ENCLOSURE 3

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324
LICENSE NOS. DPR-71 AND DPR-62
TRANSMITTAL OF CORE OPERATING LIMITS REPORTS,
SUPPLEMENTAL RELOAD LICENSING REPORT, AND
LOSS-OF-COOLANT-ACCIDENT ANALYSIS REPORT

SUPPLEMENTAL RELOAD LICENSING REPORT FOR BRUNSWICK STEAM ELECTRIC PLANT UNIT 2 RELOAD 12, CYCLE 13

JUNE 1998

GE Nuclear Energy

24A5412
Revision 2
Class I
June 1998

Supplemental Reload Licensing Report
for
BRUNSWICK STEAM ELECTRIC PLANT UNIT 2
Reload 12 Cycle 13

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Supplemental Reload Licensing Report

for
Brunswick Steam Electric Plant Unit 2

Reload 12 Cycle 13

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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 G.M. Baka, H.J. Pearson and H.M. Schrum. The Supplemental Reload Licensing Report was prepared by D. P. Stier. This document has been verified by G. M. Baka.

The basis for this report is *General Electric Standard Application for Reactor Fuel*, NEDE–24011–P–A–13, August 1996; and the U.S. Supplement, NEDE–24011–P–A–13–US, August 1996.

1. Plant–unique Items

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2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated:		
GE10–P8HXB329–12GZ1–100M–150–T (GE8x8NB–3)	10	24
GE10–P8HXB322–11GZ–70M–150–T (GE8x8NB–3)	11	8
GE10–P8HXB320–11GZ–100M–150–T (GE8x8NB–3)	11	32
GE10–P8HXB324–12GZ–70M–150–T (GE8x8NB–3)	11	112
GE13–P9DTB363–11GZ1–100T–146–T (GE13)	12	64
GE13–P9DTB363–11GZ–100T–146–T (GE13)	12	136
New:		
GE13–P9DTB393–4G6.0/9G5.0–100T–146–T (GE13)	13	104
GE13–P9DTB395–12G5.0–100T–146–T (GE13)	13	80
Total		560

3. Reference Core Loading Pattern

Nominal previous cycle core average exposure at end of cycle:	27753 MWd/MT (25177 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	27381 MWd/MT (24840 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	15361 MWd/MT (13935 MWd/ST)
Assumed reload cycle core average exposure at end of cycle:	28148 MWd/MT (25535 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	1.107
Fully controlled	0.964
Strongest control rod out	0.987
R, Maximum increase in cold core reactivity with exposure into cycle, Δk	0.000

5. Standby Liquid Control System Shutdown Capability

Boron (ppm)	Shutdown Margin (Δk) (20°C, Xenon Free)
660	0.038

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

Exposure: BOC13 to EOC13–2205 MWd/MT (2000 MWd/ST) with ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.56	1.35	1.020	6.954	109.1	1.30

Exposure: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.44	1.46	1.020	6.421	114.1	1.33

Exposure: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTR							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.61	1.51	1.020	7.135	111.1	1.19

Exposure: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with MSIVOOS and ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R–Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.46	1.46	1.020	6.488	113.7	1.32

7. Selected Margin Improvement Options

Recirculation pump trip:	No
Rod withdrawal limiter:	No
Thermal power monitor:	Yes
Improved scram time:	Yes (ODYN Option B)
Measured scram time:	No
Exposure dependent limits:	Yes
Exposure points analyzed:	2 (EOC13–2205 MWd/MT and EOC13)

8. Operating Flexibility Options

Single–loop operation:	Yes
Load line limit:	Yes
Extended load line limit:	Yes
Maximum extended load line limit:	Yes
Increased core flow throughout cycle:	Yes
Flow point analyzed:	104.5 %
Increased core flow at EOC:	Yes
Feedwater temperature reduction throughout cycle:	Yes
Temperature reduction:	110.3°F
Final feedwater temperature reduction:	Yes
ARTS Program:	Yes
Maximum extended operating domain:	Yes

Moisture separator reheater OOS:	No
Turbine bypass system OOS:	No
Safety/relief valves OOS: (credit taken for 9 of 11 valves)	Yes (Additional evaluations are required to support this option.)
ADS OOS:	Yes (2 valves OOS)
EOC RPT OOS:	No
Main steam isolation valves OOS:	Yes

9. Core-wide AOO Analysis Results

Methods used: GEMINI; GEXL-PLUS

Exposure range: BOC13 to EOC13-2205 MWd/MT (2000 MWd/ST) with ICF				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	272	114	0.21	2
Turbine Trip w/o Bypass	268	114	0.21	6

Exposure range: EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	335	120	0.24	3
Turbine Trip w/o Bypass	292	117	0.25	7

Exposure range: EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTR				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
FW Controller Failure	183	113	0.10	4

Exposure range: EOC13-2205 MWd/MT (2000 MWd/ST) to EOC13 with MSIVOOS and ICF				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	291	118	0.23	5

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

The rod withdrawal error 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, dated February 1989. The MCPR limit for rod withdrawal error is bounded by the operating limit MCPRs presented in Section 11 of this report for RBM setpoints shown in Tables 10–5(a) or 10–5(b) of NEDC–31654P. Additionally, the RBM operability requirements specified in Section 10.5 of NEDC–31654P have been evaluated and shown to be sufficient to ensure that the Safety Limit MCPR and cladding 1% plastic strain criteria will not be exceeded in the event of an un–blocked RWE event.

11. Cycle MCPR Values[1] [2]

In agreement with commitments to the NRC (letter from M.A. Smith to Document Control Desk, *10CFR Part 21, Reportable Condition, Safety Limit MCPR Evaluation, May 24, 1996*) a cycle–specific Safety Limit MCPR calculation was performed and is reported in the Safety Limit MCPR shown below. CP&L, however, has elected to retain the current Technical Specification Safety Limit of 1.09 and the Operating Limit MCPR values shown below are based on this value. The cycle–specific single loop operation Safety Limit was calculated to be 0.01 greater than the two loop Safety Limit MCPR as shown below. This cycle specific SLMCPR was determined using the analysis basis documented in GESTAR with the following exceptions:

1. The reference core loading (Figure 1) was analyzed.
2. The actual bundle parameters (e.g., local peaking) were used.
3. The full cycle exposure range was analyzed.

Safety limit:	1.08 calculated	1.09 assumed
Single loop operation safety limit:	1.09 calculated	1.10 assumed

Non–pressurization events:

Exposure Range: BOC13 to EOC13	
	GE13
Fuel Loading Error (misoriented)	1.29
Rod Withdrawal Error (for RBM setpoint of 108%)	1.25

1. The Operating Limit MCPR for two loop operation (TLO) bounds the Operating Limit MCPR for single loop operation (SLO); therefore, the Operating Limit MCPR need not be changed for SLO.

2. The GE13 fuel type MCPR values bound the GE8x8NB–3 MCPR values for all events.

Pressurization events:

Exposure range: BOC13 to EOC13–2205 MWd/MT (2000 MWd/ST) with ICF[3] **Exposure point: EOC13–2205 MWd/MT (2000 MWd/ST)**		
	Option A	**Option B**
	GE13	**GE13**
Load Reject w/o Bypass	1.35	1.30
Turbine Trip w/o Bypass	1.35	1.30

Exposure range: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF[4] **Exposure point: EOC13**		
	Option A	**Option B**
	GE13	**GE13**
Load Reject w/o Bypass	1.43	1.35
Turbine Trip w/o Bypass	1.44	1.36

Exposure range: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTR **Exposure point: EOC13**		
	Option A	**Option B**
	GE13	**GE13**
FW Controller Failure	1.29	1.21

Exposure range: EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with MSIVOOS and ICF **Exposure point: EOC13**		
	Option A	**Option B**
	GE13	**GE13**
Load Reject w/o Bypass	1.41	1.33

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram)	1286	1322	Figure 8

3. The ICF Operating Limits for the exposure range of BOC13 to EOC13–2205 MWd/MT (2000 MWd/ST) bound the Operating Limits for the following domains: MELLL, ICF and FWTR, MSIVOOS and ICF.

4. The ICF Operating Limits for the exposure range of EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 bound the Operating Limits for the MELLL domain.

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes[5]

Misoriented Fuel Bundle	ΔCPR
GE13–P9DTB363–11GZ1–100T–146–T (GE13)	0.13
GE13–P9DTB363–11GZ–100T–146–T (GE13)	0.13
GE13–P9DTB395–12G5.0–100T–146–T (GE13)	0.19
GE13–P9DTB393–4G6.0/9G5.0–100T–146–T (GE13)	0.20

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

GE SIL–380 recommendations and GE interim corrective actions have been included in the Brunswick Steam Electric Plant Unit 2 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)*, are applicable to Brunswick 2.

16. Loss–of–Coolant Accident Results

LOCA method used: SAFER/GESTR–LOCA

The GE8x8EB LOCA analysis results presented in Sections 5 and 6 of *Brunswick Steam Electric Plant Units 1 and 2 SAFER/GESTR–LOCA Loss–of–Coolant Accident Analysis*, NEDC–31624P, Revision 2, July 1990, conservatively bound the LOCA analysis of the GE8x8NB–3 fuel types. This analysis yielded a licensing basis peak clad temperature of 1537°F, a peak local oxidation fraction of <0.31%, and a core–wide metal–water reaction of 0.036%.

An additional LOCA analysis was performed for the GE13 fuel type. The results, presented in *Brunswick Steam Electric Plant Units 1 and 2 SAFER/GESTR–LOCA Loss–of–Coolant Accident Analysis: Application to GE13 Fuel*, NEDC–31624P, Supplement 3, Rev. 0, January 1996, indicate that the GE13 fuel is bounded by the results from GE8x8EB fuel.

A single loop operation MAPLHGR multiplier of 0.80 is applicable to both GE8x8NB–3 and GE13 fuel types. Therefore, the power– and flow–dependent MAPLHGR adjustment factors identified in Figures 4–2 and 4–4 of *Maximum Extended Operating Domain Analysis for the Brunswick Steam Electric Plant*, NEDC–31654P, Class III (GE Nuclear Energy Proprietary), February 1989, should be used with the limitation that no multiplier greater than 0.80 is used during SLO.

The most and the least limiting MAPLHGRs for the new GE13 fuel designs are as follows:

5. Includes a 0.02 penalty due to variable water gap R–factor uncertainty.

16. Loss-of-Coolant Accident Results (cont)

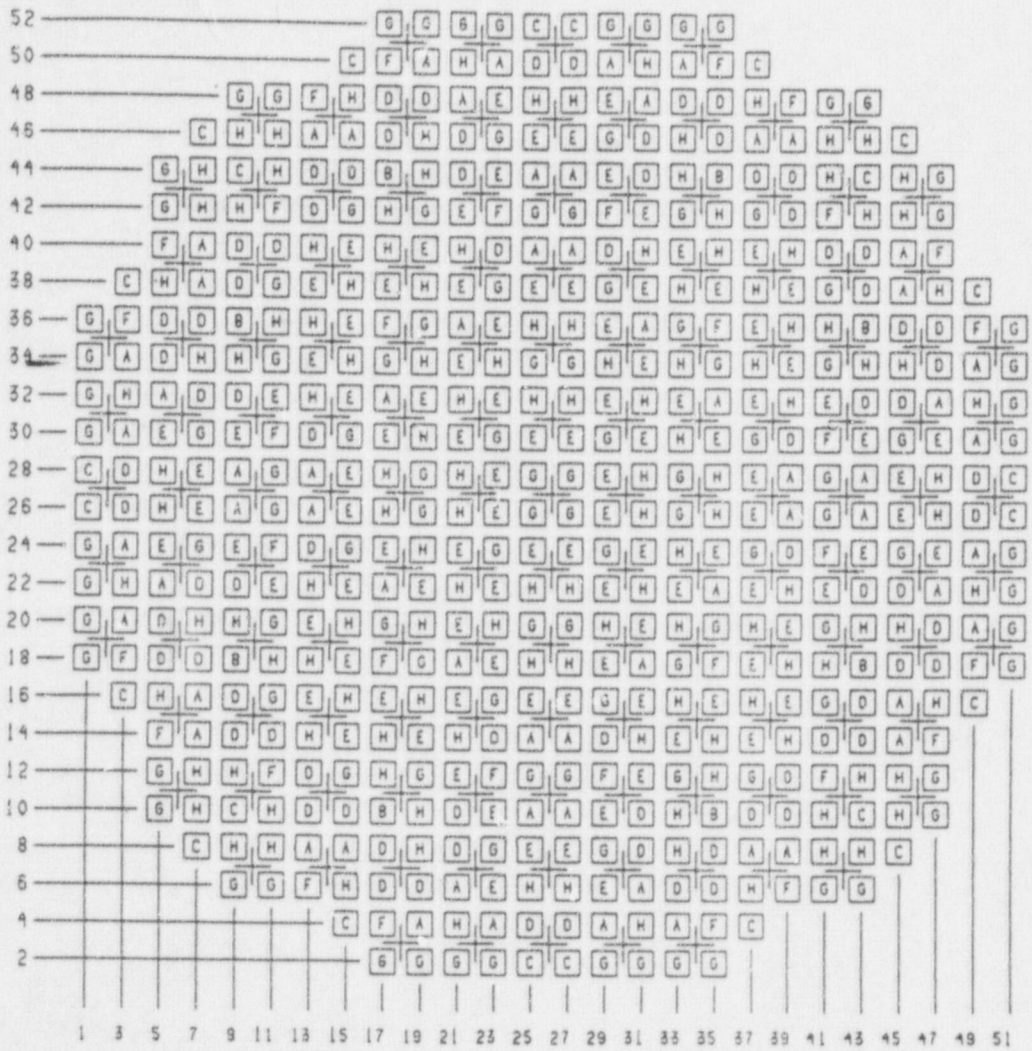
Bundle Type: GE13-P9DTB395-12G5.0-100T-146-T

Average Planar Exposure		MAPLHGR(kW/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	11.15	11.28
0.20	0.22	11.24	11.34
1.00	1.10	11.38	11.42
2.00	2.20	11.50	11.53
3.00	3.31	11.57	11.66
4.00	4.41	11.66	11.75
5.00	5.51	11.74	11.83
6.00	6.61	11.83	11.92
7.00	7.72	11.92	12.02
8.00	8.82	12.02	12.11
9.00	9.92	12.11	12.21
10.00	11.02	12.21	12.31
12.50	13.78	12.21	12.33
15.00	16.53	12.04	12.13
17.50	19.29	11.78	11.86
20.00	22.05	11.51	11.59
25.00	27.5	10.98	11.06
30.00	33.07	10.44	10.53
35.00	38.58	9.73	9.89
40.00	44.09	9.03	9.18
45.00	49.60	8.33	8.49
50.00	55.12	7.64	7.82
55.00	60.63	6.95	7.16
58.32	64.28	6.49	6.70
58.75	64.76	—	6.64

16. Loss–of–Coolant Accident Results (cont)

Bundle Type: GE13–P9DTB393–4G6.0/9G5.0–100T–146–T

Average Planar Exposure		MAPLHGR(kW/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	11.03	11.09
0.20	0.22	11.09	11.12
1.00	1.10	11.19	11.21
2.00	2.20	11.28	11.32
3.00	3.31	11.37	11.42
4.00	4.41	11.47	11.52
5.00	5.51	11.57	11.63
6.00	6.61	11.67	11.74
7.00	7.72	11.78	11.85
8.00	8.82	11.89	11.97
9.00	9.92	12.00	12.09
10.00	11.02	12.11	12.22
12.50	13.78	12.12	12.25
15.00	16.53	12.00	12.10
17.50	19.29	11.76	11.84
20.00	22.05	11.50	11.57
25.00	27.56	10.96	11.01
30.00	33.07	10.28	10.43
35.00	38.58	9.54	9.71
40.00	44.09	8.85	9.00
45.00	49.60	8.19	8.31
50.00	55.12	7.55	7.62
55.00	60.63	6.92	6.93
58.18	64.14	6.48	6.51
58.60	64.60	—	6.46



Fuel Type			
A=GE13–P9DTB363–11GZ1–100T–146–T	(Cycle 12)	E=GE13–P9DTB393–4G6.0/9G5.0–100T–146–T	(Cycle 13)
B=GE10–P8HXB322–11GZ–70M–150–T	(Cycle 11)	F=GE10–P8HXB320–11GZ–100M–150–T	(Cycle 11)
C=GE10–P8HXB329–12GZ1–100M–150–T	(Cycle 10)	G=GE10–P8HXB324–12GZ–70M–150–T	(Cycle 11)
D=GE13–P9DTB395–12G5.0–100T–146–T	(Cycle 13)	H=GE13–P9DTB363–11GZ–100T–146–T	(Cycle 12)

Figure 1 Reference Core Loading Pattern

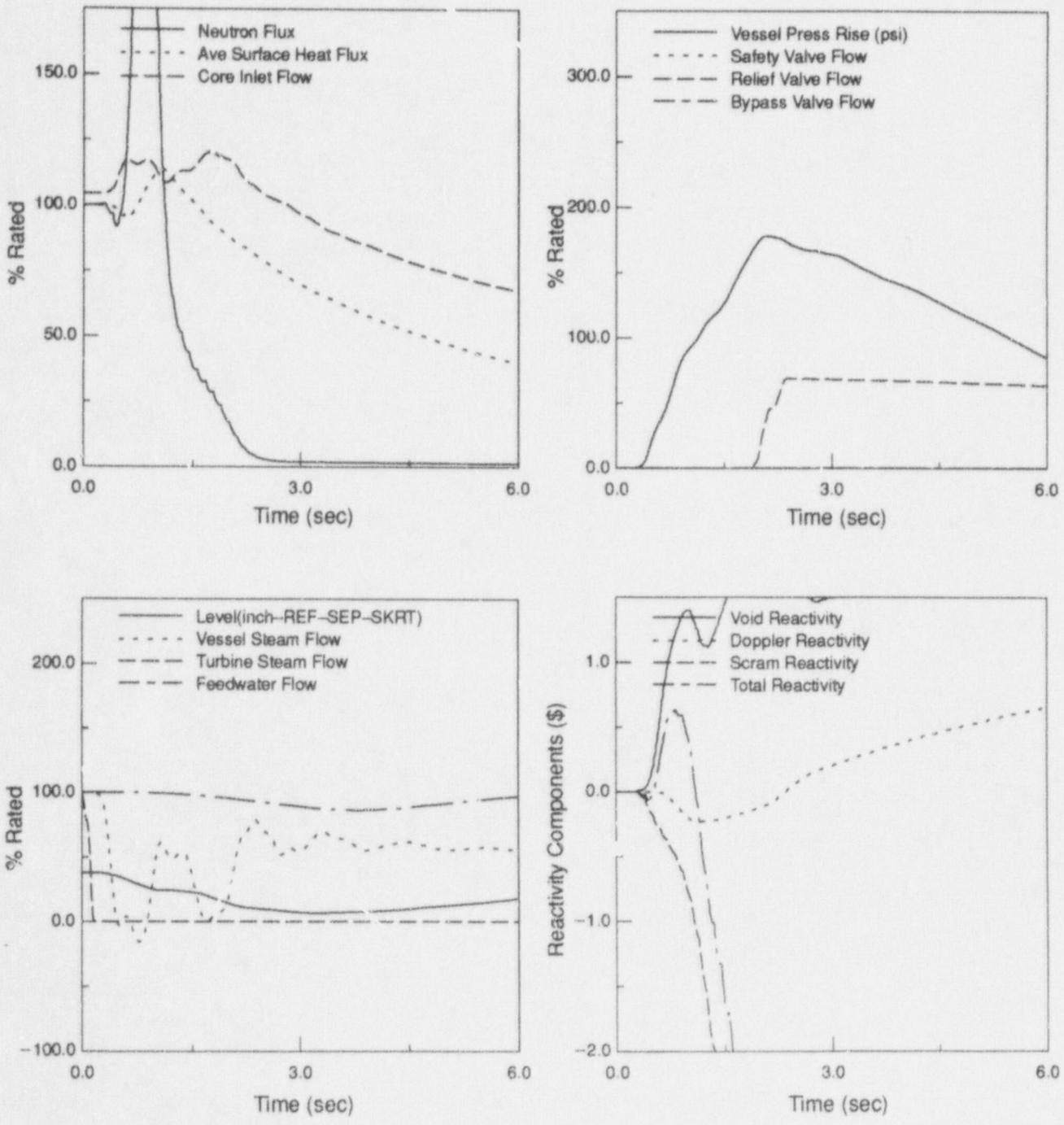


Figure 2 Plant Response to Load Reject w/o Bypass (BOC13 to EOC13–2205 MWd/MT (2000 MWd/ST) with ICF)

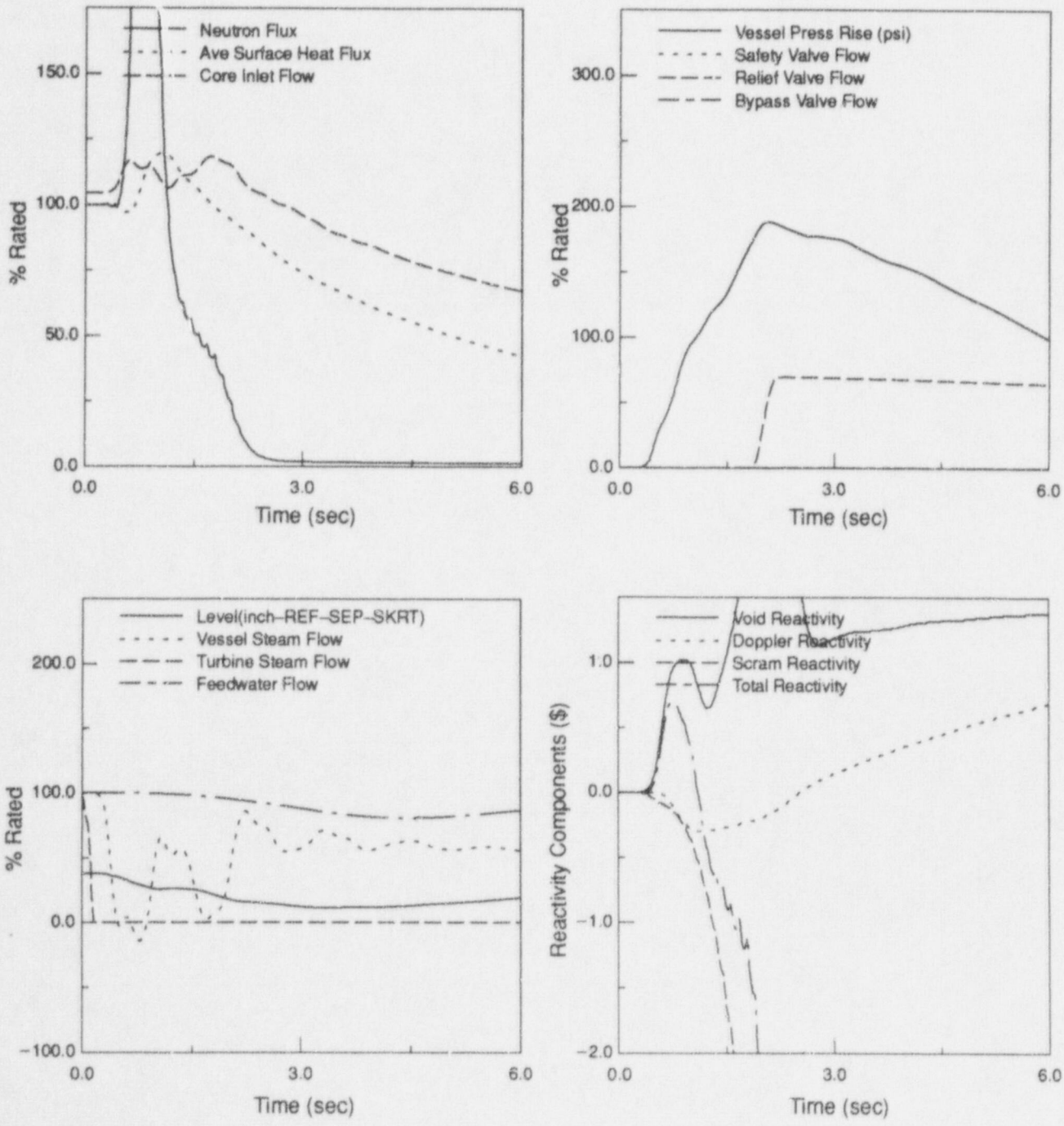


Figure 3 Plant Response to Load Reject w/o Bypass (EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF)

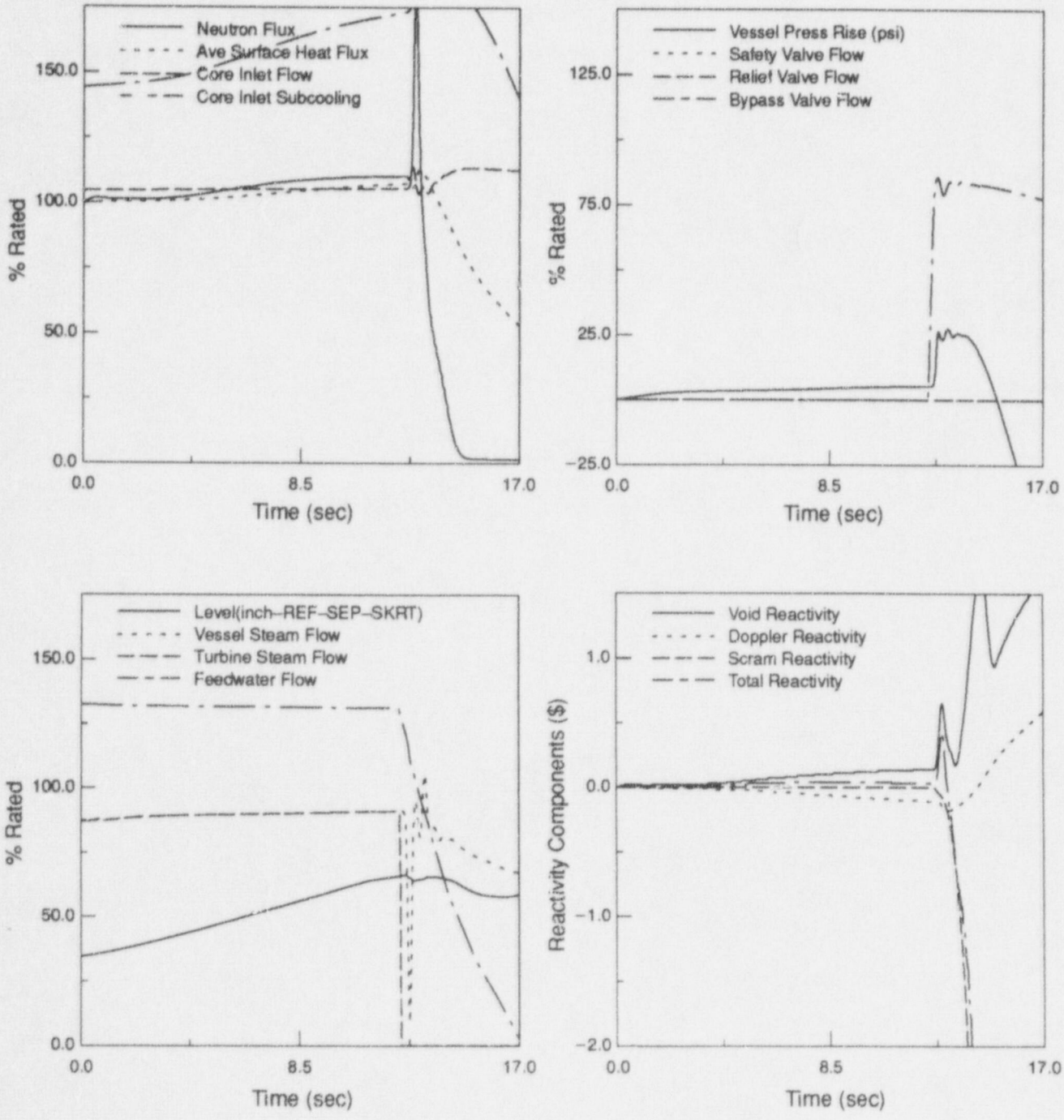


Figure 4 Plant Response to FW Controller Failure (EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF and FWTR)

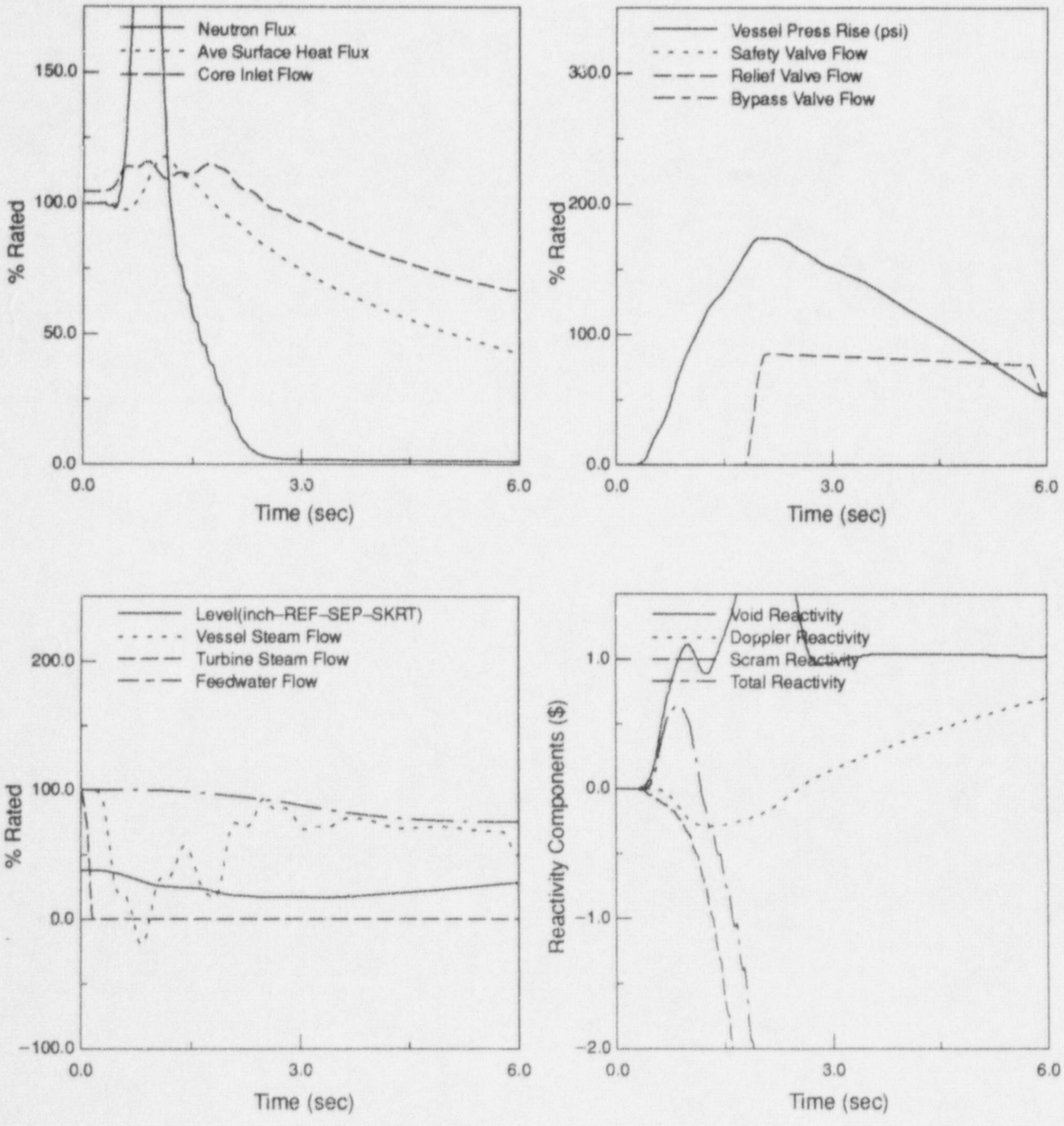


Figure 5 Plant Response to Load Reject w/o Bypass (EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with MSIVOOS and ICF)

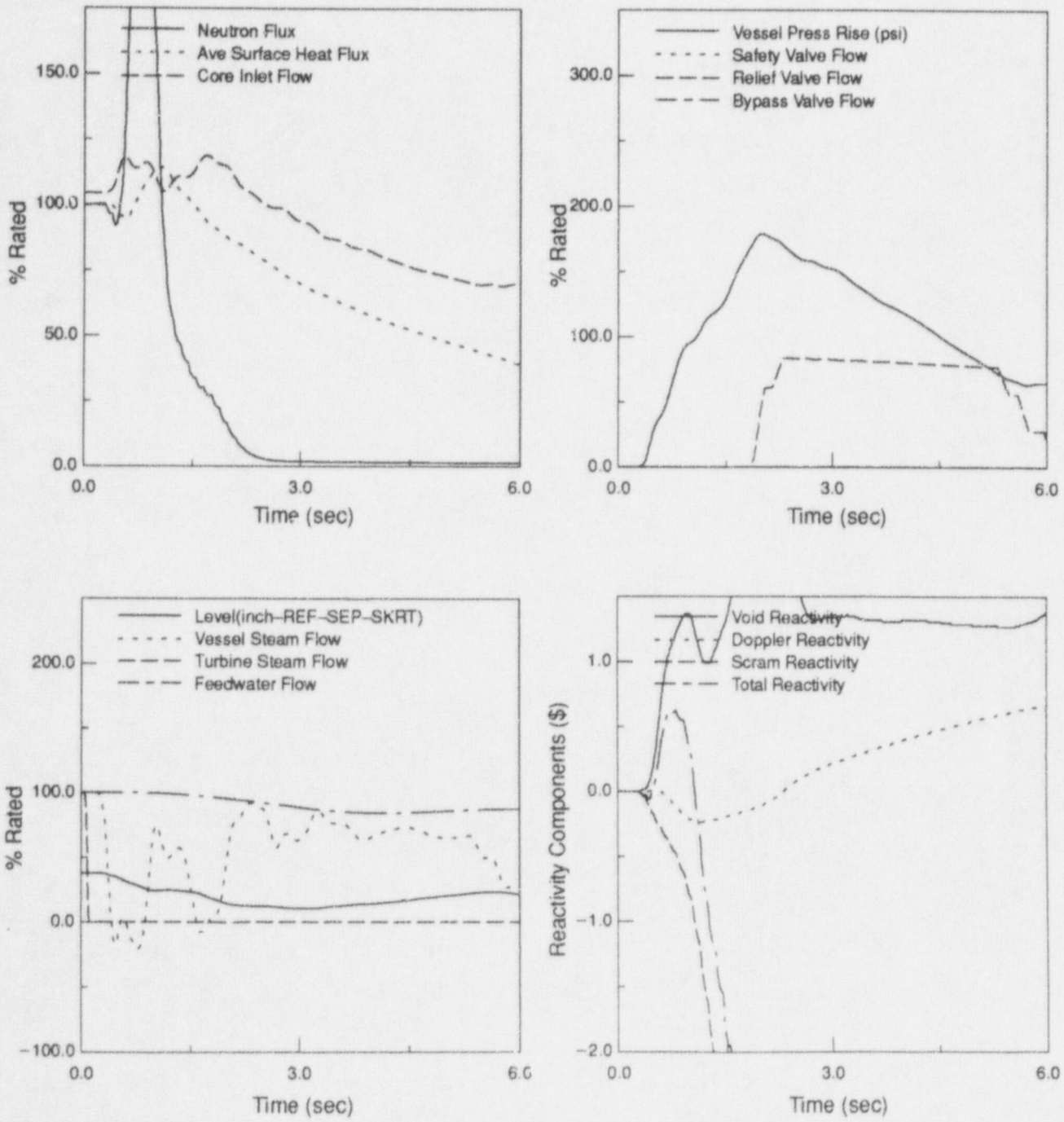


Figure 6 Plant Response to Turbine Trip w/o Bypass (BOC13 to EOC13–2205 MWd/MT (2000 MWd/ST) with ICF)

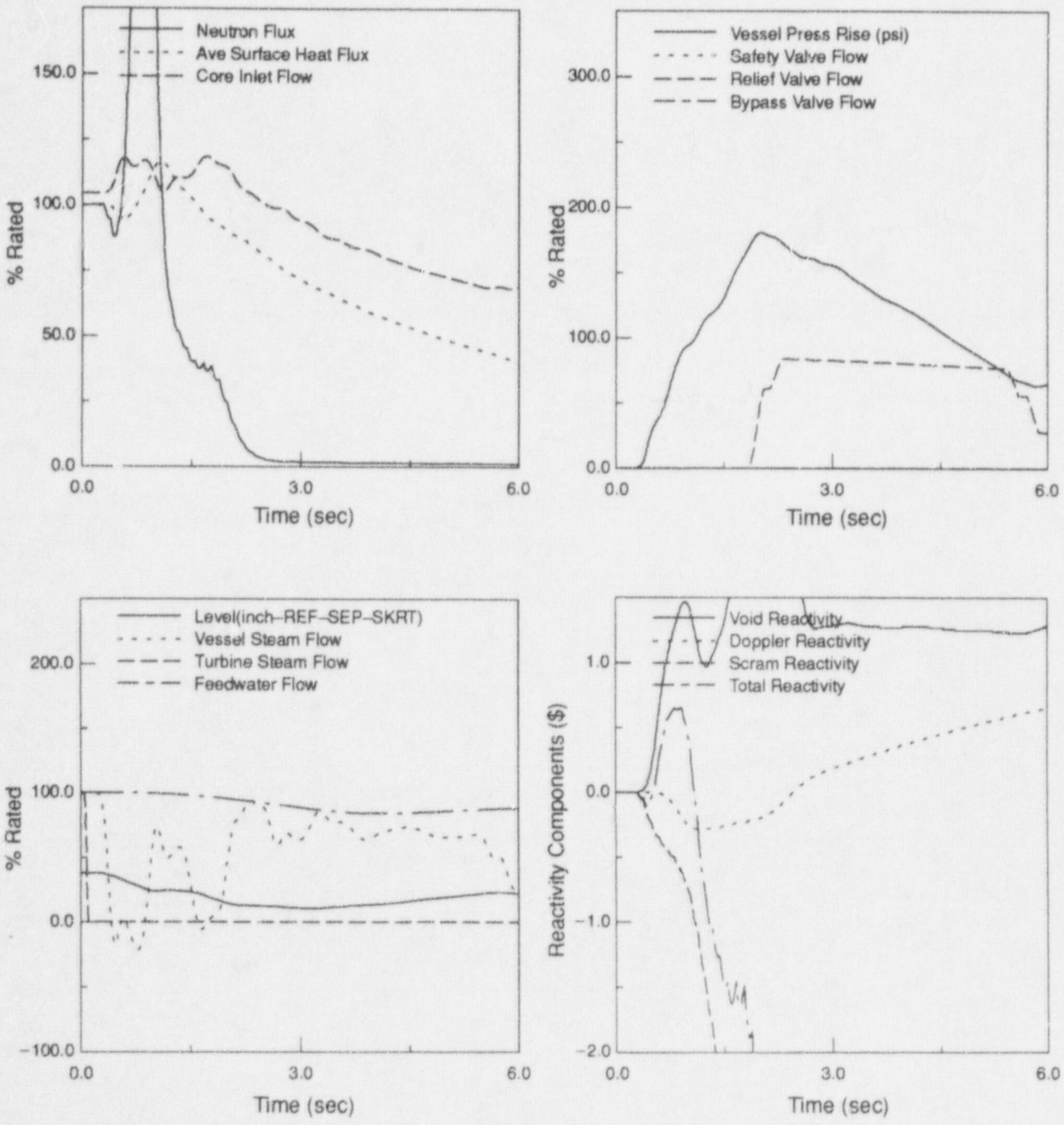


Figure 7 Plant Response to Turbine Trip w/o Bypass (EOC13–2205 MWd/MT (2000 MWd/ST) to EOC13 with ICF)

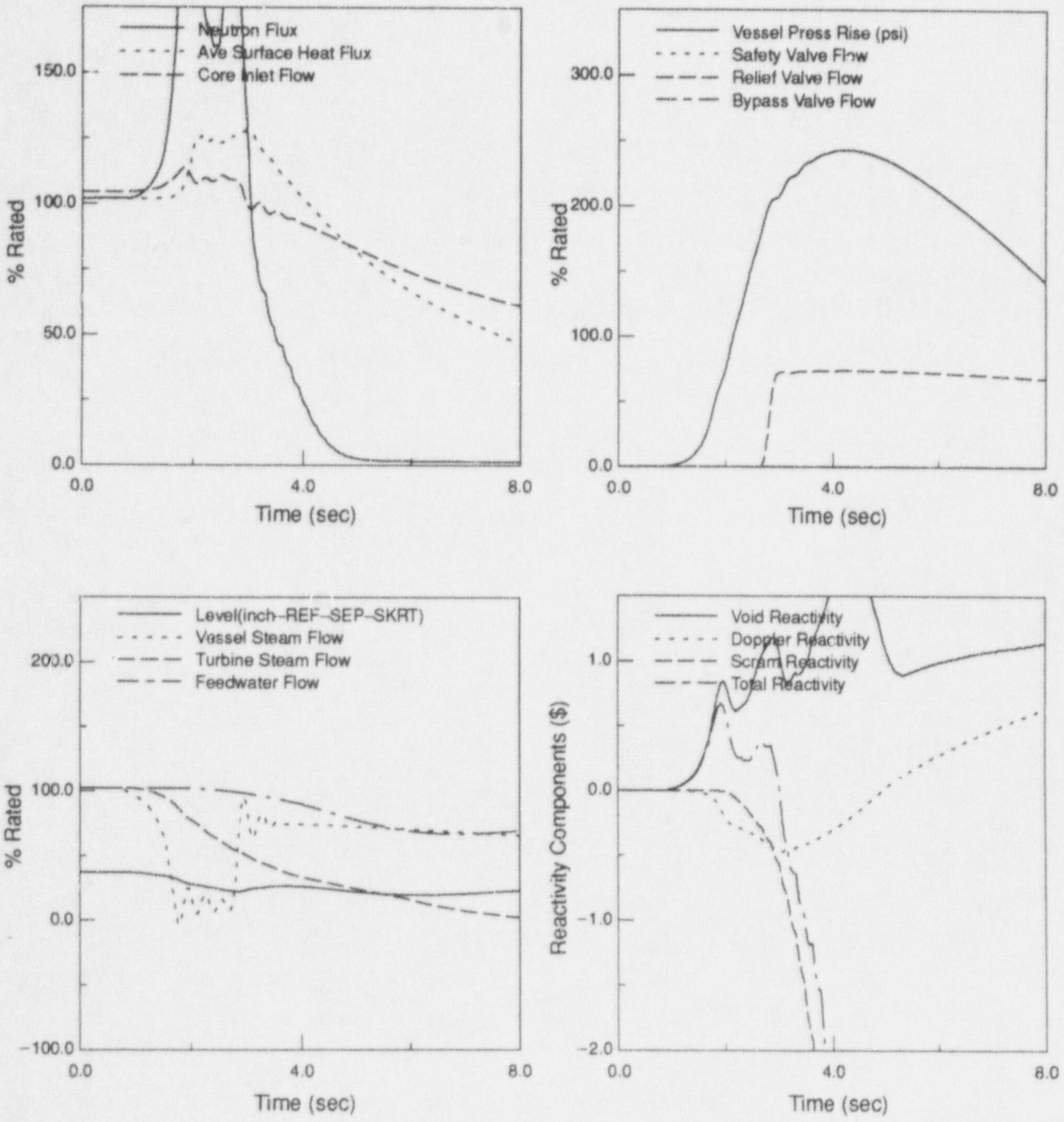


Figure 8 Plant Response to MSIV Closure (Flux Scram)

Appendix A
Analysis Conditions

This is the first reload core for Brunswick Unit 2 which will operate at an uprated power of 105% (2558 MWt). To reflect actual plant parameters accurately, the values shown in Table A–1 were used for this cycle.

Table A–1

	Analysis Value		
Parameter	**ICF**	**ICF and FWTR**	**MSIVOOS and ICF**
Thermal power, MWt	2558.0	2558.0	2558.0
Core flow, Mlb/hr	80.5	80.5	80.5
Reactor pressure, psia	1060.9	1059.6	1060.9
Inlet enthalpy, BTU/lb	530.7	519.4	530.7
Non–fuel power fraction	0.037	0.037	0.037
Steam flow analysis, Mlb/hr	11.09	9.67	11.09
Dome pressure, psig	1030.0	1030.0	1045.0
Turbine pressure, psig	969.0	984.2	941.6
No. of Safety/Relief Valves	9	9	11
Relief mode lowest setpoint, psig	1164.0	1164.0	1164.0
Recirculation pump power source	on–site[6]	on–site[6]	on–site[6]
Turbine control valve mode of operation	Partial arc	Partial arc	Partial arc

6. Bounds operation with off–site power source for reload licensing events for Cycle 13.

Appendix B
Main Steamline Isolation Valve Out of Service (MSIVOOS)

Reference B–1 provided a basis for operation of Brunswick Steam Electric Plant (BSEP) with one Main Steamline Isolation Valve Out of Service (MSIVOOS) (three steamline operation) and all S/RVs in service. For this mode of operation in BSEP Unit 2 throughout Cycle 13, the MCPR limits presented in Section 11 of this report are bounding and should be applied when operating in the MSIVOOS mode at any time during the cycle. The peak steamline and peak vessel pressures for the limiting overpressurization event (MSIV closure with flux scram) were not calculated for the MSIVOOS mode of operation. In this mode of operation it is required that all S/RVs be operational versus the assumed 2 S/RVs OOS for the events evaluated during normal plant operation. Previous cycles analyses have shown that the MSIV closure with flux scram, evaluated in the MSIVOOS mode, has resulted in the peak vessel pressure being reduced by more than 25 psi, when compared to the same case evaluated with all (four) steamlines operational.

Reference

B–1. *Main Steamline Isolation Valve Out of Service for the Brunswick Steam Electric Plant*, EAS–117–0987, GE Nuclear Energy, April 1988.

Appendix C
Decrease in Core Coolant Temperature Events

The Loss of Feedwater Heater (LFWH) event and the HPCI inadvertent start–up event are the only cold water injection AOOs checked on a cycle–by–cycle basis. A Cycle 11 analysis showed a LFWH ΔCPR of 0.13 and a Cycle 10 analysis showed a HPCI inadvertent start–up ΔCPR of 0.15. As was the case for Cycle 12 also, there is no reason why these events would be expected to be more severe for Cycle 13. The results of the AOOs presented in Section 11 of this report sufficiently bound the expected results of the LFWH and HPCI inadvertent start–up events, therefore these events were not analyzed for Cycle 13.

Appendix D
Feedwater Temperature Reduction (FWTR)

Reference D–1 provides the basis for operation of the Brunswick Steam Electric Plant with FWTR. The MCPR limits presented in Section 11 of this report are bounding and should be applied when operating with FWTR. Previous analysis has shown the FWCF event is most severe at ICF and FWTR.

Reference

D–1. *Feedwater Temperature Reduction with Maximum Extended Load Line Limit and Increased Core Flow for Brunswick Steam Electric Plant Units 1 and 2*, NEDC–32457P, Revision 1, December 1995.

Appendix E
Maximum Extended Operating Domain (MEOD)

Reference E–1 provided a basis for operation of the Brunswick Steam Electric Plant in the Maximum Extended Operating Domain (MEOD). The reload licensing analysis performed for Cycle 13 and documented herein is consistent with and provides the cycle–specific update to the reference E–1 analysis. Application of the GEXL–PLUS correlation to the reload fuel has been confirmed as required in reference E–1. The applicability of GE13 was addressed and found acceptable.

Reference

E–1. *Maximum Extended Operating Domain Analysis for Brunswick Steam Electric Plant*, NEDC–31654P, GE Nuclear Energy (Proprietary), February 1989.

Appendix F
Turbine Trip Calculations with Reduced Steamline Pressure Drop

References F–1, F–2 and F–3 provided the basis for the Turbine Trip without Bypass (TTNBP) calculations with reduced steamline pressure drop. The steamline pressure drop used in the TTNBP calculations is 48.4 psid. The Turbine Trip without Bypass with Increased Core Flow with the reduced steamline pressure drop sets the EOC13 operating limits.

References:

F–1. Letter from Ann T. Kremer to W. H. Hetzel, "Clarification of Steamline Pressure Drop, OPL–3 Item 1.1.C", Serial no. NF–97A–0331, November 11, 1997.

F–2. Letter from David J. Brager to Ann T. Kremer, "Pressure Drop Calculation and Transient Analysis GE Proposal No. 523–1HPJS–KB0", GKB0–98–008, February 12, 1998.

F–3. Letter from W. H. Hetzel to Ann T. Kremer, "Brunswick Main Stop Valve Pressure Drop Analysis", WHH:98–050, May 20, 1998.