



Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

OCT 27 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of)	Docket No.50-390
Tennessee Valley Authority)	

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1- CORE OPERATING LIMITS
REPORT FOR CYCLE 6, REVISIONS 3 AND 4

The purpose of this letter is to provide the Cycle 6 Core Operating Limits Report (COLR) in accordance with WBN Technical Specification 5.9.5.d. Enclosed are Revisions 3 and 4 of the COLR. Revision 3, which was effective on September 29, 2003, was limited to Modes 6 and 5 of the Cycle 5 Refueling Outage in order to permit core load and reactor assembly to proceed in advance of NRC's approval of the License Amendment Requests for Robust Fuel Assemblies and Boron Concentration Reductions in the refueling water storage tank and the cold leg accumulators. Revision 4 of the COLR was effective October 13, 2003, and removed the restrictions identified in Revision 3 following NRC's approval of the above License Amendment Requests in Amendments 46 and 48, respectively.

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If you have any questions about these reports, please contact me
at (423) 365-1824.

Sincerely,



P. L. Pace
Manager, Site Licensing
and Industry Affairs

Enclosures

Core Operating Limits Report, Unit 1 Cycle 6, Revision 3
Core Operating Limits Report, Unit 1 Cycle 6, Revision 4

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QA Record

WATTS BAR NUCLEAR PLANT, UNIT 1, CYCLE 6

CORE OPERATING LIMITS REPORT

October 2003

Prepared:

John Strange 10/10/03
Nuclear Fuel Date

Reviewed:

Thomas F. Huth for CSF 10/10/03
Reactor Engineering Supervisor Date

Approved:

John B. Kolen for TDW 10/10/03
Operations Manager Date

H.D. PL 10/10/03
PORC Chairman Date

Revision	Date of PORC Approval	PORC Meeting Number	Affected Pages	Reason for Revision
0	n/a	n/a	All	Initial issue
1	n/a	n/a	All	Early shutdown of cycle 5
2	n/a	n/a	1 and 9	Add missing data to Figure 4
3	9/26/03	3989	1,3-4,13-18	consistency with TS nomenclature
4	10/10/03	3993	All	Redesign due to damage to assembly G20

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 1 Cycle 6 has been prepared in accordance with the requirements of the Technical Specifications 5.9.5.

The Technical Specifications affected by this report are listed below:

- 3.1.4 Moderator Temperature Coefficient (MTC)
- 3.1.6 Shutdown Bank Insertion Limits
- 3.1.7 Control Bank Insertion Limits
- 3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)
- 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)
- 3.2.3 Axial Flux Difference (AFD)
- 3.5.1 Accumulators
- 3.5.4 Refueling Water Storage Tank (RWST)
- 3.9.1 Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in section 1.0 are presented in the following subsections. These limits have been developed using the NRC approved methodologies specified in the Technical Specifications Section 5.9.5.

The following abbreviations are used in this section:

- BOL -- Beginning of Cycle Life
- ARO -- All Rods Out
- HZP -- Hot Zero Thermal Power
- EOL -- End of Cycle Life
- RTP -- Rated Thermal Power

COLR for Watts Bar Unit 1, Cycle 6 – TPC Redesign

2.1 MODERATOR TEMPERATURE COEFFICIENT - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

The BOL/ARO/HZP - MTC shall be less positive than or equal to 0 $\Delta k/k/^\circ F$ (upper limit). With the measured BOL/ARO/HZP - MTC more positive than $-0.70 \times 10^{-5} \Delta k/k/^\circ F$ (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to 0 $\Delta k/k/^\circ F$ (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to $-4.5 \times 10^{-4} \Delta k/k/^\circ F$ (lower limit).

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm /ARO/RTP-MTC should be less negative than or equal to $-3.75 \times 10^{-4} \Delta k/k/^\circ F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm /ARO/RTP-MTC should be less negative than or equal to $-4.28 \times 10^{-4} \Delta k/k/^\circ F$.

2.2 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.6)

2.2.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.3 CONTROL BANK INSERTION LIMITS (LCO 3.1.7)

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

2.3.2 Table 1 shows the control rod overlap positions.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

2.4 HEAT FLUX HOT CHANNEL FACTOR - $F_Q(Z)$ (LCO 3.2.1)

$$F_Q(Z) \leq [CFQ / P] * K(Z) \quad \text{for } P > 0.5$$

$$F_Q(Z) \leq [CFQ / 0.5] * K(Z) \quad \text{for } P \leq 0.5$$

Where P = Thermal Power / Rated Thermal Power

$$2.4.1 \text{ CFQ} = 2.50$$

2.4.2 $K(Z)$ is provided in Figure 2.

$$2.4.3 F_Q^c(Z) = F_Q^m(Z) * 1.0815$$

where: $F_Q^m(Z)$ is the measured value of $F_Q(Z)$ obtained from incore flux map results and 1.0815 is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

$$2.4.4 F_Q^w(Z) = F_Q^c(Z) * W(Z)$$

where: $W(Z)$ values are provided in Figures 4 through 7. The figures provide sufficient information to determine $W(Z)$ versus core height for all cycle burnups.

$$2.4.5 F_Q^w(Z) \text{ Penalty Factor}$$

The $F_Q^w(Z)$ penalty factor is provided in Table A.1.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

2.5 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR - $F_{\Delta H}^N$ (LCO 3.2.2)

$$F_{\Delta H}^N \leq F_{\Delta H}^{RTP} * (1 + PF * (1-P))$$

where P = Thermal Power / Rated Thermal Power

$F_{\Delta H}^{RTP} = 1.65$ for RFA-2 fuel, and

$F_{\Delta H}^{RTP} = 1.62$ for VANTAGE+/PERFORMANCE+ fuel

PF = 0.3

2.6 AXIAL FLUX DIFFERENCE - AFD (LCO 3.2.3)

2.6.1 The AFD limits for Cycle 6 are provided in Figure 3.

2.7 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.7.1 The refueling boron concentration shall be ≥ 2103 ppm.

2.8 ACCUMULATORS (LCO 3.5.1)

2.8.1 There are 240 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 6.

2.9 REFUELING WATER STORAGE TANK - RWST (LCO 3.5.4)

2.9.1 There are 240 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 6.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

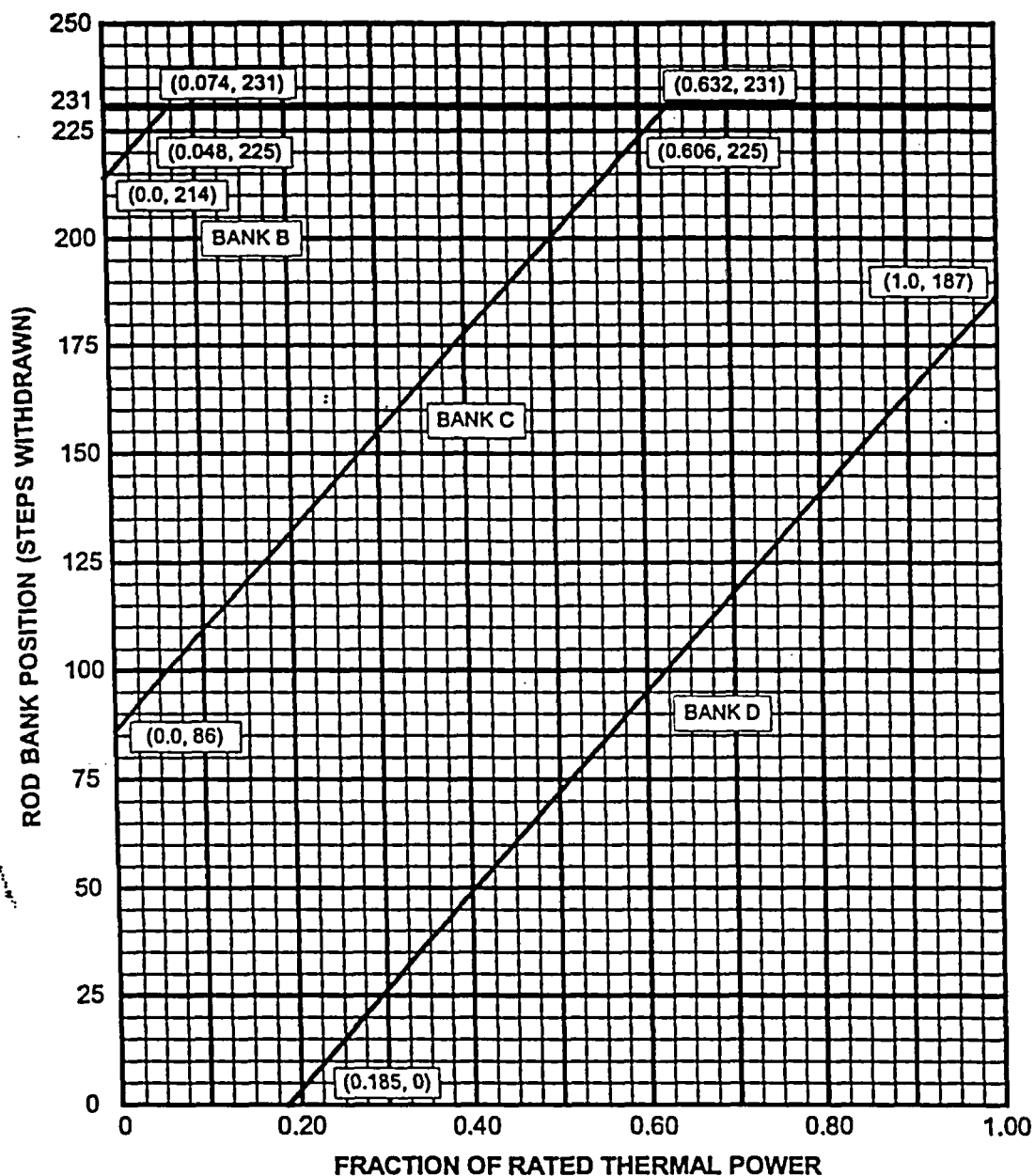


Figure 1
Control Bank Insertion Limits Versus Thermal Power
Four Loop Operation

- * Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

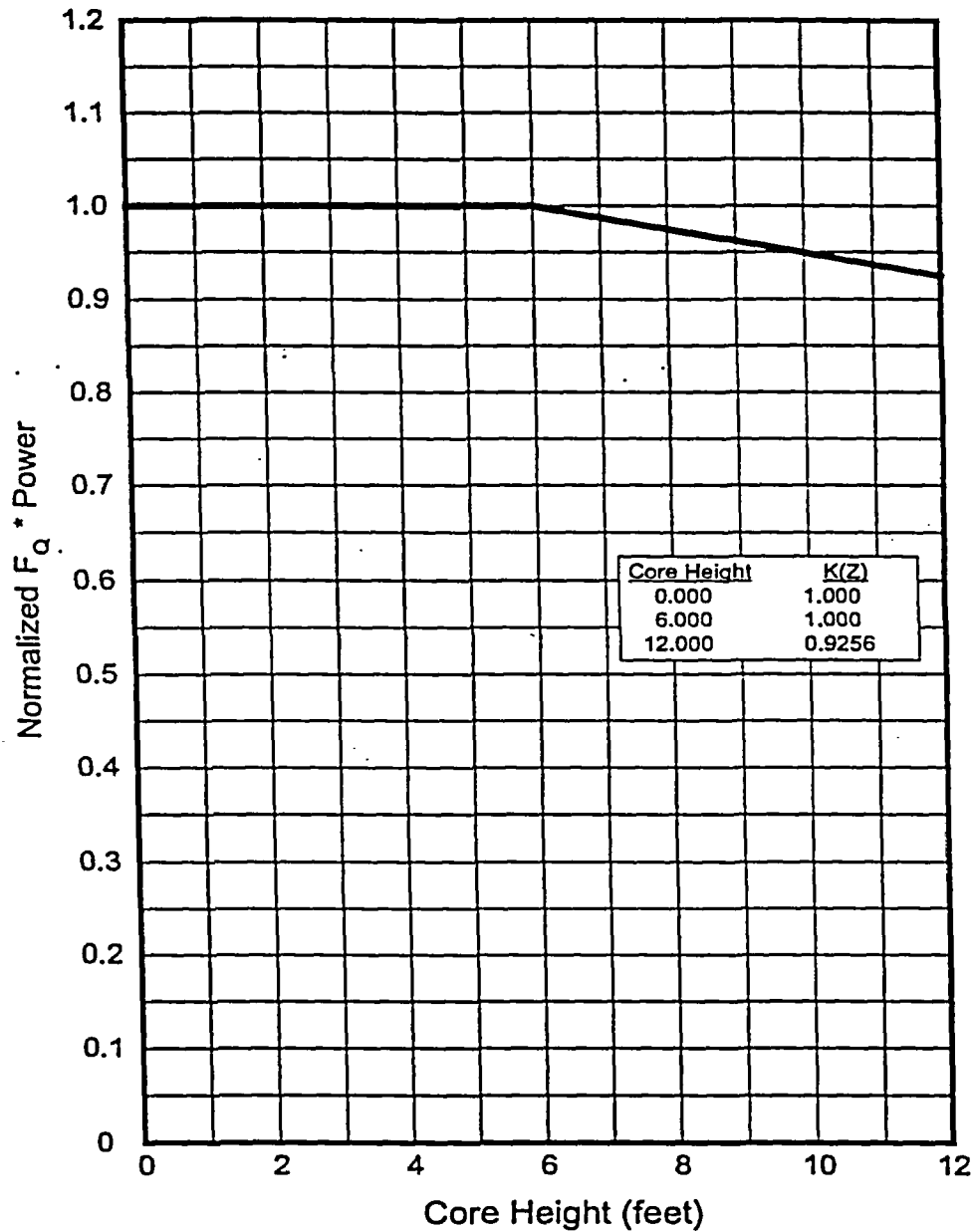


Figure 2
 $K(Z)$ - Normalized $F_q(Z)$ as a Function of Core Height

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

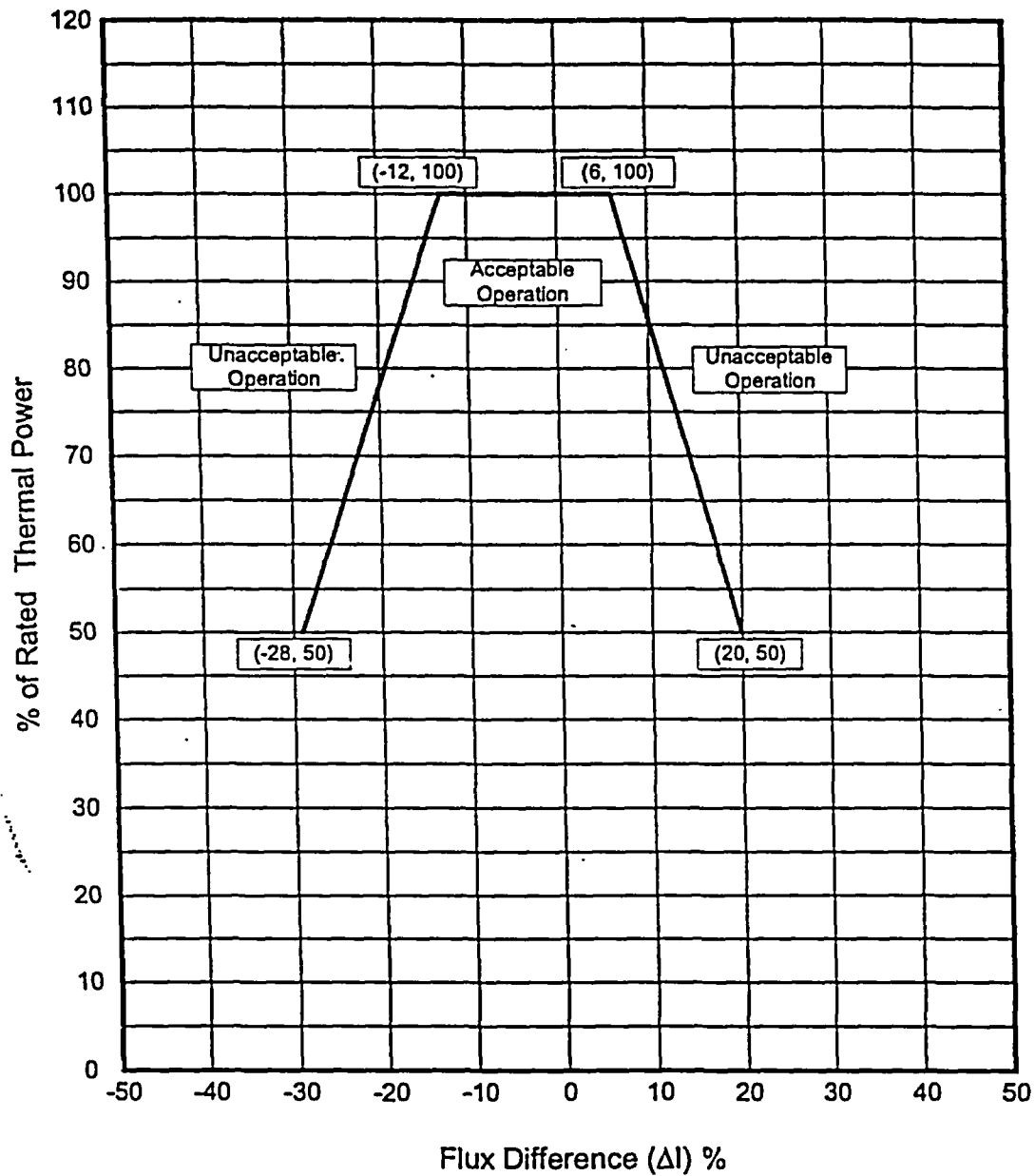
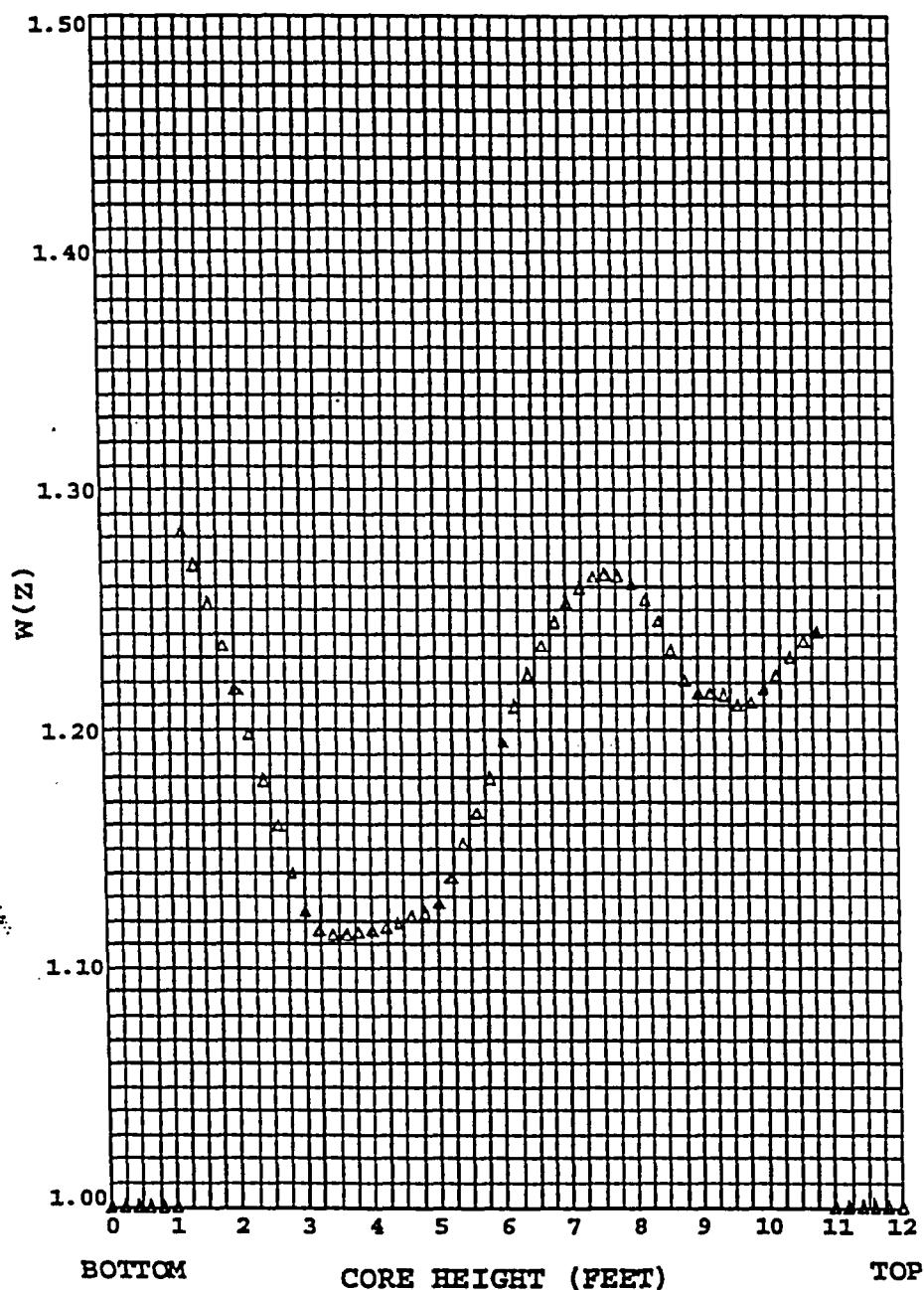


Figure 3
Axial Flux Difference Acceptable Operation Limits as a
Function of Rated Thermal Power (RAOC)

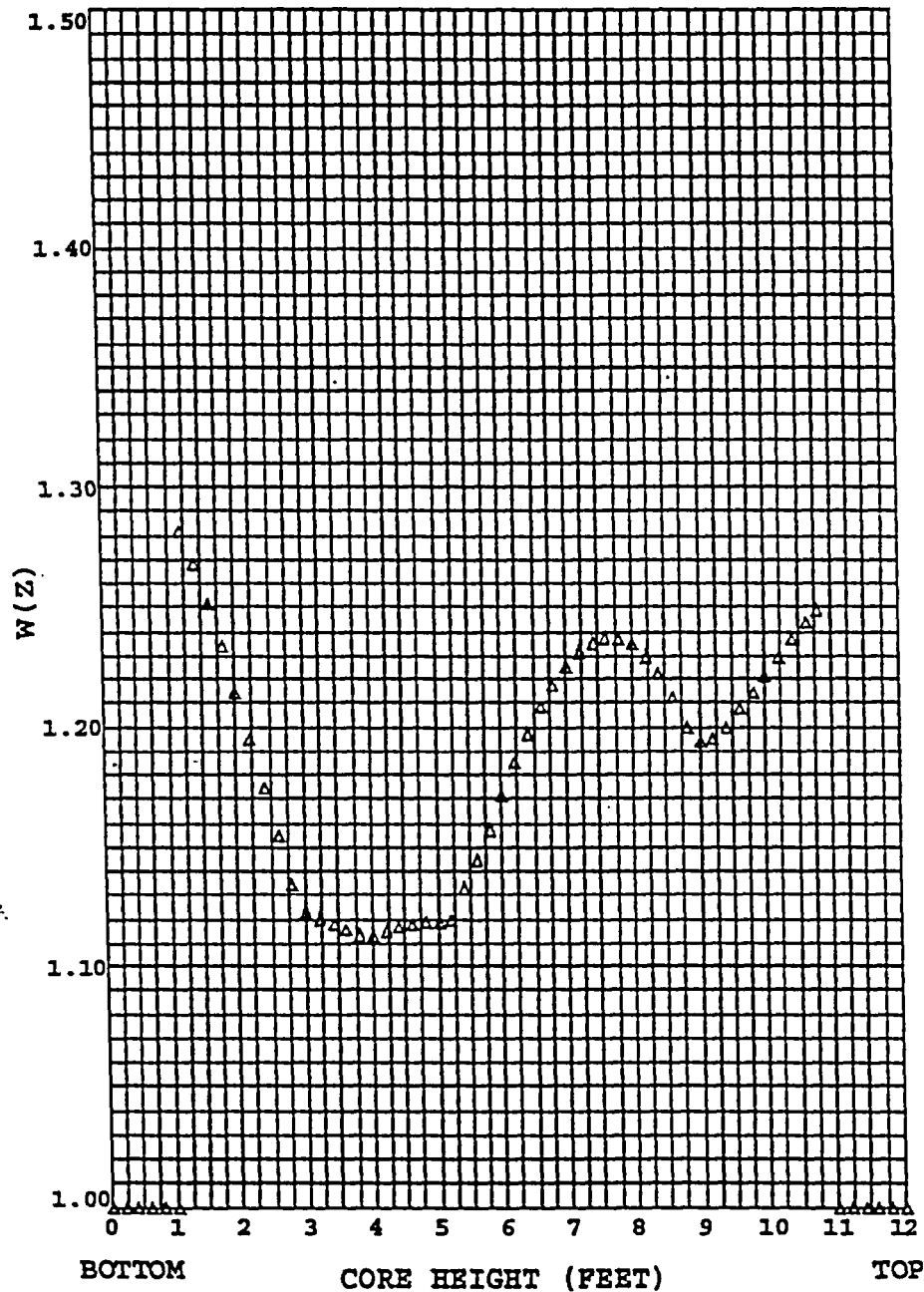
COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2820
1.4000	1.2685
1.6000	1.2526
1.8000	1.2352
2.0000	1.2169
2.2000	1.1980
2.4000	1.1787
2.6000	1.1594
2.8000	1.1394
3.0000	1.1236
3.2000	1.1158
3.4000	1.1142
3.6000	1.1141
3.8000	1.1149
4.0000	1.1160
4.2000	1.1170
4.4000	1.1190
4.6000	1.1215
4.8000	1.1229
5.0000	1.1270
5.2000	1.1374
5.4000	1.1521
5.6000	1.1653
5.8000	1.1796
6.0000	1.1951
6.2000	1.2099
6.4000	1.2232
6.6000	1.2349
6.8000	1.2449
7.0000	1.2530
7.2000	1.2591
7.4000	1.2631
7.6000	1.2646
7.8000	1.2637
8.0000	1.2602
8.2000	1.2541
8.4000	1.2452
8.6000	1.2330
8.8000	1.2206
9.0000	1.2152
9.2000	1.2149
9.4000	1.2146
9.6000	1.2102
9.8000	1.2111
10.0000	1.2176
10.2000	1.2229
10.4000	1.2303
10.6000	1.2366
10.8000	1.2409
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 4
RAOC Summary of Max W(z) at 150 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

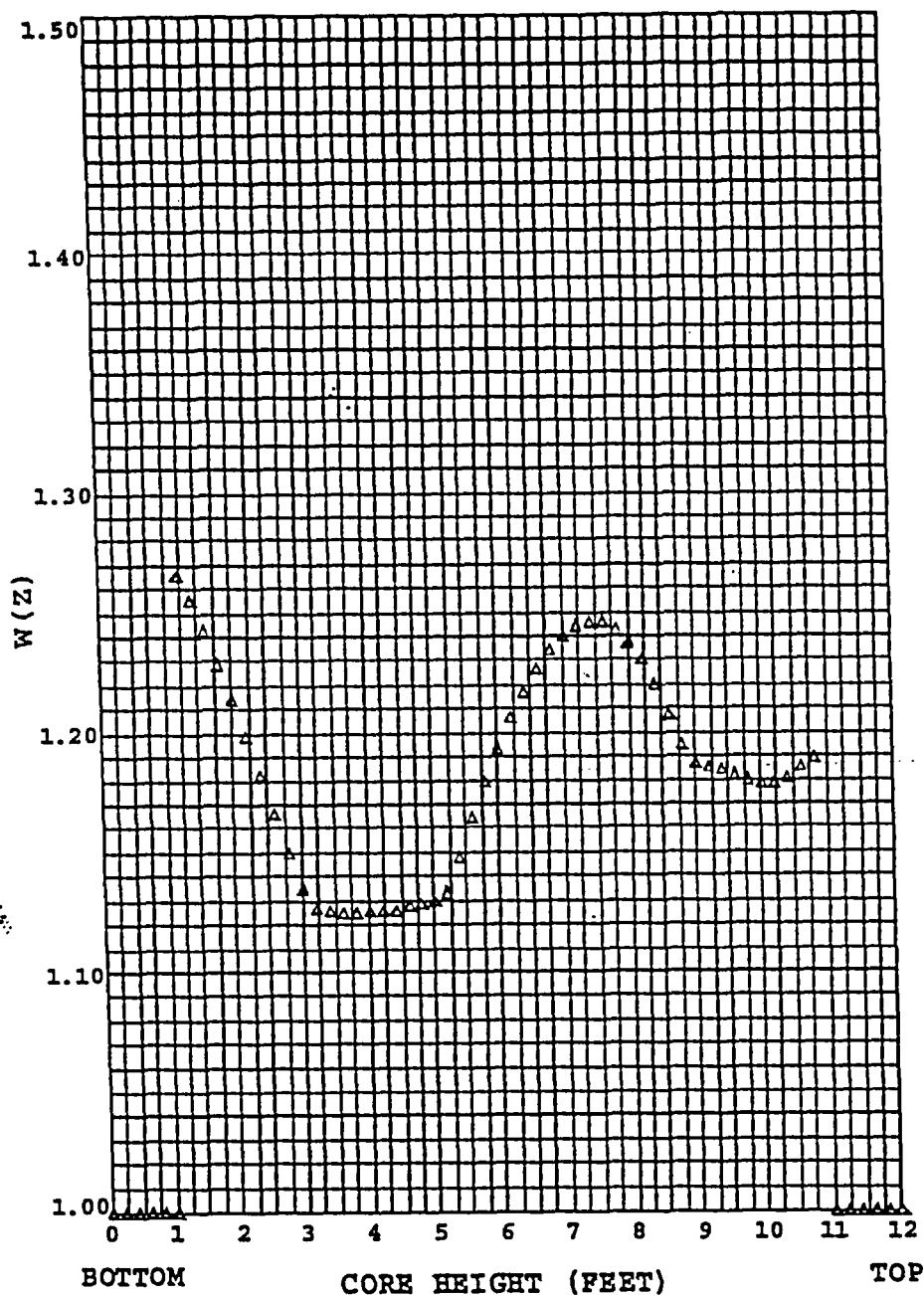
COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2818
1.4000	1.2679
1.6000	1.2515
1.8000	1.2335
2.0000	1.2144
2.2000	1.1947
2.4000	1.1746
2.6000	1.1546
2.8000	1.1344
3.0000	1.1231
3.2000	1.1201
3.4000	1.1174
3.6000	1.1156
3.8000	1.1132
4.0000	1.1131
4.2000	1.1153
4.4000	1.1166
4.6000	1.1176
4.8000	1.1187
5.0000	1.1185
5.2000	1.1200
5.4000	1.1329
5.6000	1.1445
5.8000	1.1572
6.0000	1.1714
6.2000	1.1850
6.4000	1.1972
6.6000	1.2082
6.8000	1.2176
7.0000	1.2253
7.2000	1.2313
7.4000	1.2353
7.6000	1.2372
7.8000	1.2370
8.0000	1.2344
8.2000	1.2294
8.4000	1.2220
8.6000	1.2120
8.8000	1.1995
9.0000	1.1937
9.2000	1.1948
9.4000	1.1999
9.6000	1.2075
9.8000	1.2145
10.0000	1.2209
10.2000	1.2287
10.4000	1.2369
10.6000	1.2439
10.8000	1.2489
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 5
RAOC Summary of Max W(z) at 3000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

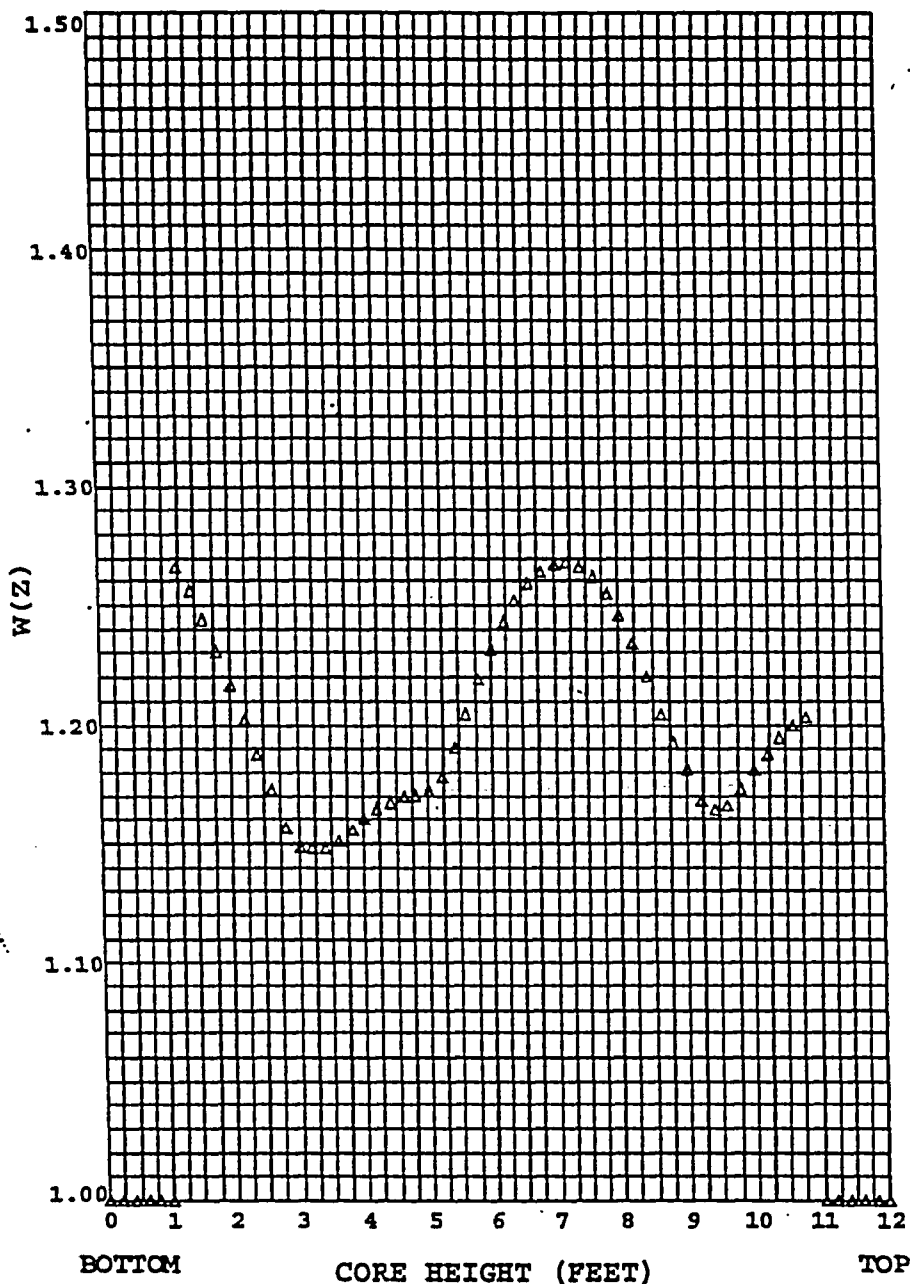
COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2660
1.4000	1.2557
1.6000	1.2431
1.8000	1.2290
2.0000	1.2141
2.2000	1.1985
2.4000	1.1826
2.6000	1.1663
2.8000	1.1498
3.0000	1.1350
3.2000	1.1268
3.4000	1.1257
3.6000	1.1248
3.8000	1.1250
4.0000	1.1258
4.2000	1.1261
4.4000	1.1261
4.6000	1.1274
4.8000	1.1289
5.0000	1.1298
5.2000	1.1330
5.4000	1.1481
5.6000	1.1644
5.8000	1.1796
6.0000	1.1936
6.2000	1.2061
6.4000	1.2172
6.6000	1.2267
6.8000	1.2344
7.0000	1.2403
7.2000	1.2442
7.4000	1.2459
7.6000	1.2455
7.8000	1.2428
8.0000	1.2376
8.2000	1.2301
8.4000	1.2201
8.6000	1.2071
8.8000	1.1946
9.0000	1.1872
9.2000	1.1855
9.4000	1.1840
9.6000	1.1820
9.8000	1.1800
10.0000	1.1787
10.2000	1.1786
10.4000	1.1804
10.6000	1.1850
10.8000	1.1889
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 6
RAOC Summary of Max W(z) at 10000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2660
1.4000	1.2561
1.6000	1.2441
1.8000	1.2308
2.0000	1.2168
2.2000	1.2023
2.4000	1.1875
2.6000	1.1725
2.8000	1.1567
3.0000	1.1487
3.2000	1.1481
3.4000	1.1481
3.6000	1.1507
3.8000	1.1556
4.0000	1.1605
4.2000	1.1643
4.4000	1.1674
4.6000	1.1696
4.8000	1.1703
5.0000	1.1719
5.2000	1.1781
5.4000	1.1902
5.6000	1.2046
5.8000	1.2190
6.0000	1.2319
6.2000	1.2430
6.4000	1.2521
6.6000	1.2592
6.8000	1.2643
7.0000	1.2671
7.2000	1.2677
7.4000	1.2659
7.6000	1.2618
7.8000	1.2551
8.0000	1.2460
8.2000	1.2344
8.4000	1.2203
8.6000	1.2044
8.8000	1.1926
9.0000	1.1812
9.2000	1.1678
9.4000	1.1639
9.6000	1.1660
9.8000	1.1730
10.0000	1.1810
10.2000	1.1880
10.4000	1.1944
10.6000	1.1997
10.8000	1.2032
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 7
RAOC Summary of Max W(z) at 16000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

COLR for Watts Bar Unit 1, Cycle 6 – TPC Redesign

Table A.1

$F_Q^w(Z)$ Penalty Factor

Core Burnup (MWD/MTU)	$F_Q^w(Z)$ Penalty Factor
All burnups	1.0200

Note:

1. The Penalty Factor, which is applied to $F_Q^w(Z)$ for compliance with Surveillance Requirement 3.2.1.2.a, is the maximum factor by which $F_Q^w(Z)$ is expected to increase per 31 Effective Full Power Days (EFPD) starting from the burnup at which the $F_Q^w(Z)$ was determined.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
0	0			
2	2			
4	4			
6	6			
8	8			
10	10			
12	12			
14	14			
16	16			
18	18			
20	20			
22	22			
24	24			
26	26			
28	28			
30	30			
32	32			
34	34			
36	36			
38	38			
40	40			
42	42			
44	44			
46	46			
48	48			
50	50			
52	52			
54	54			
56	56			
58	58			
60	60			
62	62			
64	64			
66	66			
68	68			
70	70			

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
72	72			
74	74			
76	76			
78	78			
80	80			
82	82			
84	84			
86	86			
88	88			
90	90			
92	92			
94	94			
96	96			
98	98			
100	100			
102	102			
104	104			
106	106			
108	108			
110	110			
112	112			
114	114			
116	116			
118	118			
120	120			
122	122			
124	124			
126	126			
128	128	0		
130	130	2		
132	132	4		
134	134	6		
136	136	8		
138	138	10		
140	140	12		
142	142	14		

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
144	144	16		
146	146	18		
148	148	20		
150	150	22		
152	152	24		
154	154	26		
156	156	28		
158	158	30		
160	160	32		
162	162	34		
164	164	36		
166	166	38		
168	168	40		
170	170	42		
172	172	44		
174	174	46		
176	176	48		
178	178	50		
180	180	52		
182	182	54		
184	184	56		
186	186	58		
188	188	60		
190	190	62		
192	192	64		
194	194	66		
196	196	68		
198	198	70		
200	200	72		
202	202	74		
204	204	76		
206	206	78		
208	208	80		
210	210	82		
212	212	84		
214	214	86		
216	216	88		
218	218	90		

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
220	220	92		
222	222	94		
224	224	96		
226	226	98		
228	228	100		
230	230	102		
232	232	104		
234		106		
236		108		
238		110		
240		112		
242		114		
244		116		
246		118		
248		120		
250		122		
252		124		
254		126		
256		128	0	
258		130	2	
260		132	4	
262		134	6	
264		136	8	
266		138	10	
268		140	12	
270		142	14	
272		144	16	
274		146	18	
276		148	20	
278		150	22	
280		152	24	
282		154	26	
284		156	28	
286		158	30	
288		160	32	
290		162	34	
292		164	36	
294		166	38	

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
296		168	40	
298		170	42	
300		172	44	
302		174	46	
304		176	48	
306		178	50	
308		180	52	
310		182	54	
312		184	56	
314		186	58	
316		188	60	
318		190	62	
320		192	64	
322		194	66	
324		196	68	
326		198	70	
328		200	72	
330		202	74	
332		204	76	
334		206	78	
336		208	80	
338		210	82	
340		212	84	
342		214	86	
344		216	88	
346		218	90	
348		220	92	
350		222	94	
352		224	96	
354		226	98	
356		228	100	
358		230	102	
360		232	104	
362			106	
364			108	
366			110	
368			112	

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
370			114	
372			116	
374			118	
376			120	
378			122	
380			124	
382			126	
384			128	0
386			130	2
388			132	4
390			134	6
392			136	8
394			138	10
396			140	12
398			142	14
400			144	16
402			146	18
404			148	20
406			150	22
408			152	24
410			154	26
412			156	28
414			158	30
416			160	32
418			162	34
420			164	36
422			166	38
424			168	40
426			170	42
428			172	44
430			174	46
432			176	48
434			178	50
436			180	52
438			182	54
440			184	56
442			186	58

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
444			188	60
446			190	62
448			192	64
450			194	66
452			196	68
454			198	70
456			200	72
458			202	74
460			204	76
462			206	78
464			208	80
466			210	82
468			212	84
470			214	86
472			216	88
474			218	90
476			220	92
478			222	94
480			224	96
482			226	98
484			228	100
486			230	102
488			232	104
490				106
492				108
494				110
496				112
498				114
500				116
502				118
504				120
506				122
508				124
510				126
512				128
514				130
516				132

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
518				134
520				136
522				138
524				140
526				142
528				144
530				146
532				148
534				150
536				152
538				154
540				156
542				158
544				160
546				162
548				164
550				166
552				168
554				170
556				172
558				174
560				176
562				178
564				180
566				182
568				184
570				186
572				188
574				190
576				192
578				194
580				196
582				198
584				200
586				202
588				204
590				206

COLR for Watts Bar Unit 1, Cycle 6 - TPC Redesign

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
592				208
594				210
596				212
598				214
600				216
602				218
604				220
606				222
608				224
610				226
612				228
614				230
616				232

This information is provided in 2 step increments. One step increments can be derived by interpolation. Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn. The Table indicates a maximum step of 232 to be consistent with 2 step increments.

QA Record

CORE OPERATING LIMITS REPORT, REVISION 2308 4/26/03

September 2003

John Stange, 9/26/03
Nuclear Fuel Date

Reviewed: 1
12/1/83
Reactor Engineering Supervisor Date 12/1/83

Approved: John B. Jordan per TOW, 9/26/03
Operations Manager Date

APL 19/24/23
PORC Chairman Date

Revision	Date of PORC Approval	PORC Meeting Number	Affected Pages	Reason for Revision
0	n/a	n/a	All	Initial issue
1	n/a	n/a	All	Early shutdown of cycle 5
2	n/a	n/a	1 and 9	Add missing data to Figure 4
3	9/26/03	3989	1, 3-4, 13-18 US 9/26/03	consistency with TS nomenclature

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Watts Bar Unit 1 Cycle 6 has been prepared in accordance with the requirements of the Technical Specifications 5.9.5.

The Technical Specifications affected by this report are listed below:

- 3.1.4 Moderator Temperature Coefficient (MTC)
- 3.1.6 Shutdown Bank Insertion Limits
- 3.1.7 Control Bank Insertion Limits
- 3.2.1 Heat Flux Hot Channel Factor ($F_q(Z)$)
- 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F_{\Delta H}^N$)
- 3.2.3 Axial Flux Difference (AFD)
- 3.5.1 Accumulators
- 3.5.4 Refueling Water Storage Tank (RWST)
- 3.9.1 Boron Concentration

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in section 1.0 are presented in the following subsections. These limits have been developed using the NRC approved methodologies specified in the Technical Specifications Section 5.9.5.

The following abbreviations are used in this section:

- BOL -- Beginning of Cycle Life
- ARO -- All Rods Out
- HZP -- Hot Zero Thermal Power
- EOL -- End of Cycle Life
- RTP -- Rated Thermal Power

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

2.1 MODERATOR TEMPERATURE COEFFICIENT - MTC (LCO 3.1.4)

2.1.1 The MTC limits are:

The BOL/ARO/HZP - MTC shall be less positive than or equal to $0 \Delta k/k/^{\circ}F$ (upper limit). With the measured BOL/ARO/HZP - MTC more positive than $-0.70 \times 10^{-4} \Delta k/k/^{\circ}F$ (as-measured MTC limit), establish control rod withdrawal limits to ensure the MTC remains less positive than or equal to $0 \Delta k/k/^{\circ}F$ (upper limit) for all times in core life.

The EOL/ARO/RTP - MTC shall be less negative than or equal to $-4.5 \times 10^{-4} \Delta k/k/^{\circ}F$ (lower limit).

2.1.2 The 300 ppm surveillance limit is:

The measured 300 ppm /ARO/RTP-MTC should be less negative than or equal to $-3.75 \times 10^{-4} \Delta k/k/^{\circ}F$.

2.1.3 The 60 ppm surveillance limit is:

The measured 60 ppm /ARO/RTP-MTC should be less negative than or equal to $-4.28 \times 10^{-4} \Delta k/k/^{\circ}F$.

2.2 SHUTDOWN BANK INSERTION LIMITS (LCO 3.1.6)

2.2.1 The shutdown banks shall be withdrawn to a position greater than or equal to 225 steps withdrawn.

2.3 CONTROL BANK INSERTION LIMITS (LCO 3.1.7)

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

2.3.2 Table 1 shows the control rod overlap positions.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

2.4 HEAT FLUX HOT CHANNEL FACTOR - $F_q(Z)$ (LCO 3.2.1)

$$F_q(Z) \leq [CFQ / P] * K(Z) \quad \text{for } P > 0.5$$

$$F_q(Z) \leq [CFQ / 0.5] * K(Z) \quad \text{for } P \leq 0.5$$

Where P = Thermal Power / Rated Thermal Power

$$2.4.1 \text{ CFQ} = 2.50$$

2.4.2 $K(Z)$ is provided in Figure 2.

$$2.4.3 F_q^c(Z) = F_q^m(Z) * 1.0815$$

where: $F_q^m(Z)$ is the measured value of $F_q(Z)$ obtained from incore flux map results and 1.0815 is a factor that accounts for fuel manufacturing tolerances and flux map measurement uncertainty.

$$2.4.4 F_q^w(Z) = F_q^c(Z) * W(Z)$$

where: $W(Z)$ values are provided in Figures 4 through 7. The figures provide sufficient information to determine $W(Z)$ versus core height for all cycle burnups.

$$2.4.5 F_q^w(Z) \text{ ~Penalty Factor}$$

The $F_q^w(Z)$ penalty factor is provided in Table A.1.

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

2.5 NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR – $F_{\Delta H}^N$ (LCO 3.2.2)

$$F_{\Delta H}^N \leq F_{\Delta H}^{KTP} * (1 + PF * (1-P))$$

where P = Thermal Power / Rated Thermal Power

$F_{\Delta H}^{KTP} = 1.65$ for RFA-2 fuel, and

$F_{\Delta H}^{KTP} = 1.62$ for VANTAGE+/PERFORMANCE+ fuel

$PF = 0.3$

2.6 AXIAL FLUX DIFFERENCE - AFD (LCO 3.2.3)

2.6.1 The AFD limits for Cycle 6 are provided in Figure 3.

2.7 REFUELING BORON CONCENTRATION (LCO 3.9.1)

2.7.1 The refueling boron concentration shall be ≥ 2103 ppm.

2.8 ACCUMULATORS (LCO 3.5.1)

2.8.1 There are 240 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 6.

2.9 REFUELING WATER STORAGE TANK – RWST (LCO 3.5.4)

2.9.1 There are 240 tritium producing burnable absorber rods (TPBARs) in the reactor core for Cycle 6.

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

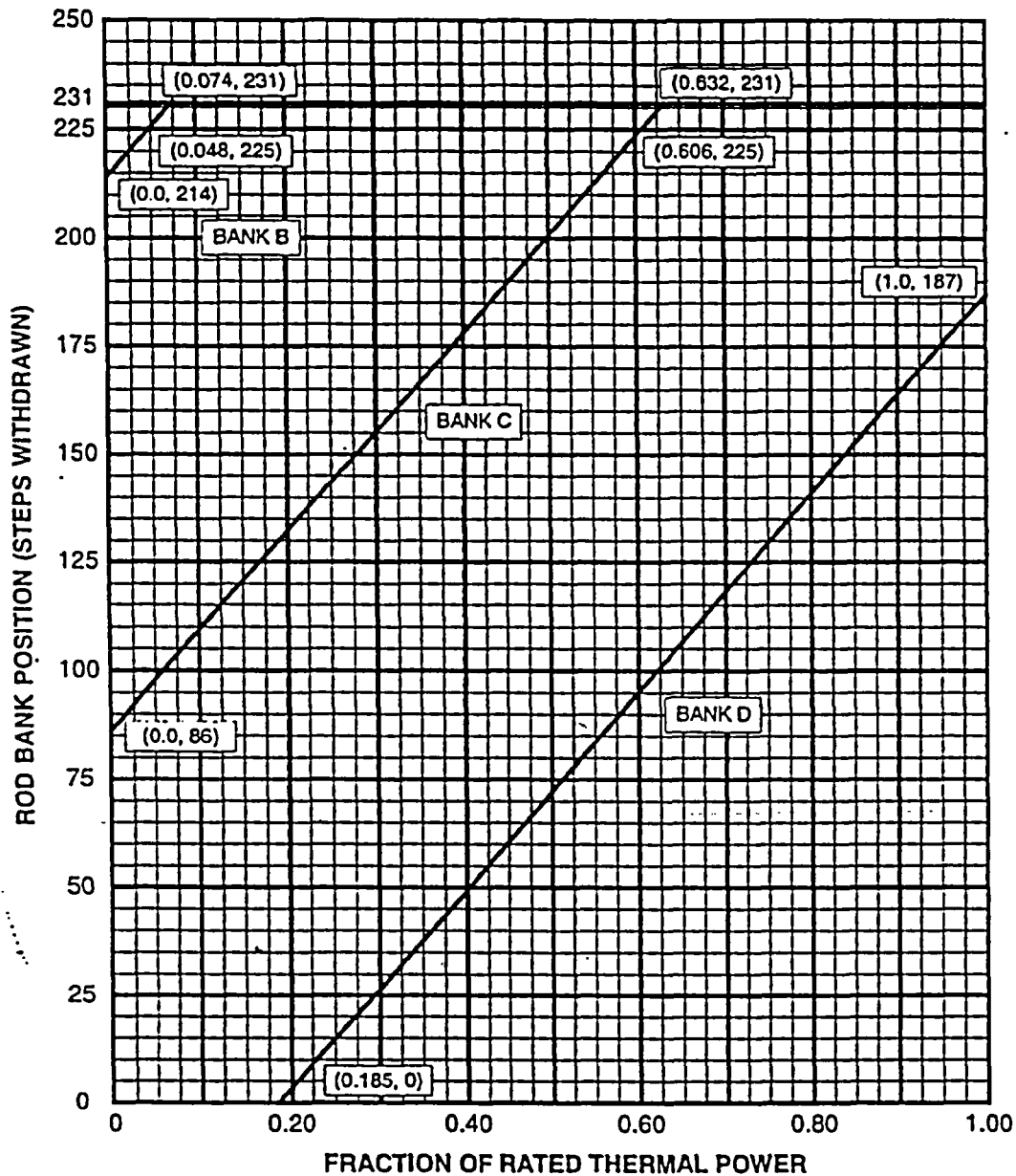


Figure 1
Control Bank Insertion Limits Versus Thermal Power
Four Loop Operation

* Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn.

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

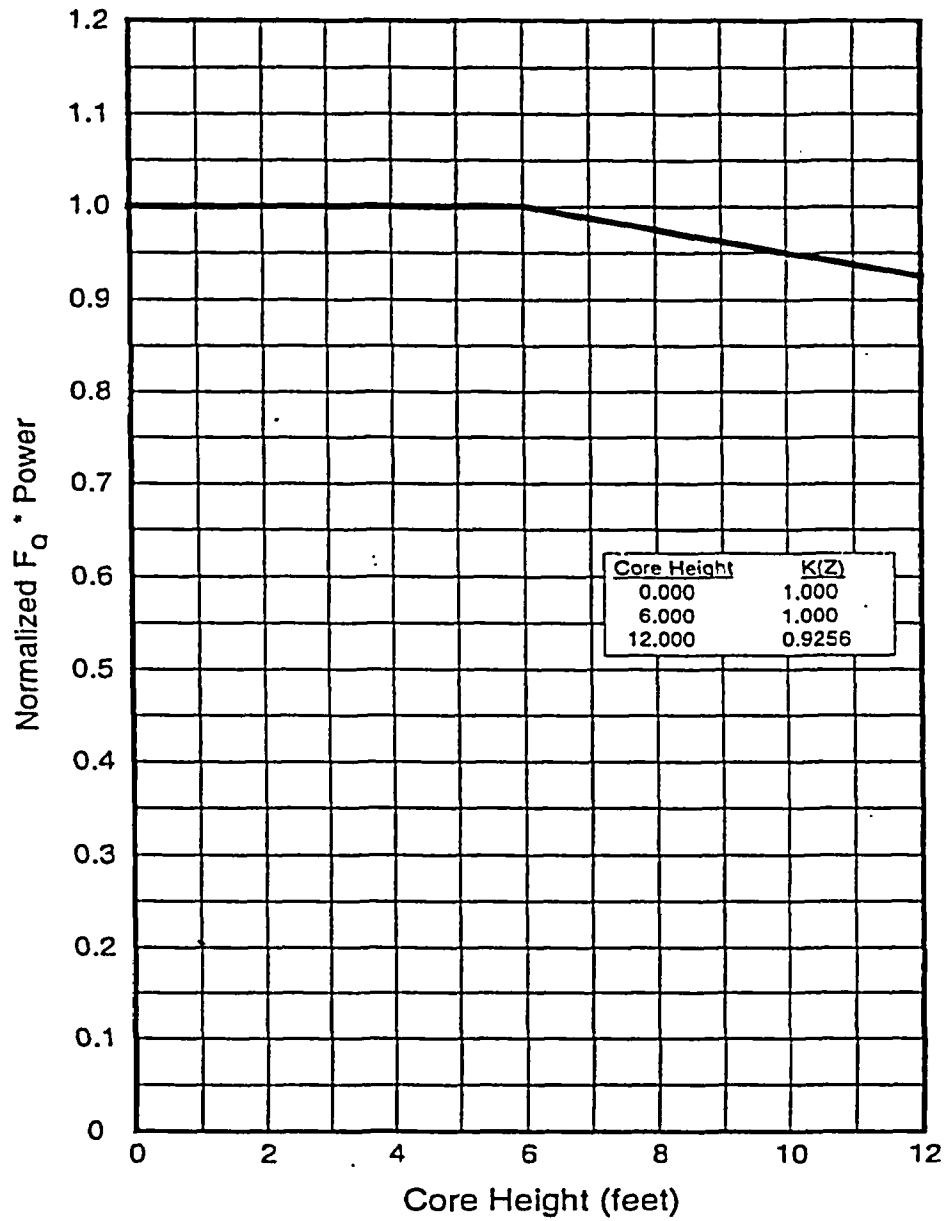


Figure 2
 $K(Z)$ - Normalized $F_q(Z)$ as a Function of Core Height

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

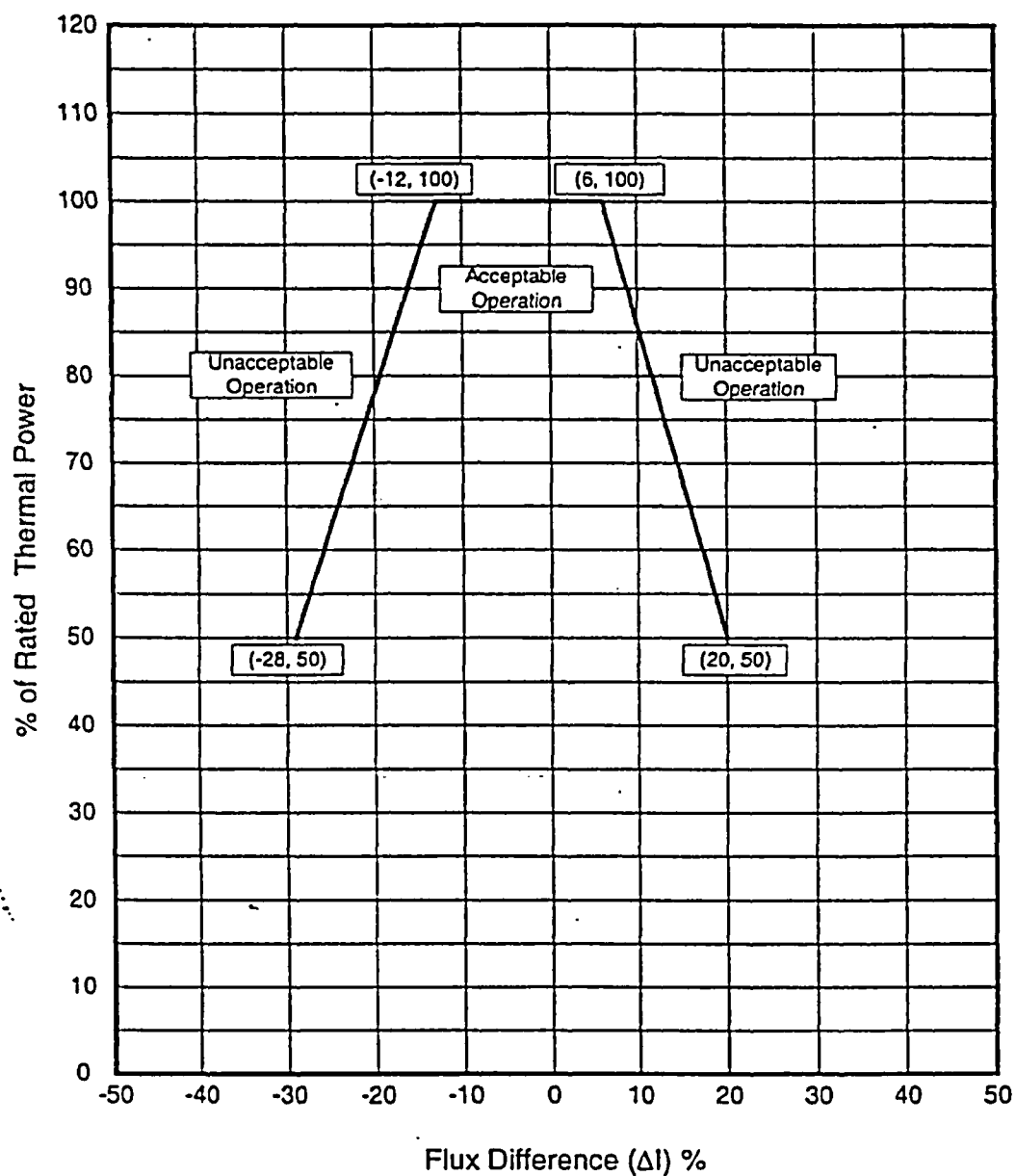
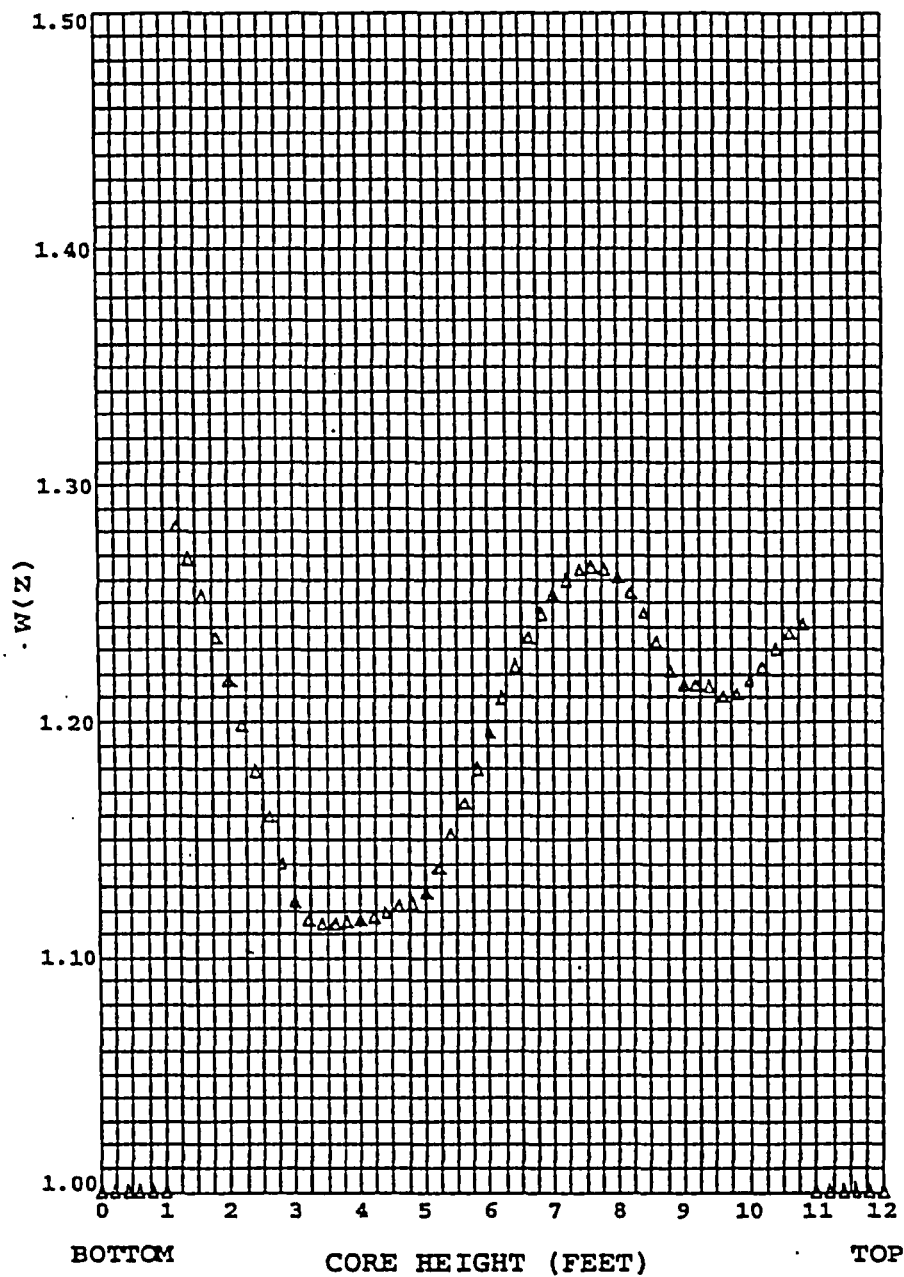


Figure 3
Axial Flux Difference Acceptable Operation Limits as a
Function of Rated Thermal Power (RAOC)

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2820
1.4000	1.2685
1.6000	1.2526
1.8000	1.2352
2.0000	1.2169
2.2000	1.1980
2.4000	1.1787
2.6000	1.1594
2.8000	1.1394
3.0000	1.1236
3.2000	1.1158
3.4000	1.1142
3.6000	1.1141
3.8000	1.1149
4.0000	1.1160
4.2000	1.1170
4.4000	1.1190
4.6000	1.1215
4.8000	1.1229
5.0000	1.1270
5.2000	1.1374
5.4000	1.1521
5.6000	1.1653
5.8000	1.1796
6.0000	1.1951
6.2000	1.2099
6.4000	1.2232
6.6000	1.2349
6.8000	1.2449
7.0000	1.2530
7.2000	1.2591
7.4000	1.2631
7.6000	1.2646
7.8000	1.2637
8.0000	1.2602
8.2000	1.2541
8.4000	1.2452
8.6000	1.2330
8.8000	1.2206
9.0000	1.2152
9.2000	1.2149
9.4000	1.2146
9.6000	1.2102
9.8000	1.2111
10.0000	1.2176
10.2000	1.2229
10.4000	1.2303
10.6000	1.2366
10.8000	1.2409
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 4
RAOC Summary of Max W(z) at 150 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

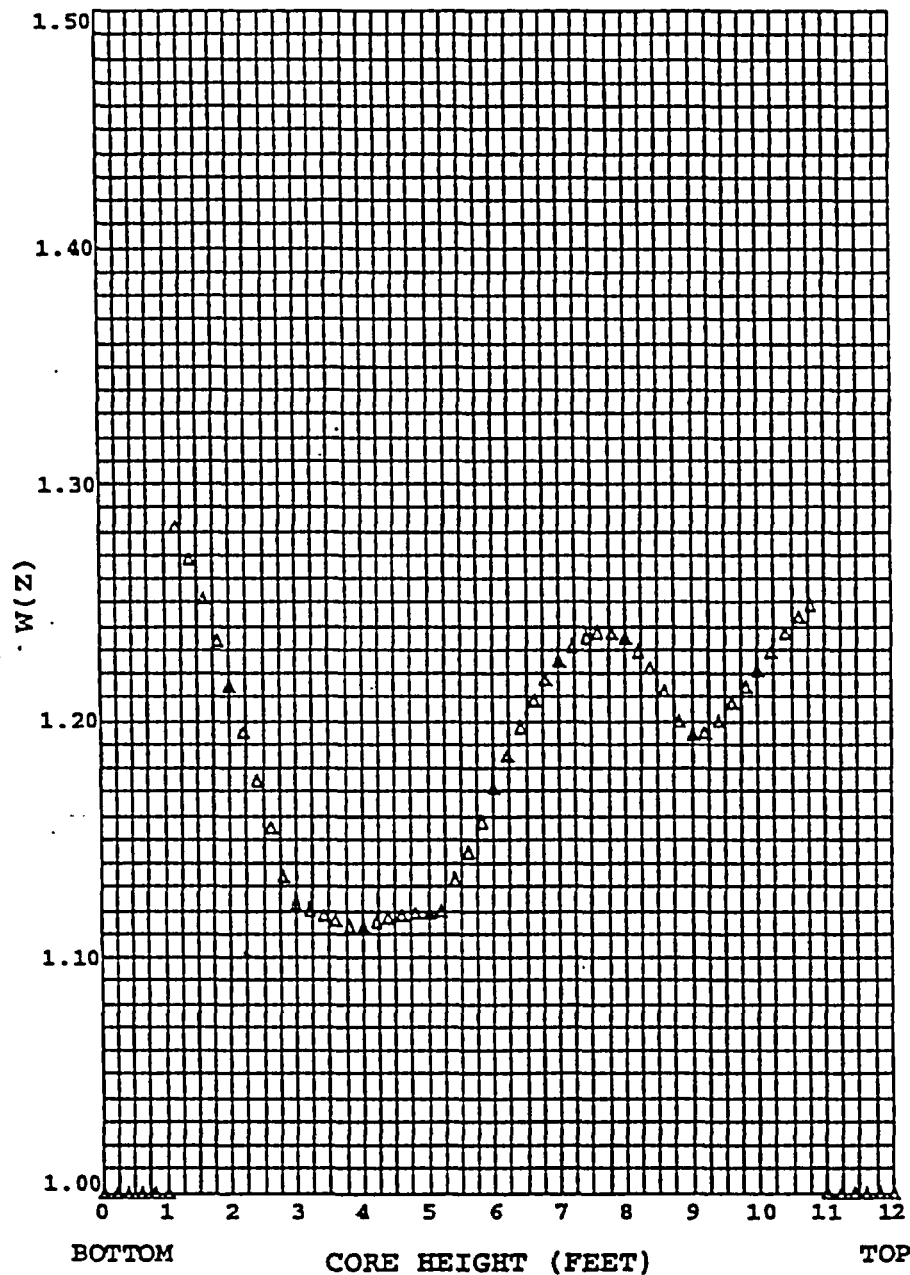
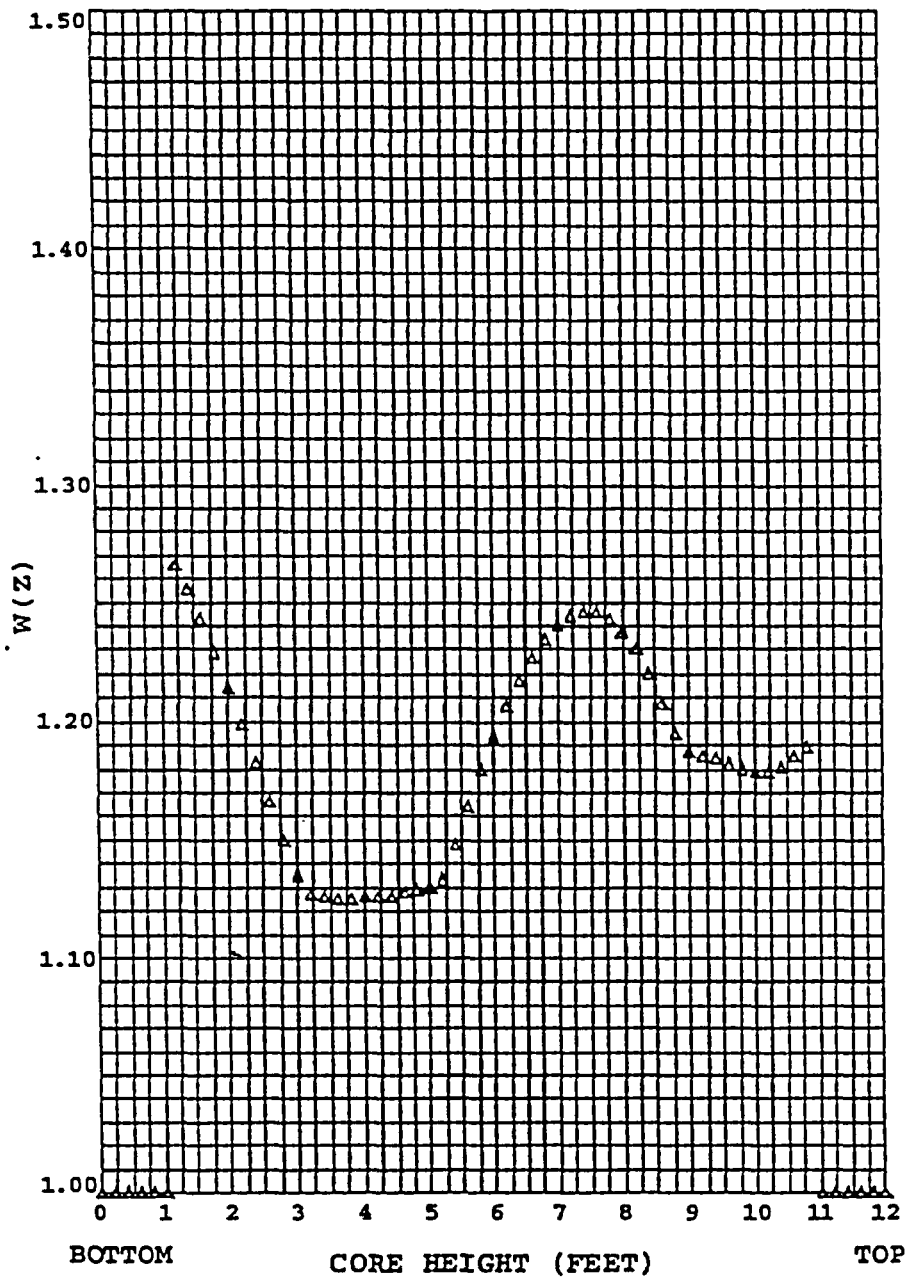


Figure 5
RAOC Summary of Max $W(z)$ at 3000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

Height (feet)	Max. $W(z)$
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2818
1.4000	1.2679
1.6000	1.2515
1.8000	1.2335
2.0000	1.2144
2.2000	1.1947
2.4000	1.1746
2.6000	1.1546
2.8000	1.1344
3.0000	1.1231
3.2000	1.1201
3.4000	1.1174
3.6000	1.1156
3.8000	1.1132
4.0000	1.1131
4.2000	1.1153
4.4000	1.1166
4.6000	1.1176
4.8000	1.1187
5.0000	1.1185
5.2000	1.1200
5.4000	1.1329
5.6000	1.1445
5.8000	1.1572
6.0000	1.1714
6.2000	1.1850
6.4000	1.1972
6.6000	1.2082
6.8000	1.2176
7.0000	1.2253
7.2000	1.2313
7.4000	1.2353
7.6000	1.2372
7.8000	1.2370
8.0000	1.2344
8.2000	1.2294
8.4000	1.2220
8.6000	1.2120
8.8000	1.1995
9.0000	1.1937
9.2000	1.1948
9.4000	1.1999
9.6000	1.2075
9.8000	1.2145
10.0000	1.2209
10.2000	1.2287
10.4000	1.2369
10.6000	1.2439
10.8000	1.2489
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design



Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2660
1.4000	1.2557
1.6000	1.2431
1.8000	1.2290
2.0000	1.2141
2.2000	1.1935
2.4000	1.1826
2.6000	1.1663
2.8000	1.1498
3.0000	1.1350
3.2000	1.1268
3.4000	1.1257
3.6000	1.1248
3.8000	1.1250
4.0000	1.1258
4.2000	1.1261
4.4000	1.1261
4.6000	1.1274
4.8000	1.1289
5.0000	1.1298
5.2000	1.1330
5.4000	1.1481
5.6000	1.1644
5.8000	1.1796
6.0000	1.1936
6.2000	1.2061
6.4000	1.2172
6.6000	1.2267
6.8000	1.2344
7.0000	1.2403
7.2000	1.2442
7.4000	1.2459
7.6000	1.2455
7.8000	1.2428
8.0000	1.2376
8.2000	1.2301
8.4000	1.2201
8.6000	1.2071
8.8000	1.1946
9.0000	1.1872
9.2000	1.1855
9.4000	1.1840
9.6000	1.1820
9.8000	1.1800
10.0000	1.1787
10.2000	1.1786
10.4000	1.1804
10.6000	1.1850
10.8000	1.1889
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

Figure 6
RAOC Summary of Max W(z) at 10000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

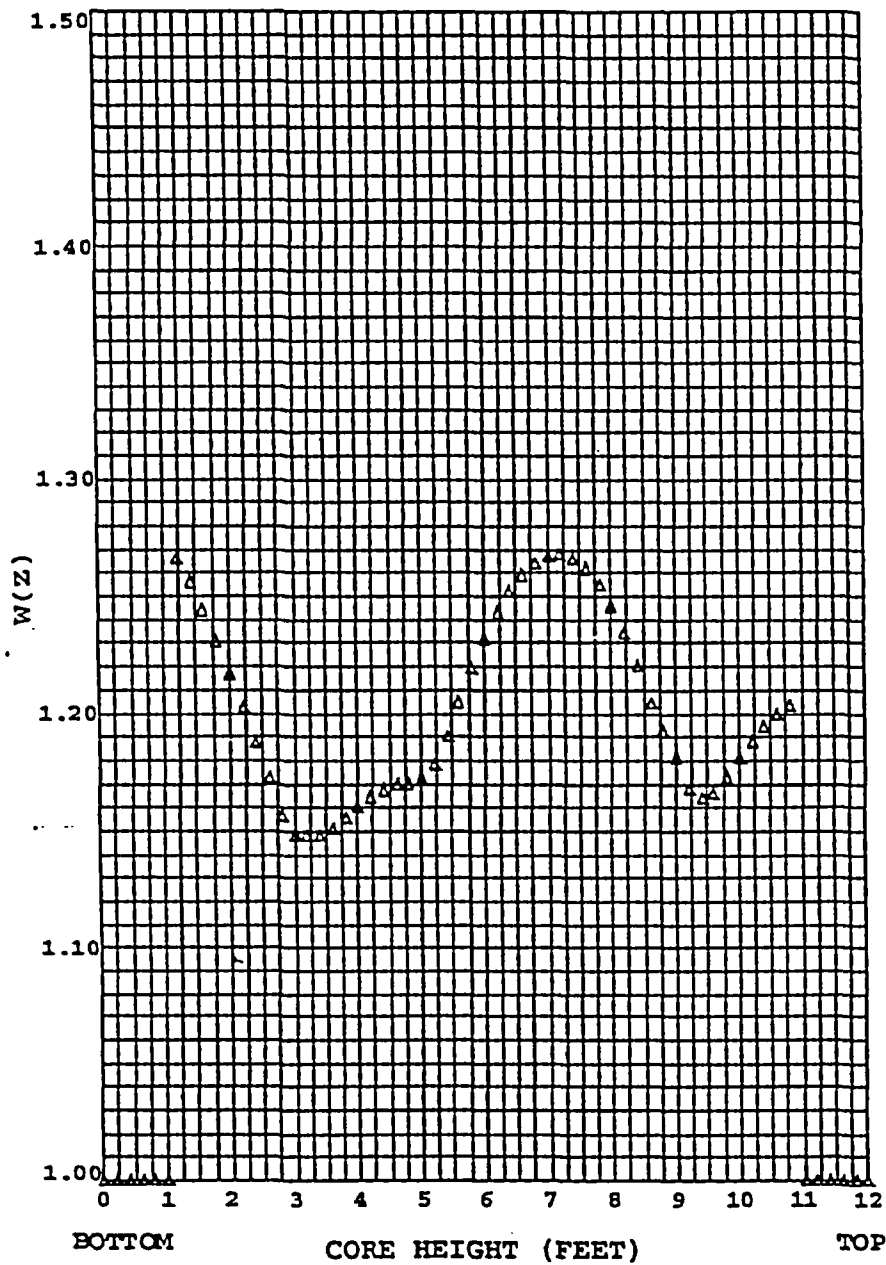


Figure 7
RAOC Summary of Max W(z) at 16000 MWD/MTU
with HFP AFD Band of -12/+6 %
(Top and Bottom 10% Excluded)

Height (feet)	Max. W(z)
0.0000	1.0000
0.2000	1.0000
0.4000	1.0000
0.6000	1.0000
0.8000	1.0000
1.0000	1.0000
1.2000	1.2660
1.4000	1.2561
1.6000	1.2441
1.8000	1.2308
2.0000	1.2168
2.2000	1.2023
2.4000	1.1875
2.6000	1.1725
2.8000	1.1567
3.0000	1.1487
3.2000	1.1481
3.4000	1.1481
3.6000	1.1507
3.8000	1.1556
4.0000	1.1605
4.2000	1.1643
4.4000	1.1674
4.6000	1.1696
4.8000	1.1703
5.0000	1.1719
5.2000	1.1781
5.4000	1.1902
5.6000	1.2046
5.8000	1.2190
6.0000	1.2319
6.2000	1.2430
6.4000	1.2521
6.6000	1.2592
6.8000	1.2643
7.0000	1.2671
7.2000	1.2677
7.4000	1.2659
7.6000	1.2618
7.8000	1.2551
8.0000	1.2460
8.2000	1.2344
8.4000	1.2203
8.6000	1.2044
8.8000	1.1926
9.0000	1.1812
9.2000	1.1678
9.4000	1.1639
9.6000	1.1660
9.8000	1.1730
10.0000	1.1810
10.2000	1.1880
10.4000	1.1944
10.6000	1.1997
10.8000	1.2032
11.0000	1.0000
11.2000	1.0000
11.4000	1.0000
11.6000	1.0000
11.8000	1.0000
12.0000	1.0000

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

Table A.1

$F_q^w(Z)$ Penalty Factor

Core Burnup (MWD/MTU)	$F_q^w(Z)$ Penalty Factor
8149	1.0200
8300	1.0208
8450	1.0212
8601	1.0203
8752	1.0200

Notes:

1. The Penalty Factor, which is applied to $F_q^w(Z)$ for compliance with Surveillance Requirement 3.2.1.2.a, is the maximum factor by which $F_q^w(Z)$ is expected to increase per 31 Effective Full Power Days (EFPD) starting from the burnup at which the $F_q^w(Z)$ was determined.
2. Linear interpolation is adequate for intermediate cycle burnups.
3. For all cycle burnups outside the range of the table, a penalty factor of 1.020 shall be used for compliance with Surveillance Requirement 3.2.1.2.a.

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
0	0			
2	2			
4	4			
6	6			
8	8			
10	10			
12	12			
14	14			
16	16			
18	18			
20	20			
22	22			
24	24			
26	26			
28	28			
30	30			
32	32			
34	34			
36	36			
38	38			
40	40			
42	42			
44	44			
46	46			
48	48			
50	50			
52	52			
54	54			
56	56			
58	58			
60	60			
62	62			
64	64			
66	66			
68	68			
70	70			

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
72	72			
74	74			
76	76			
78	78			
80	80			
82	82			
84	84			
86	86			
88	88			
90	90			
92	92			
94	94			
96	96			
98	98			
100	100			
102	102			
104	104			
106	106			
108	108			
110	110			
112	112			
114	114			
116	116			
118	118			
120	120			
122	122			
124	124			
126	126			
128	128	0		
130	130	2		
132	132	4		
134	134	6		
136	136	8		
138	138	10		
140	140	12		
142	142	14		

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
144	144	16		
146	146	18		
148	148	20		
150	150	22		
152	152	24		
154	154	26		
156	156	28		
158	158	30		
160	160	32		
162	162	34		
164	164	36		
166	166	38		
168	168	40		
170	170	42		
172	172	44		
174	174	46		
176	176	48		
178	178	50		
180	180	52		
182	182	54		
184	184	56		
186	186	58		
188	188	60		
190	190	62		
192	192	64		
194	194	66		
196	196	68		
198	198	70		
200	200	72		
202	202	74		
204	204	76		
206	206	78		
208	208	80		
210	210	82		
212	212	84		
214	214	86		
216	216	88		
218	218	90		

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
220	220	92		
222	222	94		
224	224	96		
226	226	98		
228	228	100		
230	230	102		
232	232	104		
234		106		
236		108		
238		110		
240		112		
242		114		
244		116		
246		118		
248		120		
250		122		
252		124		
254		126		
256		128	0	
258		130	2	
260		132	4	
262		134	6	
264		136	8	
266		138	10	
268		140	12	
270		142	14	
272		144	16	
274		146	18	
276		148	20	
278		150	22	
280		152	24	
282		154	26	
284		156	28	
286		158	30	
288		160	32	
290		162	34	
292		164	36	
294		166	38	

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
296		168	40	
298		170	42	
300		172	44	
302		174	46	
304		176	48	
306		178	50	
308		180	52	
310		182	54	
312		184	56	
314		186	58	
316		188	60	
318		190	62	
320		192	64	
322		194	66	
324		196	68	
326		198	70	
328		200	72	
330		202	74	
332		204	76	
334		206	78	
336		208	80	
338		210	82	
340		212	84	
342		214	86	
344		216	88	
346		218	90	
348		220	92	
350		222	94	
352		224	96	
354		226	98	
356		228	100	
358		230	102	
360		232	104	
362			106	
364			108	
366			110	
368			112	

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
370			114	
372			116	
374			118	
376			120	
378			122	
380			124	
382			126	
384			128	0
386			130	2
388			132	4
390			134	6
392			136	8
394			138	10
396			140	12
398			142	14
400			144	16
402			146	18
404			148	20
406			150	22
408			152	24
410			154	26
412			156	28
414			158	30
416			160	32
418			162	34
420			164	36
422			166	38
424			168	40
426			170	42
428			172	44
430			174	46
432			176	48
434			178	50
436			180	52
438			182	54
440			184	56
442			186	58

COLR for Watts Bar Unit 1, Cycle 6 - TPC Design

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
444			188	60
446			190	62
448			192	64
450			194	66
452			196	68
454			198	70
456			200	72
458			202	74
460			204	76
462			206	78
464			208	80
466			210	82
468			212	84
470			214	86
472			216	88
474			218	90
476			220	92
478			222	94
480			224	96
482			226	98
484			228	100
486			230	102
488			232	104
490				106
492				108
494				110
496				112
498				114
500				116
502				118
504				120
506				122
508				124
510				126
512				128
514				130
516				132

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
518				134
520				136
522				138
524				140
526				142
528				144
530				146
532				148
534				150
536				152
538				154
540				156
542				158
544				160
546				162
548				164
550				166
552				168
554				170
556				172
558				174
560				176
562				178
564				180
566				182
568				184
570				186
572				188
574				190
576				192
578				194
580				196
582				198
584				200
586				202
588				204
590				206

COLR for Watts Bar Unit 1, Cycle 6 – TPC Design

Table 1: Control Rod Overlap

Band Overlap Counter (steps)	A Bank	B Bank	C Bank	D Bank
592				208
594				210
596				212
598				214
600				216
602				218
604				220
606				222
608				224
610				226
612				228
614				230
616				232

This information is provided in 2 step increments. One step increments can be derived by interpolation. Fully withdrawn region shall be the condition where shutdown and control banks are at a position within the interval of ≥ 225 and ≤ 231 steps withdrawn. The Table indicates a maximum step of 232 to be consistent with 2 step increments.