ENCLOSURE 2

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 1
DOCKET NO. 50-325
LICENSE NO. DPR-71
TRANSMITTAL OF CORE OPERATING LIMITS REPORT,
SUPPLEMENTAL RELOAD LICENSING REPORT, AND
LOSS-OF-COOLANT-ACCIDENT ANALYSIS REPORT

"SUPPLEMENTAL RELOAD LICENSING REPORT
FOR
BRUNSWICK STEAM ELECTRIC PLANT UNIT 1
RELOAD 11 CYCLE 12,"
J1103244SRLR, REVISION 0, CLASS I, APRIL 1998

GE Nuclear Energy

J1103244SRLR
Revision 0
Class I
April 1998

Supplemental Reload Licensing Report
for
BRUNSWICK STEAM ELECTRIC PLANT UNIT 1
Reload 11 Cycle 12

GE Nuclear Energy

J1103244SRLR
Revision 0
Class I
April 1998

J1103244SRLR, Rev. 0

Supplemental Reload Licensing Report

for

Brunswick Steam Electric Plant Unit 1

Reload 11 Cycle 12

Approved

G. A. Watford, Manager
Nuclear Fuel Engineering

Approved

W. H. Hetzel
Fuel Project Manager

Important Notice Regarding

Contents of This Report

Please Read Carefully

This report was prepared by General Electric Company (GE) solely for Carolina Power and Light Company (CP&L) for CP&L's use in defining operating limits for the Brunswick Steam Electric Plant Unit 1. The information contained in this report is believed by GE to be an accurate and true representation of the facts known or obtained or provided to GE at the time this report was prepared.

The only undertakings of GE respecting information in this document are contained in the contract between CP&L and GE for nuclear fuel and related services for the nuclear system for Brunswick Steam Electric Plant Unit 1 and nothing contained in this document shall be construed as changing said contract. The use of this information except as defined by said contract, or for any purpose other than that for which it is intended, is not authorized; and with respect to any such unauthorized use, neither GE nor any of the contributors to this document makes any representation or warranty (expressed or implied) as to the completeness, accuracy or usefulness of the information contained in this document or that such use of such information may not infringe privately owned rights; nor do they assume any responsibility for liability or damage of any kind which may result from such use of such information.

Acknowledgement

The engineering and reload licensing analyses, which form the technical basis of this Supplemental Reload Licensing Report, were performed by S. B. Shelton, F.M. Schrum, and P. Wei. The Supplemental Reload Licensing Report was prepared by S. B. Shelton. This document has been verified by J. Su.

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

Appendix A: Analysis Conditions
Appendix B: Main Steamline Isolation Valve Out of Service (MSIVOOS)
Appendix C: Decrease in Core Coolant Temperature Events
Appendix D: Feedwater Temperature Reduction (FWTR)
Appendix E: Maximum Extended Operating Domain (MEOD)
Appendix F: Turbine Bypass Out of Service (TBPOOS)

2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated:		
GE10-P8HXB322-11GZ-70M-150-T (GE8x8NB-3)	9	8
GE10-P8HXB346-12GZ-100M-150-T (GE8x8NB-3)	10	156
GE13-P9DTB380-10G5.0A-100T-146-T (GE13)	11	132
GE13-P9DTB380-11G5.0A-100T-146-T (GE13)	11	68
New:		
GE13-P9DTB403-7G6.0/7G5.0-100T-146-T (GE13)	12	160
GE13-P9DTB403-5G6.0/7G5.0-100T-146-T (GE13)	12	36
Total		560

3. Reference Core Loading Pattern

Nominal previous cycle core average exposure at end of cycle:	27730 MWd/MT (25156 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	27450 MWd/MT[1] (24902 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	14253 MWd/MT (12930 MWd/ST)
Assumed reload cycle core average exposure at end of cycle:	29865 MWd/MT (27093 MWd/ST)
Reference core loading pattern:	Figure 1

[1] This value corresponds to 492.2 EFPD

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

Beginning of Cycle, $k_{effective}$	
Uncontrolled	1.112
Fully controlled	0.958
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 20°C, Xenon Free)
660	0.032

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

Exposure: BOC12 to EOC12-2205 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	1.45	1.40	1.020	6.466	109.5	1.35

Exposure: EOC12-2205 MWd/MT (2000 MWd/ST) to EOC12 with ICF							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.40	1.47	1.020	6.217	112.7	1.36

Exposure: BOC12 to EOC12 with TBPOOS							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.48	1.19	1.020	6.569	108.1	1.39

Exposure: BOC12 to EOC12 with TBPOOS and FWTR							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE13	1.45	1.51	1.24	1.020	6.676	106.9	1.39

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 (EOC12-2205 MWd/MT and EOC12)

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:	104.3 %
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:	Yes
Safety/relief valves OOS:	Yes

(credit taken for 9 of 11 valves, however, ATWS evaluations require 10 in-service for power uprate)

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: BOC12 to EOC12-2205 MWd/MT (2000 MWd/ST) with ICF				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Load Reject w/o Bypass	502	121	0.26	2

Exposure range: EOC12-2205 MWd/MT (2000 MWd/ST) to EOC12 with ICF				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
Turbine Trip w/o Bypass	569	125	0.27	3

Exposure range: BOC12 to EOC12 with TBPOOS				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
FW Controller Failure	369	122	0.30	4

Exposure range: BOC12 to EOC12 with TBPOOS and FWTR				
			Uncorrected ΔCPR	
Event	Flux (%NBR)	Q/A (%NBR)	GE13	Fig.
FW Controller Failure	403	125	0.30	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, 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 [2] [3]

In agreement with commitments to the NRC (letter from M. A. Smith to the 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 has been reported in both the Safety Limit MCPR and the Operating Limit MCPR shown below. This cycle specific SLMCPR was determined using the analysis basis documented in GESTAR with the following exceptions:

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

Safety limit: 1.09

Single loop operation safety limit: 1.10

Non-pressurization events:

Exposure range: BOC12 to EOC12	
	GE13
Fuel Loading Error (misoriented)	1.26

Pressurization events:

Exposure range: BOC12 to EOC12-2205 MWd/MT (2000 MWd/ST) with ICF[4] **Exposure point: EOC12-2205 MWd/MT (2000 MWd/ST)**		
	Option A	**Option B**
	GE13	**GE13**
Load Reject w/o Bypass	1.40	1.35

[2] 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.
[3] The GE13 fuel type MCPR values bound the GE8x8NB-3 MCPR values for all events.
[4] The ICF Operating Limits for the exposure range of BOC12 to EOC12-2205 MWd/MT (2000 MWd/ST) bound the Operating Limits for the following domains: MELLL, ICF and FWTR, MSIVOOS and ICF.

Exposure range: EOC12-2205 MWd/MT (2000 MWd/ST) to EOC12 with ICF[5] Exposure point: EOC12		
	Option A	Option B
	GE13	GE13
Turbine Trip w/o Bypass	1.46	1.38

Exposure range: BOC12 to EOC12 with TBPOOS Exposure point: EOC12		
	Option A	Option B
	GE13	GE13
FW Controller Failure	1.49	1.41

Exposure range: BOC12 to EOC12 with TBPOOS and FWTR Exposure point: EOC12		
	Option A	Option B
	GE13	GE13
FW Controller Failure	1.50	1.42

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram)	1285	1316	Figure 6

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes [6]

Misoriented Fuel Bundle	ΔCPR
GE13-P9DTB403-5G6.0/7G5.0-100T-146-T (GE13)	0.06
GE13-P9DTB403-7G6.0/7G5.0-100T-146-T (GE13)	0.10
GE13-P9DTB380-10G5.0A-100T-146-T (GE13)	0.16
GE13-P9DTB380-11G5.0A-100T-146-T (GE13)	0.17

[5] The ICF Operating Limits for the exposure range of EOC12-2205 MWd/MT (2000 MWd/ST) to EOC12 bound the Operating Limits for the following domains: MELLL, ICF and FWTR, MSIVOOS and ICF.

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

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 1 operating procedures. Regions of restricted operation defined in Attachment 1 to NRC Bulletin No. 88-07, Supplement 1, *Power Oscillations in Boiling Water Reactors Reactors (BWRs)*, are applicable to Brunswick 1.

Brunswick Unit 1 Cycle 11, Reactor Stability Long-Term Solution Enhanced Option I-A, Stability Region Boundary Generation and Validation, GENE-A13-00367-47 documents the Enhanced Option I-A (E1A) stability region boundaries for Brunswick Unit 1 Cycle 11 and the analysis associated with their generation and validation. Reload validation of these stability region boundaries has been performed in accordance with NEDO-32339-A, Revision 1, *Reactor Stability, Long Term Solution: Enhanced Option I-A*. The Reload Validation Matrix confirms best-estimate code boundary validation stability criteria. The results are shown in Figure 7.

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 1533 °F, a peak local oxidation fraction of <0.30%, and a core-wide metal-water reaction of 0.046%.

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, Revision 0, January 1996, show a licensing basis peak clad temperature of 1535 °F. The peak local oxidation fraction and core-wide metal-water reaction were shown to be bounded by the results from GE8x8EB LOCA analysis.

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

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

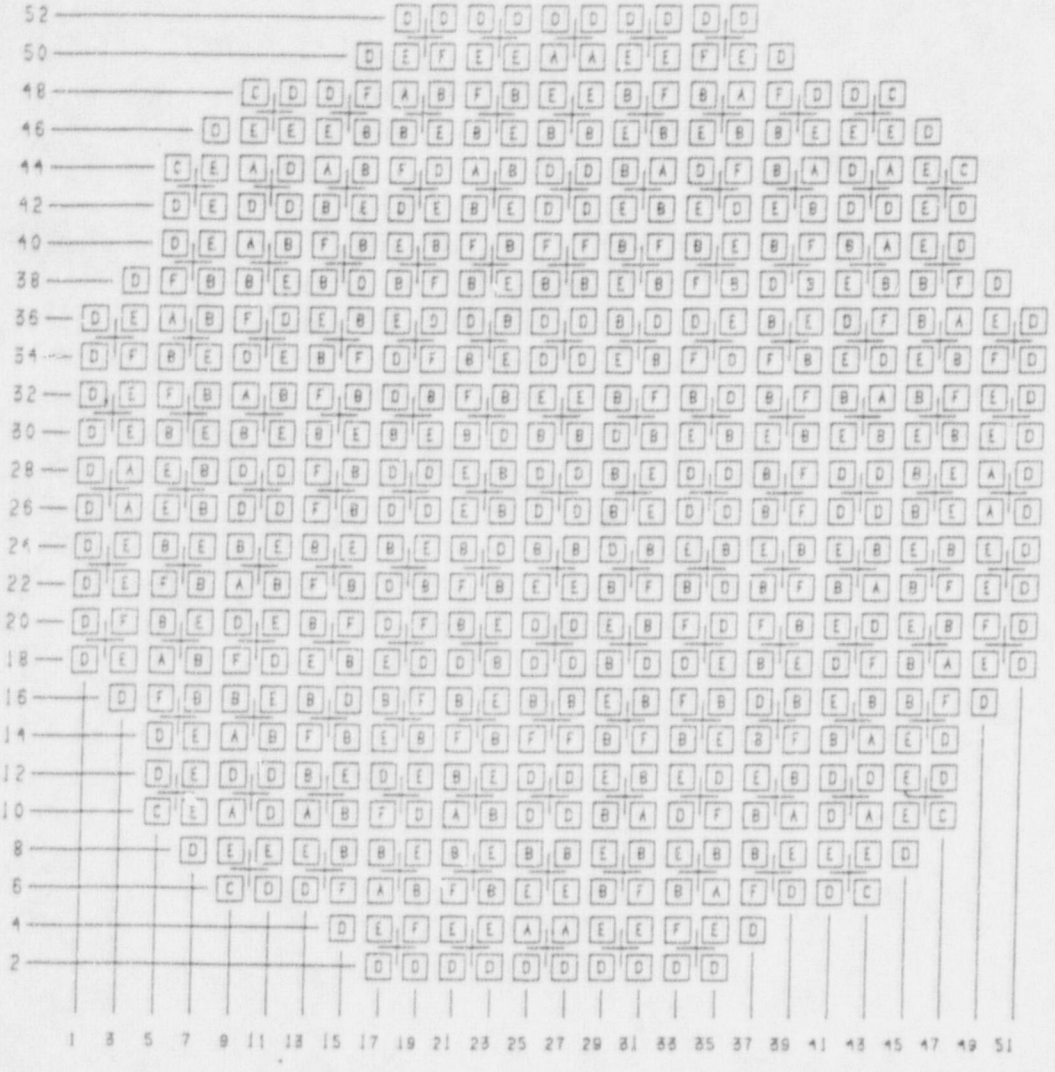
Bundle Type: GE13-P9DTB403-5G6.0/7G5.0-100T-146-T

Average Planar Exposure		MAPLHGR (kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	10.65	10.73
0.20	0.22	10.72	10.79
1.00	1.10	10.85	10.88
2.00	2.20	11.00	11.03
3.00	3.31	11.12	11.21
4.00	4.41	11.25	11.35
5.00	5.51	11.38	11.50
6.00	6.61	11.52	11.66
7.00	7.72	11.66	11.82
8.00	8.82	11.81	11.99
9.00	9.92	11.95	12.12
10.00	11.02	12.05	12.26
12.50	13.78	12.04	12.36
15.00	16.53	11.97	12.29
17.50	19.29	11.79	12.07
20.00	22.05	11.54	11.79
25.00	27.56	11.02	11.23
30.00	33.07	10.44	10.49
35.00	38.58	9.69	9.85
40.00	44.09	8.98	9.14
45.00	49.60	8.30	8.44
50.00	55.12	7.64	7.74
55.00	60.63	7.00	7.05
58.49	64.48	6.54	6.55
59.19	65.25	--	6.45

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

Bundle Type: GE13-P9DTB403-7G6.0/7G5.0-100T-146-T

Average Planar Exposure		MAPLHGR (kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.00	0.00	10.44	10.44
0.20	0.22	10.51	10.51
1.00	1.10	10.61	10.63
2.00	2.20	10.74	10.77
3.00	3.31	10.88	10.93
4.00	4.41	11.02	11.09
5.00	5.51	11.17	11.26
6.00	6.61	11.32	11.43
7.00	7.72	11.48	11.59
8.00	8.82	11.62	11.74
9.00	9.92	11.73	11.89
10.00	11.02	11.85	12.04
12.50	13.78	11.86	12.16
15.00	16.53	11.86	12.21
17.50	19.29	11.76	12.06
20.00	22.05	11.54	11.80
25.00	27.56	11.02	11.25
30.00	33.07	10.49	10.70
35.00	38.58	9.85	10.01
40.00	44.09	9.13	9.26
45.00	49.60	8.43	8.52
50.00	55.12	7.73	7.81
55.00	60.63	7.03	7.14
58.33	64.29	6.56	6.61
59.06	65.11	--	6.49



Fuel Type	
A=GE13-P9DTB403-5G6.0/7G5.0-100T-146-T (Cycle 12)	D=GE10-P8HXB346-12GZ-100M-150-T (Cycle 10)
B=GE13-P9DTB403-7G6.0/7G5.0-100T-146-T (Cycle 12)	E=GE13-P9DTB380-10G5.0A-100T-146-T (Cycle 11)
C=GE10-P8HXB322-11GZ-70M-150-T (Cycle 9)	F=GE13-P9DTB380-11G5.0A-100T-146-T (Cycle 11)

Figure 1 Reference Core Loading Pattern

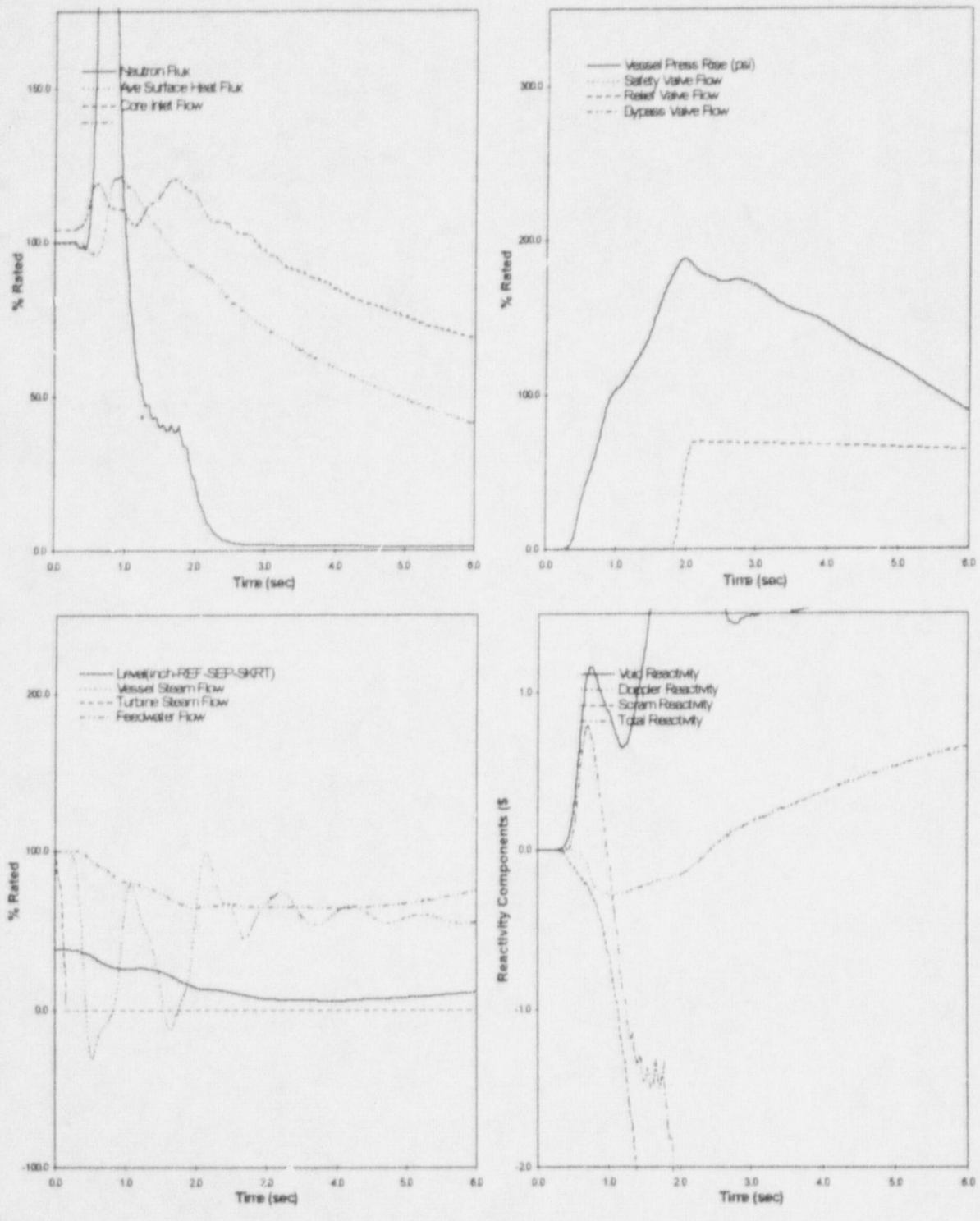


Figure 2 Plant Response to Load Reject w/o Bypass (BOC12 to EOC12-2205 MWd/MT (2000 MWd/ST) ICF_HBB)

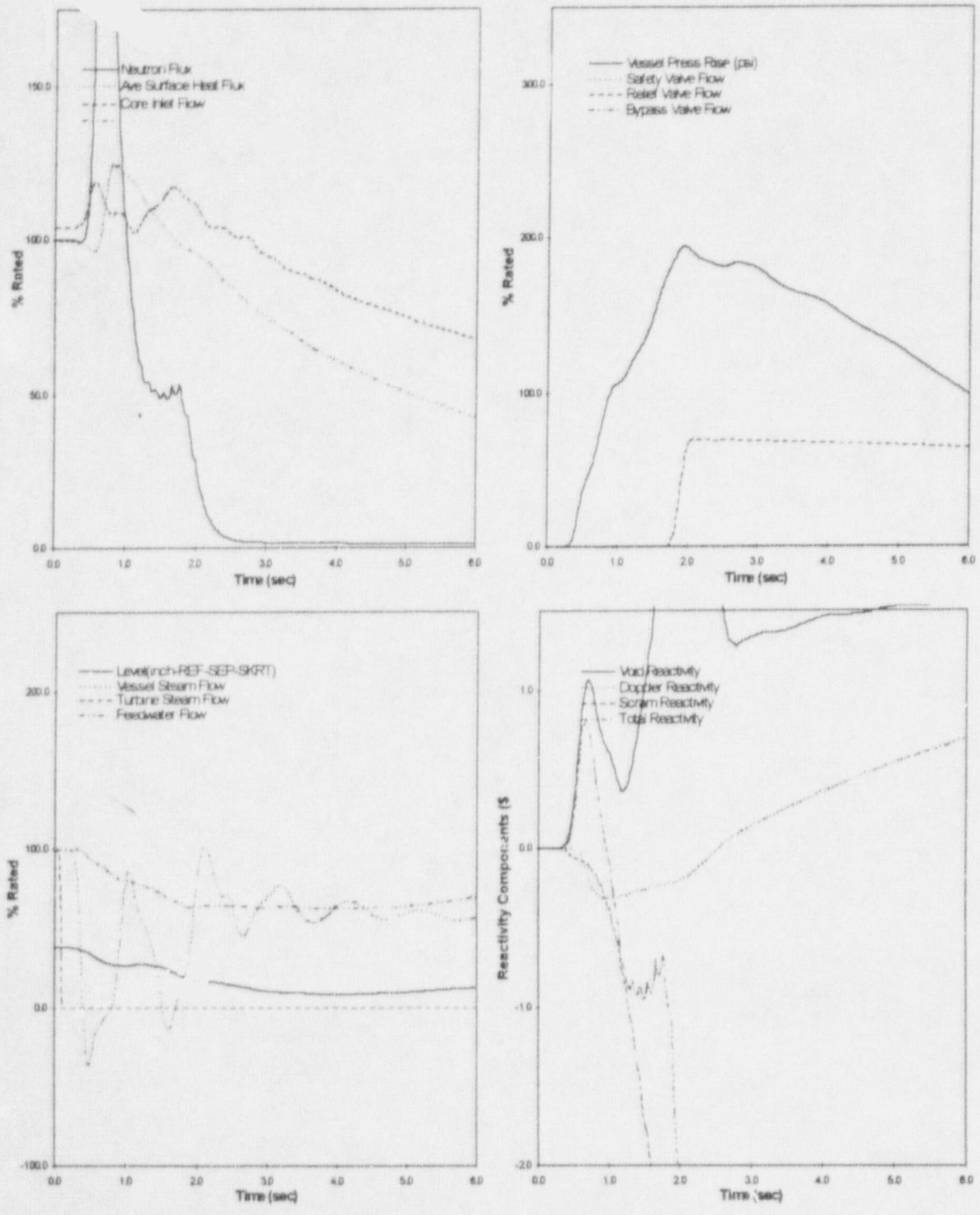


Figure 3 Plant Response to Turbine Trip w/o Bypass (EOC12-2205 MWd/MT (2000 MWd/ST) to EOC12 ICF_HBB)

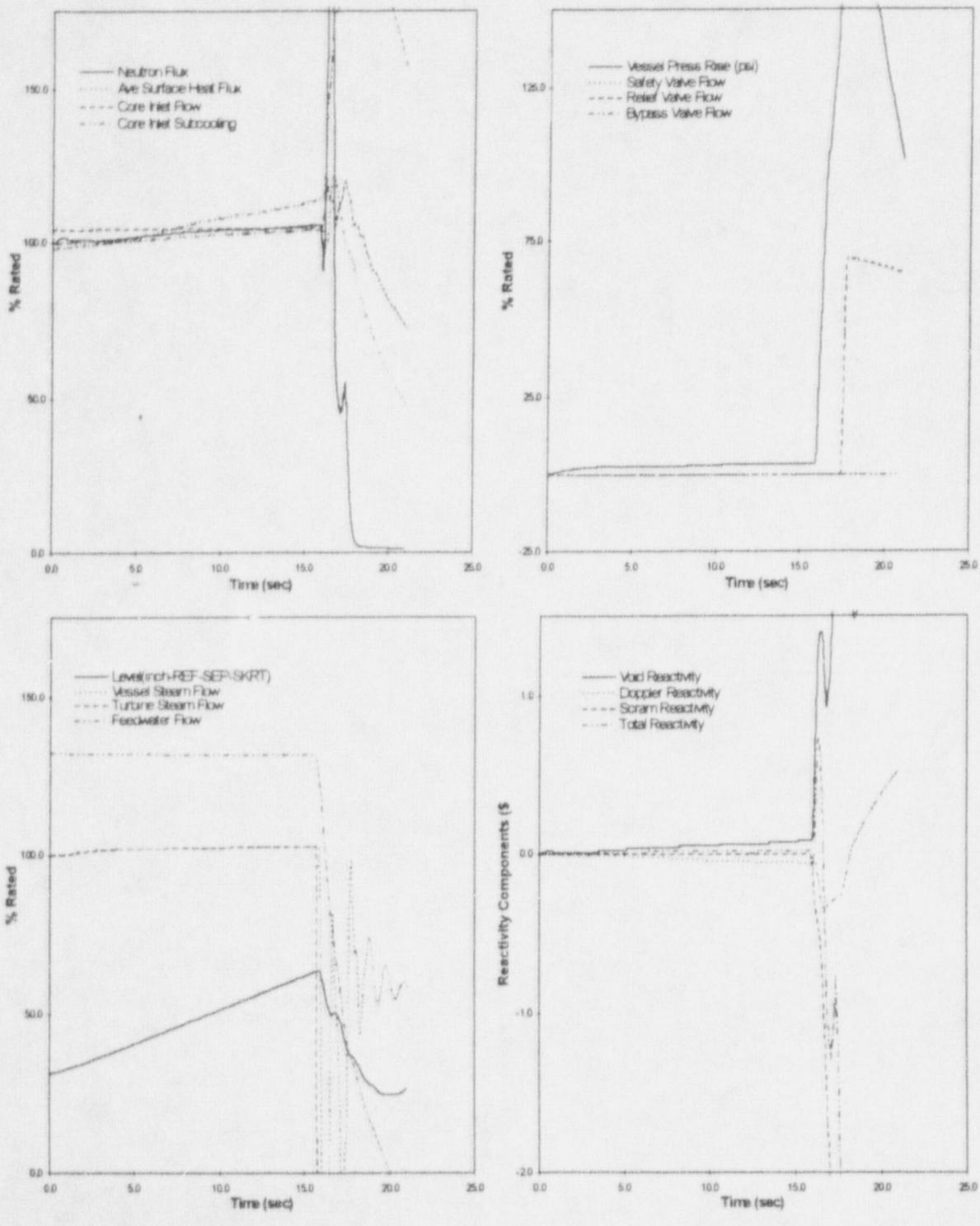


Figure 4 Plant Response to FW Controller Failure (BOC12 to EOC12 TBPOOS_NOM)

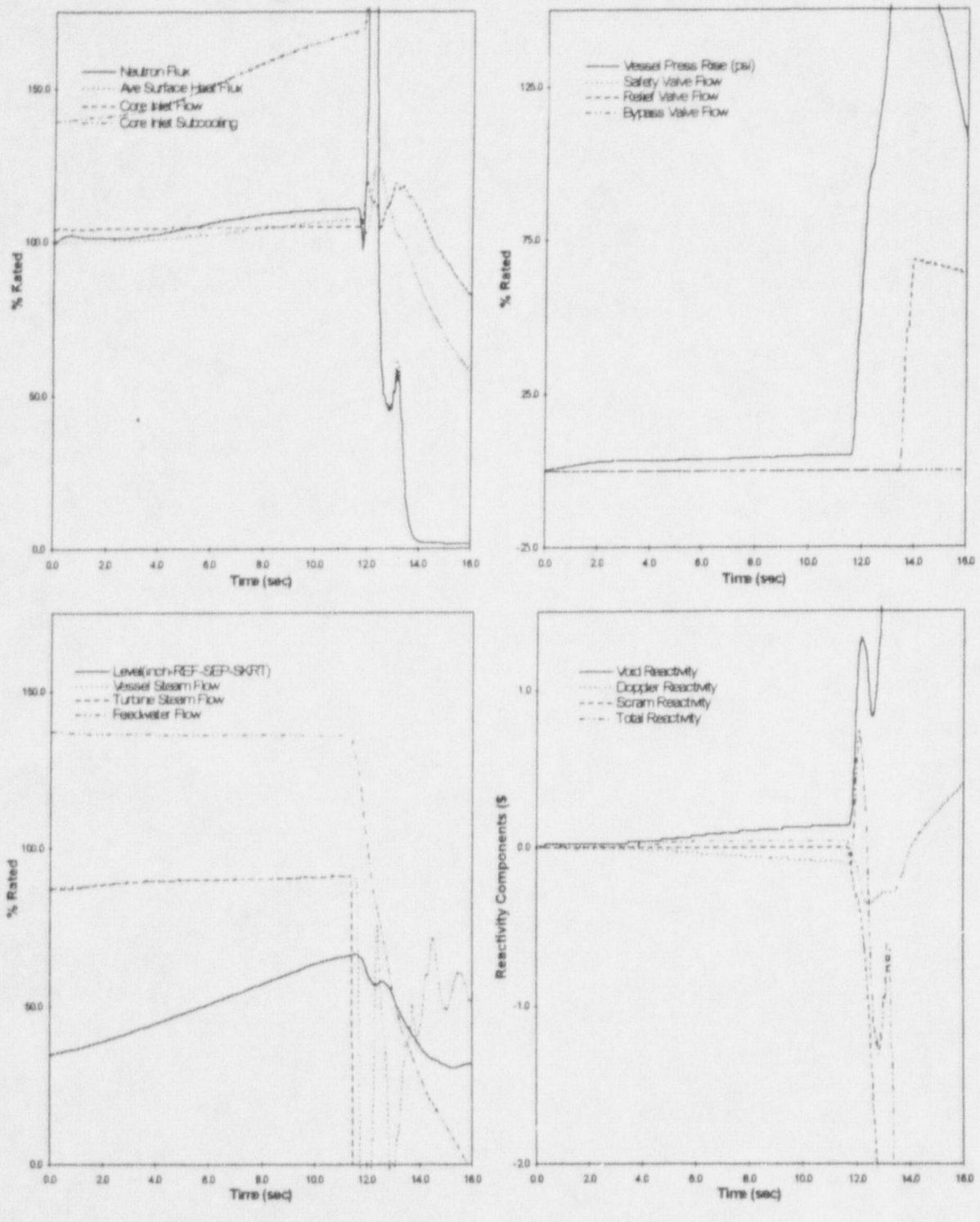


Figure 5 Plant Response to FW Controller Failure (BOC12 to EOC12 TBPOOS_FWTR_NOM)

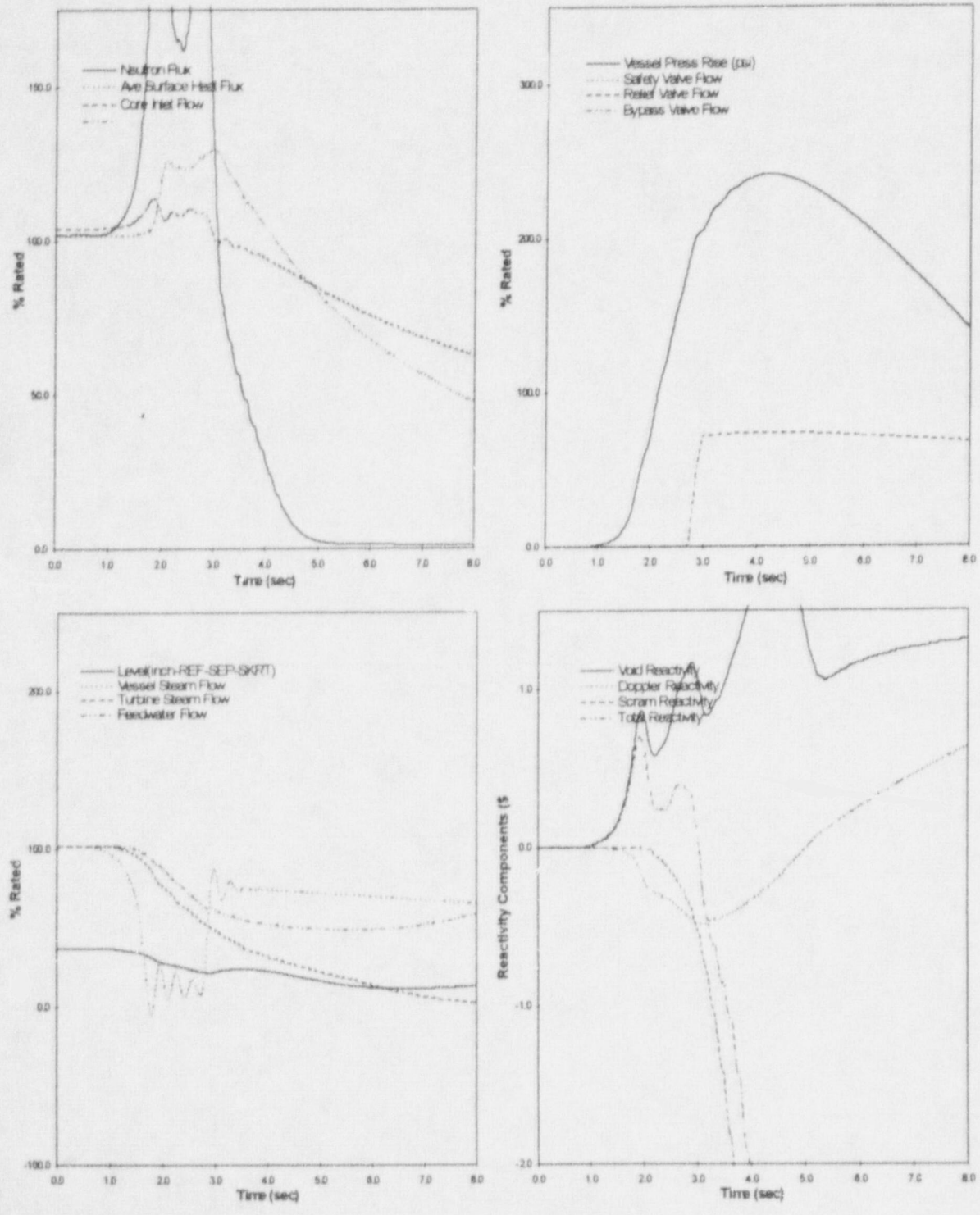


Figure 6 Plant Response to MSIV Closure (Flux Scram)

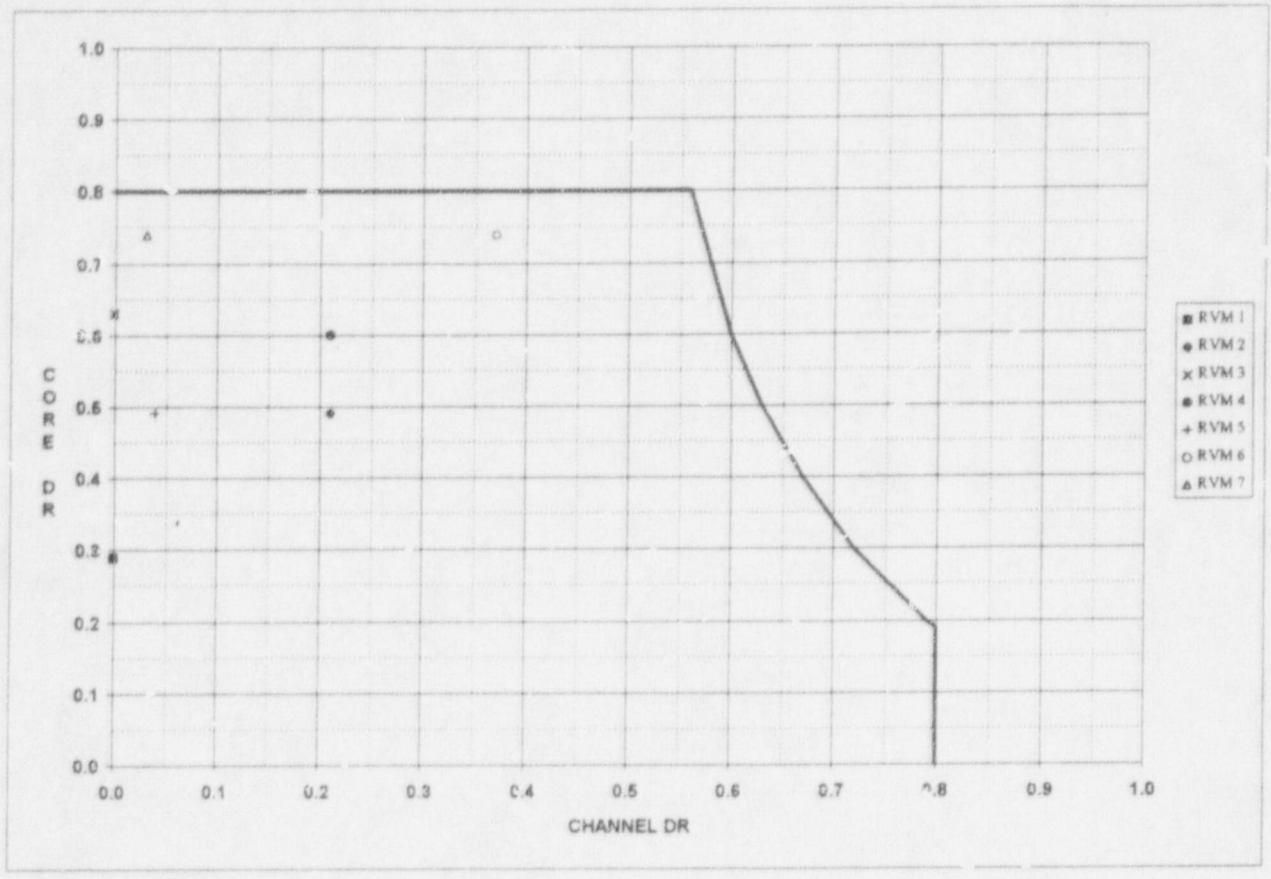


Figure 7 RVM Results versus ODYSY Stability Criteria

Appendix A
Analysis Conditions

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

Table A-1

	Analysis Value	
Parameter	ICF_HBB	FWTR_HBB
Thermal power, MWt	2558.0	2558.0
Core flow, Mlb/hr	80.3	80.3
Reactor pressure, psia	1060.8	1041.2
Inlet enthalpy, BTU/lb	530.7	517.0
Non-fuel power fraction	0.036	0.036
Steam flow analysis, Mlb/hr	11.09	9.67
Dome pressure, psig	1030.0	1011.7
Turbine pressure, psig	984.8	976.9
No. of Safety/Relief Valves	9	9
Relief mode lowest setpoint, psig	1164.0	1164.0
Recirculation pump power source	on-site [7]	on-site [7]
Turbine control valve mode of operation	Partial arc	Partial arc

[7] Bounds operation with off-site power source for reload licensing events for Cycle 12.

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 1 throughout Cycle 12, 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 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 0.12. The HPCI event was shown to be bounded by the LFWH event for Cycle 11. There is no reason why these events would be expected to be more severe for Cycle 12. The results of the AOOs presented in Section 11 of this report sufficiently bound the expected results of the LWFH and HPCI inadvertent start-up events, therefore these events were not analyzed for Cycle 12.

Appendix D
Feedwater Temperature Reduction (FWTR)

Reference D-1 provides the basis for operation of Brunswick Steam Electric Plant (BSEP) 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. The analyses used to calculate FWTR limits were based on constant turbine pressure which bounds constant dome pressure.

Reference

D-1. *Feedwater Temperature Reduction with Maximum Extended Load line 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 Brunswick Steam Electric Plant (BSEP) in the Maximum Extended Operating Domain (MEOD). Previous cycles have shown that these low flow conditions are bounded by ICF, therefore this domain was not analyzed for Cycle 12. 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 the Brunswick Steam Electric Plant*, NEDC-31654P, GE Nuclear Energy (Proprietary) , February 1989.

Appendix F
Turbine Bypass Out of Service (TBPOOS)

Reference F-1 provides a basis for operation of Brunswick Steam Electric Plant (BSEP) with all Turbine Bypass Valves Out of Service (TBPOOS) and 2 S/RVs Out of Service (2 SRVOOS). Reference F-1 has been confirmed applicable to the operation of Brunswick-1, Cycle 12. This is the first cycle of operation with this operating domain. Section 11 of this report presents the MCPR limits for the modes of operation with TBPOOS.

Reference

F-1. *Turbine Bypass Out of Service Analysis for Carolina Power & Light Company's Brunswick Nuclear Plant Units 1 and 2*,NEDC-32813P, Revision 1, GE Nuclear Energy (Proprietary) , March 1998.