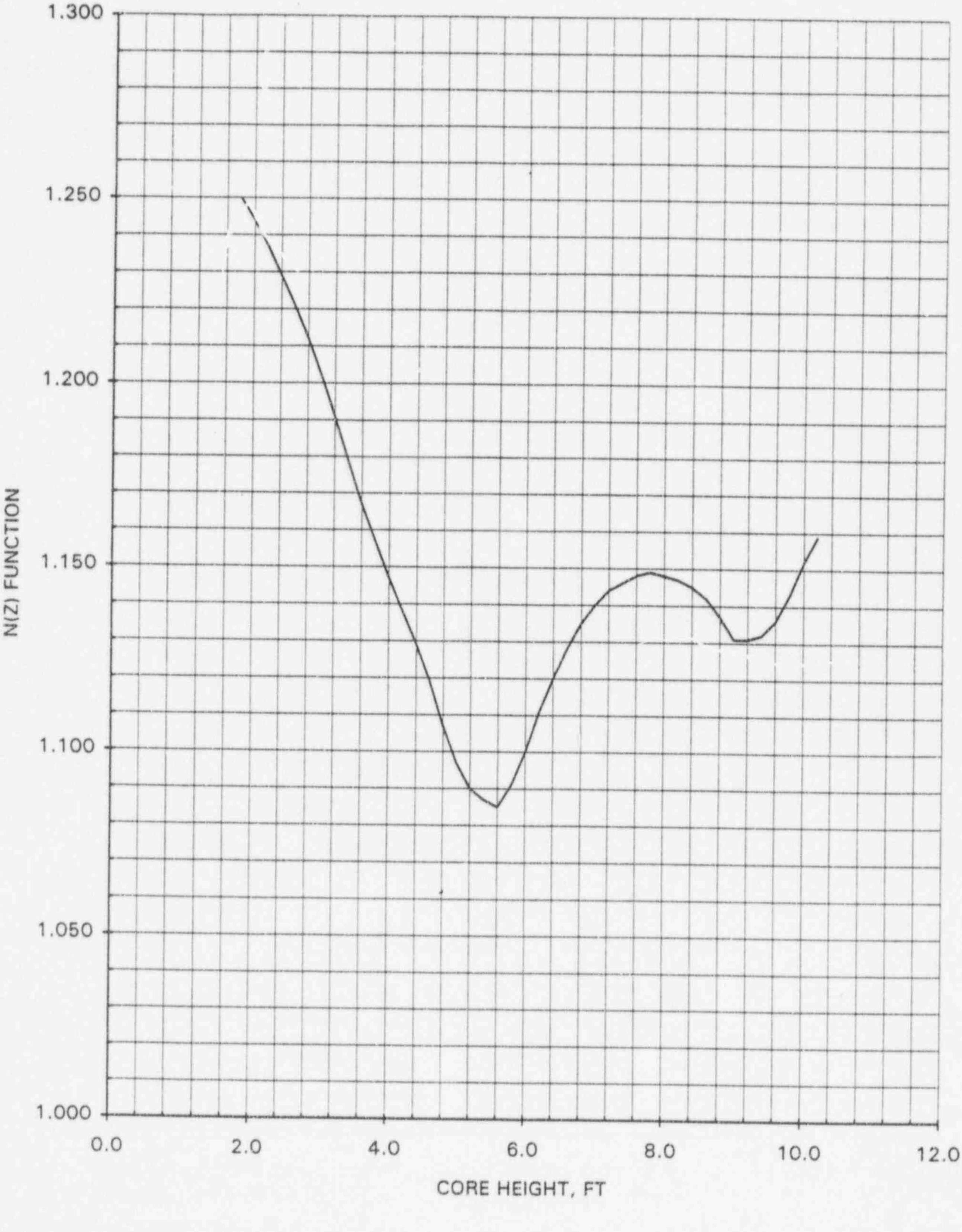

FIGURE 5
N1C12 NON-EQUILIBRIUM MULTIPLIER
1000 - 3000 MWD/MTU BURNUP

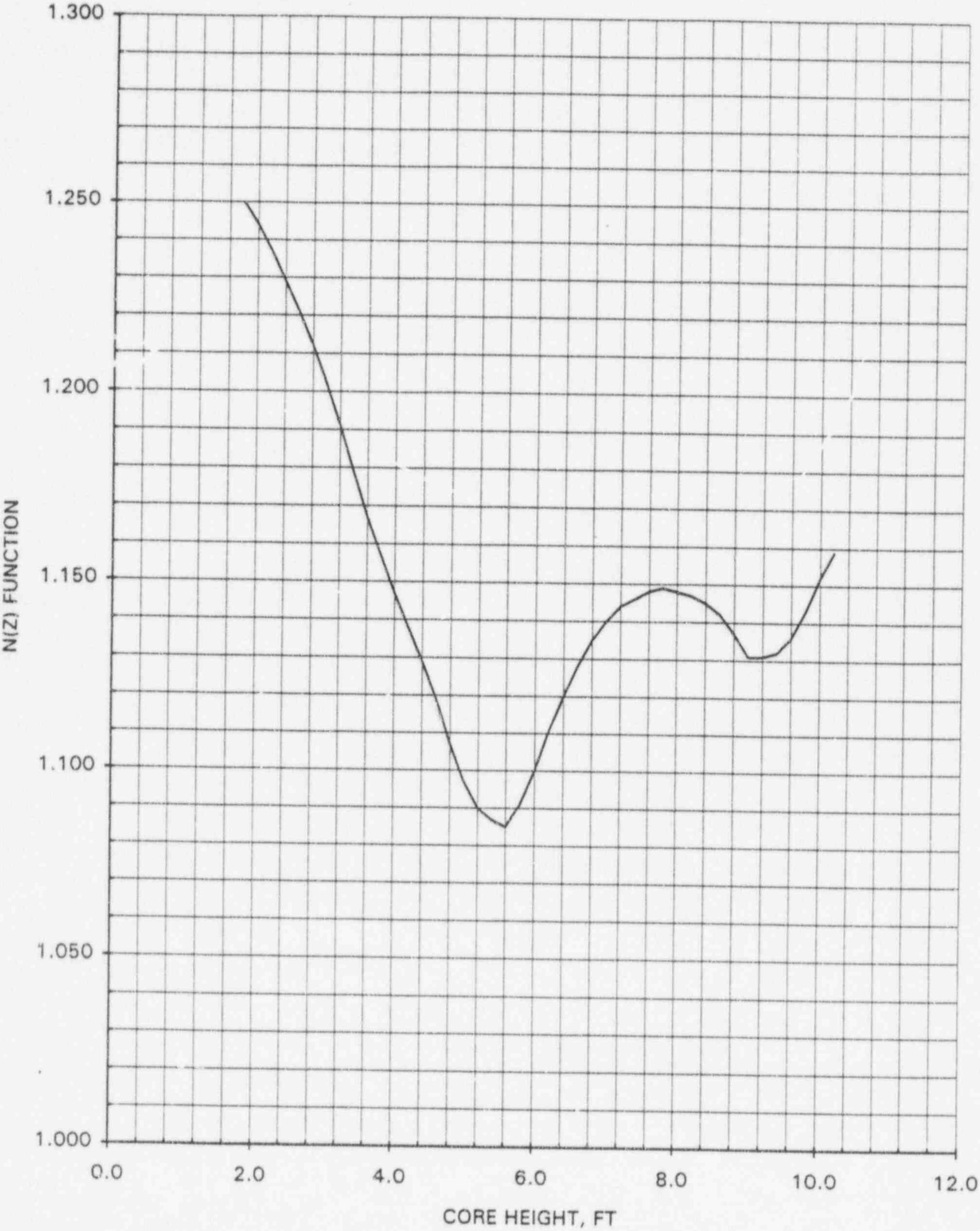

FIGURE 6
N1C12 NON-EQUILIBRIUM MULTIPLIER
3000 - 5000 MWD/MTU BURNUP

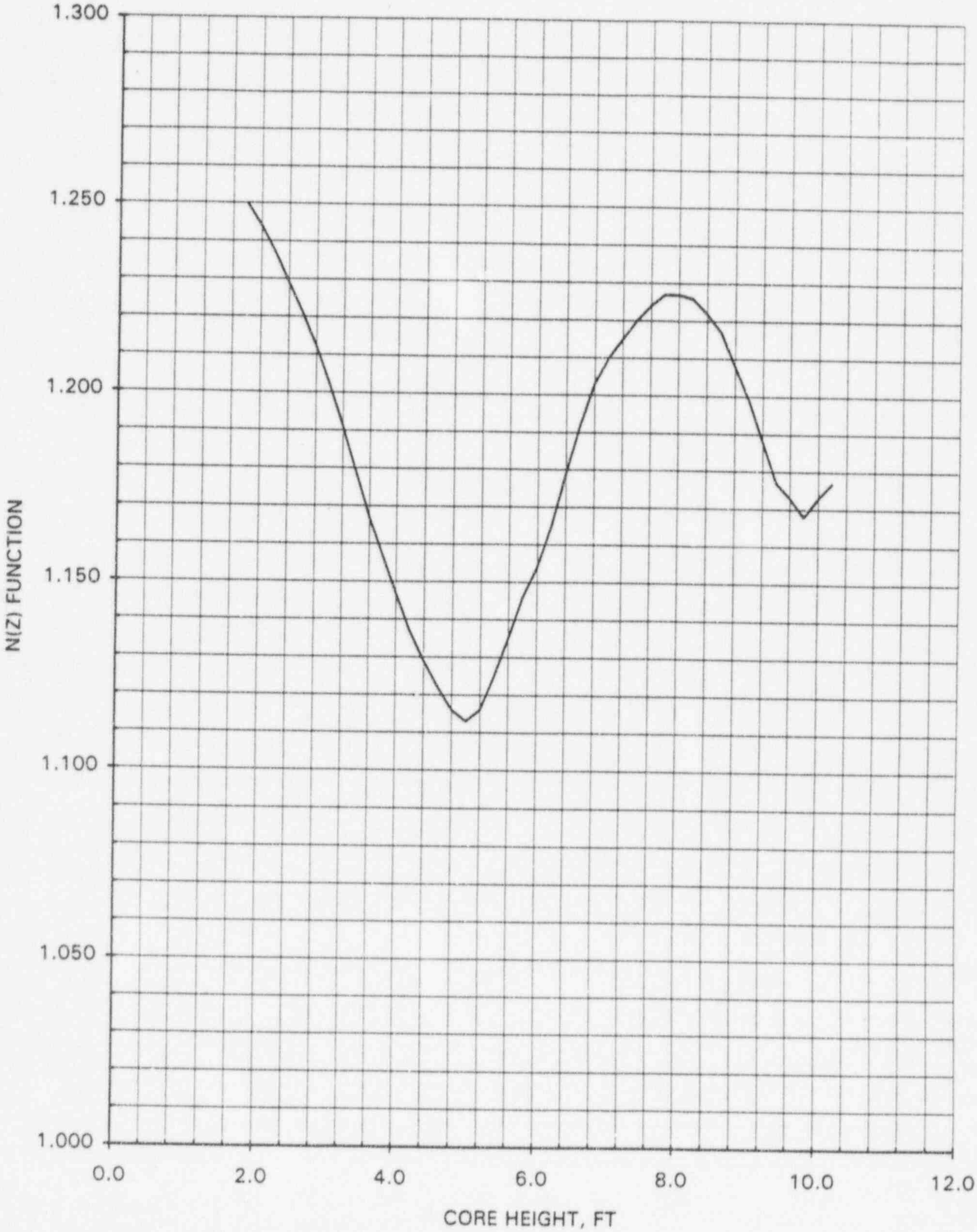

FIGURE 7
N1C12 NON-EQUILIBRIUM MULTIPLIER
5000 - 7000 MWD/MTU BURNUP

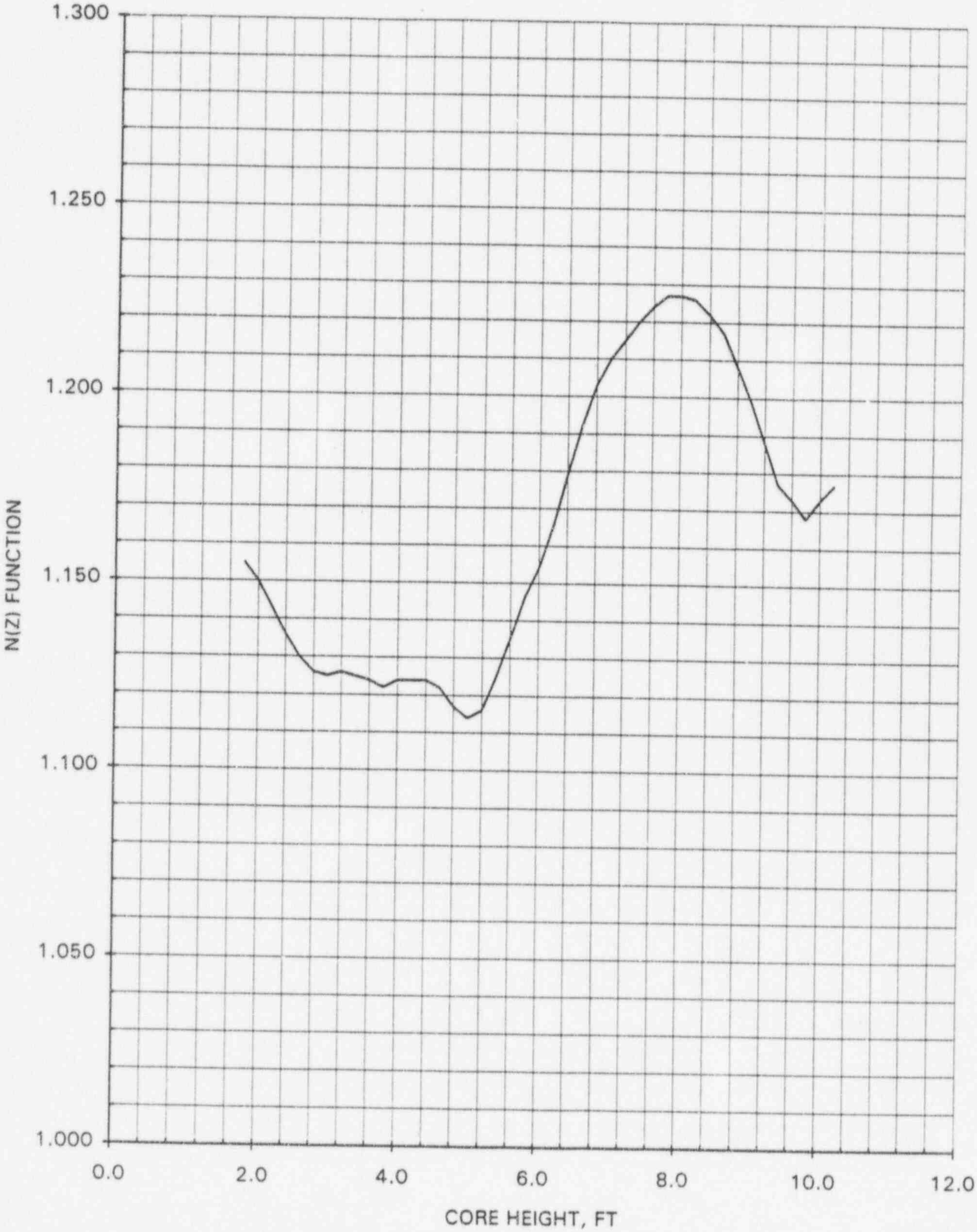

FIGURE 8

N1C12 NON-EQUILIBRIUM MULTIPLIER

7000 - 9000 MWD/MTU BURNUP

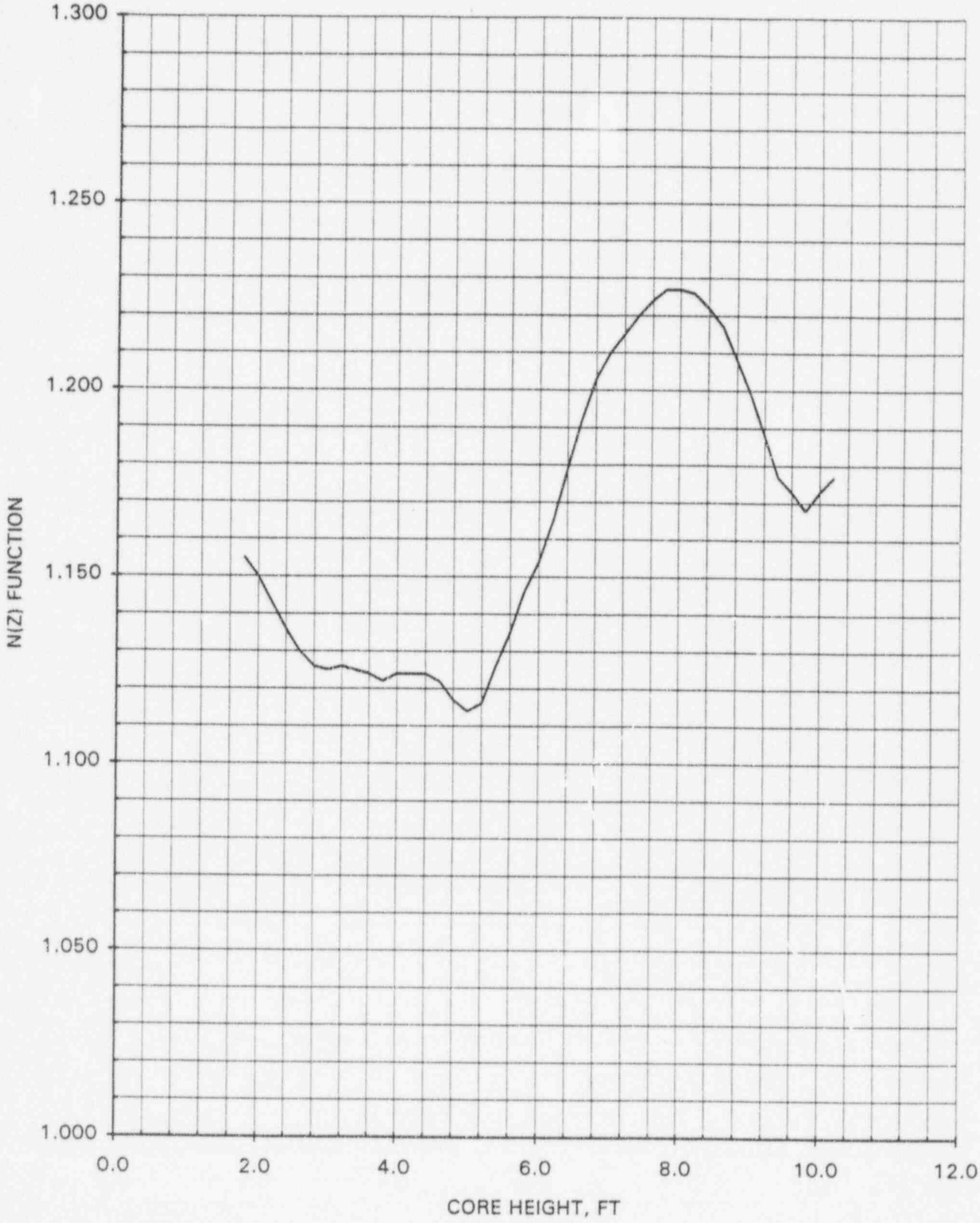

FIGURE 9
N1C12 NON-EQUILIBRIUM MULTIPLIER
9000 - 17800 MWD/MTU BURNUP

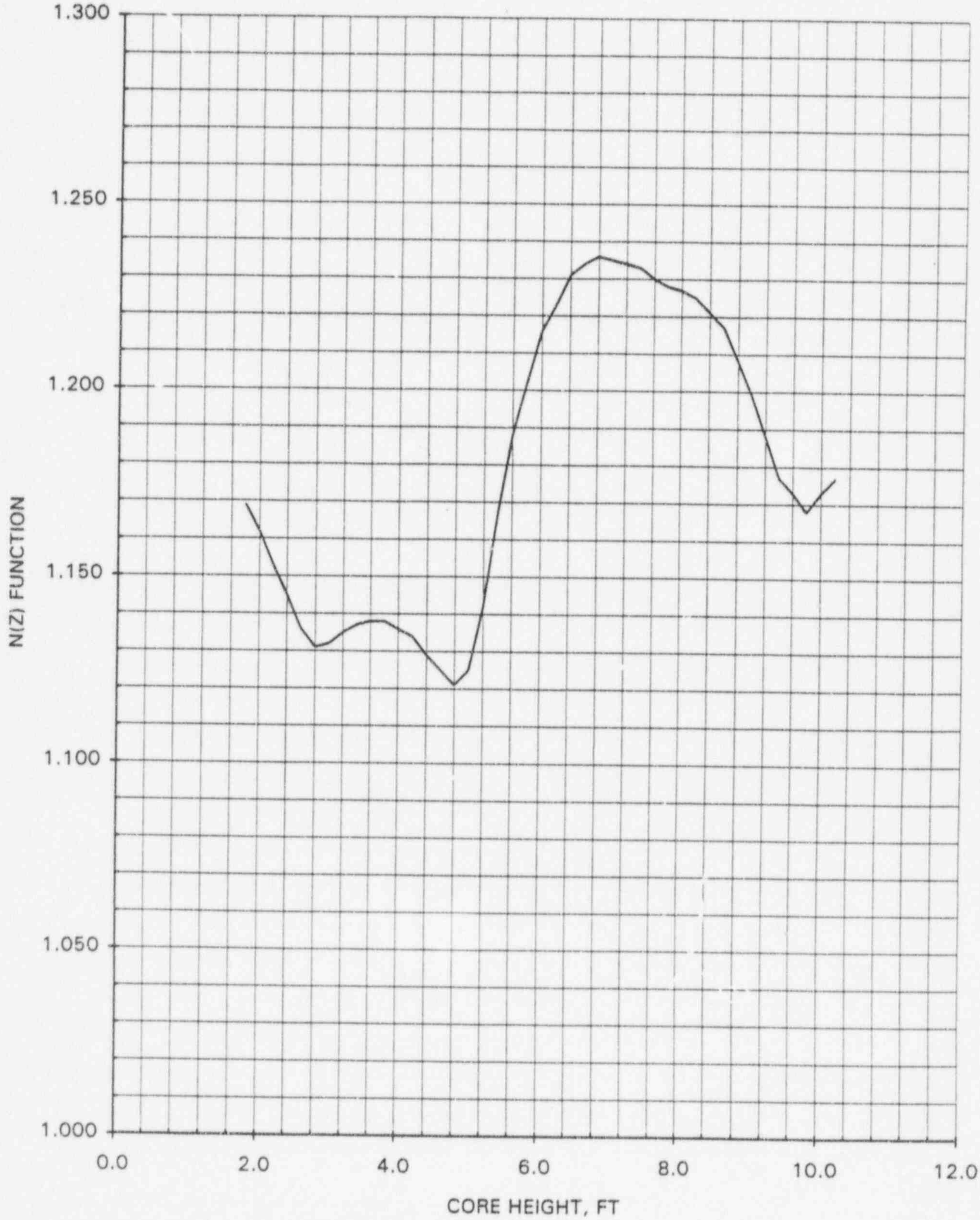

FIGURE 10
N1C12 NON-EQUILIBRIUM MULTIPLIER
>17800 MWD/MTU BURNUP