

CORE OPERATING LIMITS REPORT (COLR)  
NORTH ANNA 1 CYCLE 10 PATTERN VN  
REVISION 0 (FEBRUARY, 1993)

CORE OPERATING LIMITS REPORT (COLR)  
N1C10 PATTERN VN

1.0 INTRODUCTION

The Core Operating Limits Report (COLR) for North Anna Unit 1 Cycle 10 has been prepared in accordance with the requirements of 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 10 for the specifications listed above are provided in 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  $+0.6E-4 \Delta k/k/^{\circ}F$  below 70 percent of RATED THERMAL POWER.

The BOC/ARO-MTC shall be less positive than or equal to  $0.0E-4 \Delta k/k/^{\circ}F$  at or above 70 percent of RATED THERMAL POWER.

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

#### 2.1.2 The MTC Surveillance limits are:

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

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

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)

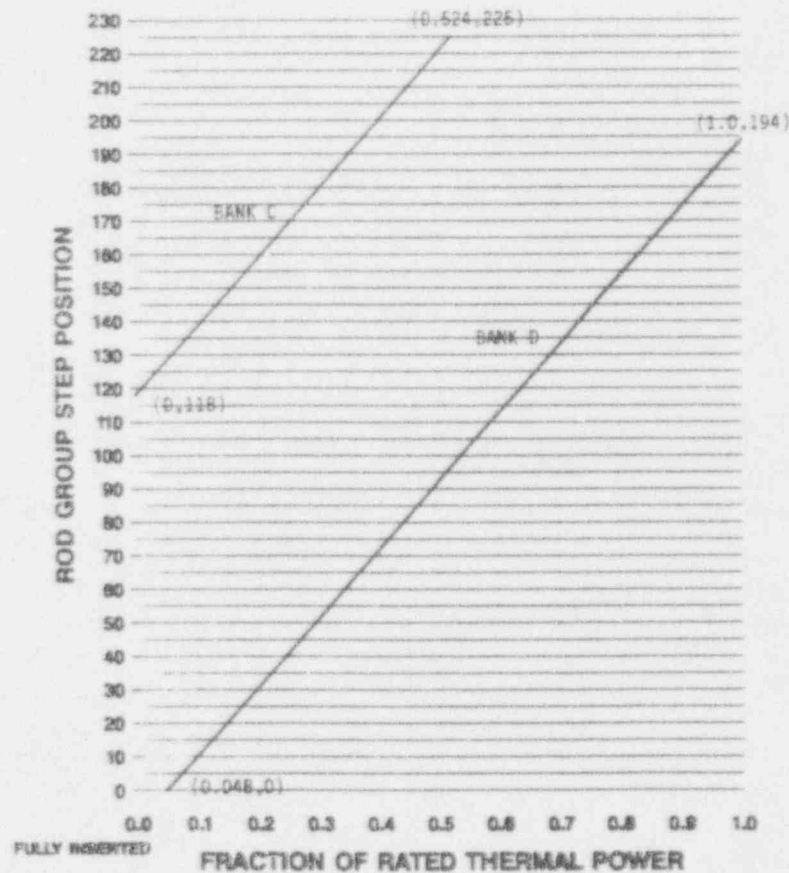
2.2.1 The shutdown rods shall be withdrawn to at least 225 steps.

## 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.

FIGURE 1  
NORTH ANNA UNIT 1 CYCLE 10  
CONTROL ROD BANK INSERTION LIMITS VS. PERCENT RATED THERMAL POWER

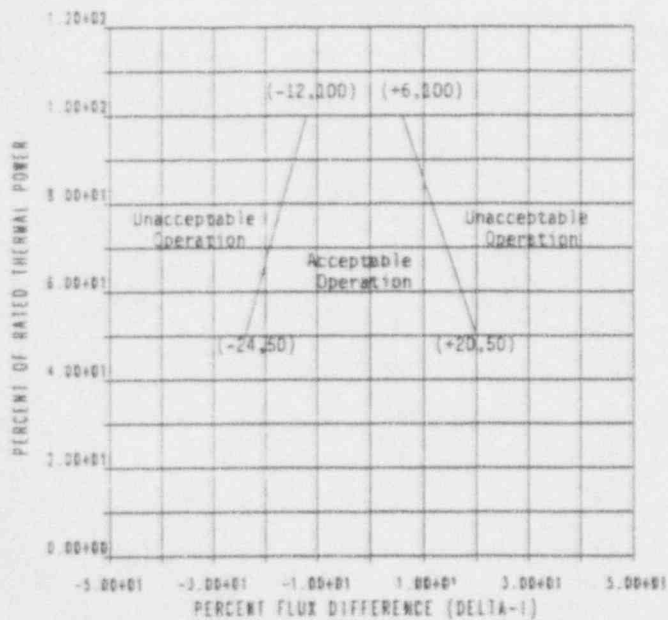
FULLY WITHDRAWN = 225



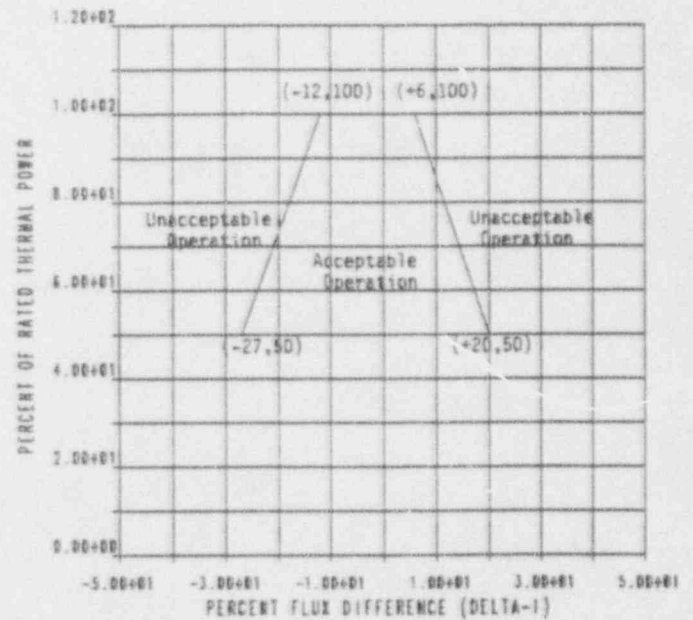
## 2.4 Axial Flux Difference (Specification 3/4.2.1)

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

FIGURE 2  
AXIAL FLUX DIFFERENCE LIMITS  
AS A FUNCTION OF RATED THERMAL POWER



N1C10/VN AFD LIMITS - BOC TO 7000 MWd/MTU



N1C10/VN AFD LIMITS - 7000 MWd/MTU TO EOC

## 2.5 Heat Flux Hot Channel Factor-FQ(Z) (Specification 3/4.2.2)

2.5.1 The  $F_Q(Z)$  limits are:

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

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

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:

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

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

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

$K(Z)$  is provided in Figure 3, and

$N(Z)$  values are provided in Figure 4

FIGURE 3  
K(Z) - NORMALIZED FQ AS A FUNCTION OF CORE HEIGHT

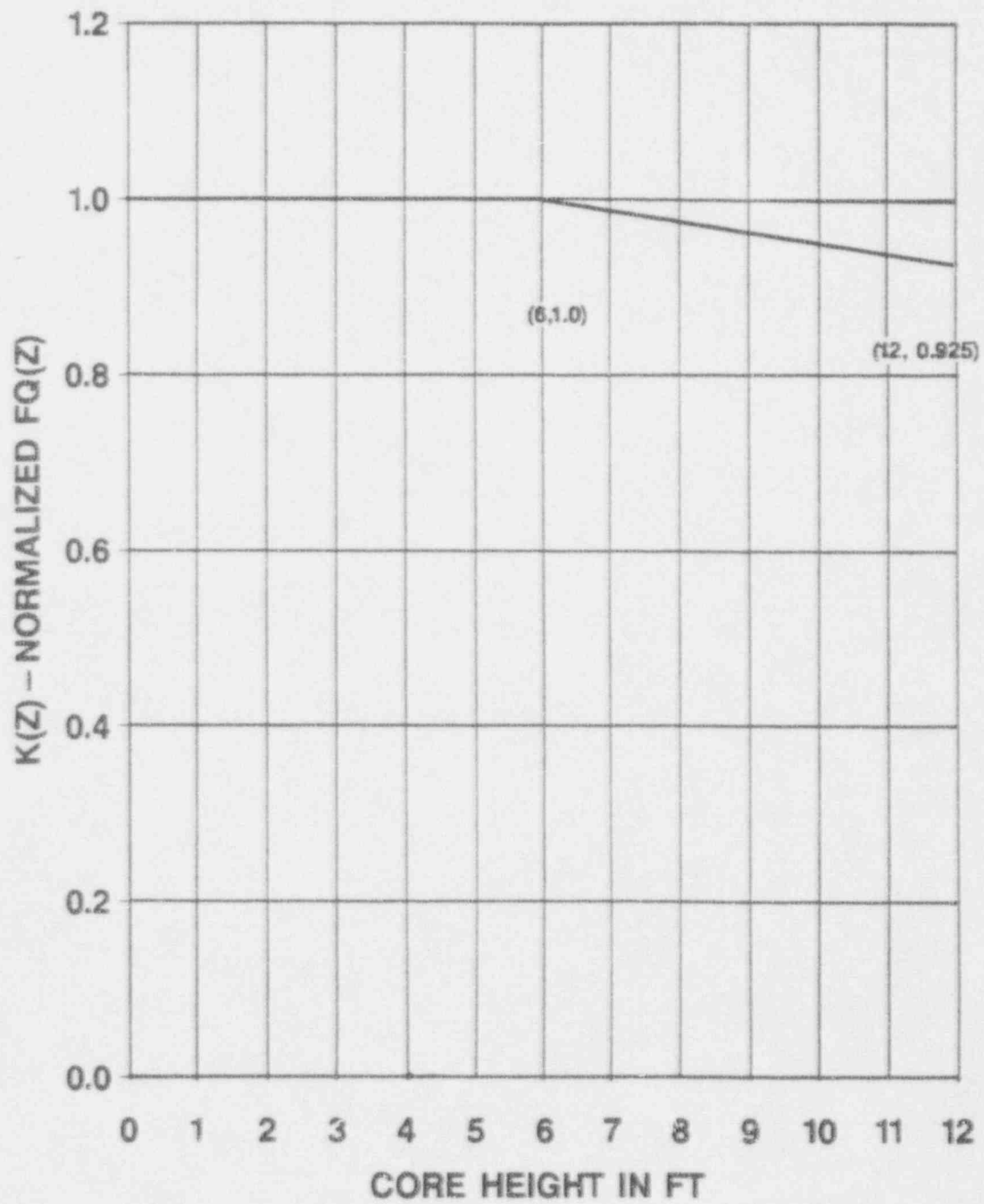
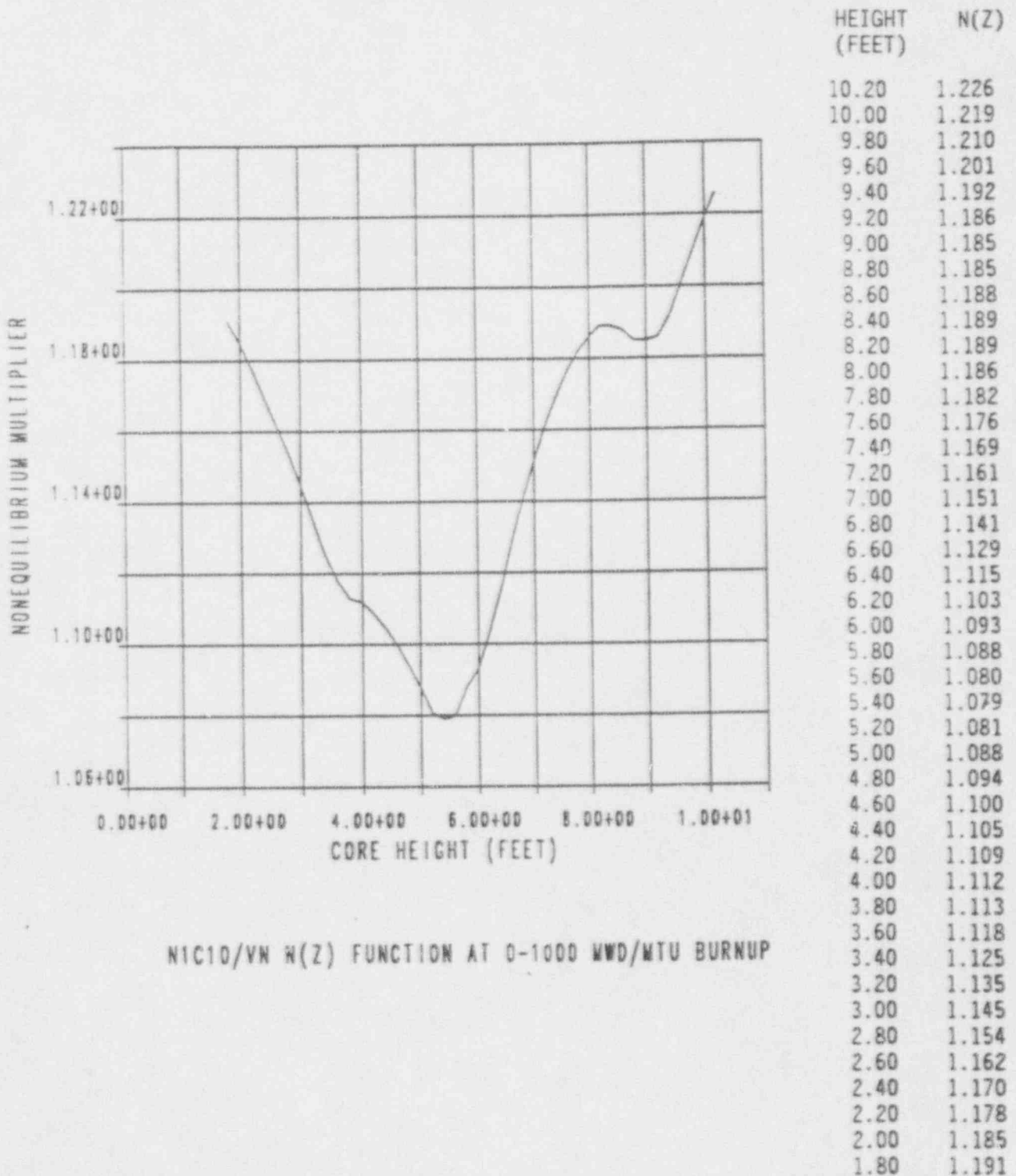


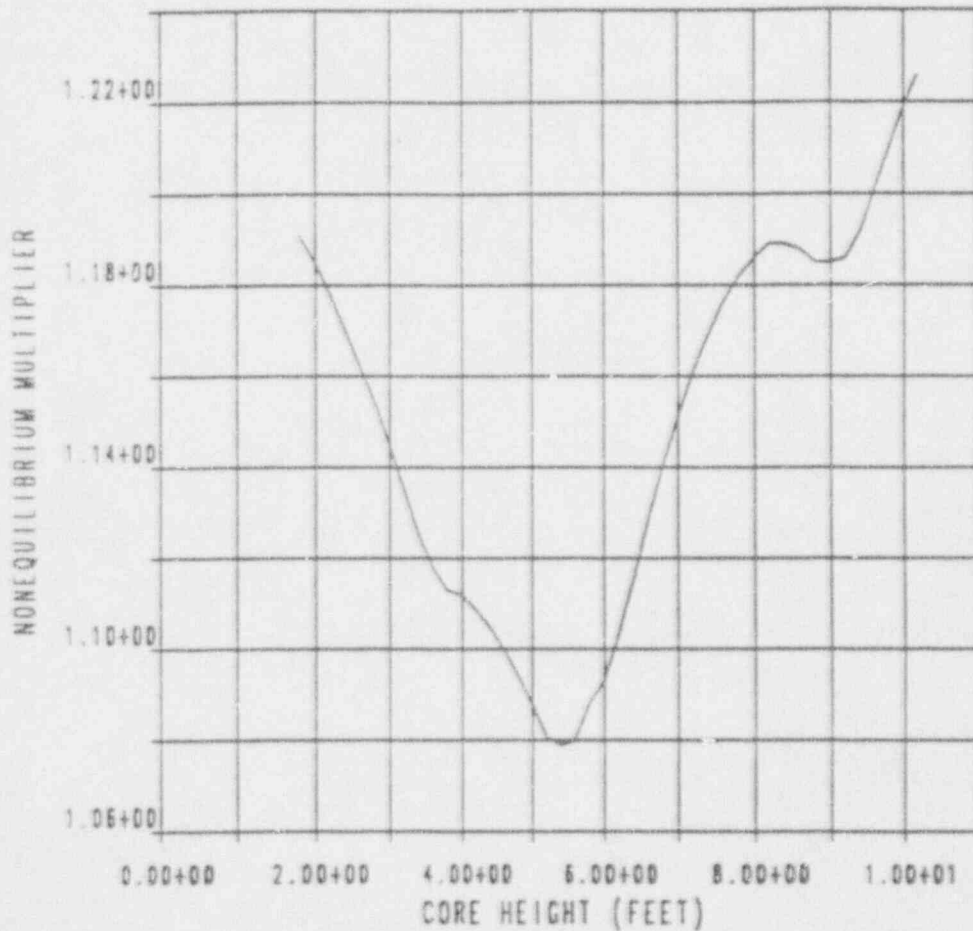
FIGURE 4  
N(Z) FUNCTION FOR N1C10  
FROM 0 to 1000 MWD/MTU BURNUP  
TOP AND BOTTOM 15 PERCENT EXCLUDED  
AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 0-1000 MWD/MTU BURNUP



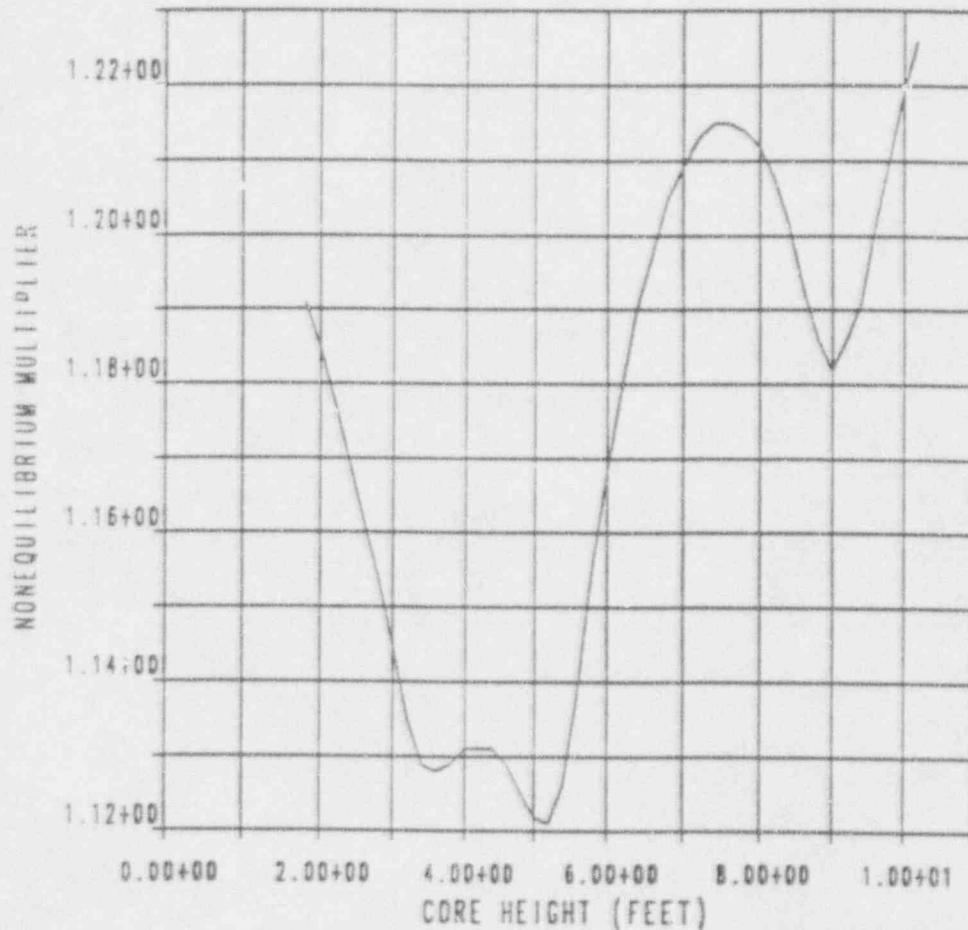
FIGURE 4 (CONTINUED)  
 N(Z) FUNCTION FOR N1C10  
 FROM 1000 to 3000 MWD/MTU BURNUP  
 TOP AND BOTTOM 15 PERCENT EXCLUDED  
 AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 1000-3000 MWD/MTU BURNUP

HEIGHT (FEET)	N(Z)
10.20	1.226
10.00	1.219
9.80	1.210
9.60	1.201
9.40	1.192
9.20	1.186
9.00	1.185
8.80	1.185
8.60	1.188
8.40	1.189
8.20	1.189
8.00	1.186
7.80	1.182
7.60	1.176
7.40	1.169
7.20	1.161
7.00	1.151
6.80	1.141
6.60	1.129
6.40	1.115
6.20	1.103
6.00	1.093
5.80	1.088
5.60	1.080
5.40	1.079
5.20	1.081
5.00	1.088
4.80	1.094
4.60	1.100
4.40	1.105
4.20	1.109
4.00	1.112
3.80	1.113
3.60	1.118
3.40	1.125
3.20	1.135
3.00	1.145
2.80	1.154
2.60	1.162
2.40	1.170
2.20	1.178
2.00	1.185
1.80	1.191

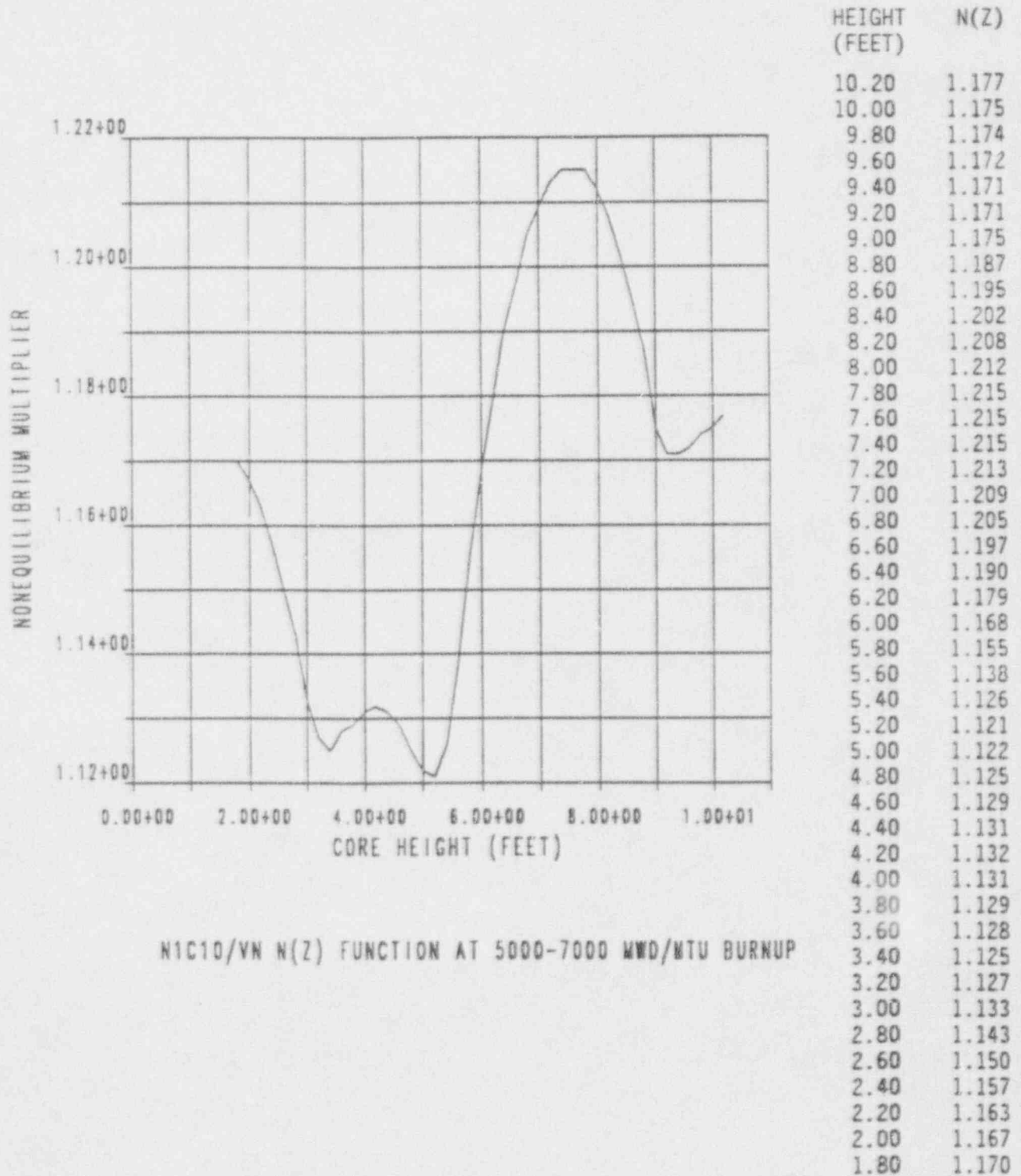
FIGURE 4 (CONTINUED)  
 N(Z) FUNCTION FOR N1C10  
 FROM 3000 to 5000 MWD/MTU BURNUP  
 TOP AND BOTTOM 15 PERCENT EXCLUDED  
 AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 3000-5000 MWD/MTU BURNUP

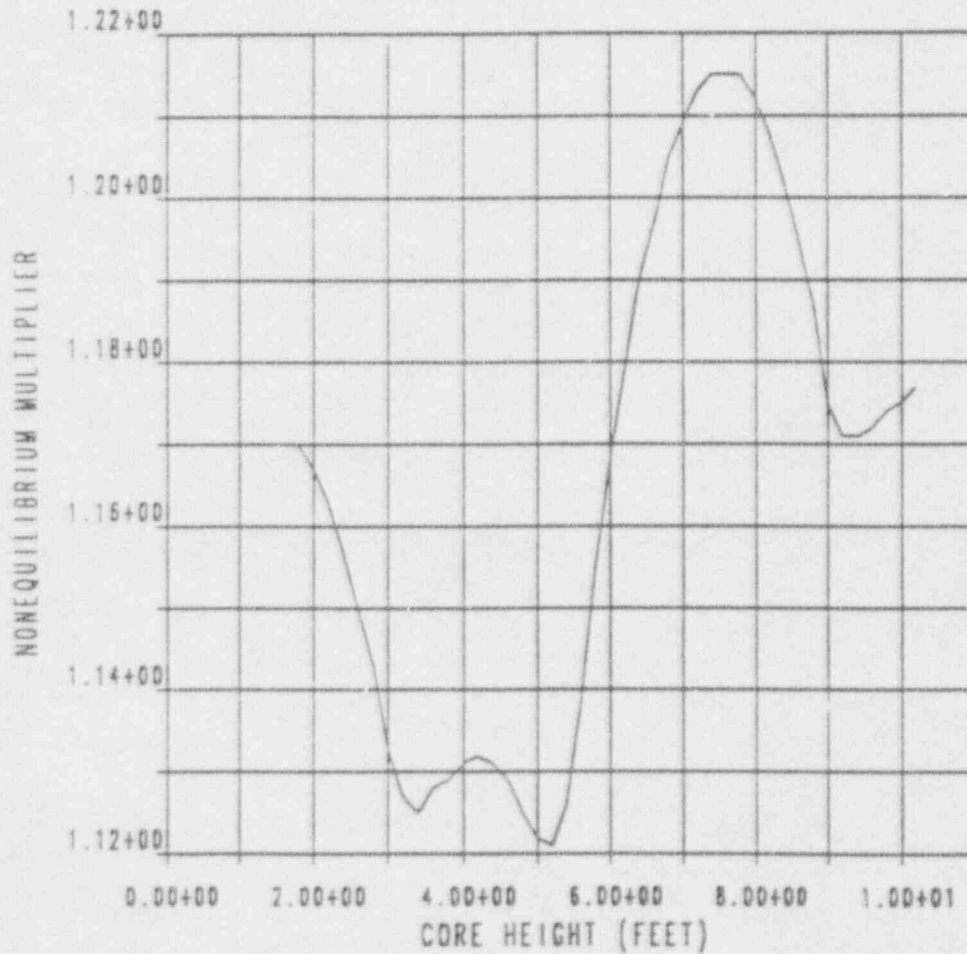
HEIGHT (FEET)	N(Z)
10.20	1.226
10.00	1.219
9.80	1.210
9.60	1.201
9.40	1.191
9.20	1.186
9.00	1.182
8.80	1.186
8.60	1.193
8.40	1.202
8.20	1.208
8.00	1.212
7.80	1.214
7.60	1.215
7.40	1.215
7.20	1.213
7.00	1.209
6.80	1.205
6.60	1.197
6.40	1.190
6.20	1.179
6.00	1.168
5.80	1.155
5.60	1.138
5.40	1.126
5.20	1.121
5.00	1.122
4.80	1.125
4.60	1.129
4.40	1.131
4.20	1.131
4.00	1.131
3.80	1.129
3.60	1.128
3.40	1.129
3.20	1.135
3.00	1.145
2.80	1.154
2.60	1.162
2.40	1.170
2.20	1.178
2.00	1.185
1.80	1.191

FIGURE 4 (CONTINUED)  
N(Z) FUNCTION FOR N1C10  
FROM 5000 to 7000 MWD/MTU BURNUP  
TOP AND BOTTOM 15 PERCENT EXCLUDED  
AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 5000-7000 MWD/MTU BURNUP

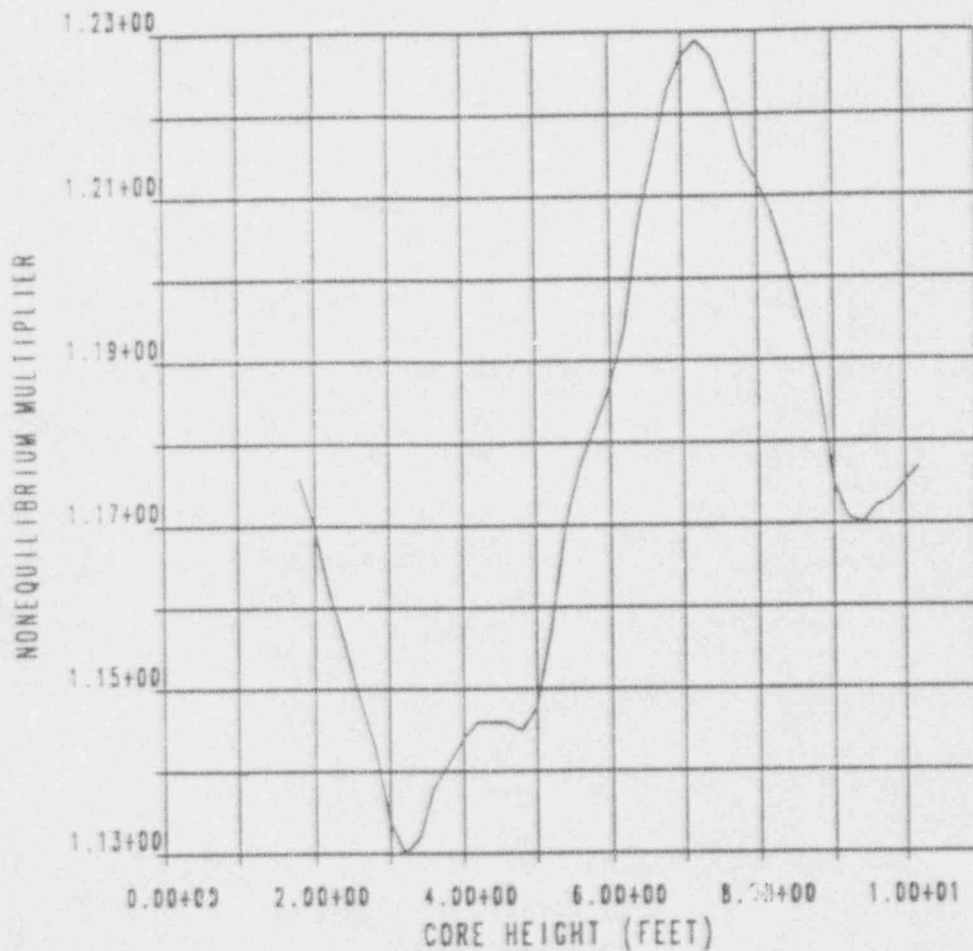
FIGURE 4 (CONTINUED)  
 N(Z) FUNCTION FOR N1C10  
 FROM 7000 to 9000 MWD/MTU BURNUP  
 TOP AND BOTTOM 15 PERCENT EXCLUDED  
 AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 7000-9000 MWD/MTU BURNUP

HEIGHT (FEET)	N(Z)
10.20	1.177
10.00	1.175
9.80	1.174
9.60	1.172
9.40	1.171
9.20	1.171
9.00	1.175
8.80	1.187
8.60	1.195
8.40	1.202
8.20	1.208
8.00	1.212
7.80	1.215
7.60	1.215
7.40	1.215
7.20	1.213
7.00	1.209
6.80	1.205
6.60	1.197
6.40	1.190
6.20	1.179
6.00	1.168
5.80	1.155
5.60	1.138
5.40	1.126
5.20	1.121
5.00	1.122
4.80	1.125
4.60	1.129
4.40	1.131
4.20	1.132
4.00	1.131
3.80	1.129
3.60	1.128
3.40	1.125
3.20	1.127
3.00	1.133
2.80	1.143
2.60	1.150
2.40	1.157
2.20	1.163
2.00	1.167
1.80	1.170

FIGURE 4 (CONTINUED)  
N(Z) FUNCTION FOR N1C10  
FROM 9000 to 16900 MWD/MTU BURNUP  
TOP AND BOTTOM 15 PERCENT EXCLUDED  
AS PER TECH SPEC 4.2.2.2.G

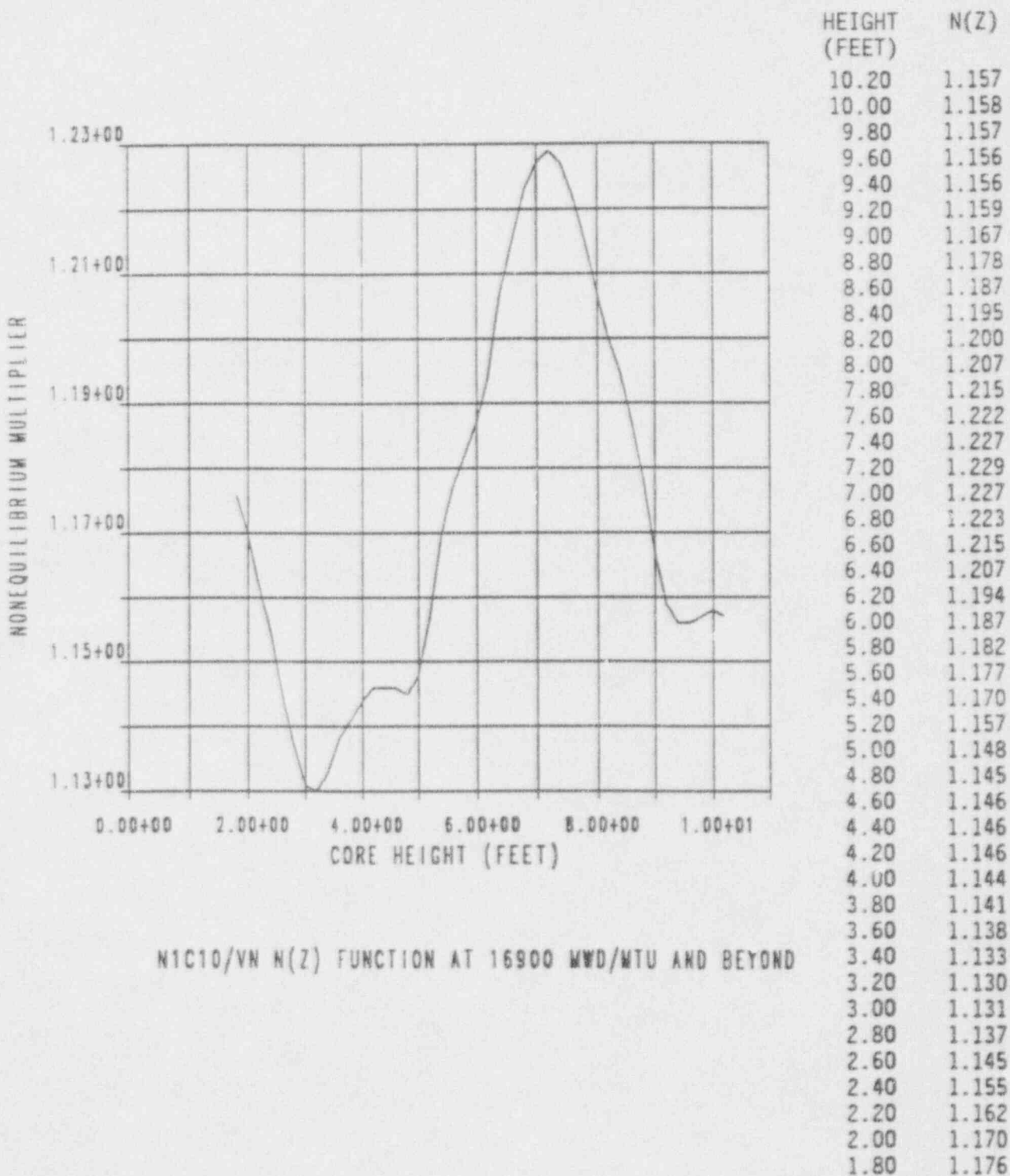


HEIGHT (FEET)	N(Z)
10.20	1.177
10.00	1.175
9.80	1.173
9.60	1.172
9.40	1.170
9.20	1.171
9.00	1.175
8.80	1.187
8.60	1.195
8.40	1.202
8.20	1.208
8.00	1.212
7.80	1.215
7.60	1.222
7.40	1.227
7.20	1.229
7.00	1.227
6.80	1.223
6.60	1.215
6.40	1.207
6.20	1.194
6.00	1.187
5.80	1.182
5.60	1.177
5.40	1.170
5.20	1.157
5.00	1.148
4.80	1.145
4.60	1.146
4.40	1.146
4.20	1.146
4.00	1.144
3.80	1.141
3.60	1.138
3.40	1.132
3.20	1.130
3.00	1.134
2.80	1.143
2.60	1.149
2.40	1.156
2.20	1.162
2.00	1.170
1.80	1.176

N1C10/VN N(Z) FUNCTION AT 9000-16900 MWD/MTU BURNUP



FIGURE 4 (CONTINUED)  
 N(Z) FUNCTION FOR N1C10  
 FROM 16900 MWD/MTU BURNUP AND BEYOND  
 TOP AND BOTTOM 15 PERCENT EXCLUDED  
 AS PER TECH SPEC 4.2.2.2.G



N1C10/VN N(Z) FUNCTION AT 16900 MWD/MTU AND BEYOND

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

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

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