Appendix 4B. Figures





Figure 4-2. Deleted Per 2001 Update

Figure 4-3. Deleted Per 2016 Update.

Figure 4-4. Deleted Per 1993 Update

Figure 4-5. Deleted Per 1993 Update

Figure 4-6. Deleted Per 2001 Update

Figure 4-7. Deleted Per 2001 Update

Figure 4-8. Deleted Per 2001 Update



Figure 4-9. Full Length Rod Cluster Control and Drive Rod Assembly with Interfacing Components

Figure 4-10. Rod Cluster Control Assembly Outline

Catawba Nuclear Station

Appendic 4. Chapter 4 Tables and Figures



Figure 4-10. Rod Cluster Control Assembly Outline

Figure 4-11. Hybrid B₄C Absorber Rod



Figure 4-12. Deleted Per 2001 Update

Figure 4-13. Deleted Per 2000 Update

Figure 4-14. Deleted Per 1994 Update

Figure 4-15. Deleted Per 2001 Update

Figure 4-16. Thimble Plug Assembly





Figure 4-17. Fuel Loading Arrangement

twice or thrice burnen assemblies once burnt burned assemblies feed assemblies



Figure 4-18. Fuel Loading Arrangement

twice or thrice burnen assemblies once burnt burned assemblies feed assemblies







Figure 4-20. Boron Concentration Versus Typical Cycle Burnup With and Without Burnable Poison

Figure 4-21. Deleted Per 2000 Update

1		_														
'		R	P	Ν	M	L	к	J	н	G	F	E	D	С	в	Α
	1															
	2					48	80	80	1 0 4	80	80	48				
	3				104	104		128		128		104	104			
	4			104			128		128		128	-		104		
	5		48	104		128		128		128		128		104	48	
	6	7	80		128				128				128		80	
	7		80	128		128		128		128		128		128	80	
	8		104		128		128				128		128		104	
	9		80	128		128		128		128		128		128	80	
	10		80		128				128				128		80	
	1 1		48	104		128		128		128		128		104	48	
$\overline{}$	12			104			128		128		128			104		
	13				104	104		128		128		104	104			
	14	÷				48	80	80	104	80	80	48				•
	15		-										# IFB/	A fuel	rods	

Figure 4-22. Typical Burnable Poison Loading Pattern IBFA Fuel

si.

								<u>180</u>	0						
1]			
2					8		16		16		8			7	
3				16		20			1	20	+	16	1	<u>+</u>	7
4			16		24	1	20		20	1	24	+	16		1
5		8		24		16		20		16		24		8	<u> </u>
6			20		16		16		16		16	†	20		<u> </u>
7		16		20		16		16		16		20	 	16	
8			88		20		16		16		20	<u> </u>	SS	<u> </u>	
9		16		20		16		16		16		20		16	
10			20		16		16		16		16		20		
11		8		24		16		20		16		24		8	
12			16		24		20		20		24		16		
13				16		20				20		16			
14					8		16		16		8]	
15												SS So # Bur	urce R hable	ođ Poisio	D8
	R	₽	N	M	L	ĸ	J	н 0°	G	F	E	D	с	B	х

Figure 4-23. Typical Burnable Poison Loading Pattern Burnable Poison Rods

Figure 4-24. Normalized Power Density Distribution Near Beginning-Of-Life, Unrodded Core, Hot Full Power, No Xenon - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

	Н	G	F	E	D	С	В	Α	
8	0.9658	1.2644	0.9792	1.2407	0.9628	1.2797	0.9798	0.4747	
9	1.2646	1.1814	1.2876	1.1732	1.2226	1.2075	1.1771	0.4323	
10	0.9786	1.2868	0.9911	1.2229	1.2069	1.2358	1.0820	0.4794	
11	1.2392	1.1710	1.2219	1.2092	1.2262	1.2116	1.1509	0.3234	
12	0.9620	1.2218	1.2067	1.2270	1.1890	1.2276	0.6302		
13	1.2794	1.2074	1.2363	1.2131	1.2298	0.7372	0.2608		
14	0.9799	1.1774	1.0828	1.1522	0.6310	0.2608			
15	0.4748	0.4325	0.4803	0.3239	Assembly Average Power				

Figure 4-25. Normalized Power Density Distribution Near Beginning-Of-Life, Unrodded Core, Hot Full, Equilibrum Xenon - *HISTORICAL INFORMATION NOT NOT REQUIRED TO BE REVISED*

	H	G	F	E	D	с 	В	Α		
8	0.9735	1.2608	0.9845	1.2363	0.9678	1.2725	0.9861	0.4908		
9	1.2610	1.1806	1.2808	1.1707	1.2156	1.2046	1.1757	0.4462		
10	0.9840	1.2800	0.9922	1.2142	1.2005	1.2264	1.0864	0.4943		
11	1.2349	1.1686	1.2133	1.2034	1.2148	1.2061	1.1475	0.3353		
12	0.9671	1.2149	1.2003	1.2156	1.1819	1.2182	0.6395			
13	1.2722	1.2045	1.2268	1.2075	1.2203	0.7471	0.2728			
14	0.9861	1.1759	1.0871	1.1487	0.6403	0.2728				
15	0.4908	0.4464	0.4952	0.3358	Assembly Average Power					

Figure 4-26. Normalized Power Density Distribution Near Beginning-Of-Life, Group D 28% Inserted, Hot Full Power, Equilibrum Xenon - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

	н	G	F	E	D	с 	В	A		
8	0.8992	1.2510	0.9931	1.2622	0.9848	1.2947	1.0010	0.4972		
9	1.2510	1.1779	1.2984	1.1865	1.2375	1.2214	1.1927	0.4506		
10	0.9921	1.2967	1.0001	1.2267	1.2061	1.2374	1.0941	0.4978		
11	1.2602	1.1836	1.2251	1.1955	1.1938	1.1905	1.1497	0.3331		
12	0.9837	1.2362	1.2055	1.1947	1.0838	1.1822	0.6243			
13	1.2942	1.2209	1.2376	1.1916	1.1844	0.7171	0.2622			
14	1.0009	1.1928	1.0946	1.1506	0.6249	0.2622				
15	0.4972	0.4508	0.4985	0.3336	Assembly Average Power					

Figure 4-27. Normalized Power Density Distribution Near Middle-Of-Life, Hot Full Power, Equilibrum Xenon - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

	H	G	F	E	D	C	В	А		
8	1.0071	1.3360	1.0102	1.3325	1.0036	1.3031	0.9455	0.5075		
9	1.3362	1.1723	1.3397	1.1828	1.3208	1.1597	1.1339	0.4568		
10	1.0099	1.3393	1.0251	1.3312	1.1902	1.2623	1.0044	0.4942		
11	1.3316	1.1813	1.3305	1.2044	1.2761	1.1132	1.0317	0.3353		
12	1.0031	1.3203	1.1900	1.2766	1.1054	1.1396	0.6100			
13	1.3029	1.1596	1.2624	1.1138	1.1408	0.7160	0.2863			
14	0.9455	1.1340	1.0047	1.0322	0.6103	0.2861				
15	0.5075	0.4569	0.4948	0.3356	Assembly Average Power					

Figure 4-28. Normalized Power Density Distribution Near End-Of-Life, Unrodded Core, Hot Full Power, Equilibrum Xenon - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

	н	G	F	E	D	c	B	Α		
8	0.9644	1.2601	0.9760	1.2918	0.9897	1.2699	0.9453	0.5614		
9	1.2603	1.0998	1.2859	1.1312	1.3044	1.1246	1.1286	0.5060		
10	0.9759	1.2857	1.0017	1.3150	1.1604	1.2829	1.0106	0.5493		
11	1.2916	1.1304	1.3147	1.1780	1.3149	1.1029	1.0409	0.3854		
12	0.9895	1.3044	1.1603	1.3152	1.0996	1.1441	0.6582			
13	1.2699	1.1246	1.2829	1.1032	1.1448	0.7630	0.3405			
14	0.9454	1.1287	1.0107	1.0411	0.6583	0.3403				
15	0.5614	0.5060	0.5498	0.3857	Assembly Average Power					

Figure 4-29. Normalized Power Density Distribution Near End-Of-Life, Group D 28% Inserted, Hot Full Power, Equilibrum Xenon - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

	Н	G	F	E	D	С	В	А		
8	0.8710	1.2422	0.9833	1.3183	1.0083	1.2975	0.9674	0.5735		
9	1.2425	1.0947	1.3023	1.1476	1.3292	1.1439	1.1531	0.5163		
10	0.9833	1.3018	1.0106	1.3274	1.1655	1.2971	1.0212	0.5562		
11	1.3181	1.1466	1.3268	1.1665	1.2877	1.0849	1.0415	0.3846		
12	1.0082	1.3291	1.1655	1.2882	0.9844	1.1003	0.6410			
13	1.2976	1.1439	1.2972	1.0853	1.1012	0.7322	0.3264			
14	0.9674	1.1532	1.0213	1.0417	0.6410	0.3262				
15	0.5736	0.5163	0.5567	0.3849	Assembly Average Power					

Figure 4-30. Rodwise Power Distribution in a Typical Assembly (G-9) Near Beginnig-Of-Life, Hot Full Power, Equilibrium Xenon, Unrodded Core - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*



Figure 4-31. Rodwise Power Distribution in a Typical Assembly (G-9) Near End-Of-Life, Hot Full Power, Equilibrium Xenon, Unrodded Core - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

.90																
.90	.91															
.90	.92	.94		_												
.91	.93	.92	X		_											
.91	.94	.99	1.00	.99												
.92	.96	\boxtimes	1.00	1.00	Х											
.92	. 9 5	.98	.98	.98	1.00	. 9 8		_								
.92	.95	.98	.97	.98	1.00	.98	.98									
.92	.96	Х	.99	.99	Х	1.00	1.00	Х		_						
.92	.95	.98	.97	.98	1.00	. 9 8	.98	1.00	.98		_					
.92	.95	.98	.98	.98	1.00	.98	.98	1.00	.98	.98		_				
.92	.96	\boxtimes	1.00	1.00	Х	1.00	1.00	Х	1.00	1.00	\boxtimes		_			
.91	.94	.98	1.00	.99	1.00	.98	.98	.99	.98	.98	1.00	.99				
.91	.93	.97	Х	1.00	1.00	.98	.97	.99	.97	.98	1.00	1.00	\boxtimes		_	
.90	.92	. 94	.97	.98	Х	.98	.98	Х	.98	.98	Х	.98	.97	.94		_
.90	.91	.92	. ,93	.94	.96	.95	.95	.96	.95	.95	.96	.94	.93	.92	.91	
.90	.90	.90	.91	.91	.92	.92	.92	.92	.92	.92	.92	.91	.91	.90	.90	.90



Figure 4-32. Typical Axial Power Shapes Occurring at Beginning-Of-Life - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*



Figure 4-33. Typical Axial Power Shapes Occurring at Middle-Of-Life - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*



Figure 4-34. Typical Axial Power Shapes Occurring at End-Of-Life - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*



Figure 4-35. Comparison of Assembly Axial Power Distribution with Core Average Axial Distribution, D Bank Slightly Inserted - *HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED*

Figure 4-36. Deleted Per 1998 Update

Figure 4-37. Deleted Per 2000 Update

Figure 4-38. Deleted Per 2000 Update

Figure 4-39. Deleted Per 2000 Update









Figure 4-42. Typical Comparison Between Calculated and Measured Relative Fuel Assembly Power Distribution - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

	Н	G	F	Е	D	С	В	Α
				1.326		0.896		0.436
8				1.329		0.909		0.436
	1			-0.002		-0.014		0.000
	1.340		1.346				1.149	
9	1.341		1.346				1.133	
	-0.001		0.000				0.014	
					1.055			
10					1.061			
					-0.006			
	1.330		1.354	1.214		1.110		0.400
11	1.329		1.345	1.216		1.104		0.320
	0.001		0.007	-0.002		0.005		0.250
12								
	0.904					0.831	0.317	
13	0.909					0.821	0.315	
	-0.006				<u> </u>	0.012	0.005	
		1.160					Calculated	
14		1.135					Measured	
		0.022					Error (C-M/N	/)
	0.439			0.318				
15	0.436			0.320				
	0.007			-0.006				







Figure 4-44. Comparison of Calculated and Measured Peaking Factors, FQ X PREL MAX Envelope as a Function of Core Height - HIST. INFOR. NOT REQUIRED TO BE REVISED



Figure 4-45. Doppler Temperature Coefficient at BOL and EOL, Cycle 1 - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED




Figure 4-47. Doppler - Only Power Defect Coefficient - BOL, EOL, Cycle 1 - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED













Figure 4-50. Moderator Temperature Coefficient as a Function of Boron Concentration - BOL Cycle 1, No Rods - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED



Figure 4-51. Hot Full Power Temperature Coefficient During Cycle 1 for the Critical Boron Concentration - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED

(22 OCT 2001)











Figure 4-54. Rod Cluster Control Assembly Pattern

CONTROL BANK	NUMBER Of RODS	SHUTDOWN Bank	NUMBER OF RODS
Α	¥	SA	8
B	8	SB	8
С	8	SC	4
D	5	SD	4
TOTAL	25	SE	4
		TOTAL	28

Figure 4-55. Accidental Simultaneous Withdrawal of Two Control Banks, EOL, HZP, Banks C and B Moving in the Same Plane - HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED



(22 OCT 2001)

Figure 4-56. Deleted Per 1998 Update

Figure 4-57. Deleted Per 1998 Update



Figure 4-58. Axial Offset Versus Time PWR Core with 12-ft. Height and 121 Assemblies



Figure 4-59. XY Xenon Test Thermocouple Response Quadrant Tilt Difference Versus Time

Figure 4-60. Deleted Per 1998 Update



Figure 4-61. Comparison of Calculated and Measured Boron Concentration for 2-Loop Plant, 121 Assemblies, 12-Foot Core



Figure 4-62. Comparison of Calculated and Measured CB 3-Loop Plant with 157 Assemblies, 12-Foot Core



Figure 4-63. Comparison of Calculated and Measured CB 4-Loop Plant, 193 Assemblies, 12-Foot Core

Figure 4-64. Deleted Per 1997 Update







Figure 4-65. Measured Versus Predicted Critical Heat Flux - BWCMV





Figure 4-66. TDC Versus Reynolds Number for 26-inch Grid Spacing

Figure 4-67. Deleted Per 2001 Update

Figure 4-68. Deleted Per 2001 Update

Figure 4-69. Deleted Per 2001 Update



Figure 4-70. Void Fraction Versus Themodynamic Quality H-Hsat/Hg-Hsat

Figure 4-71. Deleted Per 2001 Update

Figure 4-72. Deleted Per 1995 Update

Figure 4-73. Deleted per 1992 Update





T= THERMOCOUPLE (65)

D= MOVABLE INCORE DETECTOR (58 LOCATIONS)

Figure 4-75. Deleted Per 2016 Update



Figure 4-76. Unit 1 Reactor Coolant System Temperature - Percent Power Map

Refer to 4.4.3.4 for applicability.



Figure 4-77. Unit 2 Reactor Coolant System Temperature - Percent Power Map

Refer to 4.4.3.4 for applicability.









Figure 4-79. Typical Burnable Poison Rod (BWFC) Cross Section

Figure 4-80. Typical Burnable Poison Arrangement within An Assembly Burnable Poison Rods



8 BP/Assembly Configuration



12 BP/Assembly Configuration



16 BP/Assembly Configuration



20 BP/Assembly Configuration



4 BP/Assembly Configuration



24 BP/Assembly Configuration

Figure 4-81. Typical Burnable Poison Arrangement within An Assembly IFBA Fuel Rods













Figure 4-84. WABA Burnable Poison Rod Cross Section

Figure 4-85. 17x17 Westinghouse Robust Fuel Assembly Outline





TOP VIEW



BOTTOM YIEW



Figure 4-86. Westinghouse Robust Fuel Rod Assembly
Figure 4-87. Hybrid B₄C Absorber Rod (BWFC Demo)



Α в D G м N 0 Р С Ε F н I J к 1. Q 1 2 3 \bigcirc 4 Б 6 7 8 9 10 -11 12 13 14 15 \odot [] 16 17 High Pu Concentration Medium Pu Concentration Low Pu Concentration Instrument Tube Guide Tube

Figure 4-88 Typical 17 x 17 Mark BW/MOX1 Fuel Assembly Configuration