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Supplemental Reload Licensing Report

for

Brunswick Steam Electric Plant Unit 1

Reload 14 Cycle 15

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Important Notice Regarding

Contents of This Report

Please Read Carefully

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Acknowledgement

The engineering and reload licensing analyses, which form the technical basis of this Supplemental Reload Licensing Report, were performed by GNF - Fuel Engineering Services and GENE - Nuclear and Safety Analysis personnel. The Supplemental Reload Licensing Report was prepared by G. M. Baka. This document has been verified by G. N. Marrotte.

The basis for this report is *General Electric Standard Application for Reactor Fuel*, NEDE-24011-P-A-14, June 2000; and the U.S. Supplement, NEDE-24011-P-A-14-US, June 2000.

1. Plant-unique Items

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Appendix B: Decrease in Core Coolant Temperature Events
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2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated:		
GE13-P9DTB405-5G6.0/7G5.0-100T-146-T (GE13)	13	46
GE13-P9DTB402-13G6.0/1G2.0-100T-146-T (GE13)	13	21
GE14-P10DNAB416-17GZ-100T-150-T-2496 (GE14C)	14	112
GE14-P10DNAB425-16GZ-100T-150-T-2497 (GE14C)	14	87
GE14-P10DNAB438-12G6.0-100T-150-T-2498 (GE14C)	14	48
New:		
GE14-P10DNAB437-12G6.0-100T-150-T-2662 (GE14C)	15	38
GE14-P10DNAB429-18GZ-100T-150-T-2661 (GE14C)	15	64
GE14-P10DNAB413-16GZ-100T-150-T-2660 (GE14C)	15	144
Total		560

3. Reference Core Loading Pattern [1]

Nominal previous cycle core average exposure at end of cycle:	33519 MWd/MT (30408 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	33096 MWd/MT (30024 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	13945 MWd/MT (12651 MWd/ST)
Assumed reload cycle core average exposure at end of cycle (full power):	32286 MWd/MT (29289 MWd/ST)
Reference core loading pattern:	Figure 1

4. Calculated Core Effective Multiplication and Control System Worth - No Voids, 20°C

Beginning of Cycle, $k_{effective}$	
Uncontrolled	1.126
Fully controlled	0.957
Strongest control rod out	0.986
R, Maximum increase in cold core reactivity with exposure into cycle, Δk	0.000

5. Standby Liquid Control System Shutdown Capability

Boron (ppm) (at 20°C)	Shutdown Margin (Δk) (at 160°C, Xenon Free)
720	0.015

[1] The previous cycle core average exposure at beginning of cycle - based on the original core configuration - was 14505 MWd/MT (13159 MWd/ST). The previous cycle core average exposures at end of cycle, however, are based on the reconfigured Cycle 14 core. Attempting to use the provided values to directly calculate incremental core average exposures will yield erroneous results.

6. Reload Unique TRACG Anticipated Operational Occurrences (AOO) Analysis Initial Condition Parameters

[2]Exposure: BOC15 to EOFPC15-5029 MWd/MT (4562 MWd/ST) with ICF, NFWT							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.0	1.43	1.24	1.040	7.454	118.5	1.37
GE13	1.0	0.65	1.26	1.020	3.383	145.3	2.90

Exposure: EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, NFWT							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.0	1.36	1.31	1.040	7.118	121.9	1.38
GE13	1.0	0.84	1.34	1.020	4.369	135.3	2.10

Exposure: BOC15 to EEOC15 with ICF, RFWT							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.0	1.28	1.36	1.040	6.687	124.4	1.63
GE13	1.0	0.75	1.43	1.020	3.923	140.9	2.64

[2] End of Full Power Capability (EOFPC) is defined as end-of-cycle all rods out, 100% power/104.5% flow, and normal feedwater temperature (NFWT).

7. Selected Margin Improvement Options

Recirculation pump trip:	No
Rod withdrawal limiter:	No
Thermal power monitor:	Yes
Improved scram time:	Yes (Option B)
Measured scram time:	No
Exposure dependent limits:	Yes
Exposure points analyzed:	2 (EOFPC15-5029 MWd/MT and EEOC15)

8. Operating Flexibility Options

Extended Operating Domain (EOD):	Yes
EOD type: Maximum Extended Load Line Limit (MELLLA)	
Minimum core flow at rated power:	99.0 %
EOD type: Maximum Extended Load Line Limit Plus (MELLLA+) [3]	
Minimum core flow at rated power:	85.0 %
Increased Core Flow:	Yes
Flow point analyzed throughout cycle:	104.5 %
Feedwater Temperature Reduction:	Yes (MELLLA)
	No (MELLLA+)
Feedwater temperature reduction during cycle:	110.3°F
Final feedwater temperature reduction:	110.3°F
ARTS Program:	Yes
Single-loop operation:	Yes (MELLLA)
	No (MELLLA+)

[3] MELLLA+ operation is not allowed until approved by the U.S. Nuclear Regulatory Commission. See Appendix F.

Equipment Out of Service:

Safety/relief valves Out of Service [4]	Yes (MELLLA)
	No (MELLLA+)
ADS Out of Service	Yes (1 valve OOS)
MSIVOOS (w/ zero SRVs OOS) [5]	Yes (MELLLA)
	No (MELLLA+)
TBPOOS [6]	Yes

9. Core-wide AOO Analysis Results

Methods used: GEMINI (TRACG); GEXL-PLUS

Exposure range: BOC15 to EOFPC15-5029 MWd/MT (4562 MWd/ST) with ICF				
			[7]Uncorrected ΔCPR/ICPR	
Event	**Flux (%NBR)**	**[8]Q/A (%NBR)**	**All Fuel Types**	**Fig.**
Load Reject w/o Bypass	267	-	0.145	2

Exposure range: EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, NFWT				
			Uncorrected ΔCPR/ICPR	
Event	**Flux (%NBR)**	**Q/A (%NBR)**	**All Fuel Types**	**Fig.**
Load Reject w/o Bypass	358	-	0.168	3

Exposure range: BOC15 to EEOC15 with ICF and TBPOOS, NFWT				
			Uncorrected ΔCPR/ICPR	
Event	**Flux (%NBR)**	**Q/A (%NBR)**	**All Fuel Types**	**Fig.**
FW Controller Failure	386	-	0.190	4

[4] Credit taken for 10 of 11 valves.
[5] The MSIVOOS option is not referenced or supported within GESTAR II.
[6] Credit taken for 3 of 4 valves.
[7] Uncorrected ΔCPR/ICPR is being reported since this is the term used in developing the operating limit for TRACG-based analyses.
[8] Not available from the TRACG transient output.

Exposure range: EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, RFWT				
			Uncorrected ΔCPR/ICPR	
Event	Flux (%NBR)	Q/A (%NBR)	All Fuel Types	Fig.
FW Controller Failure	282	-	0.193	5

Exposure range: BOC15 to EEOC15 with ICF and TBPOOS, RFWT				
			Uncorrected ΔCPR/ICPR	
Event	Flux (%NBR)	Q/A (%NBR)	All Fuel Types	Fig.
FW Controller Failure	336	-	0.212	6

10. Local Rod Withdrawal Error (With Limiting Instrument Failure) AOO Summary

The rod withdrawal error (RWE) event in the maximum extended operating domain was originally analyzed in the GE BWR Licensing Report, *Maximum Extended Operating Domain Analysis for Brunswick Steam Electric Plant*, NEDC-31654P, February 1989. The MCPRs for Brunswick Unit 1 Cycle 15 RWE are not generally bounded by the safety limit adjusted operating limit MCPRs in Table 10-5(a) or 10-5(b) of NEDC-31654P. The limiting results are shown in the table below for the RBM System setpoints shown in Table 10-5(c) of NEDC-31654P. The RBM operability requirements specified in Section 10.5 of NEDC-31654P have been evaluated to ensure that the Safety Limit MCPR and cladding 1% plastic strain criteria will not be exceeded in the event of an unblocked RWE event. The minimum OLMCPR with RBM inoperable, after cycle-specific SLMCPR adjustment, is 1.45 (=1.40*1.11/1.07).

RBM Setpoint All HTSP Without RBM Filter	Cycle 15 Results ΔCPR
108.0	0.17
111.0	0.20
114.0	0.24
117.0	0.29

11. Cycle MCPR Values [9]

Safety limit: 1.11

Single loop operation safety limit: 1.12

ECCS OLMCPR Design Basis: See Section 16

Non-pressurization events:

Exposure range: BOC15 to EOC15		
	All Fuel Types	
Control Rod Withdrawal Error (RBM setpoint at 108%)	1.28	
Loss of Feedwater Heating [10]	1.26	
Fuel Loading Error (mislocated)	Not limiting [11]	
	GE14C	**GE13**
Fuel Loading Error (misoriented)	1.23	1.24

Pressurization events:

Exposure range: BOC15 to EOFPC15-5029 MWd/MT (4562 MWd/ST) with ICF [12] **Exposure point: EOFPC15-5029 MWd/MT (4562 MWd/ST)**		
	Option A	**Option B**
	All Fuel Types	**All Fuel Types**
Load Reject w/o Bypass	1.51	1.33

[9] The Operating Limit MCPRs for two loop operation (TLO) bound the Operating Limit MCPRs for Single Loop Operation (SLO); therefore, the Operating Limit MCPRs need not be changed for SLO.
[10] See Appendix B.
[11] The mislocated bundle fuel loading error OLMCPR is bounded by the pressurization event OLMCPR.
[12] The ICF Operating Limits for the exposure range of BOC15 to EOFPC15-5029 MWd/MT (4562 MWd/ST) bound the Operating Limits for the following domains: MELLLA, MELLLA+, MSIVOOS and ICF. See Appendix F regarding the MELLLA+ domain.

Exposure range: EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, NFWT [13] Exposure point: EEOC15		
	Option A	Option B
	All Fuel Types	All Fuel Types
Load Reject w/o Bypass	1.56	1.38

Exposure range: BOC15 to EEOC15 with ICF and TBPOOS, NFWT [14] Exposure point: EEOC15		
	Option A	Option B
	All Fuel Types	All Fuel Types
FW Controller Failure	1.60	1.42

Exposure range: EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, RFWT [15] Exposure point: EEOC15		
	Option A	Option B
	All Fuel Types	All Fuel Types
FW Controller Failure	1.61	1.43

Exposure range: BOC15 to EEOC15 with ICF and TBPOOS, RFWT [16] Exposure point: EEOC15		
	Option A	Option B
	All Fuel Types	All Fuel Types
FW Controller Failure	1.66	1.48

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram)	1272	1317	Figure 7

[13] The NFWT ICF Operating Limits for the exposure range of EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 bound the Operating Limits for the following NFWT domains: MELLLA, MELLLA+, MSIVOOS and ICF. See Appendix F regarding the MELLLA+ domain.

[14] The NFWT TBPOOS ICF Operating Limits for the exposure range of BOC15 to EEOC15 bound the Operating Limits for all NFWT domains with TBPOOS.

[15] The RFWT ICF Operating Limits for the exposure range of EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 bound the Operating Limits for the following RFWT domains: MELLLA, MSIVOOS and ICF.

[16] The RFWT TBPOOS ICF Operating Limits for the exposure range of BOC15 to EEOC15 bound the Operating Limits for all RFWT domains with TBPOOS, except MELLLA+, for which RFWT is not allowed. See Appendix F regarding the MELLLA+ domain.

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes [17]

Misoriented Fuel Bundle	ΔCPR
GE13-P9DTB405-5G6.0/7G5.0-100T-146-T (GE13)	0.08
GE13-P9DTB402-13G6.0/1G2.0-100T-146-T (GE13)	0.13
GE14-P10DNAB416-17GZ-100T-150-T-2496 (GE14C)	0.06
GE14-P10DNAB425-16GZ-100T-150-T-2497 (GE14C)	0.12
GE14-P10DNAB438-12G6.0-100T-150-T-2498 (GE14C)	0.04
GE14-P10DNAB413-16GZ-100T-150-T-2660 (GE14C)	0.06
GE14-P10DNAB429-18GZ-100T-150-T-2661 (GE14C)	0.06
GE14-P10DNAB437-12G6.0-100T-150-T-2662 (GE14C)	0.04

14. Control Rod Drop Analysis Results

This is a banked position withdrawal sequence plant, therefore, the control rod drop accident analysis is not required. NRC approval is documented in NEDE-24011-P-A-US.

15. Stability Analysis Results

Due to the Potential Reportable Condition (PRC 01-07) reported by GE on the DIVOM (Delta CPR Over Initial CPR Versus Oscillation Magnitude) slope issue, it is essential to confirm that the generic DIVOM slope used in this Option III stability analysis be applicable to Brunswick Unit 1 Cycle 15 or an interim OPRM setpoint be used based on a revised DIVOM slope. Should the Option III OPRM system be declared inoperable, the BWROG Interim Corrective Action will constitute the stability licensing basis for Brunswick Unit 1 Cycle 15.

Stability Option III

Brunswick Unit 1 has implemented BWROG Long Term Stability Solution Option III (Oscillation Power Range Monitor-OPRM) as described in NEDO-31960-A, *BWR Owners Group Long-Term Stability Solutions Licensing Methodology*, November 1995. Plant specific analysis incorporating the Option III hardware is described in GE-NE-C51-00251-00-01, Revision 0, *Licensing Basis Hot Bundle Oscillation Magnitude for Brunswick 1 and 2*, March 2001.

Reload validation has been performed in accordance with NEDO-32465-A, *Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Application*, August 1996. The stability based MCPR Operating Limit is provided for two conditions as a function of OPRM amplitude setpoint

[17] Includes a 0.02 penalty due to variable water gap R-factor uncertainty.

in the following table. The two conditions evaluated are for a postulated oscillation at 45% core flow steady state operation (SS) and following a two recirculation pump trip (2PT) from the limiting full power operation state point. Current power and flow dependent limits provide adequate protection against violation of the Safety Limit MCPR for postulated reactor instability as long as the operating limit is greater than or equal to the specified value for the selected OPRM setpoint.

The stability-based OLMCPR was calculated for Cycle 15. The reload validation calculation demonstrated that reactor stability does not produce the limiting OLMCPR for Cycle 15 as long as the selected OPRM setpoint produces values for OLMCPR(SS) and OLMCPR(2PT) which are less than the corresponding acceptance criteria.

OPRM Setpoint	OLMCPR(SS)	OLMCPR(2PT)
1.05	1.2136	1.1343
1.06	1.2355	1.1548
1.07	1.2582	1.1760
1.08	1.2817	1.1980
1.09	1.3062	1.2209
1.10	1.3316	1.2447
1.11	1.3568	1.2682
1.12	1.3830	1.2927
1.13	1.4101	1.3181
1.14	1.4384	1.3445
1.15	1.4679	1.3720
Acceptance Criteria	**Off-rated OLMCPR @ 45% Flow**	**Rated Power OLMCPR as described in SRLR Section 11**

Interim Corrective Action Stability

GE SIL-380 recommendations and BWROG Interim Corrective Actions (BWROG-94079) have been included in the Brunswick Unit 1 Cycle 15 operating procedures. Regions of restricted operation defined in Attachment 1 to NRC Bulletin No 88-07, Supplement 1, *Power Oscillations in Boiling Water Reactors (BWRs)*, and expanded in BWROG-94079, are applicable to Brunswick Unit 1. The standard ICA stability regions are expanded as appropriate to offer stability protection per BWROG-02072 for Brunswick Unit 1 Cycle 15.

16. Loss-of-Coolant Accident Results

16.1 10CFR50.46 Licensing Results

The LOCA method used is SAFER/GESTR-LOCA. The licensing results applicable to each fuel type in the new cycle are summarized in the following table:

Table 16.1-1 Licensing Results

Fuel Type	Licensing Basis PCT (°F)	Local Oxidation (%)	Core-Wide Metal-Water Reaction (%)
GE14C	1557	< 1.00	< 0.10
GE13	1707	< 1.00	< 0.10

The SAFER/GESTR-LOCA analysis results for these fuel types are documented in Reference 16-1.

16.2 10CFR50.46 Error Evaluation

The 10CFR50.46 errors applicable to the Licensing Basis PCT are shown in the table below.

Table 16.2-1 Impact on Licensing Basis Peak Cladding Temperature for GE14C

10CFR50.46 Error Notifications		
Number	**Subject**	**PCT Impact (°F)**
2002-01	Error in core spray injection elevation	+5
2002-02	Error in SAFER initial bulk water level	+10
2002-05	Error in WEVOL calculation of downcomer free volume	0
2003-01	Impact of SAFER level/volume table error on PCT	-5
	Total PCT Adder (°F)	+10

The GE14C Licensing Basis PCT remains below the 10CFR50.46 limit of 2200°F.

Table 16.2-2 Impact on Licensing Basis Peak Cladding Temperature for GE13

10CFR50.46 Error Notifications		
Number	**Subject**	**PCT Impact (°F)**
2001-02	An inconsistency in the pressure rate equation	+10
2002-01	Error in core spray injection elevation	+5
2002-02	Error in SAFER initial bulk water level	+10
2002-04	SAFER computer platform change	0
2002-05	Error in WEVOL calculation of downcomer free volume	0
2003-01	Impact of SAFER level/volume table error on PCT	0
2003-03	Impact of SAFER initial pressure drop on the PCT	0
	Total PCT Adder (°F)	+25

The GE13 Licensing Basis PCT remains below the 10CFR50.46 limit of 2200°F.

16.3 ECCS-LOCA Operating Limits

The ECCS MAPLHGR operating limits have been merged with the thermal-mechanical MAPLHGR operating limits to produce a set of fuel type dependent composite MAPLHGR limits representing the most restrictive values of both. The most and least limiting values of these composite MAPLHGRs for each of the new fuel bundles in this cycle are shown in the tables below:

Table 16.3-1 MAPLHGR Limits

Bundle Type: GE14-P10DNAB413-16GZ-100T-150-T-2660

Average Planar Exposure		MAPLHGR (kW/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	9.57	9.68
0.20	0.22	9.60	9.70
1.00	1.10	9.66	9.78
2.00	2.20	9.77	9.91
3.00	3.31	9.92	10.06
4.00	4.41	10.08	10.22
5.00	5.51	10.26	10.38
6.00	6.61	10.44	10.55
7.00	7.72	10.59	10.73
8.00	8.82	10.74	10.91
9.00	9.92	10.87	11.11
10.00	11.02	11.00	11.31
11.00	12.13	11.12	11.52
12.00	13.23	11.15	11.66
13.00	14.33	11.16	11.75
14.00	15.43	11.16	11.74
14.51	15.99	11.16	11.73
15.00	16.53	11.16	11.71
17.00	18.74	11.13	11.58
19.13	21.09	11.02	11.38
20.00	22.05	10.98	11.30
25.00	27.56	10.57	10.75
30.00	33.07	10.15	10.21
35.00	38.58	9.65	9.69
40.00	44.09	9.12	9.17
45.00	49.60	8.59	8.65
50.00	55.12	8.04	8.11
55.00	60.63	6.48	6.64
57.61	63.50	5.18	5.34
58.20	64.16	4.88	5.05
58.23	64.19	--	5.03
58.48	64.46	--	4.91
58.50	64.48	--	4.90

Table 16.3-2 MAPLHGR Limits

Bundle Type: GE14-P10DNAB429-18GZ-100T-150-T-2661

Average Planar Exposure		MAPLHGR (kW/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	8.89	9.12
0.20	0.22	8.98	9.20
1.00	1.10	9.05	9.30
2.00	2.20	9.16	9.42
3.00	3.31	9.29	9.53
4.00	4.41	9.43	9.65
5.00	5.51	9.55	9.81
6.00	6.61	9.68	9.97
7.00	7.72	9.81	10.10
8.00	8.82	9.94	10.23
9.00	9.92	10.08	10.37
10.00	11.02	10.23	10.52
11.00	12.13	10.28	10.62
12.00	13.23	10.31	10.66
13.00	14.33	10.34	10.70
14.00	15.43	10.37	10.76
14.51	15.99	10.39	10.80
15.00	16.53	10.41	10.84
17.00	18.74	10.49	10.96
19.13	21.09	10.53	10.97
20.00	22.05	10.55	10.98
25.00	27.56	10.35	10.59
30.00	33.07	9.89	10.12
35.00	38.58	9.43	9.65
40.00	44.09	8.95	9.18
45.00	49.60	8.45	8.69
50.00	55.12	7.92	8.16
55.00	60.63	5.83	6.60
56.71	62.51	4.97	5.74
56.87	62.69	--	5.66
57.61	63.50	--	5.29
58.03	63.97	--	5.08
58.30	64.27	--	4.95

Table 16.3-3 MAPLHGR Limits

Bundle Type: GE14-P10DNAB437-12G6.0-100T-150-T-2662

Average Planar Exposure		MAPLHGR (kW/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	9.06	9.21
0.20	0.22	9.11	9.27
1.00	1.10	9.20	9.36
2.00	2.20	9.31	9.48
3.00	3.31	9.43	9.62
4.00	4.41	9.55	9.76
5.00	5.51	9.68	9.90
6.00	6.61	9.81	10.05
7.00	7.72	9.95	10.21
8.00	8.82	10.09	10.37
9.00	9.92	10.23	10.53
10.00	11.02	10.38	10.71
11.00	12.13	10.45	10.84
12.00	13.23	10.48	10.91
13.00	14.33	10.51	10.98
14.00	15.43	10.54	11.03
14.51	15.99	10.55	11.05
15.00	16.53	10.56	11.06
17.00	18.74	10.56	11.03
19.13	21.09	10.49	10.94
20.00	22.05	10.47	10.89
25.00	27.56	10.20	10.62
30.00	33.07	9.87	10.28
35.00	38.58	9.42	9.80
40.00	44.09	8.95	9.32
45.00	49.60	8.45	8.82
50.00	55.12	7.91	8.29
55.00	60.63	5.56	6.58
56.27	62.02	4.91	5.93
57.61	63.50	--	5.23
58.05	63.99	--	5.00
58.14	64.09	--	4.96

The single loop operation multiplier on LHGR and MAPLHGR and the ECCS Initial MCPR values applicable to each fuel type in the new cycle core are shown in the table below.

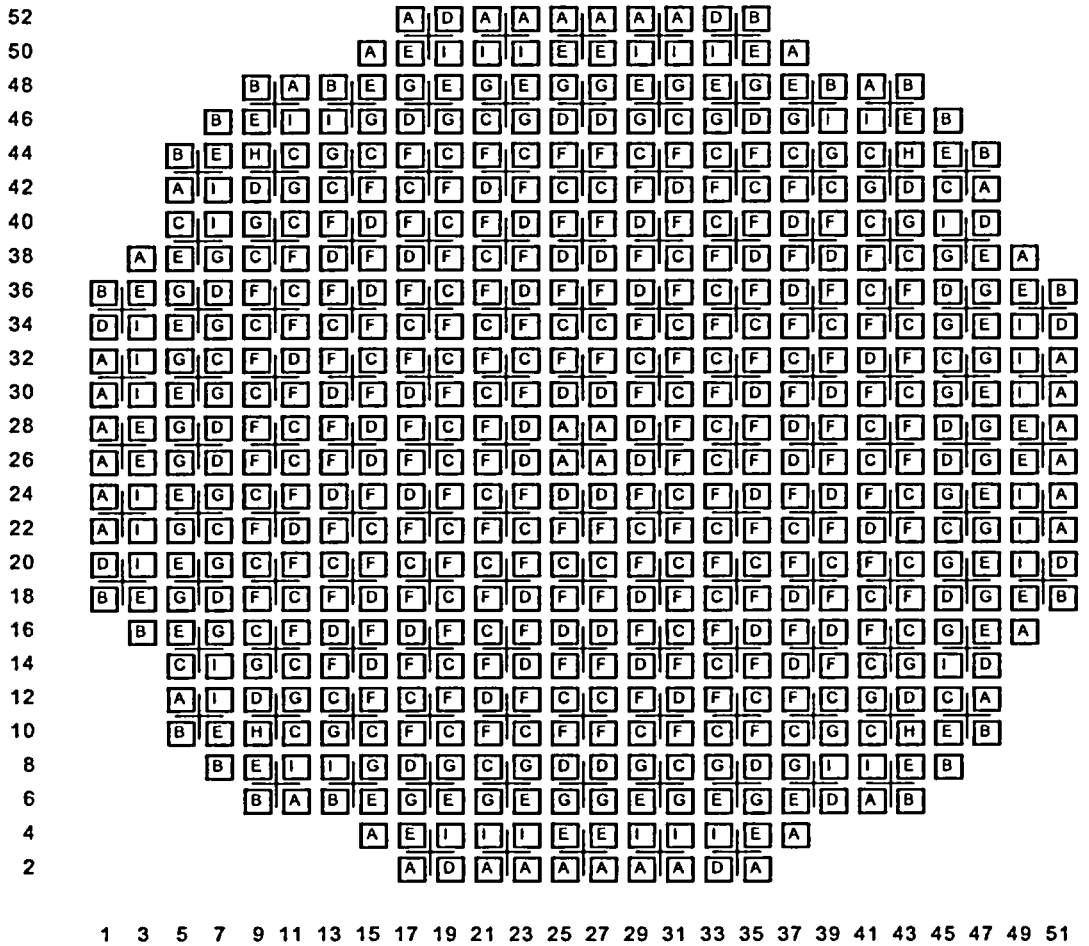
Table 16.3-4 Initial MCPR and Single Loop Operation PLHGR and MAPLHGR Multiplier

Fuel Type	Initial MCPR	Single Loop Operation PLHGR and MAPLHGR Multiplier
GE14C	1.275	0.80
GE13	1.200	0.80

16.4 References

The SAFER/GESTR-LOCA analysis base reports applicable to the new cycle core are listed below.

Reference No.	Reference
16-1	*Brunswick Nuclear Plant Unit 1 and 2 Extended Power Uprate Task 0407 ECCS-LOCA SAFER/GESTR Project Task Report*, GE-NE-A22-00113-27-01, Revision 0, June 2001.



Fuel Type	
A=GE13-P9DTB405-5G6.0/7G5.0-100T-146-T (Cycle 13)	F=GE14-P10DNAB413-16GZ-100T-150-T-2660 (Cycle 15)
B=GE13-P9DTB402-13G6.0/1G2.0-100T-146-T (Cycle 13)	G=GE14-P10DNAB429-18GZ-100T-150-T-2661 (Cycle 15)
C=GE14-P10DNAB416-17GZ-100T-150-T-2496 (Cycle 14)	H=GE14-P10DNAB429-18GZ-100T-150-T-2661 (Cycle 15)
D=GE14-P10DNAB425-16GZ-100T-150-T-2497 (Cycle 14)	I=GE14-P10DNAB437-12G6.0-100T-150-T-2662 (Cycle 15)
E=GE14-P10DNAB438-12G6.0-100T-150-T-2498 (Cycle 14)	

Figure 1 Reference Core Loading Pattern

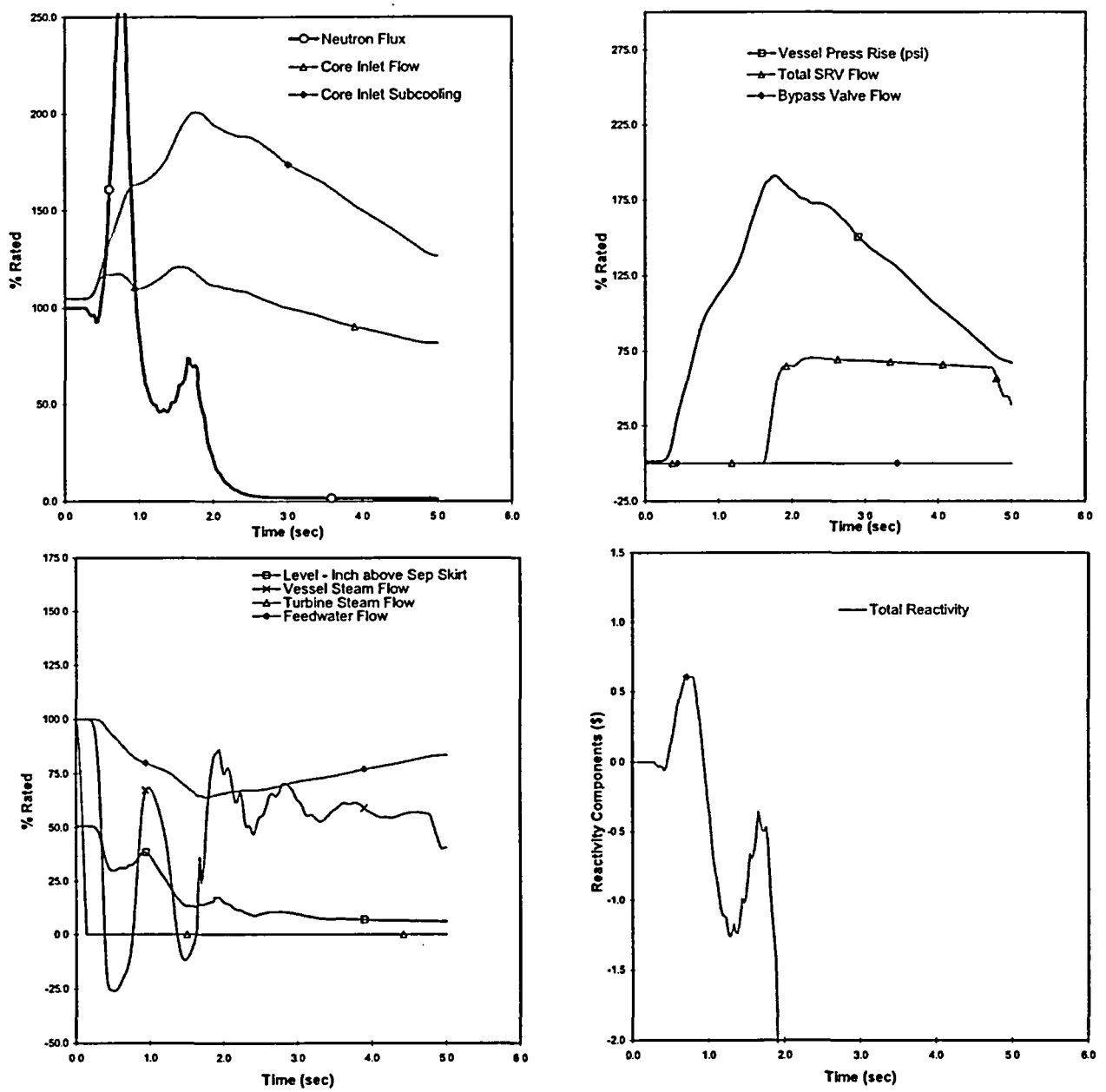


Figure 2 Plant Response to Load Reject w/o Bypass
BOC15 to EOFPC15-5029 MWd/MT (4562 MWd/ST) with ICF

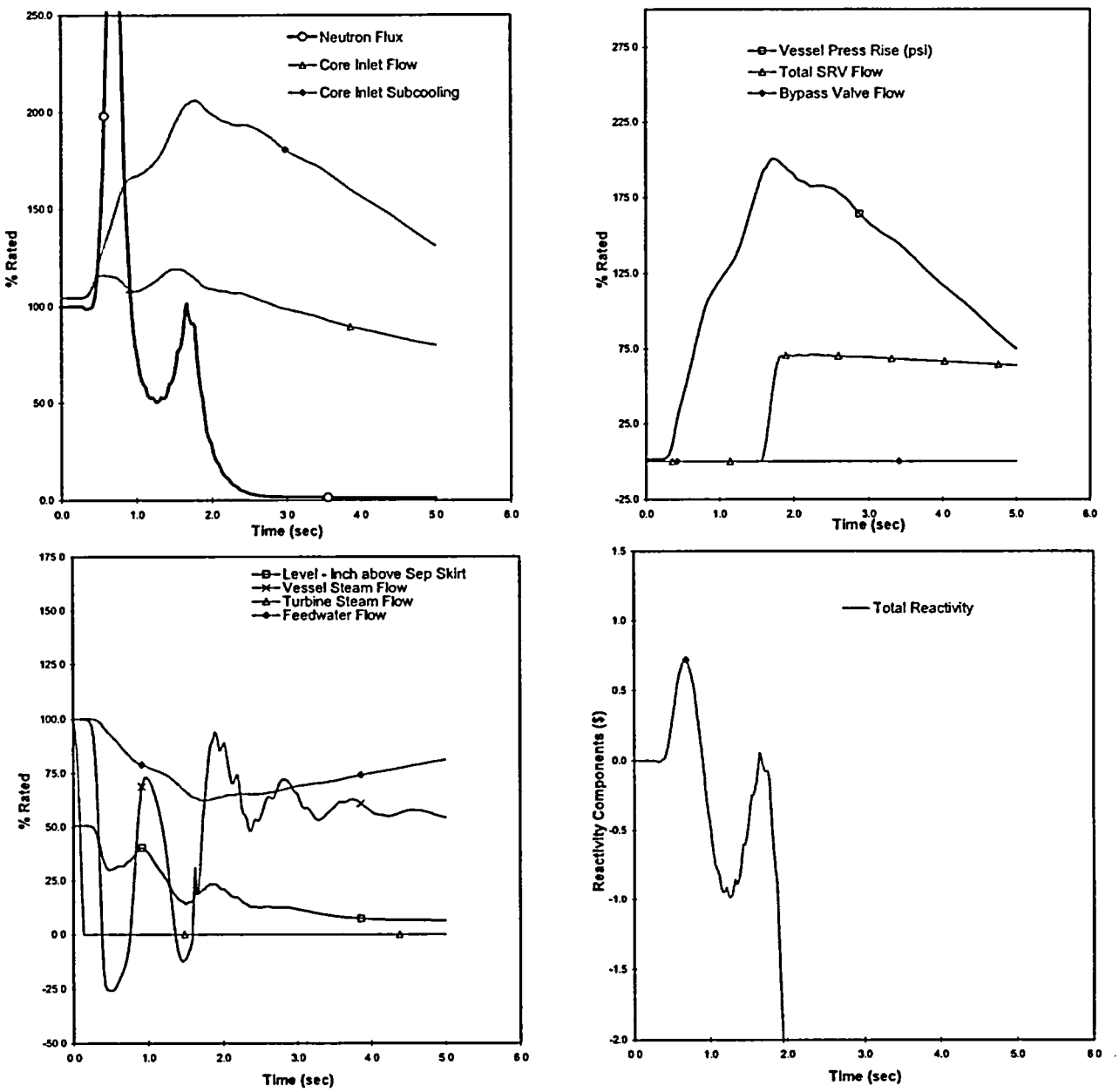


Figure 3 Plant Response to Load Reject w/o Bypass
EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, NFWT

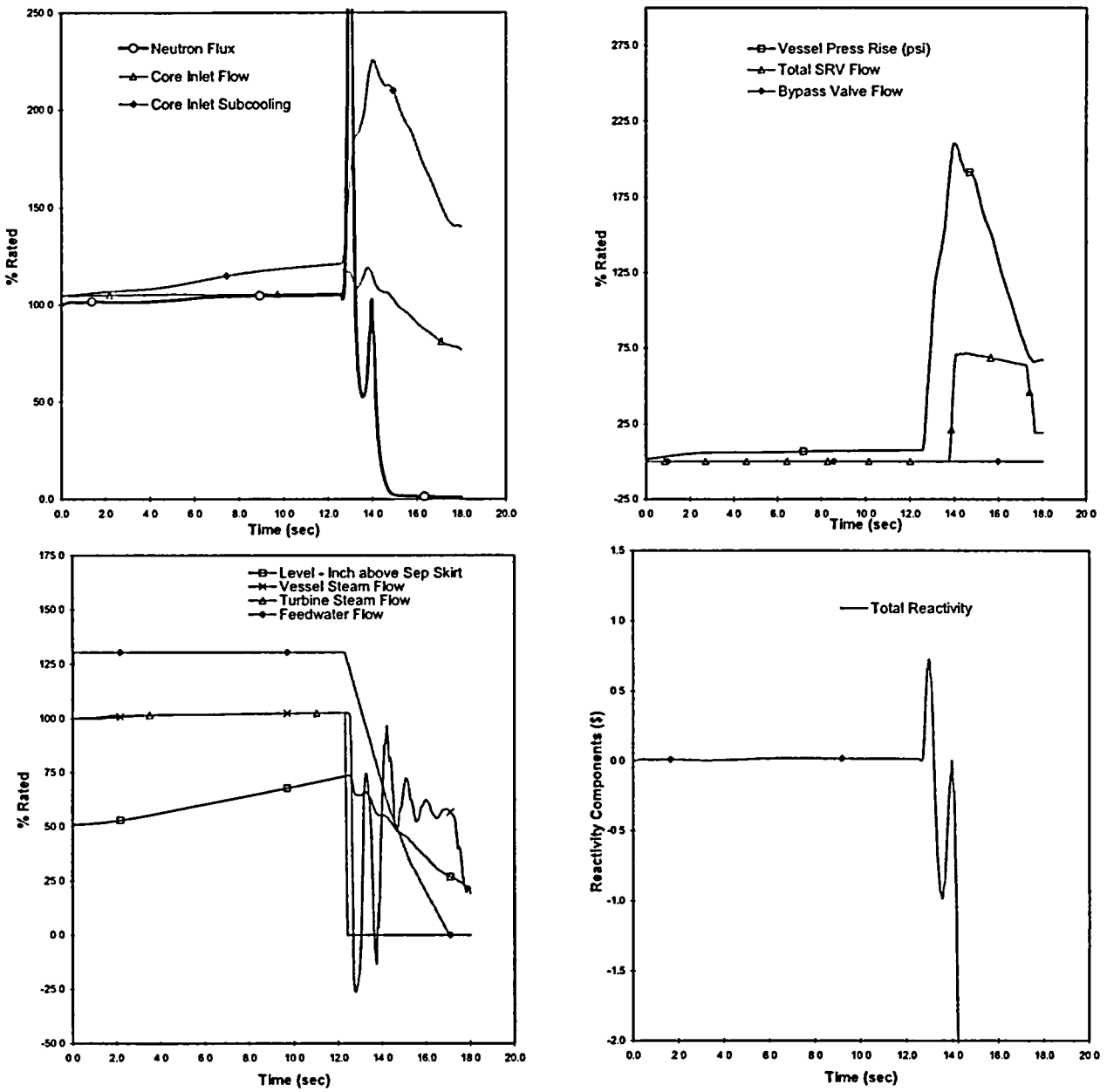


Figure 4 Plant Response to FW Controller Failure
BOC15 to EEOC15 with ICF and TBPOOS, NFWT

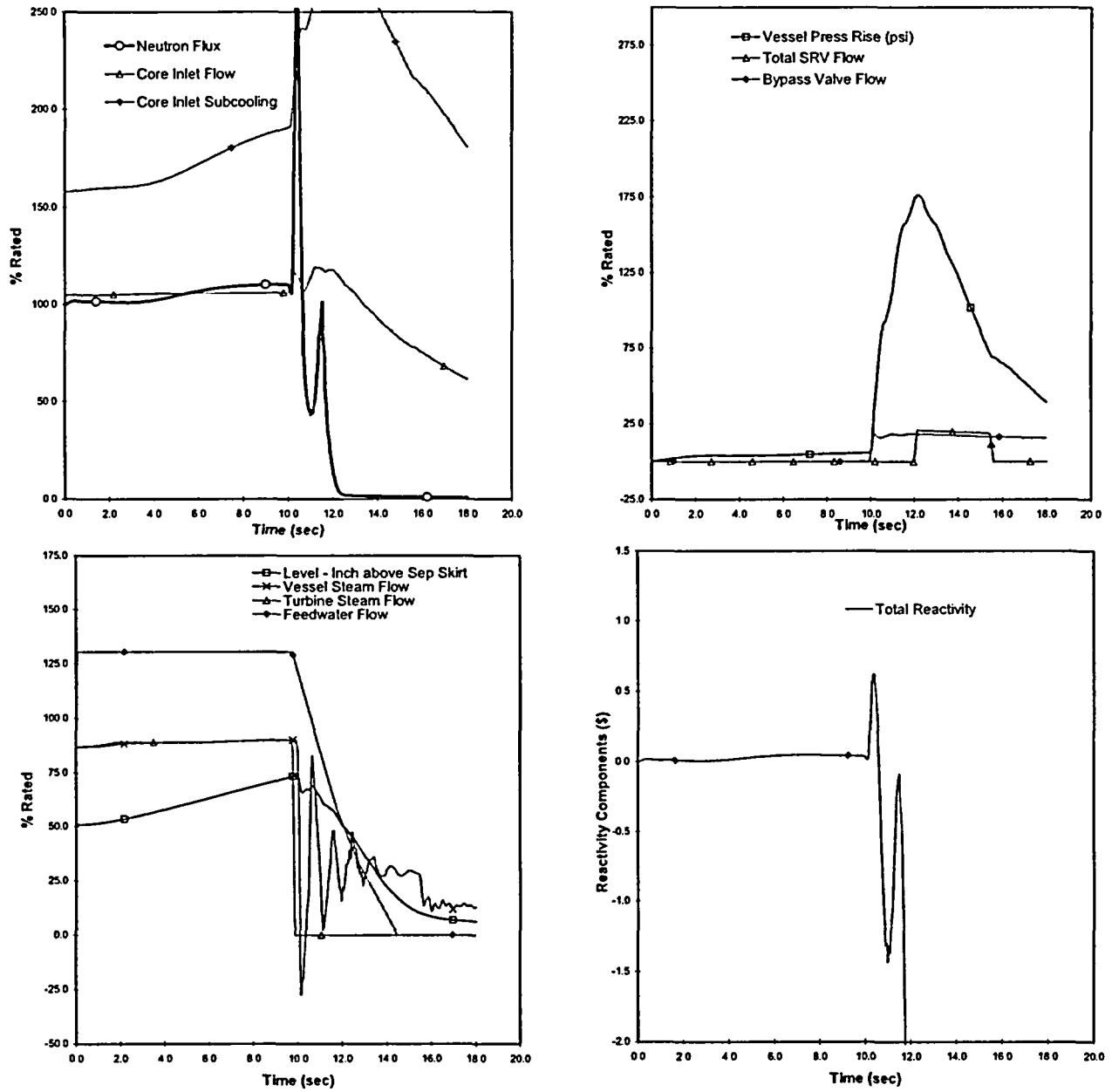


Figure 5 Plant Response to FW Controller Failure
EOFPC15-5029 MWd/MT (4562 MWd/ST) to EEOC15 with ICF, RFWT

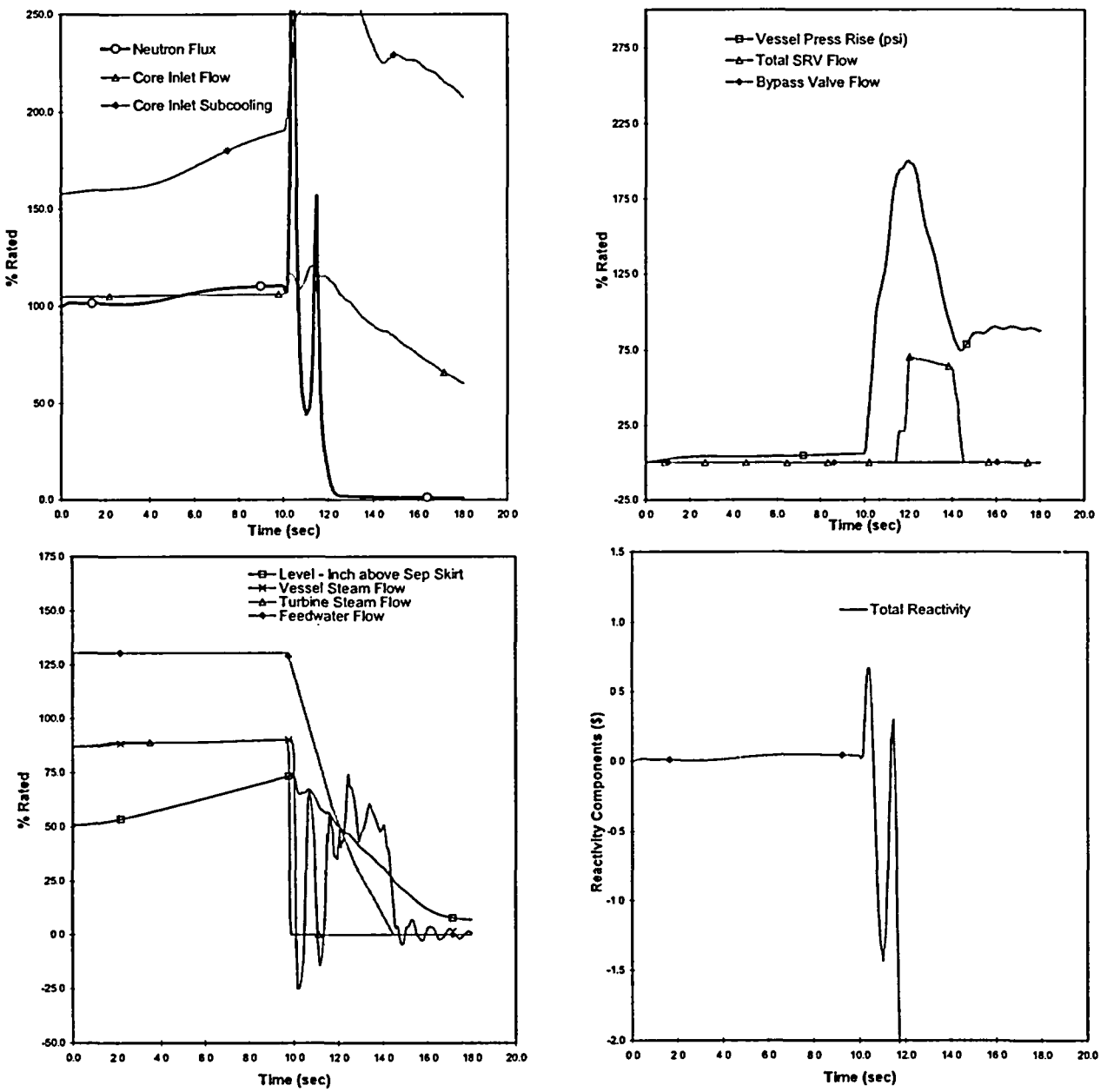


Figure 6 Plant Response to FW Controller Failure
BOC15 to EEOC15 with ICF and TBPOOS, RFWT

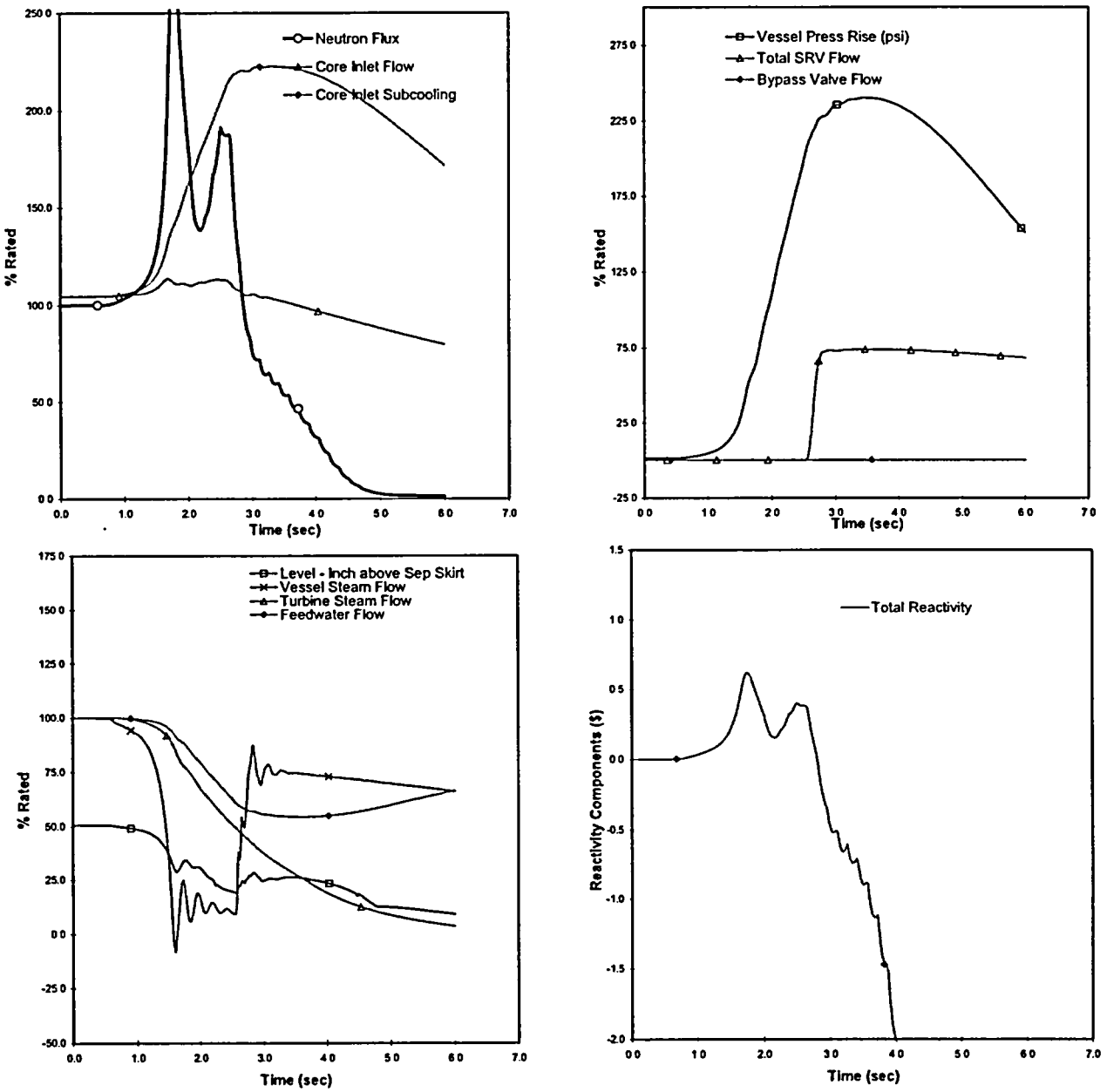


Figure 7 Plant Response to MSIV Closure Flux Scram

Appendix A
Analysis Conditions

To reflect actual plant parameters accurately, the values shown in Table A-1 were used this cycle.

Table A-1

Parameter	Analysis Value NFWT	Analysis Value RFWT
Thermal power, MWt	2923.0	2923.0
Core flow, Mlb/hr	80.5	80.5
Reactor pressure, psia	1060.3	1039.8
Inlet enthalpy, BTU/lb	529.4	513.3
Non-fuel power fraction[18]	-	-
Steam flow, Mlb/hr	12.79	11.12
Dome pressure, psig	1031.5	1012.2
Turbine pressure, psig	971.4	966.2
Number of Safety/Relief Valves	10	10
Relief mode lowest setpoint, psig	1163.9	1163.9
Recirculation pump power source	on-site [19]	on-site [19]
Turbine control valve mode of operation	Partial arc	Partial arc

[18] Not available in the TRACG output files.
[19] Bounds operation with off-site power source for reload licensing events for Cycle 15.

Appendix B
Decrease in Core Coolant Temperature Events

The Loss of Feedwater Heating (LFWH) event and the Inadvertent HPCI start-up event are the only cold water injection AOOs checked on a cycle-by-cycle basis.

The LFWH event was analyzed for Brunswick Unit 1 Cycle 15 using the BWR Simulator Code. The use of this code is permitted in GESTAR II. The transient plots, neutron flux and heat flux values normally reported in Section 9 are not an output of the BWR Simulator Code; therefore, those items are not included in this document. The OLMCPR result is shown in Section 11.

In addition, the Inadvertent HPCI start-up event was shown to be bounded by the LFWH event in Brunswick Unit 1 Cycle 15 in accordance with Reference B-1.

Reference

B-1. *Determination of Limiting Cold Water Event*, NEDC-32538P-A, February 1996.

Appendix C
Operating Flexibility Options

Reference C-1 provides a basis for operation of the Brunswick Steam Electric Plant (BSEP) with one Main Steamline Isolation Valve Out of Service (MSIVOOS) (three steamline operation) and all SRVs in service. For MSIVOOS, the OLMCPRs presented in Section 11 and peak overpressure results in Section 12 are bounding. MSIVOOS will not be allowed while operating in the MELLLA+ domain (see Appendix F).

Reference C-2 provides a basis for operation of the Brunswick Steam Electric Plant (BSEP) with Feedwater Temperature Reduction (FWTR). The required OLMCPRs are provided in Section 11. FWTR and FWHOOS will not be allowed while operating in the MELLLA+ domain (see Appendix F).

Reference C-3 provides a basis for operation of the Brunswick Steam Electric Plant (BSEP) with Maximum Extended Operating Domain (MEOD). The required OLMCPRs are provided in Section 11.

Reference C-4 provides a basis for operation of the Brunswick Steam Electric Plant (BSEP) with all Turbine Bypass Valves Out of Service (TBPOOS). The required OLMCPRs are provided in Section 11.

The impact of GE14 fuel on the operating flexibility options is addressed in Reference C-5.

The ARTS power and flow dependent operating limits for all operating flexibility options are provided in References C-3 and C-6. The safety limit change for Brunswick Unit 1 Cycle 15 from the reference safety limits used in References C-6 and C-3 requires an adjustment to the MCPR(p) below P-bypass limits and MCPR(f) limits. Further, the implementation of TRACG (Reference C-7) requires an adjustment to the K(P) above P-bypass.

The Reference C-6 MCPR(p) below P-bypass is increased for a Safety Limit of 1.11 by the ratio of $\left(\frac{1.11}{1.09}\right)$. The power-dependent limits in Figure C-1 and Figure C-2 apply to all fuel types in the core.

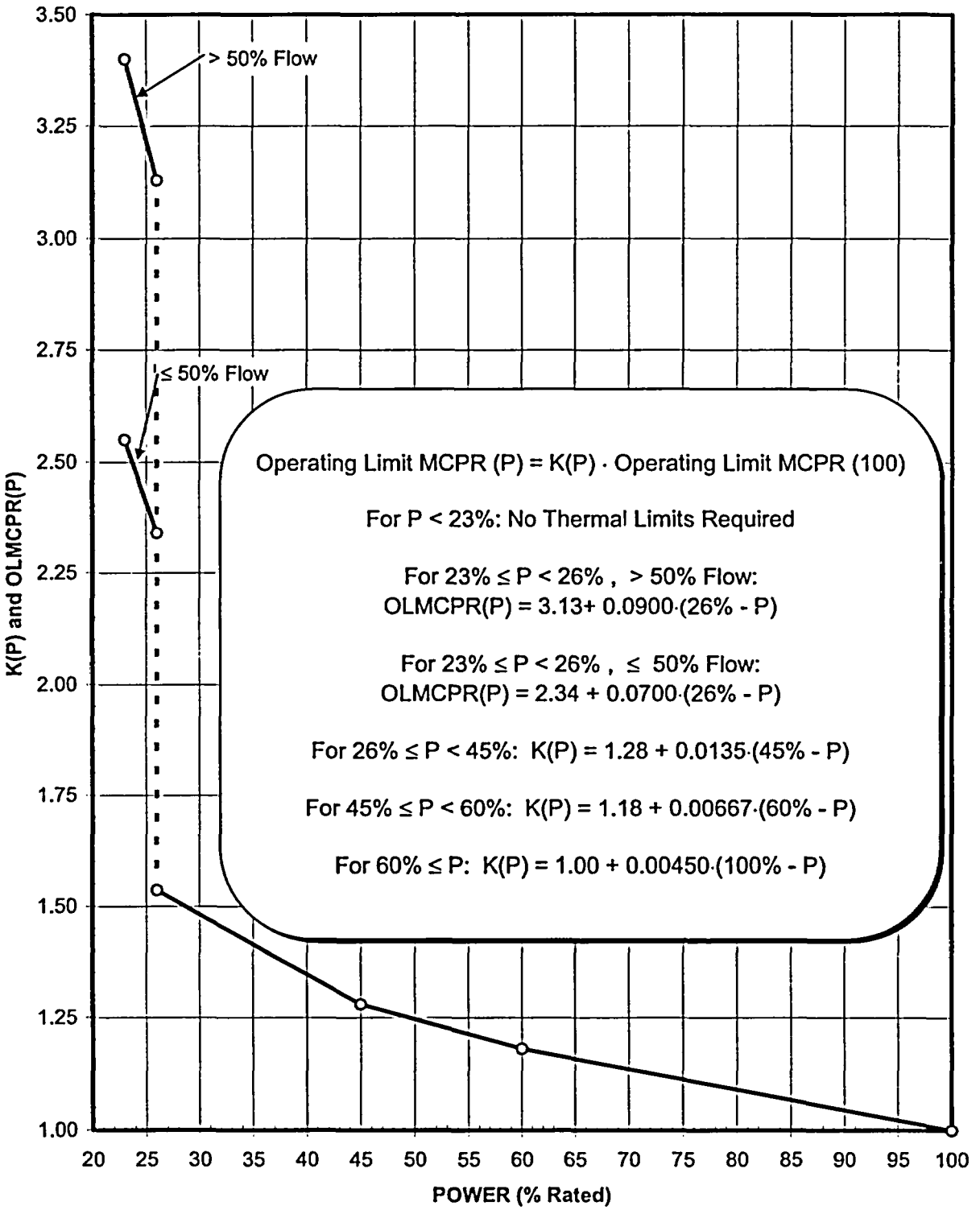


Figure C-1 Power Dependent MCPR for Brunswick Unit 1 Cycle 15

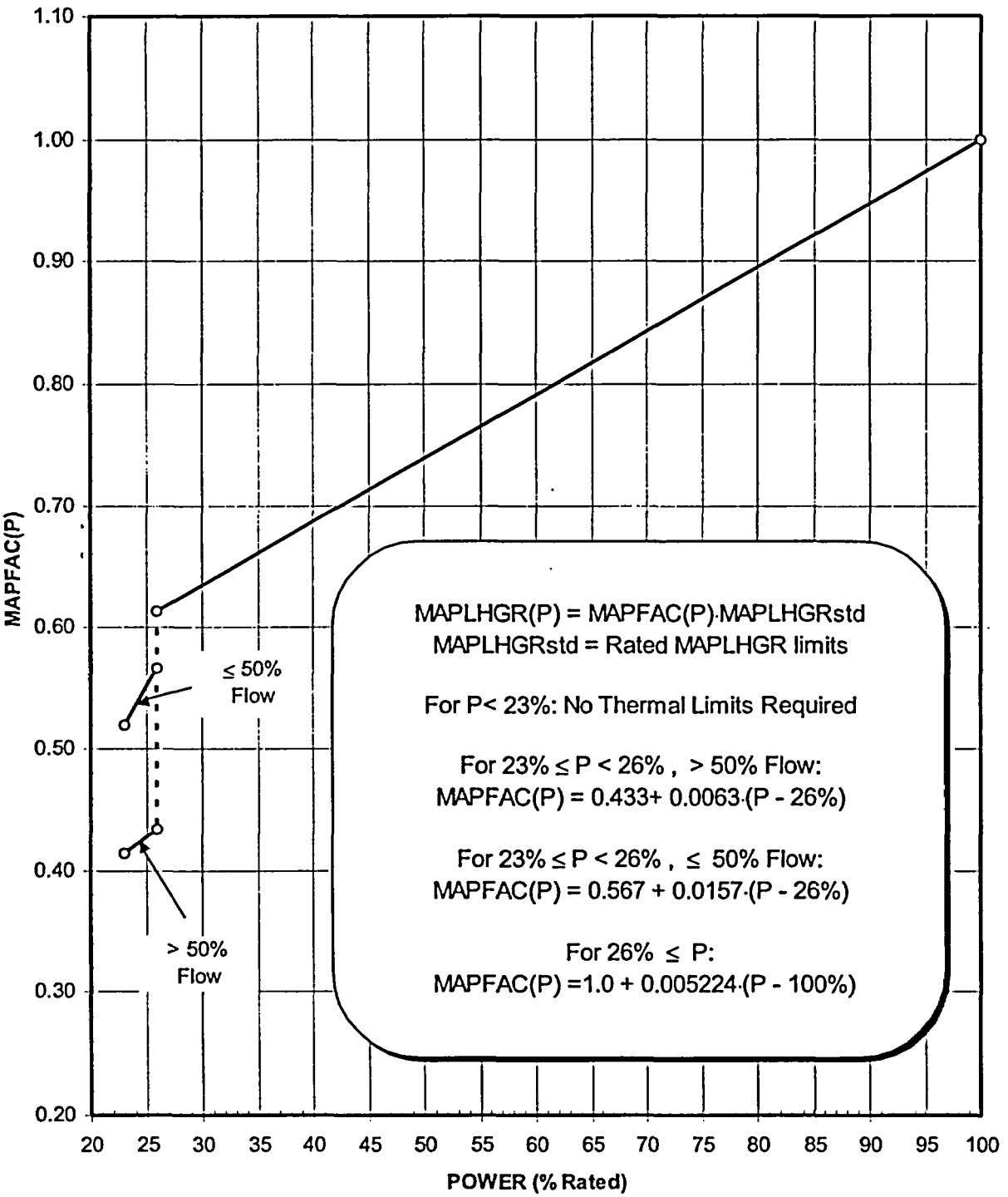


Figure C-2 Power Dependent MAPLHGR Factor for Brunswick Unit 1 Cycle 15

The Reference C-3 MCPR(f) limits are increased for a Safety Limit of 1.11 by the ratio of $\left(\frac{1.11}{1.07}\right)$.

The following coefficients apply for all fuel types in the core:

Maximum Core Flow (% of Rated)	A(f)	B(f)	Flow Intercept (% of Rated)	MCPR
102.5	-0.592	1.717	80.51	1.24
107.0	-0.608	1.760	85.61	1.24
112.0	-0.625	1.812	91.64	1.24
117.0	-0.656	1.877	97.10	1.24

The flow-dependent MAPLHGR limit multiplier, MAPFAC(f), is not altered for Brunswick Unit 1 Cycle 15.

Since the cycle-specific SLO SLMCPR is equal to 1.12, per Reference C-5, the TLO OLMCPR must be greater than or equal to 1.32 (to ensure that the SLO OLMCPR is greater than or equal to 1.40). From Reference C-5, the initial power for the licensing basis pump seizure event is 2143 MW_{th}, or 73.3% of licensed thermal power for Brunswick Unit 1 Cycle 15. The K(P) for this power, from Figure C-1, is 1.12. Therefore, the required minimum TLO OLMCPR of 1.32 is conservative for Brunswick Unit 1 Cycle 15.

References

C-1. *Main Steamline Isolation Valve Out of Service for the Brunswick Steam Electric Plant*, EAS-117-0987, GE Nuclear Energy (Proprietary), April 1988.

C-2. *Feedwater Temperature Reduction with Maximum Extended Load Line Limit and Increased Core Flow for Brunswick Steam Electric Plants Units 1 and 2*, NEDC-32457P, Revision 1, GE Nuclear Energy (Proprietary), December 1995.

C-3. *Maximum Extended Operating Domain Analysis for Brunswick Steam Electric Plant*, NEDC-31654P, GE Nuclear Energy (Proprietary), February 1989.

C-4. *Turbine Bypass Out of Service Analysis for Carolina Power & Light Company's Brunswick Nuclear Plants Units 1 and 2*, NEDC-32813, Revision 3, GE Nuclear Energy (Proprietary), June 1998.

C-5. *GE14 Fuel Design Cycle-Independent Analyses for Brunswick Steam Electric Plants Units 1 and 2*, GE-NE-L12-00876-00-01P, GE Nuclear Energy (Proprietary), February 2001.

C-6. *Safety Analysis Report for Brunswick Steam Electric Plant Units 1 and 2 Extended Power Uprate*, NEDC-33039P, GE Nuclear Energy (Proprietary), August 2001.

C-7. *Brunswick Nuclear Station TRACG Implementation for Reload Licensing Transient Analysis*, GE-NE-0000-0022-8180-R0, GE Nuclear Energy (Proprietary), February 2004.

Appendix D
Implementation of TRACG AOO Methodology

Reference D-1 provides the results of the analyses and evaluations supporting the implementation of TRACG for AOO analyses for the Brunswick Steam Electric Plant Units 1 and 2. The report requires the increase of K(P) from 1.15 to 1.18 at 60% power (See Appendix C). Additionally, the report specifies a scram speed adjustment factor (SSAF) of 0.18 for GE14 fuel. Section 11 of this report presents the MCPR limits based on the methodology of Reference D-2.

References

D-1. *Brunswick Nuclear Station TRACG Implementation for Reload Licensing Transient Analysis*, GE-NE-0000-0022-8180-R0, GE Nuclear Energy (Proprietary), February 2004.

D-2. *TRACG Application for Anticipated Operational Occurrences Transient Analysis*, NEDE-32906P-A, Revision 1, April 2003.

Appendix E
Normal and Reduced Feedwater Temperature Limits

In some cases, a distinction is made between the OLMCPR values for the normal feedwater temperature (NFWT) and reduced feedwater temperature (RFWT) domains. Specifically, for EOFPC15-5029 MWd/MT to EEOC15, the NFWT and RFWT limits are specified separately. Further, the NFWT and RFWT limits are separated at any cycle exposure for which the TBPOOS operating flexibility option is employed. The RFWT limits, when specified separately from the NFWT limits, apply to both feedwater temperature reduction and feedwater heater out of service. The results of the analyses are insensitive to feedwater temperature deviations of less than 10°F.

Appendix F
MELLLA+ Implementation

Brunswick is seeking approval to operate in the MELLLA+ domain, which would provide greater core flow flexibility, particularly as power approaches 120% of the original licensed thermal power (OLTP). Approval is not expected prior to startup of Brunswick Unit 1 Cycle 15. However, the cycle-specific reload licensing analyses were performed to support operation with or without the MELLLA+ domain. Special consideration of MELLLA+ was given during performance of the transient analyses, stability analyses, and LOCA analyses.

The pressurization transients are generally limiting at high flow conditions. However, the transients were performed at both the minimum MELLLA+ flow (85%) and the maximum ICF flow (104.5%). This ensures that the pressurization transient results bound both MELLLA and MELLLA+. Additionally, the loss of feedwater heating (LFWH) transient, which is more limiting at low flow, was performed at the minimum MELLLA+ flow. Therefore, the limiting subcooling transient bounds both MELLLA and MELLLA+. Reduced feedwater temperature (FFWTR and FWHOOS) and single loop operation (SLO) will not be allowed in conjunction with operation in the MELLLA+ domain. Further, no SRVs will be allowed to be out of service in the MELLLA+ domain. However, the pressurization transients were performed at MELLLA+ with 1 SRV out of service to ensure that both MELLLA and MELLLA+ are bounded. Finally, TBPOOS will be allowed in the MELLLA+ domain, but MSIVOOS will not.

For EPU/MELLLA+ operation, the Detect and Suppress Solution – Confirmation Density (DSS-CD) is the licensing basis for Brunswick Unit 1 Cycle 15. The reload checklist as outlined in Reference F-2 is used to confirm that the DSS-CD is applicable to Brunswick Unit 1 Cycle 15 EPU/MELLLA+ operation.

DSS-CD Plant Specific Applicability Checklist

Parameter	Criterion	Acceptance
BWR Product Line	BWR/3-6 design as of July 2002	Yes (BWR/4)
Fuel Product Line	GE14 and earlier GE designs	Yes (GE14 and GE13)
Operating Domain	≤ EPU/MELLLA+ including BWR/3-6 licensed operational flexibility features as of July 2002	Yes
Rated T_{FW} Reduction	≤ 120°F (EPU/MELLLA) No T_{FW} Reduction (MELLLA+ extension)	Yes
MCPR Margin	$\frac{OLMCPR_{Rated} - SLMCPR}{OLMCPR_{Rated}} \geq 0.067$	Yes (0.196)

The application of the ECCS-LOCA analysis to operation in the MELLLA+ power/flow region was addressed in Reference F-3. Elimination of the 1600°F Upper Bound peak cladding temperature limit has been incorporated as defined in Reference F-4.

References

F-1. *Safety Analysis Report for Brunswick Steam Electric Plant Units 1 and 2 Maximum Extended Load Line Limit Analysis Plus,* NEDC-33063P, GE Nuclear Energy (Proprietary), November 2002.

F-2. *General Electric Boiling Water Reactor Detect and Suppress Solution – Confirmation Density Licensing Topical Report,* NEDC-33075P, Revision 3, GE Nuclear Energy (Proprietary), January 2004.

F-3. *Brunswick Nuclear Plant Unit 1 and 2 MELLLA+ Task 0407 ECCS-LOCA SAFER/GESTR Project Task Report,* GE-NE-A22-00113-83-01, Revision 0, September 2002.

F-4. *GESTR-LOCA and SAFER Models for Evaluation of Loss-of-Coolant Accident Volume III, Supplement 1, Additional Information for Upper Bound PCT Calculation,* NEDE-23785P-A, Volume III, Supplement 1, Revision 1, March 2002.

Appendix G
List of Acronyms

Acronym	Description
ΔCPR	Delta Critical Power Ratio
Δk	Delta k-effective
%NBR	Percent Nuclear Boiler Rated
2PT	Two Recirculation Pump Trip
ADS	Automatic Depressurization System
ADSOOS	Automatic Depressurization System Out of Service
AOO	Anticipated Operational Occurrence
APRM	Average Power Range Monitor
ARTS	APRM, Rod Block and Technical Specification Improvement Program
BOC	Beginning of Cycle
BSP	Backup Stability Protection
BWROG	Boiling Water Reactor Owners Group
COLR	Core Operating Limits Report
CPR	Critical Power Ratio
DIVOM	Delta CPR over Initial MCPR vs. Oscillation Magnitude
DR	Decay Ratio
ECCS	Emergency Core Cooling System
EEOC	Extended End of Cycle
ELLLA	Extended Load Line Limit Analysis
EOC	End of Cycle
EOR	End of Rated (All Rods Out 100%Power / 100%Flow)
ER	Exclusion Region
FFWTR	Final Feedwater Temperature Reduction
FMCPR	Final MCPR
FOM	Figure of Merit
FWCF	Feedwater Controller Failure
FWTR	Feedwater Temperature Reduction
GDC	General Design Criterion
GETAB	General Electric Thermal Analysis Basis
GSF	General Shape Function
HAL	Haling Burn
HBB	Hard Bottom Burn
HBOM	Hot Bundle Oscillation Magnitude
HCOM	Hot Channel Oscillation Magnitude
HFCL	High Flow Control Line
ICA	Interim Corrective Action
ICF	Increased Core Flow
IMCPR	Initial MCPR
IVM	Initial Validation Matrix

LHGR	Linear Heat Generation Rate
LOCA	Loss of Coolant Accident
LPRM	Local Power Range Monitor
LRHBP	Load Rejection with Half Bypass
LRNBP	Load Rejection without Bypass
LTR	Licensing Topical Report
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MCPR	Minimum Critical Power Ratio
MELLLA	Maximum Extended Load Line Limit Analysis
MELLLA+	MELLLA Plus
MOC	Middle of Cycle
MRB	Maximal Region Boundaries
MSIV	Main Steam Isolation Valve
MSIVOOS	Main Steam Isolation Valve Out of Service
MTU	Metric Ton Uranium
MWd	Megawatt day
MWd/ST	Megawatt days per Standard Ton
MWd/MT	Megawatt days per Metric Ton
MWt	Megawatt Thermal
NBP	No Bypass
NCL	Natural Circulation Line
NFWT	Normal Feedwater Temperature
NOM	Nominal Burn
NTR	Normal Trip Reference
OLMCPR	Operating Limit MCPR
OOS	Out of Service
OPRM	Oscillation Power Range Monitor
Pdome	Peak Dome Pressure
Psl	Peak Steam Line Pressure
Pv	Peak Vessel Pressure
PCT	Peak Clad Temperature
PHE	Peak Hot Excess
PLHGR	Peak Linear Heat Generation Rate
PLUOOS	Power Load Unbalance Out of Service
PRFDS	Pressure Regulator Failure Downscale
PROOS	Pressure Regulator Out of Service
Q/A	Heat Flux
RBM	Rod Block Monitor
RC	Reference Cycle
RFWT	Reduced Feedwater Temperature
RPS	Reactor Protection System
RPT	Recirculation Pump Trip
RPTOOS	Recirculation Pump Trip Out of Service
RVM	Reload Validation Matrix
RWE	Rod Withdrawal Error
SC	Standard Cycle
SL	Safety Limit
SLMCPR	Safety Limit Minimum Critical Power Ratio
SLO	Single Loop Operation
SRLR	Supplemental Reload Licensing Report
SS	Steady State

STU	Short Tons (or Standard Tons) of Uranium
TBPOOS	Turbine Bypass Valves Out of Service
TCVOOS	Turbine Control Valve Out of Service
TCVSC	Turbine Control Valve Slow Closure
TLO	Two Loop Operation
TRF	Trip Reference Function
TTHBP	Turbine Trip with Half Bypass
TTNBP	Turbine Trip without Bypass
UB	Under Burn

BSEP 04-0037
Enclosure 3

NEDC-31624P, Supplement 1, Revision 8,
Loss-of-Coolant Accident Analysis Report
for Brunswick Steam Electric Plant Unit 1
Reload 14 Cycle 15,
February 2004