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Supplemental Reload Licensing Report

for

Perry Nuclear Power Plant Unit 1

Reload 3 Cycle 4

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Acknowledgment

The engineering and reload licensing analyses which form the technical basis of this Supplemental Reload Licensing Report, were performed by P. A. Hahn and J. L. Casillas of the Fuel Engineering Section. The Supplemental Reload Licensing Report was prepared by P. A. Lambert of Fuel Licensing. This report has been verified by Fuel Engineering and J. L. Embley of Fuel Licensing.

The basis for this report is *General Electric Standard Application for Reactor Fuel*, NEDE-24011-P-A-10, February 1991; and the U. S. Supplement, NEDE-24011-P-A- 10-US, March 1991.

1. Plant-unique Items

Appendix A: Analysis Conditions
Appendix B: Basis For Analysis of Loss-of-feedwater Heating Event
Appendix C: Analyzed Operating Domain
Appendix D: Transient Analyses
Appendix E: Rotated Bundle Analysis

2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated		
BP8SRB176 (BP8x8R)	1	10
GE8B-P8SQB301-7GZ-120M-150-T (BS301E) (GE8x8EB)	2	128
GE8B-P8SQB301-5GZ-120M-150-T (BS301F) (GE8x8EB)	2	134
GE8B-P8SQB320-9GZ-120M-150-T (GE8x8EB)	3	104
GE8B-P8SQB322-7GZ-120M-150-T (GE8x8EB)	3	168
New		
GE10-P8SXB306-11GZ3-120M-150-T (GE8x8NB-3)	4	68
GE10-P8SXB306-10GZ2-120M-150-T (GE8x8NB-3)	4	136
Total		748

3. Reference Core Loading Pattern*

	MWd/ST	MWd/MT
Nominal previous cycle core average exposure at end of cycle:	16,110	17,758
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	16,110	17,758
Assumed reload cycle core average exposure at beginning of cycle:	15,946	17,577
Assumed reload cycle core average exposure at end of cycle:	21,881	24,120
Core loading pattern:	Figure 1	

*The information in Sections 3, 4 and 5 considers only the remainder of Cycle 4; all other information applies to the entire Cycle 4.

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

Beginning of Cycle, $K_{effective}$

Uncontrolled	1.121
Fully controlled	0.956
Strongest control rod out	0.984
R, Maximum increase in cold core reactivity with exposure into cycle, ΔK	0.005

5. Standby Liquid Control System Shutdown Capability*

Boron (ppm)	Shutdown Margin (ΔK) (20°C, Xenon Free)
660	0.029

6. Reload Unique GETAB AOO Analysis Initial Condition Parameters

Fuel Design	Peaking Factors Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1,000 lb/hr)	Initial MCPR
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature 420°F							
GE8x8NB-3	1.20	1.58	1.40	1.000	7.369	116.5	1.21
GE8x8EB/ BP8x8R	1.20	1.48	1.40	1.051	6.925	120.3	1.17
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 250°F							
GE8x8NB-3	1.20	1.64	1.40	1.000	7.620	114.6	1.20
GE8x8EB/ BP8x8R	1.20	1.53	1.40	1.051	7.140	118.6	1.18
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 320°F							
GE8x8NB-3	1.20	1.61	1.40	1.000	7.523	115.3	1.20
GE8x8EB/ BP8x8R	1.20	1.51	1.40	1.051	7.048	119.3	1.18
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 370°F							
GE8x8NB-3	1.20	1.61	1.40	1.000	7.517	115.5	1.19
GE8x8EB/ BP8x8R	1.20	1.50	1.40	1.051	7.024	119.5	1.17

*The information in Sections 3, 4 and 5 considers only the remainder of Cycle 4; all other information applies to the entire Cycle 4.

7. Selected Margin Improvement Options

Recirculation pump trip:	Yes
Rod withdrawal limiter:	Yes
Thermal power monitor:	Yes
Measured scram time:	No
Exposure dependent limits:	No
Exposure points analyzed:	1 (EOC)

8. Operating Flexibility Options (S.5.2)

Single-loop operation:	Yes
Load line limit:	No
Extended load line limit:	No
Maximum extended load line limit:	No
Increased core flow at end of cycle:	Yes
Increased core flow throughout the cycle:	Yes
Flow point analyzed:	105%
Feedwater temperature reduction throughout the cycle:	Yes
Final feedwater temperature reduction:	Yes
Temperature reduction:	50°F, 100°F, 170°F
ARTS Program:	No
Maximum extended operating domain:	Yes
Main steam isolation valve out of service:	No
Recirculation pump trip out of service:	No
Turbine bypass out of service:	No

9. Core-wide AOO Analysis Results

Methods used: GEMINI and GEXL-PLUS

Event	Flux (% NBR)	Q/A (% NBR)	Uncorrected ΔCPR GE8x8NB-3	Uncorrected ΔCPR GE8x8EB/ BP8x8R	Figure
Exposure range: BOC4 to EOC4 Increased core flow/Feedwater temperature 420°F					
Load rejection without bypass	401	113	0.14	0.10	2
Feedwater controller failure (143%)	289	112	0.11	0.09	3
Pressure regulator failure downscale	146	105	0.07	0.05	4
Loss of 100°F feedwater heating	*	*	0.12	0.12	*
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 250°F					
Feedwater controller failure (143%)	280	117	0.13	0.12	5
Pressure regulator failure downscale	148	106	0.07	0.06	6
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 320°F					
Feedwater controller failure (143%)	292	116	0.12	0.11	7
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 370°F					
Feedwater controller failure (143%)	293	114	0.12	0.10	8

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

The generic bounding BWR/6 rod withdrawal error (RWE) is analyzed in NEDE-24011-P-A-9-US and GESSAR-II Appendix 15B is applied; the resulting ΔCPR is 0.11. The generic RWE ΔCPR was verified to be applicable to the new fuel design. The original generic analysis in GESSAR-II was not applicable for control cell core operation; however, it was subsequently shown to be applicable for control cell core operation and GESSAR-II was revised to reflect this application in Revision 21.

*See Appendix B.

11. Cycle MCPR Values*

Safety limit: 1.07

Single loop operation safety limit: 1.08

Exposure range: BOC4 to EOC4

Non-pressurization events

	GE8x8NB-3	GE8x8EB/ BP8x8R
Rod withdrawal error	1.18	1.18
Fuel loading error**	1.23	1.21
Loss of 100°F feedwater heating (Bounding from 420°F feedwater temperature condition)	1.19	1.19

Pressurization events

	Option A	
	GE8x8NB-3	GE8x8EB/ BP8x8R
Exposure range: BOC4 to EOC4 Increased core flow/Feedwater temperature 420°F		
Load rejection without bypass	1.21	1.18
Feedwater controller failure	1.19	1.16
Pressure regulator failure downscale	1.15	1.13
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 250°F		
Feedwater controller failure	1.21	1.20
Pressure regulator failure downscale	1.15	1.14
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 320°F		
Feedwater controller failure	1.21	1.19
Exposure: BOC4 to EOC4 Increased core flow/Feedwater temperature reduction to 370°F		
Feedwater controller failure	1.20	1.18

*GEMINI ODYN adjustment factors are provided in the letter from J. S. Charnley (GE) to M. W. Hodges (NRC), *GEMINI ODYN Adjustment Factors for BWR/6*, dated July 6, 1987. The MCPR limit does not change because of channel bow. Channel bow is reflected in the monitoring of the core.

**See Appendix E.

12. Overpressurization Analysis Summary

Event	P_{si} (psig)	P_v (psig)	Plant Response
MSIV closure (flux scram)*	1241	1272	Figure 9

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes

	ΔCPR	
Event	GE8x8NB-3	GE8x8EB/BP8x8R
Misoriented fuel bundle	0.16**	0.14**

14. Control Rod Drop Analysis Results

Banked Position Withdrawal Sequence is utilized at the Perry Nuclear Power Plant Unit 1; therefore, the bounding control rod drop analysis (CRDA) described in NEDE-24011-P-A-10-US is applied. NRC approval of the bounding analysis is given in the letter to J. S. Charnley (GE), *Acceptance for Referencing of Licensing Topical Report NEDE-24011, Revision 6, Amendment 9 "GESTAR-II General Electric Standard Application for Reactor Fuel,"* January 25, 1985.

15. Stability Analysis Results

GE SIL-380 recommendations have been included in the Perry Nuclear Power Plant Unit 1 operating procedures and/or Technical Specifications and, therefore, the stability analysis is not required. NRC approval for deletion of a cycle-specific stability analysis is documented in Amendment 8 to NEDE-24011-P-A-US. In addition, the Perry Nuclear Power Plant Unit 1 recognizes the issuance of NRC Bulletin No. 88-07, Supplement 1, *Power Oscillations in Boiling Water Reactors (BWRs)*, and will continue to comply with the recommendations contained herein.

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*The MSIV closure (flux scram) analysis is performed using GEMINI methods at the 102% power level to account for the power level uncertainties specified in Regulatory Guide 1.49. The analysis was performed with 13 highest setpoint safety valves operational.

**ΔCPR penalty of 0.02 for the tilted misoriented bundle has been applied. See Appendix E.

ee the Perry Nuclear Power Plant Unit 1
alysis Report, as amended)

20X2-150-T (GE8x8NB-3)

	MAPLHGR (kw/ft)	
G [illegible]	[illegible]/MT)	Most Limiting	Least Limiting
0.0	0.0	11.55	12.43
0.2	0.2	11.61	12.47
1.0	1.1	11.71	12.58
2.0	2.2	11.92	12.72
3.0	3.3	12.17	12.88
4.0	4.4	12.41	13.04
5.0	5.5	12.61	13.20
6.0	6.6	12.81	13.33
7.0	7.7	12.99	13.41
8.0	8.8	13.16	13.50
9.0	9.9	13.31	13.56
10.0	11.0	13.34	13.43
12.5	13.8	13.23	13.40
15.0	16.5	12.92	13.07
20.0	22.0	12.16	12.40
25.0	27.6	11.44	11.76
35.0	38.6	10.14	10.40
45.0	49.6	8.90	9.15
51.7	57.0	5.87	6.03
51.9	57.2	--	5.95

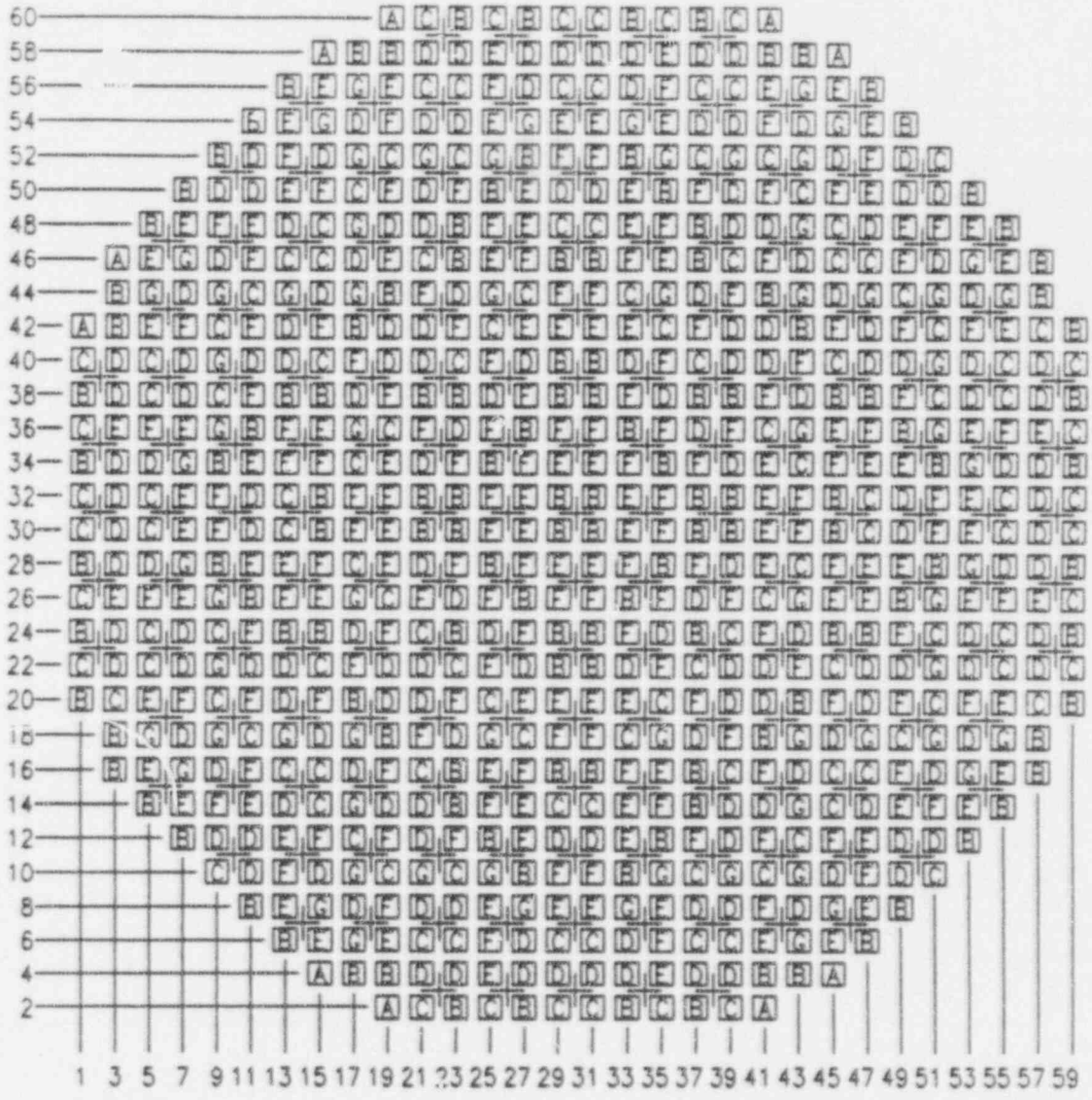
The peak clad temperature (PCT) is ≤2149°F at all exposures; the local oxidation (fraction) is ≤0.061 at all exposures. The MAPLHGR multiplier for single-loop operation (SLO) is 0.80.

16. Loss-of-coolant Accident Results (continued)

Bundle Type: GE10-P8SXB306-10GZ2-120M-150-T (GE8x8NB-3)

Average Planar Exposure		MAPLHGR (kw/ft)	
(GWd/ST)	(GWd/MT)	Most Limiting	Least Limiting
0.0	0.0	11.21	12.35
0.2	0.2	11.26	12.45
1.0	1.1	11.36	12.62
2.0	2.2	11.56	12.75
3.0	3.3	11.81	12.95
4.0	4.4	12.08	12.95
5.0	5.5	12.35	13.06
6.0	6.6	12.57	13.17
7.0	7.7	12.80	13.28
8.0	8.8	13.00	13.38
9.0	9.9	13.20	13.46
10.0	11.0	13.37	13.52
12.5	13.8	13.45	13.52
15.0	16.5	13.14	13.20
20.0	22.0	12.40	12.57
25.0	27.6	11.61	11.94
35.0	38.6	10.12	10.57
45.0	49.6	8.83	9.29
52.1	57.4	5.87	5.96
52.3	57.6	--	5.89

The Peak Clad Temperature (PCT) is ≤2129°F at all exposures; the Local Oxidation (Fraction) is ≤0.058 at all exposures. The MAPLHGR multiplier for single-loop operation (SLO) is 0.80.



FUEL TYPE	
A = BP8SRB176	E = GE8B-P8SQB320-9GZ-120M-150-T
B = GE8B-P8SQB301-5GZ-120M-150-T	F = GE10-P8SXB306-10GZ2-120M-150-T
C = GE8B-P8SQB301-7GZ-120M-150-T	G = GE10-P8SXB306-11GZ3-120M-150-T
D = GE8B-P8SQB322-7GZ-120M-150-T	

Figure 1 Reference Core Loading Pattern

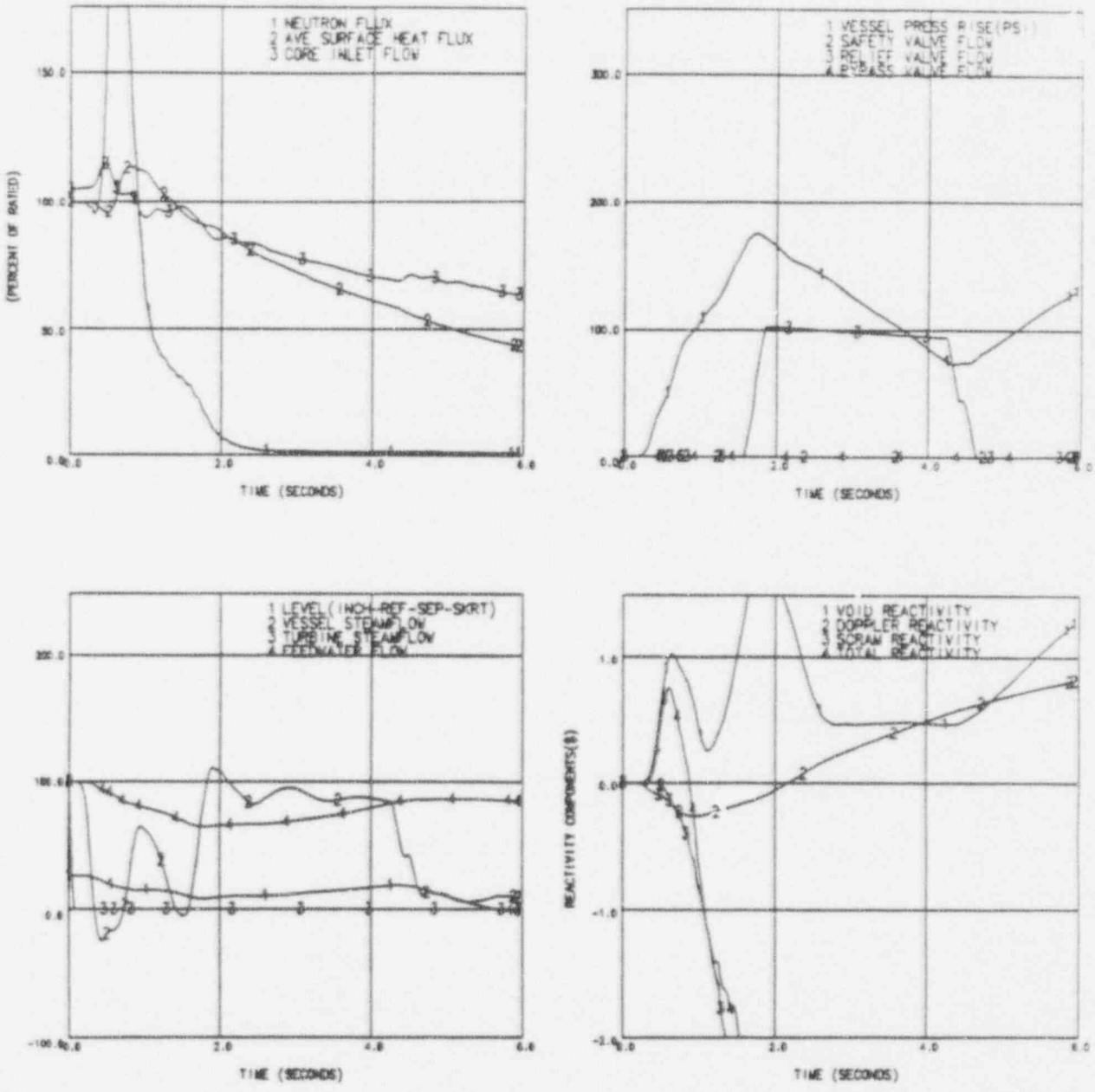


Figure 2. Plant Response to Load Rejection without Bypass (ICF/FWT 420°F)

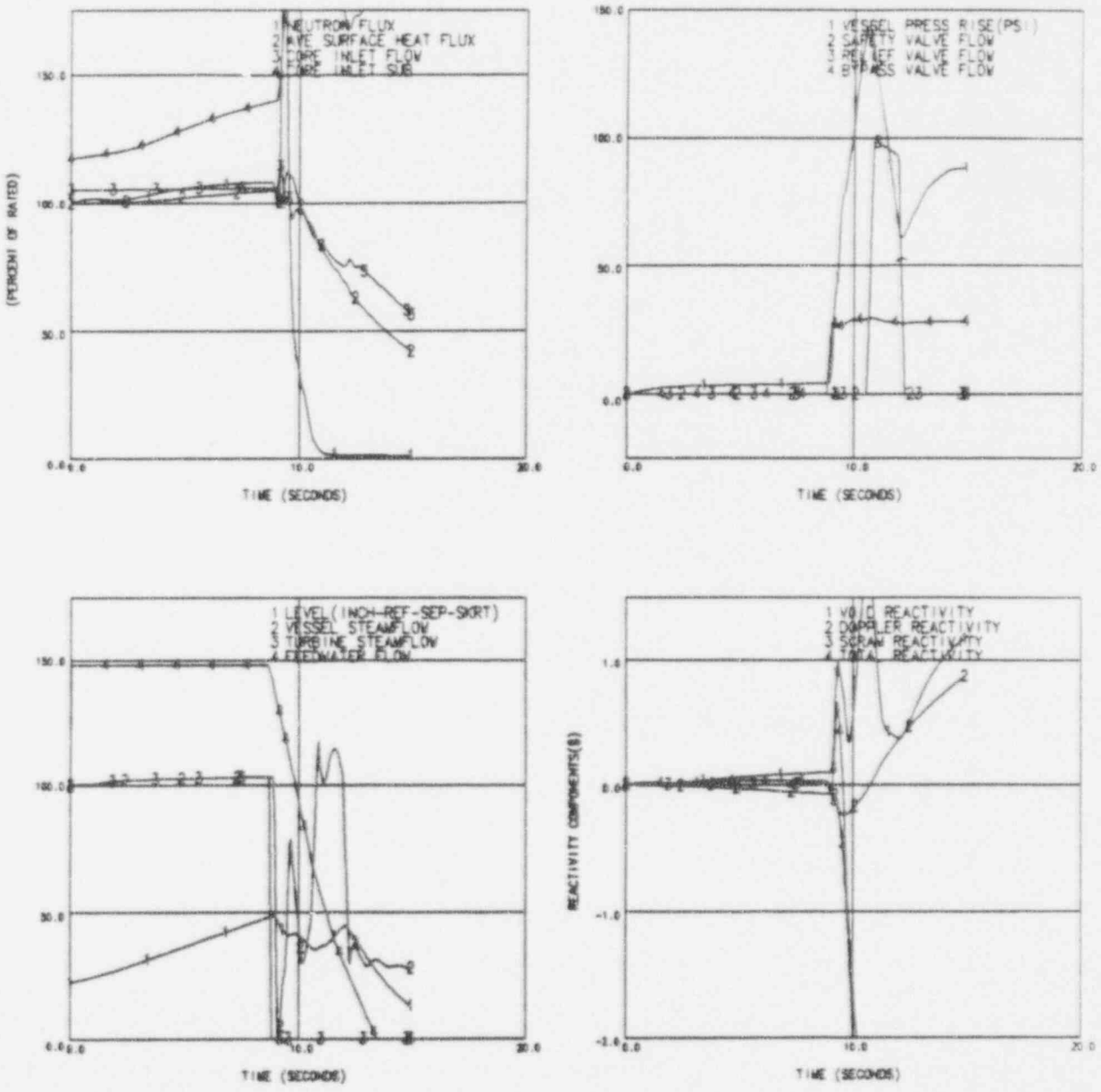


Figure 3. Plant Response to Feedwater Controller Failure
(ICF/FWT 420°F)

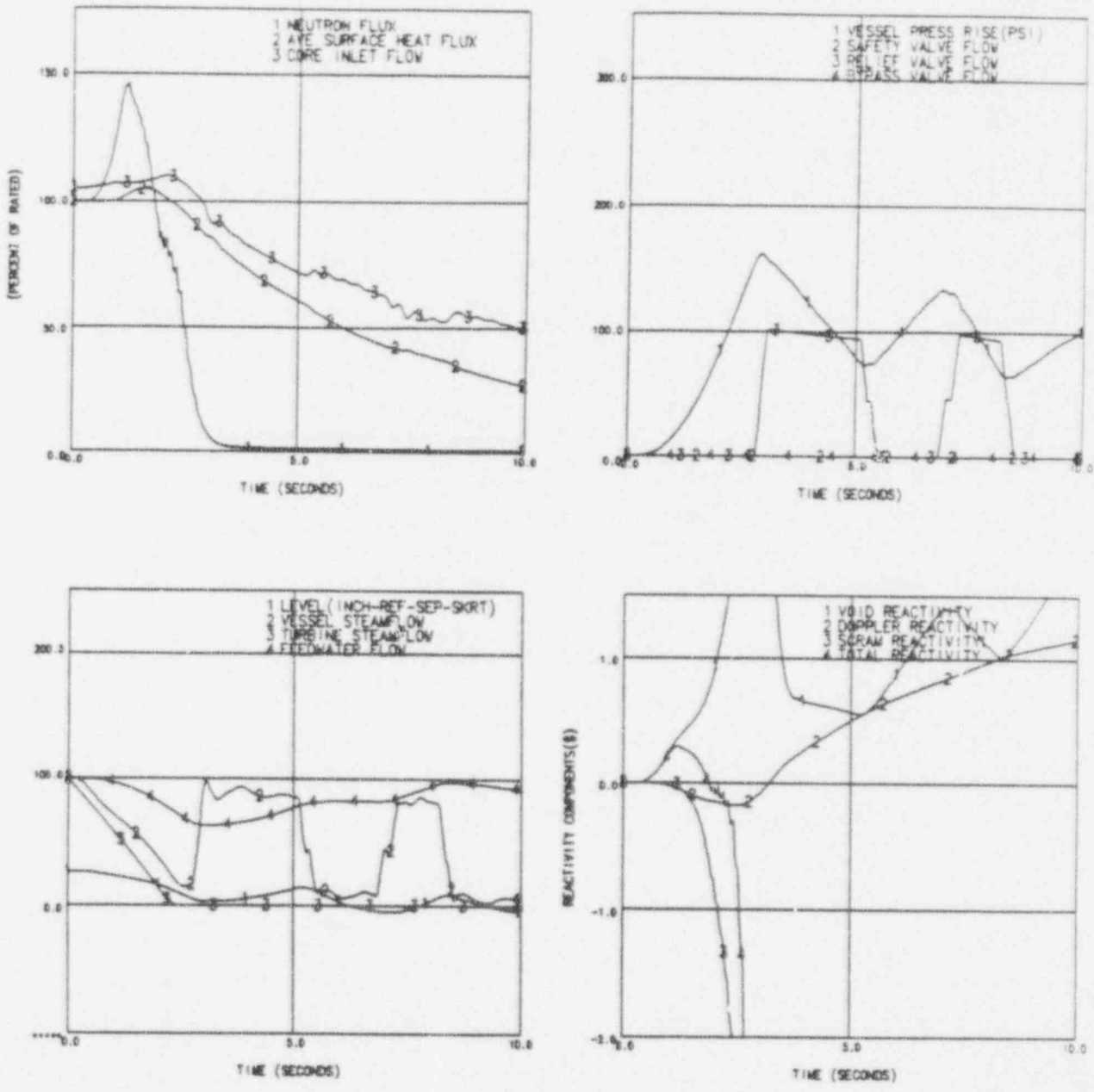


Figure 4. Plant Response to Pressure Regulator Failure Downscale (ICF/FWT 420°F)

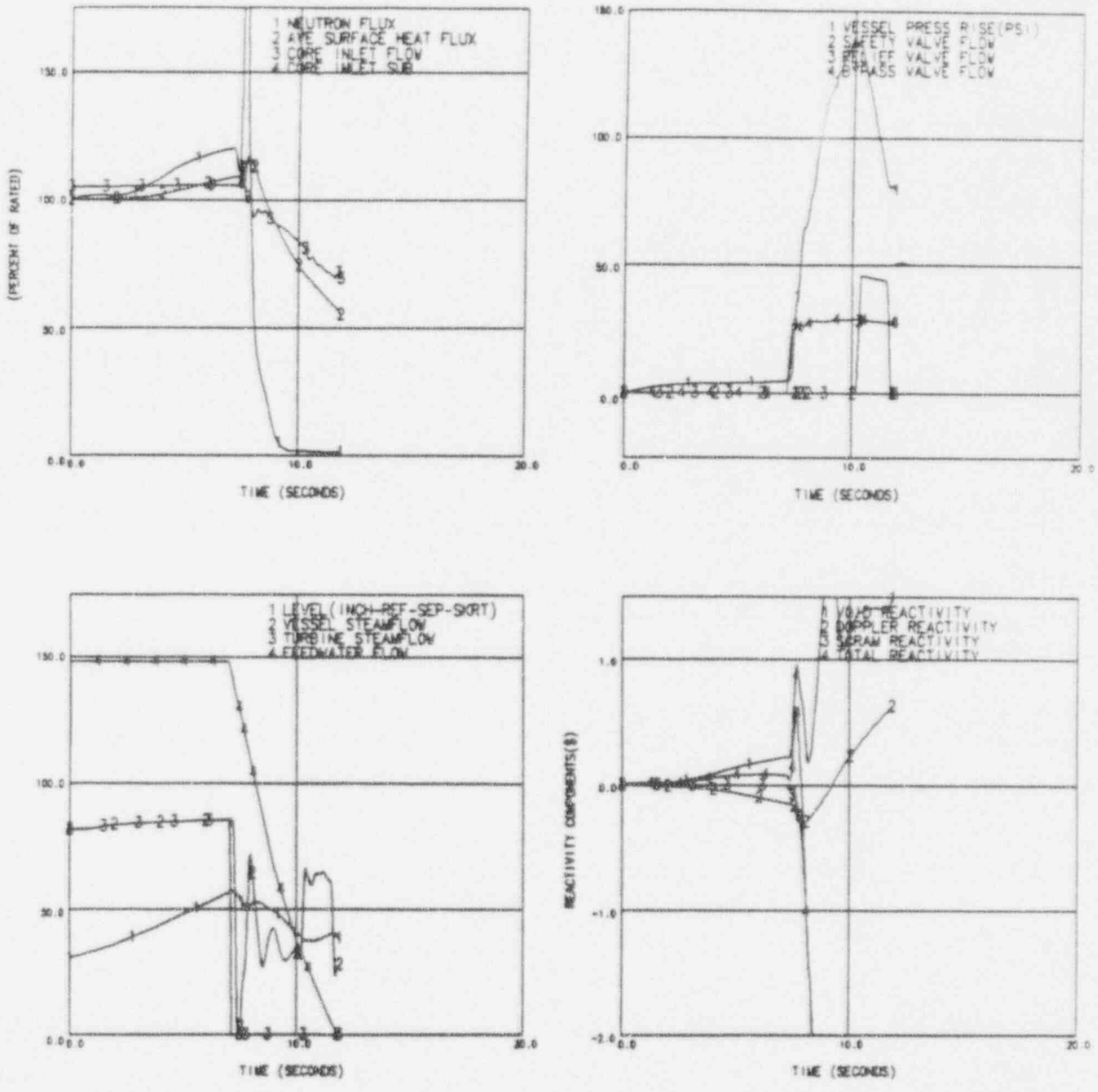


Figure 5. Plant Response to Feedwater Controller Failure (ICF/FWTR to 250°F)

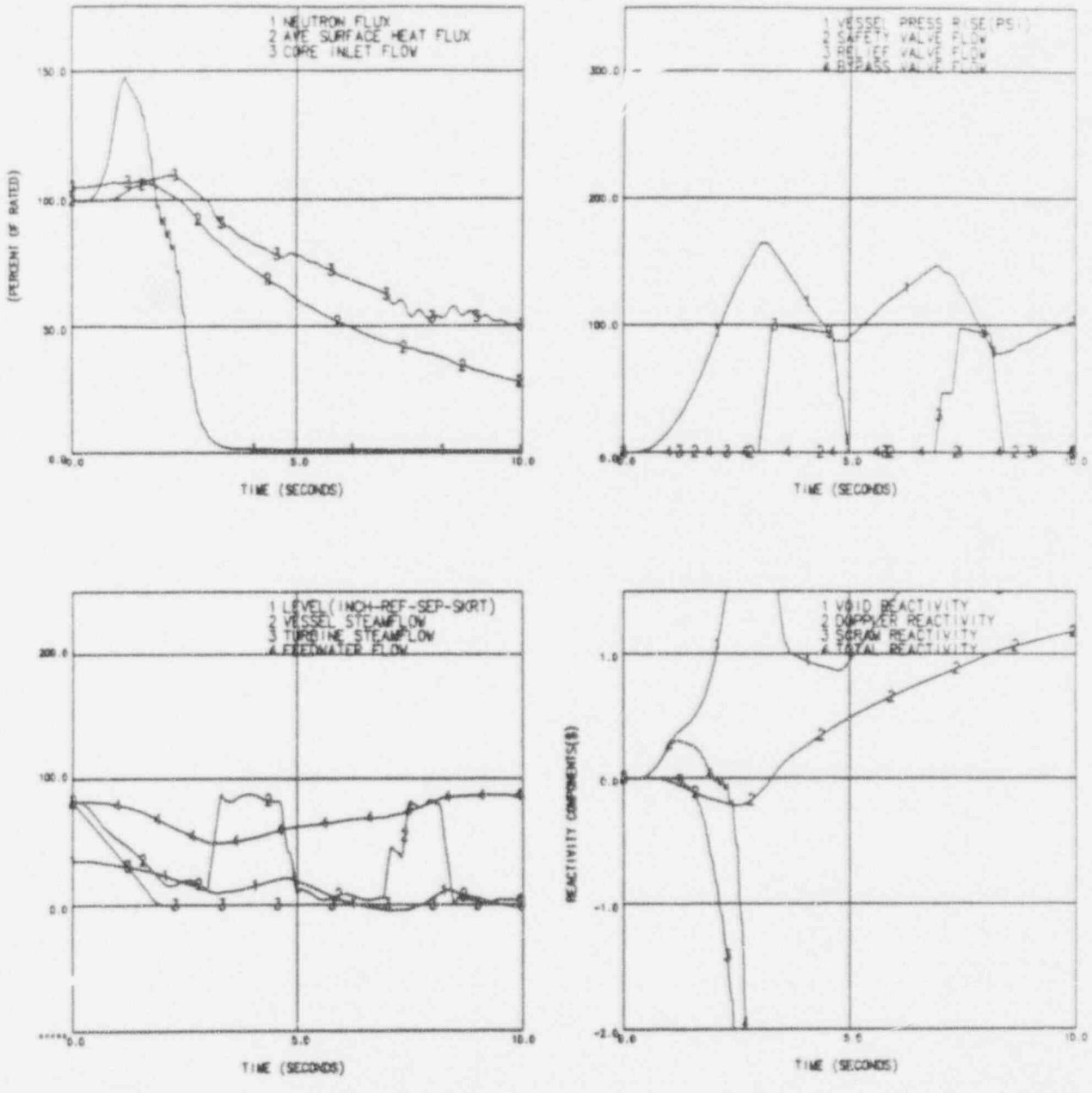


Figure 6. Plant Response to Pressure Regulator Failure Downscale (ICF/FWTR to 250°F)

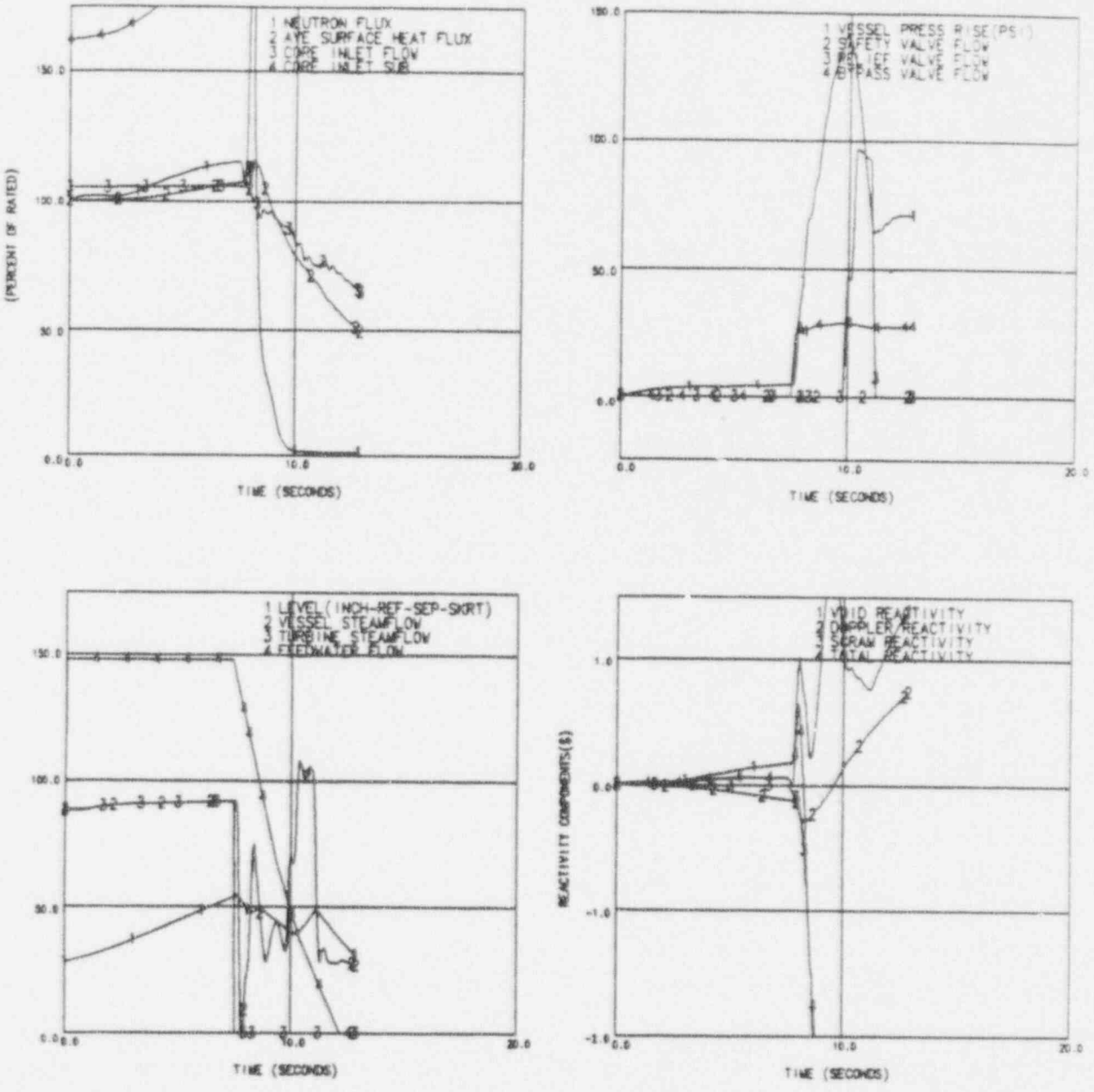


Figure 7. Plant Response to Feedwater Controller Failure (ICF/FWTR to 320°F)

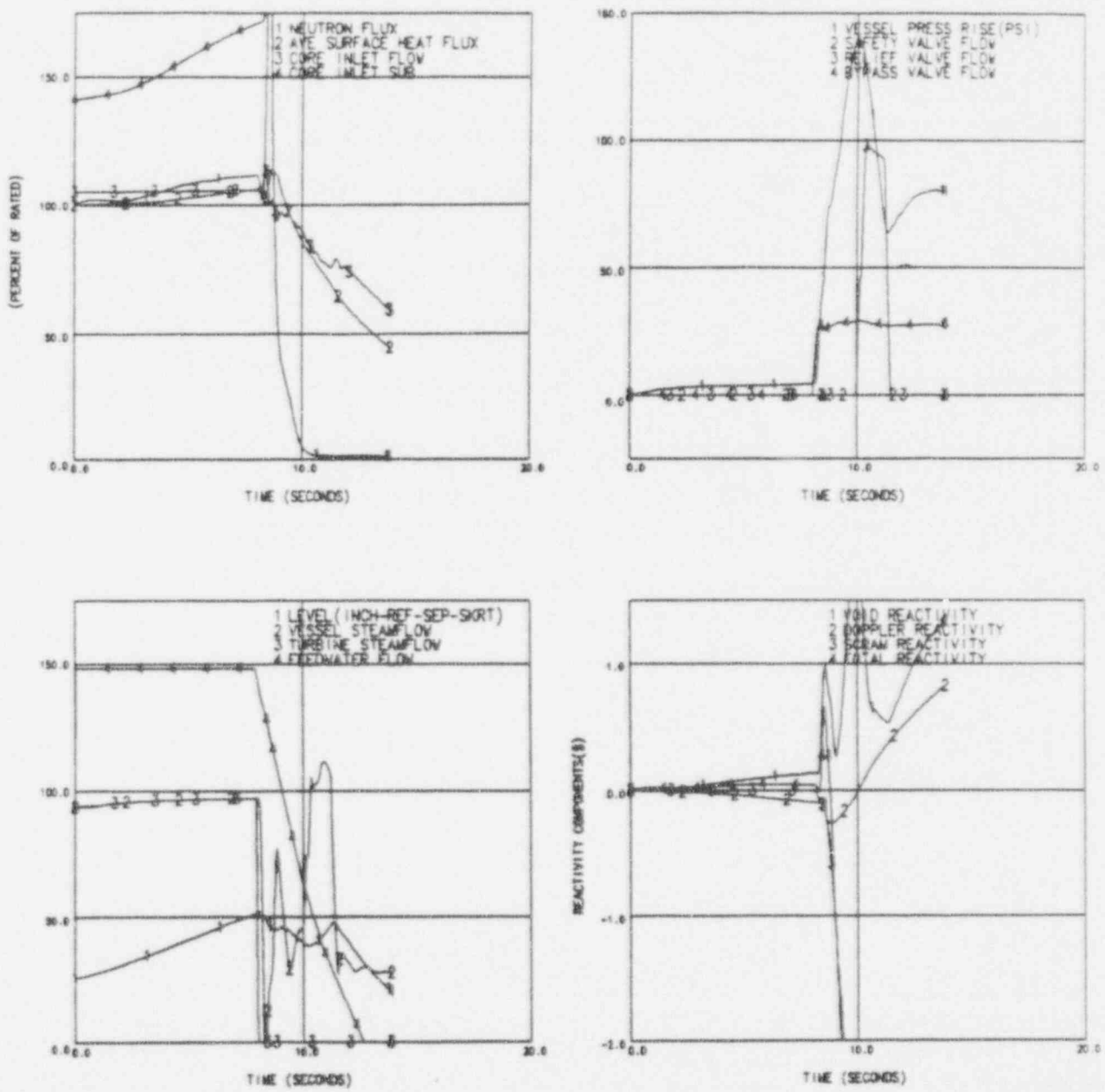


Figure 8. Plant Response to Feedwater Controller Failure (ICF/FWTR to 370°F)

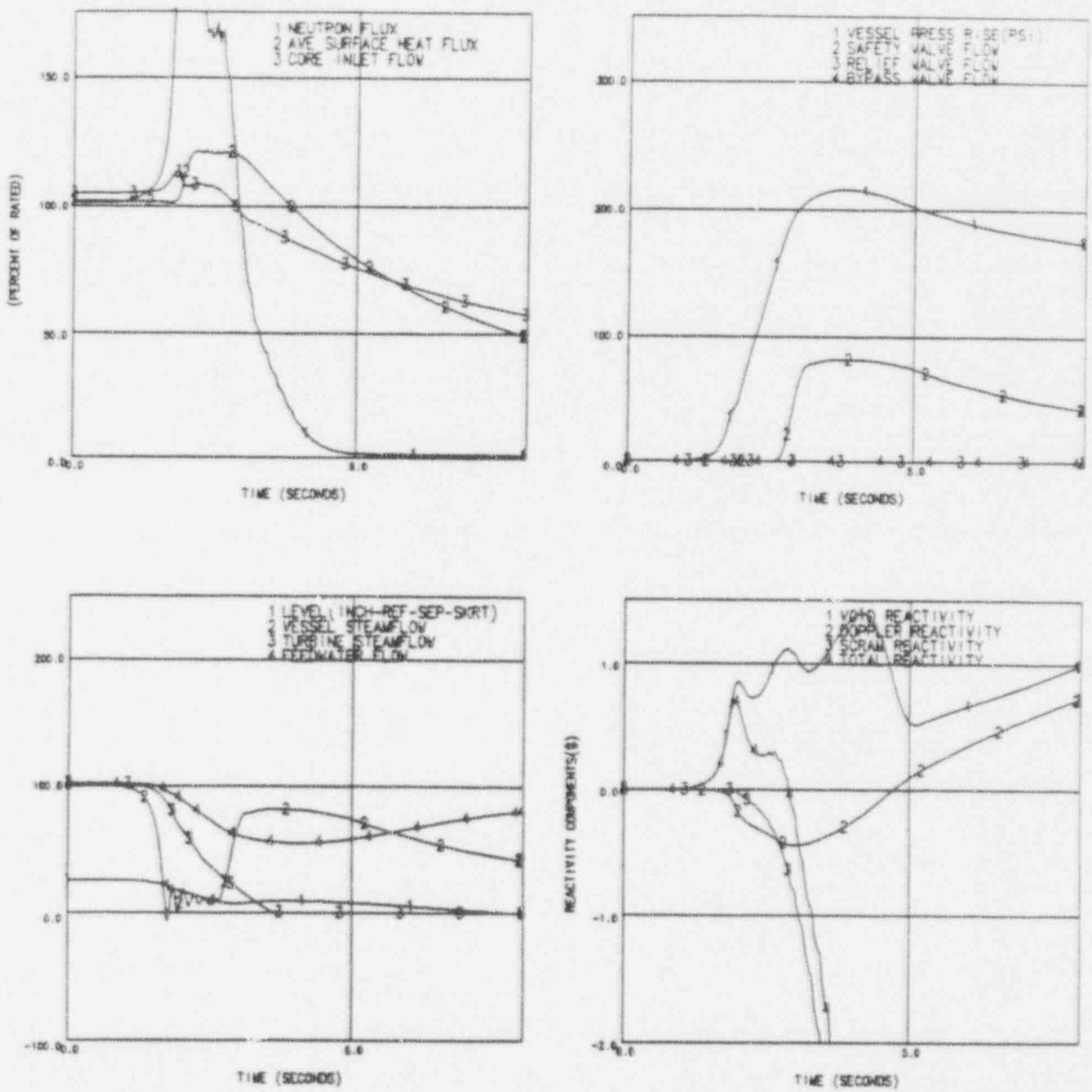


Figure 9. Plant Response to MSIV Closure, Flux Scram

Appendix A

Analysis Conditions

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

Table A-1

	Analysis Value (FW Temp.)			
Parameter	420°F	250°F	320°F	370°F
Thermal power, MWt	3579	3579	3579	3579
Dome pressure, psig	1028	1008	1015	1019
Steam flow, Mlb/hr	15.70	12.58	13.58	14.42
Turbine pressure, psig	976	974	975	975
Core flow, Mlb/hr	109.2	109.2	109.2	109.2
Reactor pressure, psia	1056	1056	1056	1056
Inlet enthalpy, Btu/lb	528.8	512.4	518.2	523.1
Non-fuel power fraction	0.038	0.038	0.038	0.038
No. of dual mode Safety/Relief Valves	17*	17*	17*	17*
Relief mode lowest setpoint, psig	1143*	1143*	1143*	1143*
Safety mode lowest setpoint, psig	1177	1177	1177	1177

*There are a total of 19 valves; the 2 lowest setpoint safety/relief valves are assumed to be out-of-service in the transient analyses.

Appendix B

Basis for Analysis of Loss-of-feedwater Heating Event

The loss-of-feedwater heating event was analyzed using the BWR Simulator Code (Reference B-1). The use of this code is permitted in GESTAR II (Reference B-2). The transient plots, neutron flux and heat flux values normally reported in Section 9 are not an output of the BWR Simulator code; therefore, these items are not included in this document.

The transient analysis inputs normally reported in Section 6 of the licensing submittal are internally calculated in the BWR Simulator Code and in ODYN.

References

B-1 *Steady-State Nuclear Methods*, NEDE-30130-P-A and NEDO-30130-A, April 1985.

B-2 *General Electric Standard Application for Reactor Fuel*, NEDE-24011-P-A-9, September 1988.

Appendix C

Analyzed Operating Domain

The core-wide abnormal operational occurrence (AOO) analysis results reported in Section 9 are the most limiting values over the entire allowable operating range. This range covers the following operating options:

1. Standard 100% power/flow map;

2. End-of-cycle power coastdown;

3. MEOD with 100% power flow range from 75% to 105% of rated; and

4. Partial feedwater heating to 320°F during the cycle with final feedwater temperature reduction to 250°F after *All Rods Out* at end of cycle.

Limiting events and conditions analyzed are based on Reference C-1 and the USAR analytical results. The Reload 3/Cycle 4 analyses were performed assuming all four turbine control valves in a full arc mode of operation. This is conservative for partial arc configuration.

The single-loop operation (SLO) analysis was reverified for the standard power/flow map with normal feedwater temperature.

References

C-1 *General Electric Standard Application for Reactor Fuel,* NEDE-24011-P-A-10-US, April 1991.

Appendix D

Transient Analyses

The turbine trip without bypass (TTNBP) analysis AOO is a pressure increase event normally checked on a cycle-by-cycle basis to determine if this AOO could potentially establish the cycle MCPR operating limit.

The Perry turbine control valves will be operated in the full arc mode throughout Cycle 4. The load rejection without bypass (LRNBP) is always more limiting in this mode of operation; therefore, the TTNBP will not be limiting for Cycle 4 and was not analyzed.

The load rejection without bypass (LRNBP) AOO was run for the standard case only since it has been shown to be more limiting than the feedwater temperature reduction cases in previous reload analyses.

Appendix E

Rotated Bundle Analysis

The results for each fuel type are listed in Table E-1.

Table E-1

	ΔCPR
BP8SRB176 (BP8x8R)	N/A
GE8B-P8SQB301-7GZ-120M-150-T (BS301E) (GE8x8EB)	0.13
GE8B-P8SQB301-5GZ-120M-150-T (BS301F) (GE8x8EB)	0.12
GE8B-P8SQB320-9GZ-120M-150-T (GE8x8EB)	0.14
GE8B-P8SQB322-7GZ-120M-150-T (GE8x8EB)	0.14
GE10-P8SXB306-11GZ3-120M-150-T (GE8x8NB-3)	0.16
GE10-P8SXB306-10GZ2-120M-150-T (GE8x8NB-3)	0.09

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