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SUPPLEMENTAL RELOAD LICENSING SUBMITTAL FOR BRUNSWICK STEAM ELECTRIC PLANT UNIT 2 RELOAD 3

GENERAL ELECTRIC

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SUPPLEMENTAL RELOAD LICENSING SUBMITTAL
FOR
BRUNSWICK STEAM ELECTRIC PLANT
UNIT 2 RELOAD 3

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GENERAL ELECTRIC

IMPORTANT NOTICE REGARDING

CONTENTS OF THIS REPORT

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1. PLANT-UNIQUE ITEMS (1.0)*

Transient Analysis Initial Conditions: Appendix B

New Bundle Loading Error Analyses Procedures: Appendix D

Linear Heat Generation Rate for Bundle Loading Error: Appendix E

Densification Power Spiking: Appendix F

2. RELOAD FUEL BUNDLES (1.0, 2.0, 3.3.1 and 4.0)*

	Fuel Type	Number	Number Drilled
Irradiated	Initial Core Type 1	64	64
	Initial Core Type 3	88	88
	Replacement 7DB230	4	4
	Reload 1 8DB274L	100	100
	Reload 1 8DB274H	40	40
	Reload 2 8DRB265H	64	64
	Reload 2 8DRB283	68	68
New	Reload 3 P8DRB265H	132	132
Total		560	560

3. REFERENCE CORE LOADING PATTERN (3.3.1)

Nominal previous cycle exposure: 12,755 MWd/t

Assumed reload cycle exposure: 14,943 MWd/t

Core loading pattern: Figure 1

*( ) refers to areas of discussion in NEDE-24011-P-A, "Generic Reload Fuel Application," August 1979.

4. CALCULATED CORE EFFECTIVE MULTIPLICATION AND CONTROL SYSTEM WORTH - NO VOIDS, 20°C (3.3.2.1.1 and 3.3.2.1.2)

BOC k_{eff}

Uncontrolled	1.097
Fully Controlled	0.939
Strongest Control Rod Out	0.976

R, Maximum Increase in Cold Core Reactivity with Exposure Into Cycle, Δk 0.007

5. STANDBY LIQUID CONTROL SYSTEM SHUTDOWN CAPABILITY (3.3.2.1.3)

ppm	Shutdown Margin (Δk) (20°C, Xenon Free)
600	0.0465

6. RELOAD-UNIQUE TRANSIENT ANALYSIS INPUTS (3.3.2.1.5 and 5.2)

	EOC4	EOC4 -1000 MWd/t	EOC4 -2000 MWd/t
Void Coefficient N/A* (c/% Rg)	-8.80/-10.99	-9.18/-11.47	-9.11/-11.38
Void Fraction (%)	41.76	41.76	41.76
Doppler Coefficient N/A (c/°F)	-0.227/-0.215	-0.221/-0.210	-0.215/-0.204
Average Fuel Temperature (°F)	1356	1356	1356
Scram Worth N/A ($)	-38.88/-31.10	-37.59/-30.07	-37.25/-29.80
Scram Reactivity versus Time	Figure 2a	Figure 2b	Figure 2C

*N = Nuclear Input Data
A = Used in Transient Analysis

7. RELOAD-UNIQUE GETAB TRANSIENT ANALYSIS INITIAL CONDITION PARAMETERS (5.2)

	7x7			8x8			8x8R			P8x8R		
	EOC4	EOC4 -1000 MWd/t	EOC4 -2000 MWd/t	EOC4	EOC4 -1000 MWd/t	EOC4 -2000 MWd/t	EOC4	EOC4 -1000 MWd/t	EOC4 -2000 MWd/t	EOC4	EOC4 -1000 MWd/t	EOC4 -2000 MWd/t
Peaking Factor (local, radial, axial)	1.24, 1.21, 1.40	1.24, 1.28, 1.40	1.24, 1.29, 1.40	1.22, 1.30, 1.40	1.22, 1.37, 1.40	1.22, 1.44, 1.40	1.20, 1.43, 1.40	1.20, 1.52, 1.40	1.20, 1.57, 1.40	1.20, 1.41, 1.40	1.20, 1.50, 1.40	1.20, 1.58, 1.40
R factor	1.100	1.100	1.100	1.098	1.098	1.098	1.051	1.051	1.051	1.051	1.051	1.051
Bundle Power (MWt)	5.172	5.453	5.515	5.529	5.859	6.133	6.087	6.455	6.647	6.009	6.372	6.722
Bundle Flow (10^3 lb/hr)	127.3	125.6	125.2	116.8	114.6	112.8	116.9	114.7	113.4	117.6	115.4	113.4
Initial MCPR	1.28	1.21	1.19	1.35	1.27	1.20	1.34	1.26	1.21	1.36	1.28	1.20

8. SELECTED MARGIN IMPROVEMENT OPTIONS (5.2.2)

Thermal Power Monitor

Exposure Dependent Limits

9. CORE-WIDE TRANSIENT ANALYSIS RESULTS (5.2.1)

Transient	Exposure	Power (%)	Flow (%)	$\dot{\omega}$ (%)	$\dot{Q}/A$ (%)	P_{s1} (psig)	P_v (psig)	ΔCPR 7x7	8x8	8x8R	P8x8R	Plant Response
Load Rejection No Bypass	EOC4	104	100	242	120	1176	1223	0.21	0.28	0.27	0.29	Figure 3a
Load Rejection No Bypass	EOC4 -1000 MWd/t	104	100	289	115	1170	1217	0.13	0.19	0.19	0.21	Figure 3b
Load Rejection No Bypass	EOC4 -2000 MWd/t	104	100	195	107	1164	1209	0.03	0.07	0.07	0.08	Figure 3c
Loss of 100°F Feedwater Heater	BOC4 EOC4	104	100	124	122	<1100	<1100	0.12	0.14	0.14	0.14	Figure 4
Feedwater Controller Failure	EOC4	104	100	117	110	1044	1091	0.05	0.06	0.06	0.06	Figure 5a
Feedwater Controller Failure	EOC4 -1000 MWd/t	104	100	119	110	1041	1088	0.05	0.06	0.06	0.07	Figure 5b
Feedwater Controller Failure	EOC4 -2000 MWd/t	104	100	118	110	1040	1087	0.05	0.06	0.06	0.07	Figure 5c

10. LOCAL ROD WITHDRAWAL ERROR (WITH LIMITING INSTRUMENT FAILURE) TRANSIENT SUMMARY (5.2.1)

Rod Block Reading	Rod Position (Feet Withdrawn)	MCPR 7x7	MCPR 8x8	MCPR 8x8R/P8x8R	MLHGR (kW/ft) 7x7	MLHGR (kW/ft) 8x8	MLHGR (kW/ft) 8x8R/P8x8R	Limiting Rod Pattern
104	3.5	0.12	0.17	0.09	16.5	15.1	16.0	Figure 6
105	4.0	0.14	0.21	0.11	17.3	16.1	17.3	Figure 6
106*	4.0	0.14	0.21	0.11	17.3	16.1	17.3	Figure 6
107	4.5	0.16	0.24	0.13	17.5	16.5	17.7	Figure 6
108	5.0	0.18	0.27	0.16	17.7	16.8	17.9	Figure 6
109	5.0	0.18	0.27	0.16	17.7	16.8	17.9	Figure 6

11. OPERATING MCPR LIMIT (5.2)

BOC4 to EOC4 -2000 MWd/t	EOC4 -2000 MWd/t to EOC4 -1000 MWd/t	EOC4 -1000 MWd/t to EOC4	
1.21	1.21	1.28	(7x7 fuel)
1.28	1.28	1.35	(8x8 fuel)
1.21	1.26	1.34	(8x8R fuel)
1.21	1.28	1.36	(P8x8R fuel)

12. OVERPRESSURIZATION ANALYSIS SUMMARY (5.3)

Transient	Power (%)	Core Flow (%)	P_{sl} (psig)	P_v (psig)	Plant Response
MSIV Closure (Flux Scram)	104	100	1238	1268	Figure 7

13. STABILITY ANALYSIS RESULTS (5.4)

Decay Ratio: Figure 8

Reactor Core Stability:

Decay Ratio, x_2/x_0 (105% Rod Line - Natural Circulation Power)	0.75

Channel Hydrodynamic Performance	Decay Ratio, x_2/x_0 Extrapolated Rod Block Line - Natural Circulation Power)
7x7/8x8/8x8R channel	0.16/0.28/0.21

*Indicates set point selected

14. LOSS-OF-COOLANT ACCIDENT RESULTS, (5.5.2)

P8DRB265H

Exposure (MWd/t)	MAPLHGR (kW/ft)	PCT (°F)	Location Oxidation Fraction
200	11.5	2138	0.028
1000	11.6	2146	0.028
5000	11.9	2174	0.030
10,000	12.1	2187	0.031
15,000	12.1	2196	0.032
20,000	11.9	2177	0.030
25,000	11.3	2101	0.024
30,000	10.7	2016	0.018

15. LOADING ERROR RESULTS (5.5.4)

Limiting Event: Rotated P8DRB265H

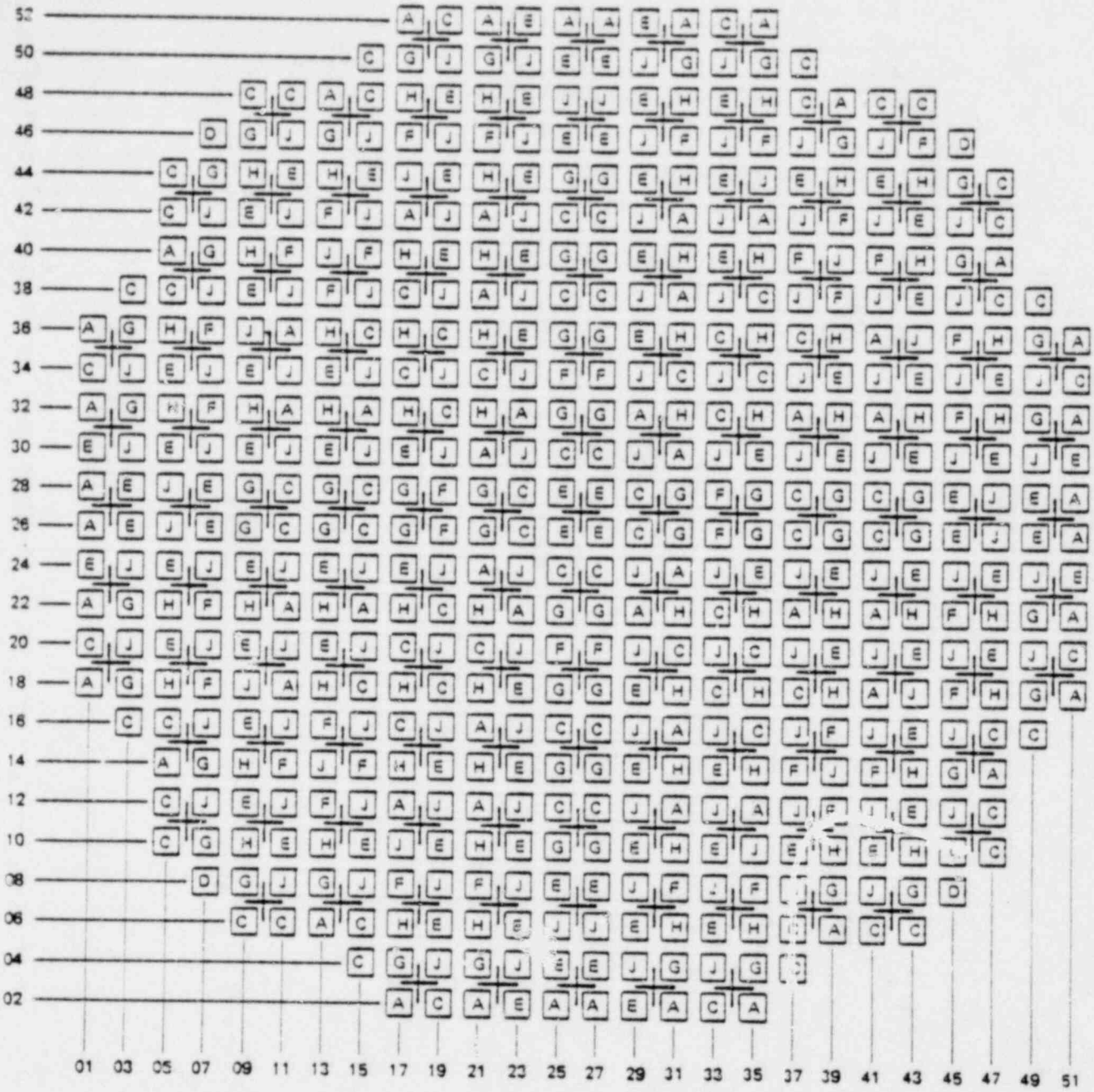
MCPR: 1.07

16. CONTROL ROD DROP ANALYSIS RESULTS (5.5.1)

Doppler Reactivity Coefficient: Figure 9

Accident Reactivity Shape Function: Figures 10 and 11

Scram Reactivity Functions: Figures 12 and 13



FUEL TYPE	
A = INITIAL CORE TYPE 1	E = RELOAD 1 8D8274L
B = NOT USED	F = RELOAD 1 8D8274H
C = INITIAL CORE TYPE 3	G = RELOAD 2 8DR8265H
D = REPLACEMENT 7D8230	H = RELOAD 2 8DR8283
	J = RELOAD 3 P8DR8265H

Figure 1. Reference Core Loading Pattern

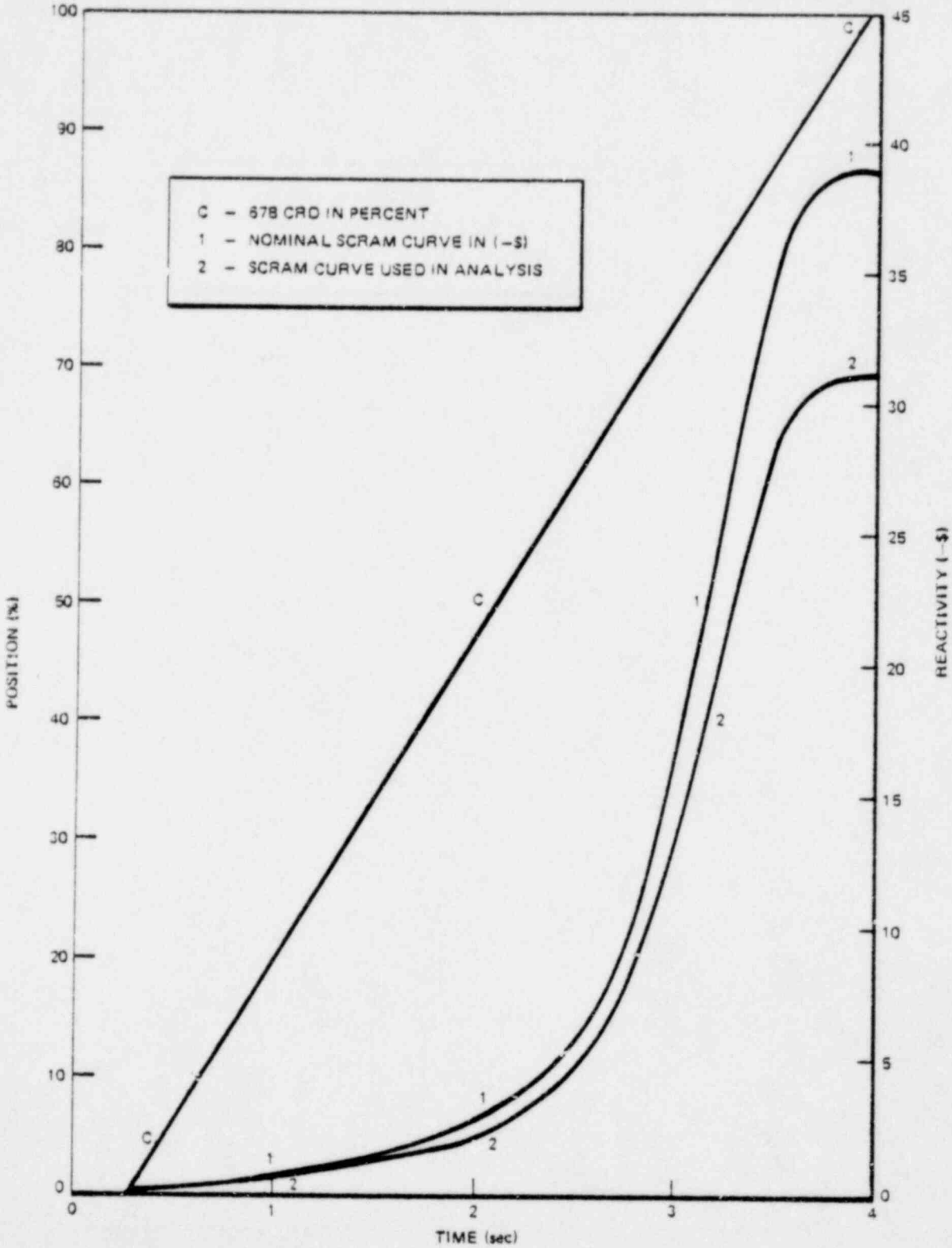


Figure 2a. Scram Reactivity and Control Rod Drive Specifications, EOC4

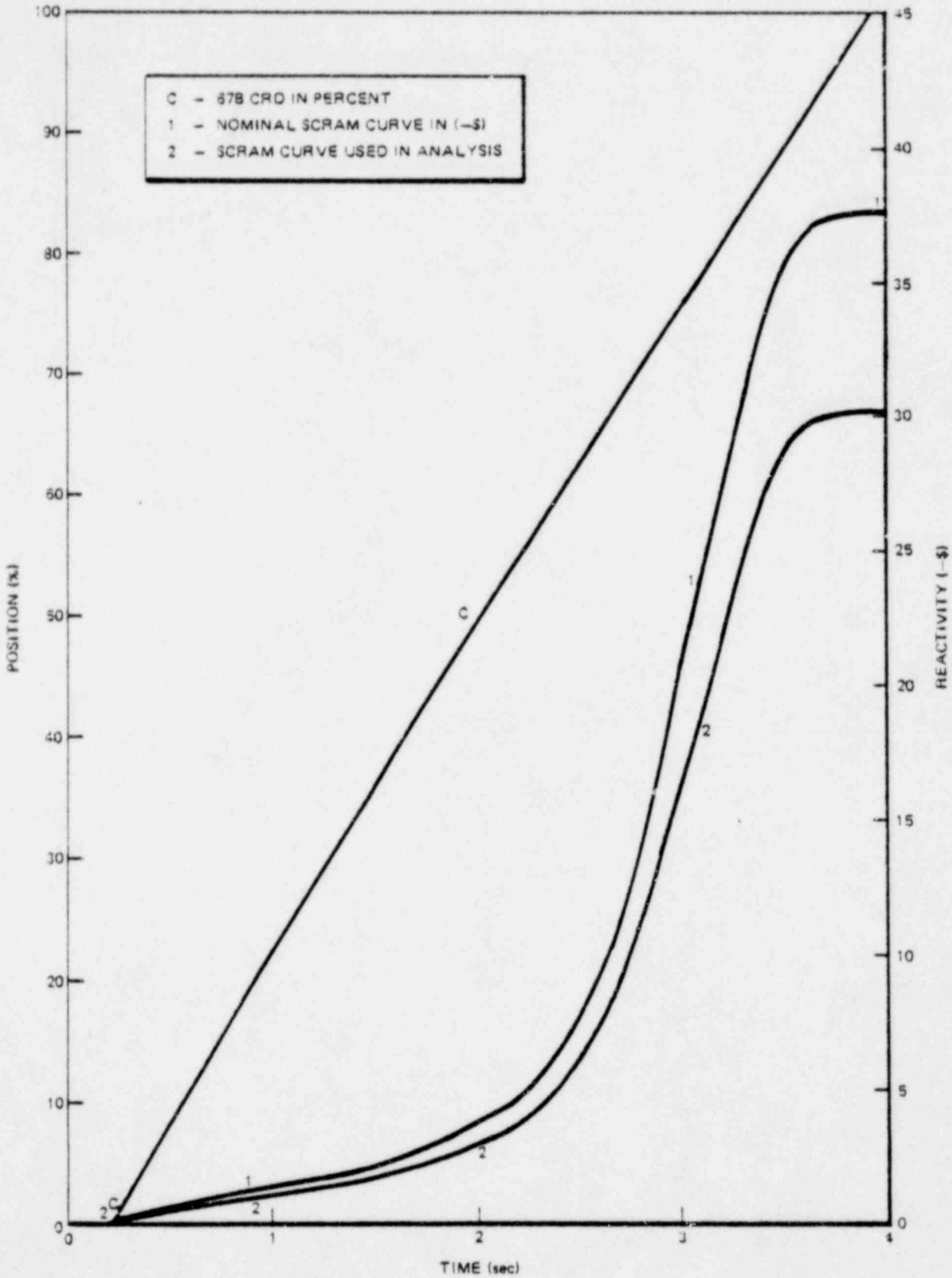


Figure 2b. Scram Reactivity and Control Rod Drive Specifications, EOC4 -1000 MWd/t

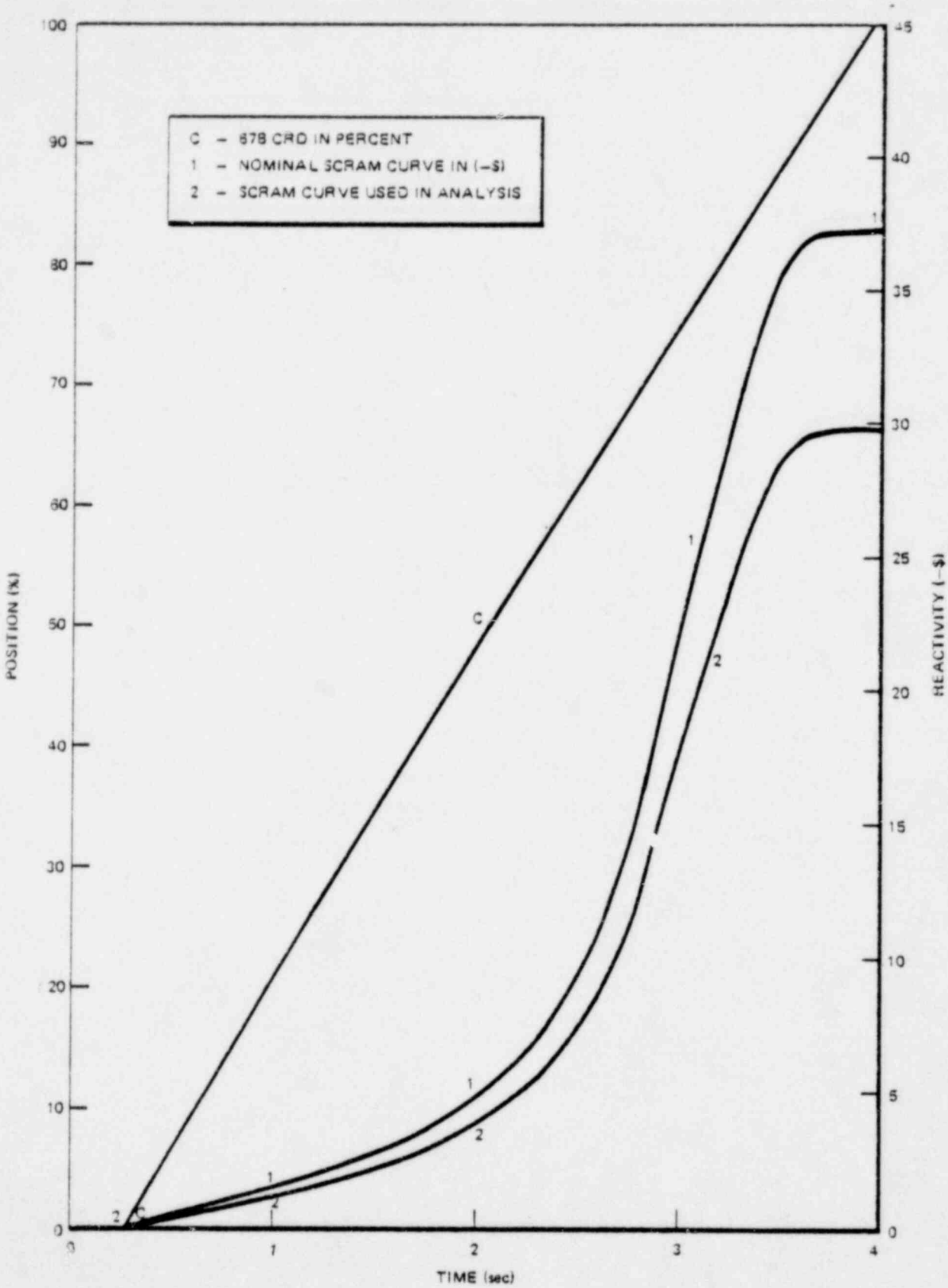


Figure 2c. Scram Reactivity and Control Rod Drive Specifications EOC4 -2000 MWd/t

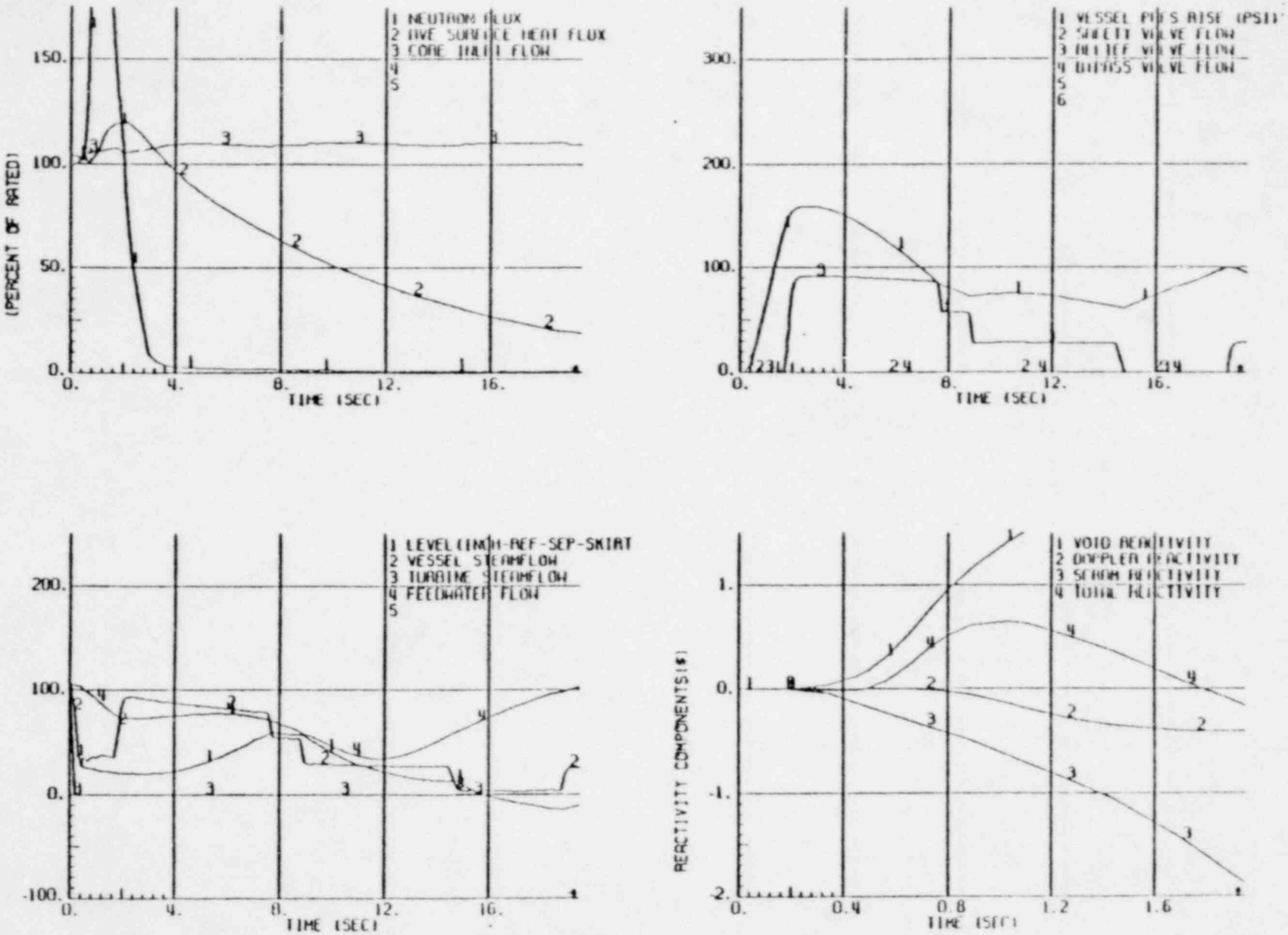


Figure 3a. Plant Response to Generator Load Rejection, Without Bypass, EOC4

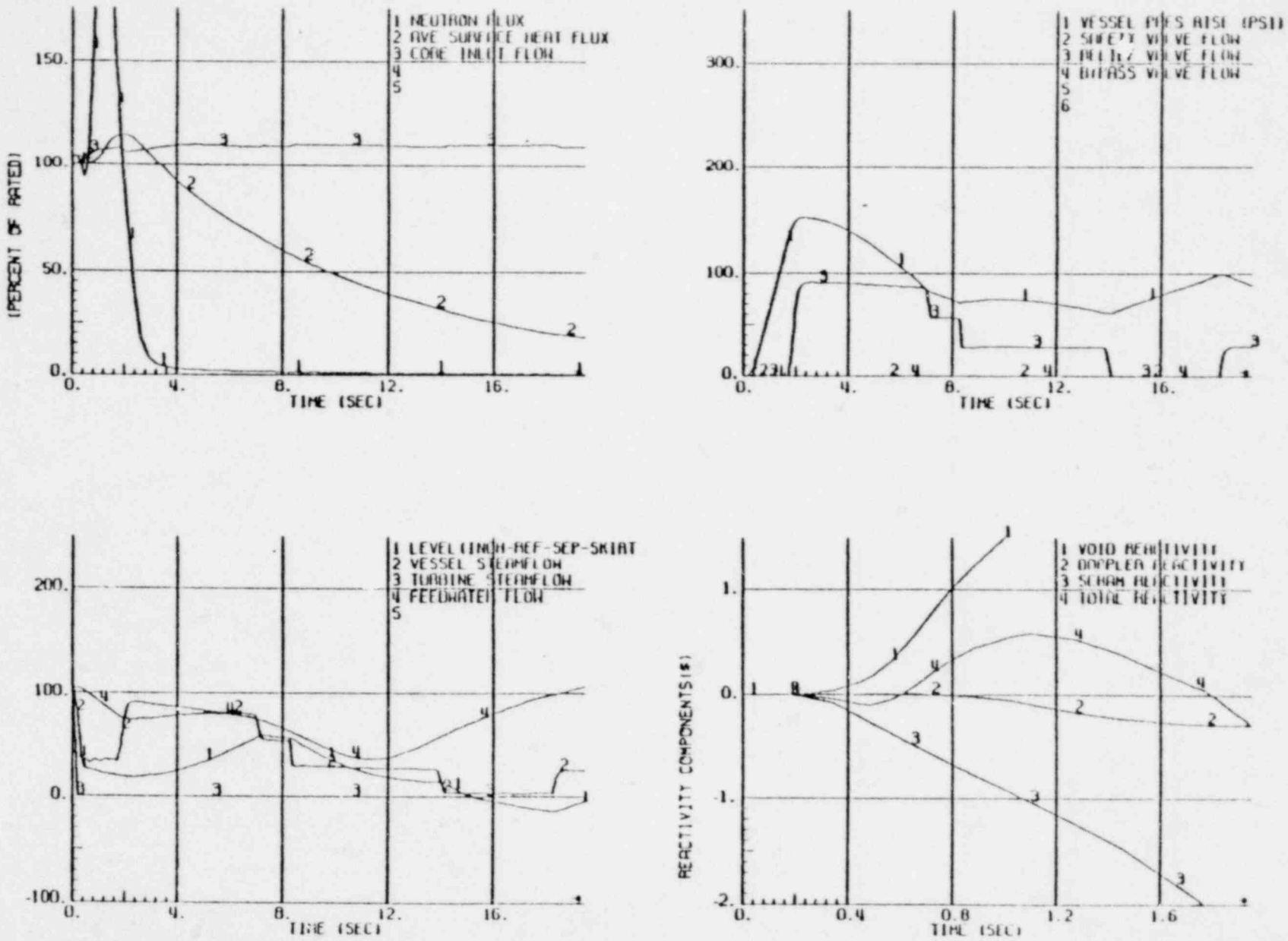


Figure 3b. Plant Response to Generator Load Rejection, Without Bypass, EOC4 -1000 MWd/t

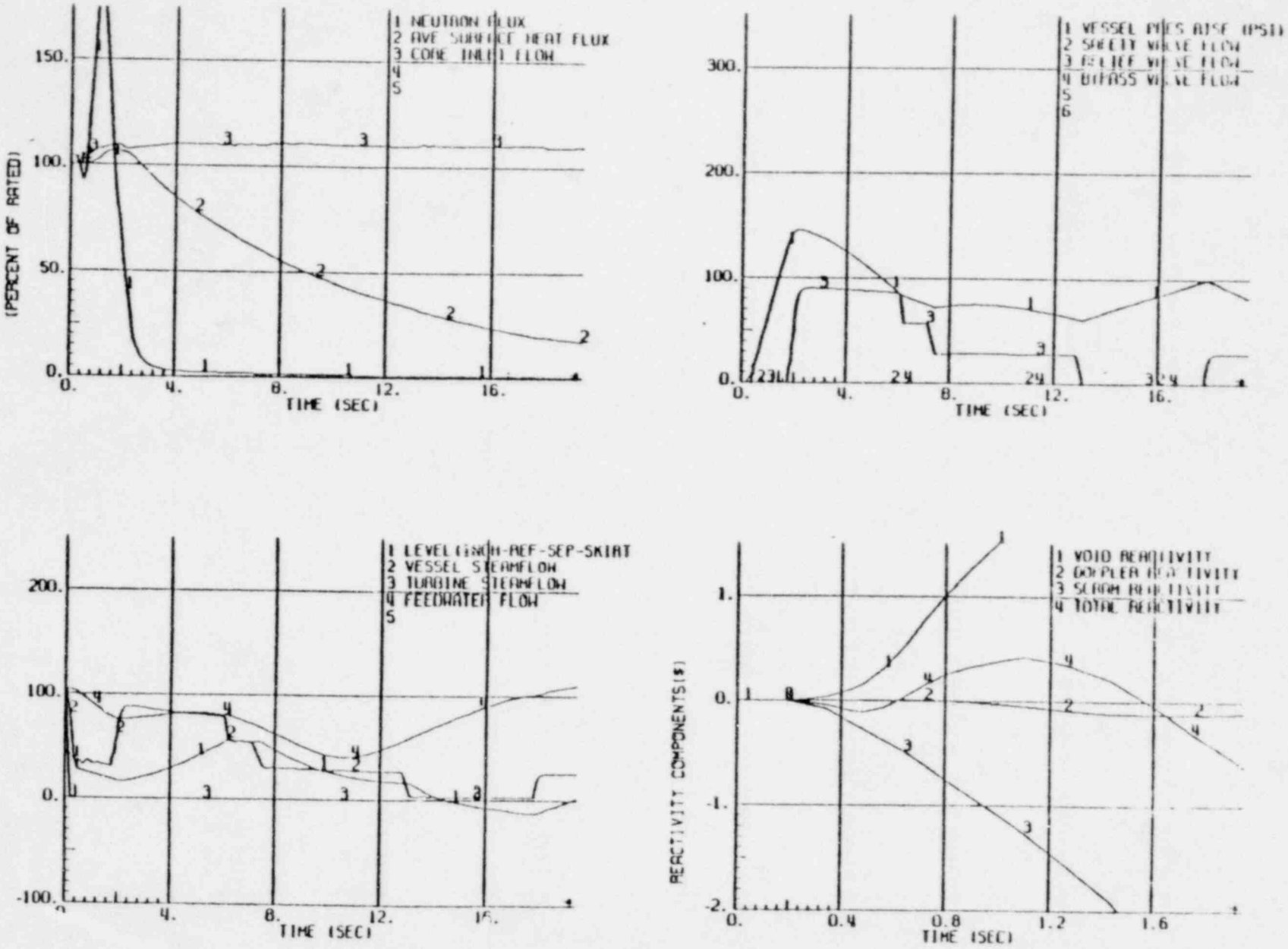


Figure 3c. Plant Response to Generator Load Rejection, Without Bypass, EOC4 -2000 MWd/t

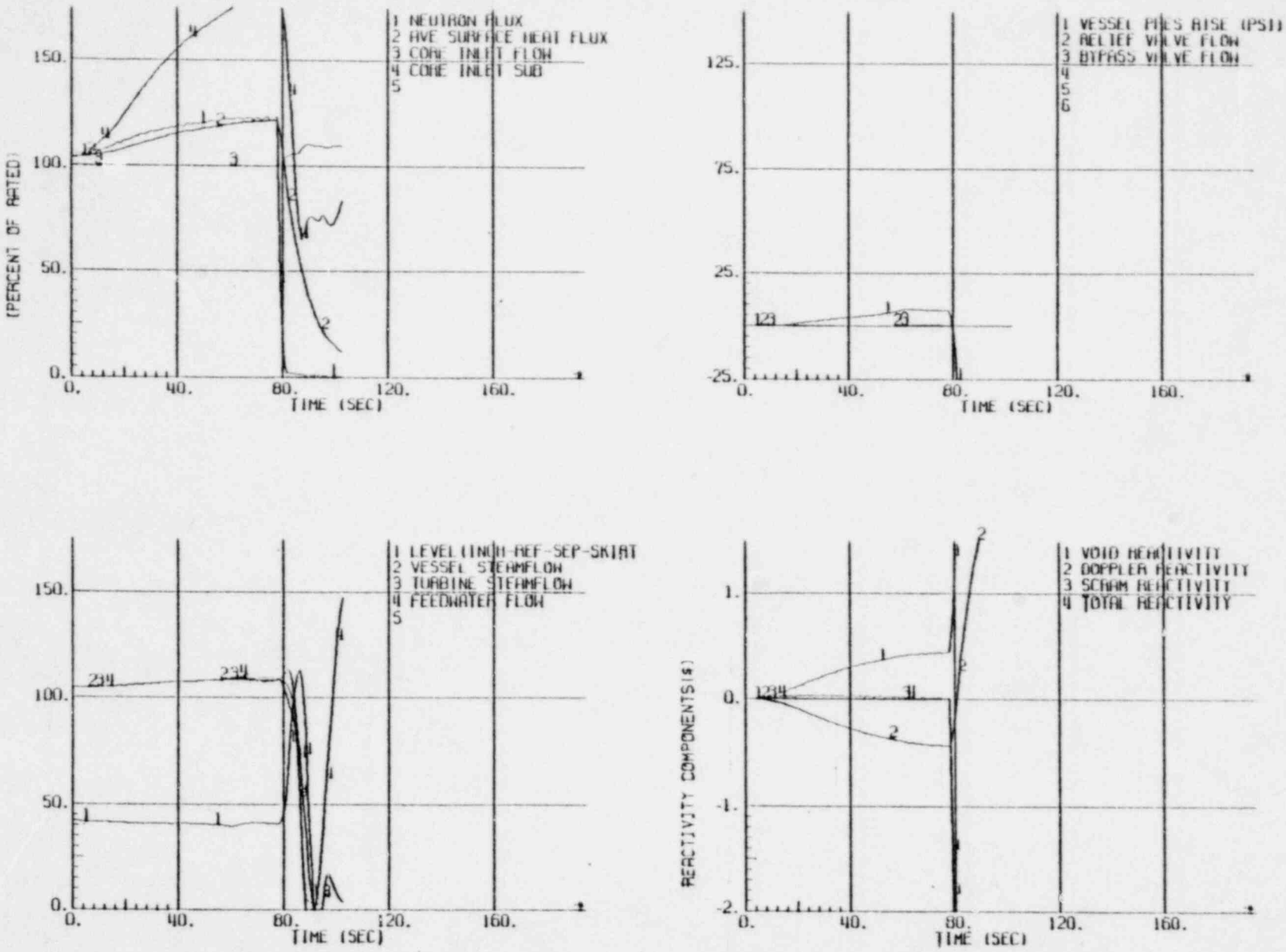


Figure 4. Plant Response to Loss of 100°F Feedwater Heating

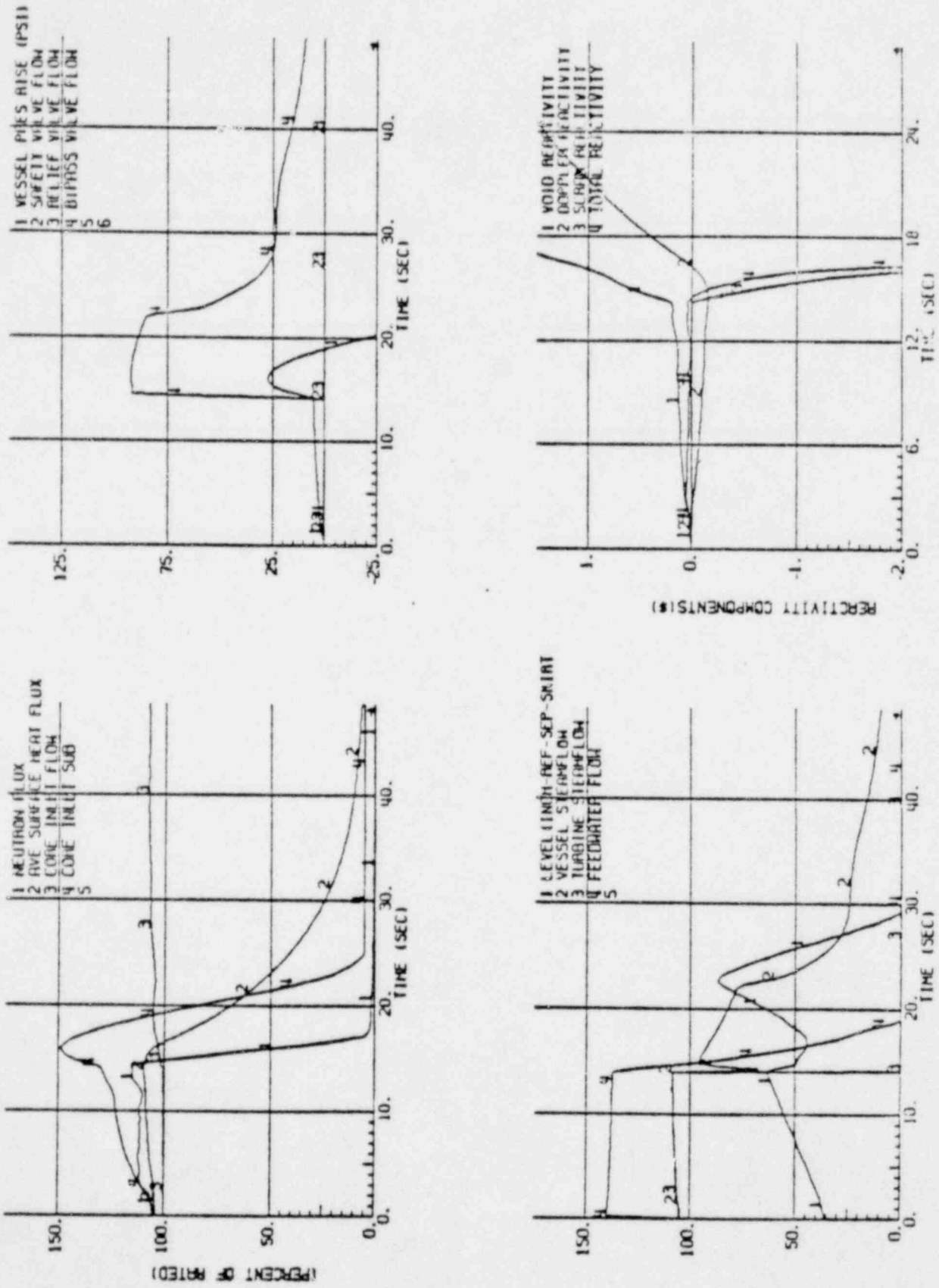


Figure 5a. Plant Response to Feedwater Controller Failure, EOC4

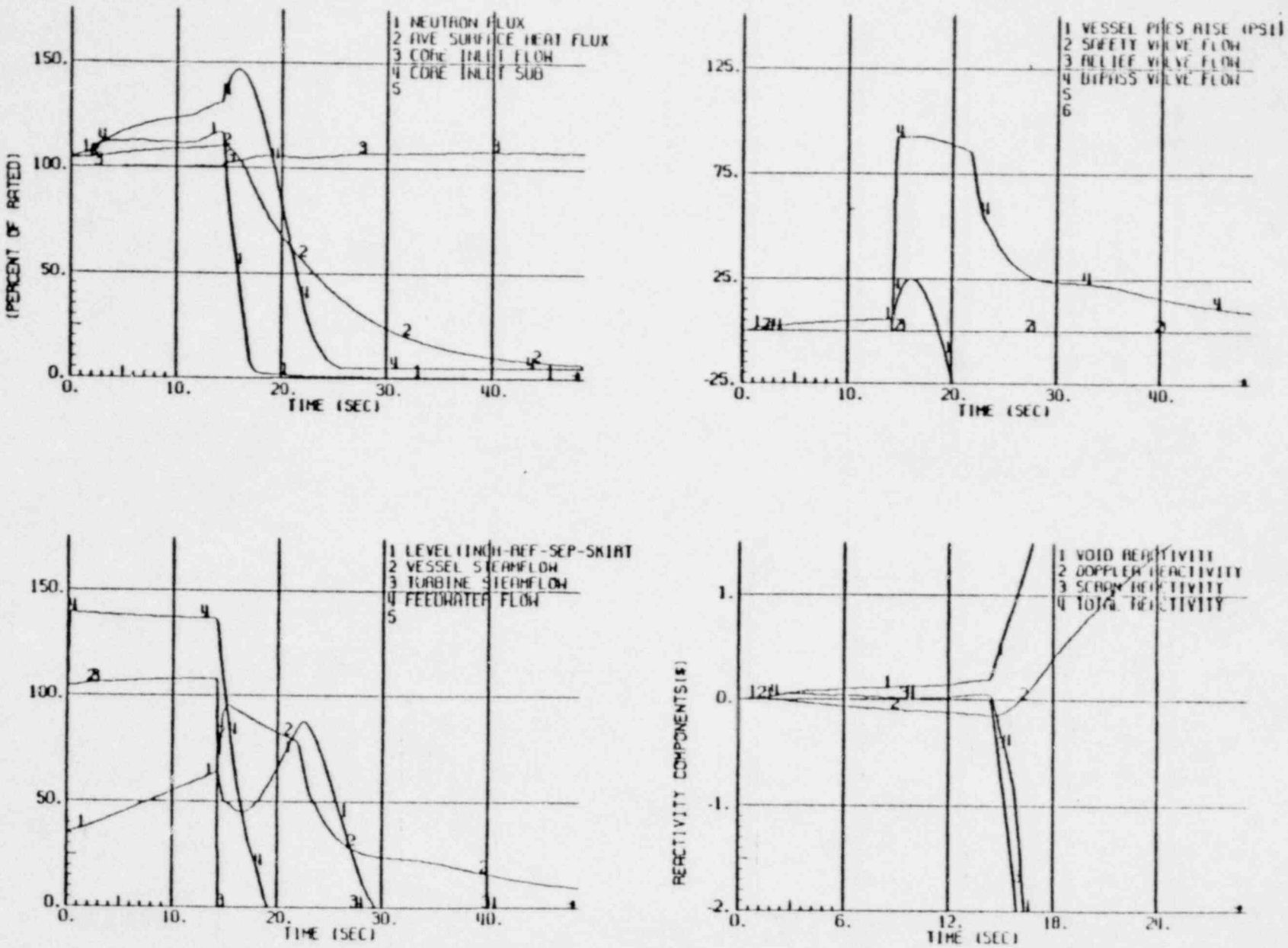


Figure 5b. Plant Response to Feedwater Controller Failure, EOC4 -1000 MWd/t

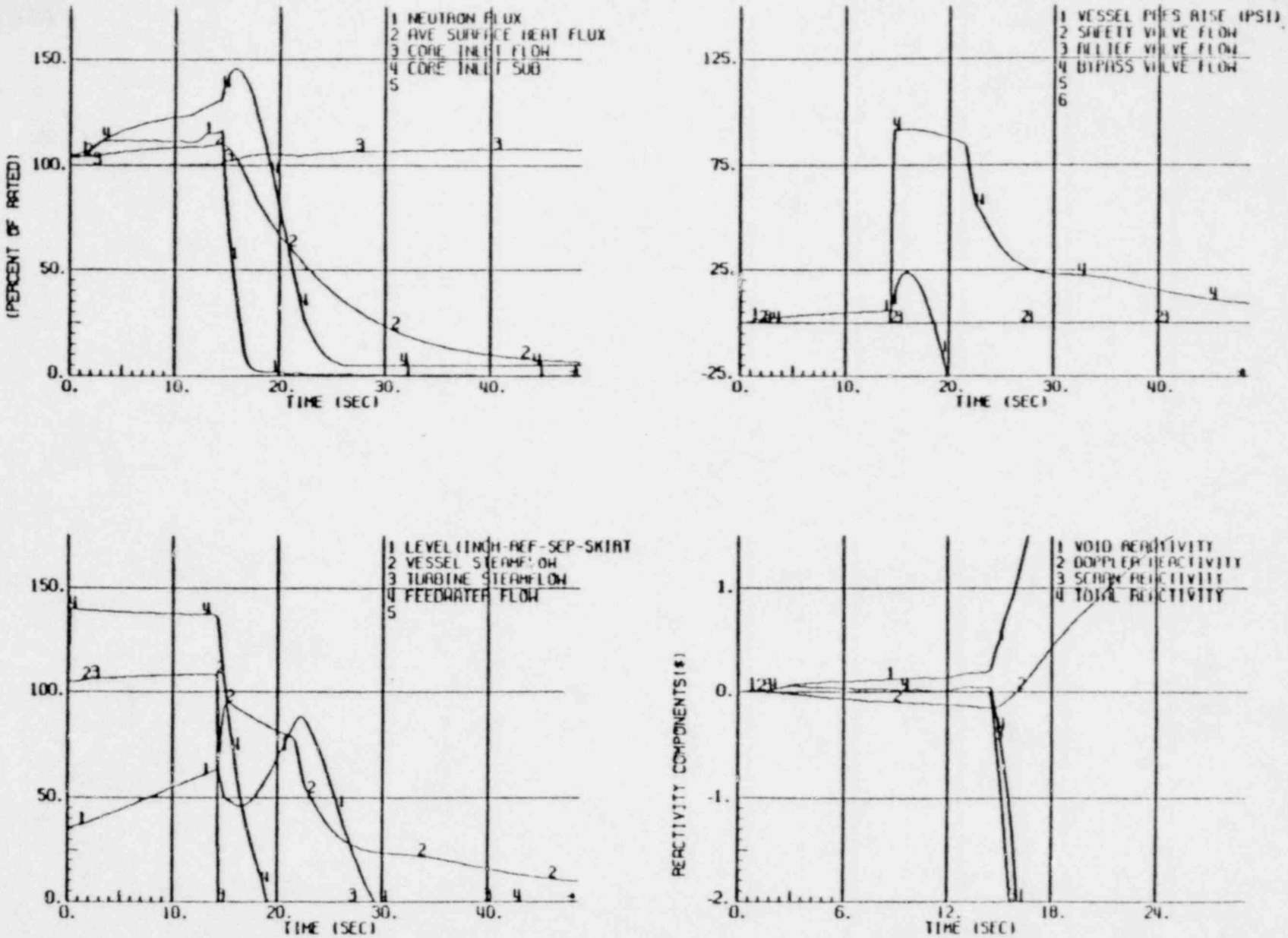


Figure 5c. Plant Response to Feedwater Controller Failure, EOC4 -2000 MWd/t

	02	06	10	14	18	22	26
51					10		12
47							
43			2		6		8
39							
35	10		6		26		0
31						36	
27	12		2		12		26

Notes:
1. Rod Pattern Is 1/4 Core Mirror Symmetric, Upper Left Quadrant Shown on Map.
2. Numbers Indicate Number of Notches Withdrawn out of 48. Blank Is a Withdrawn Rod.
3. Error Rod Is 26-35.

Figure 6. Limiting RWE Rod Pattern

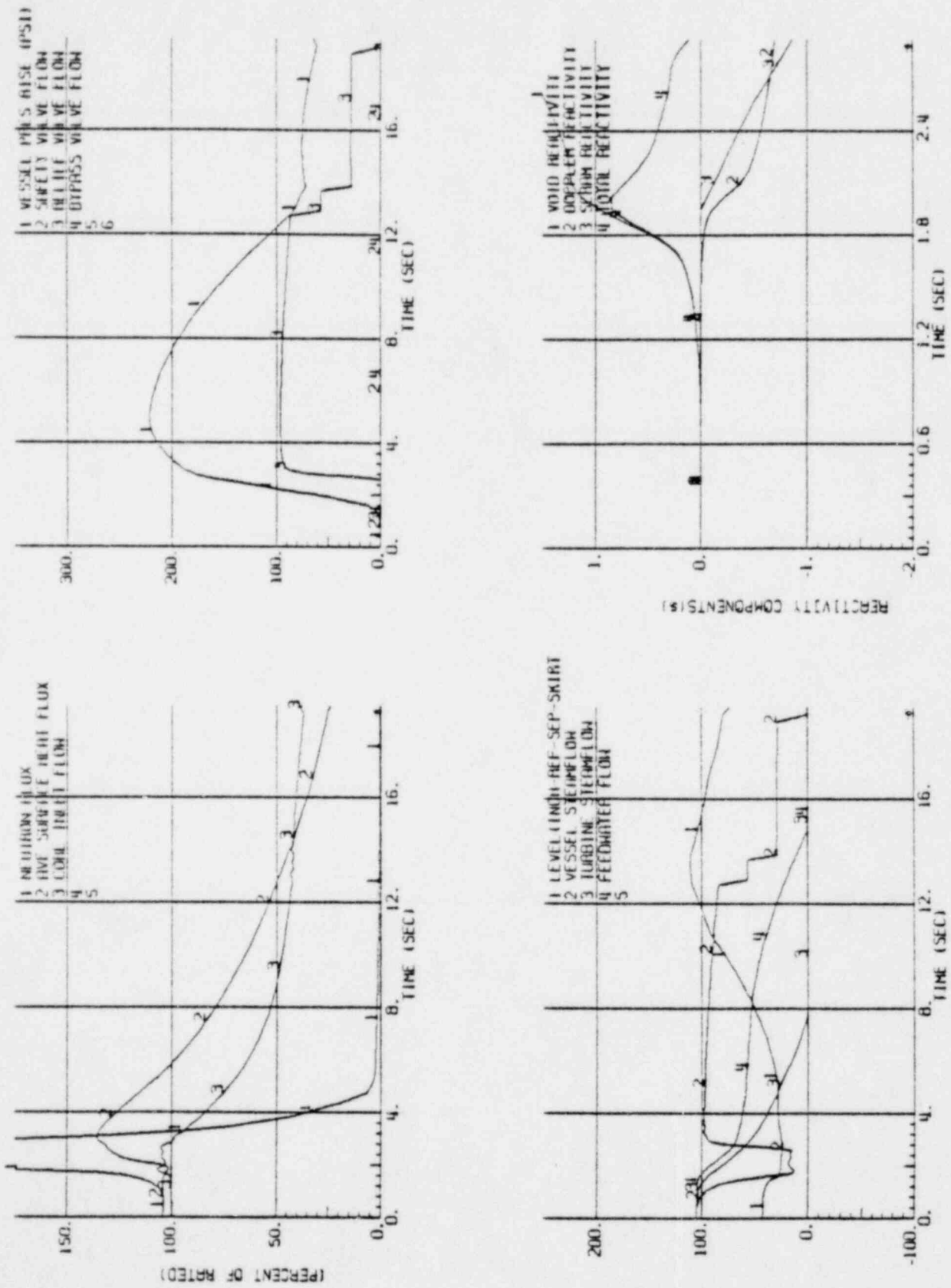


Figure 7. Plant Response to MSIV Closure

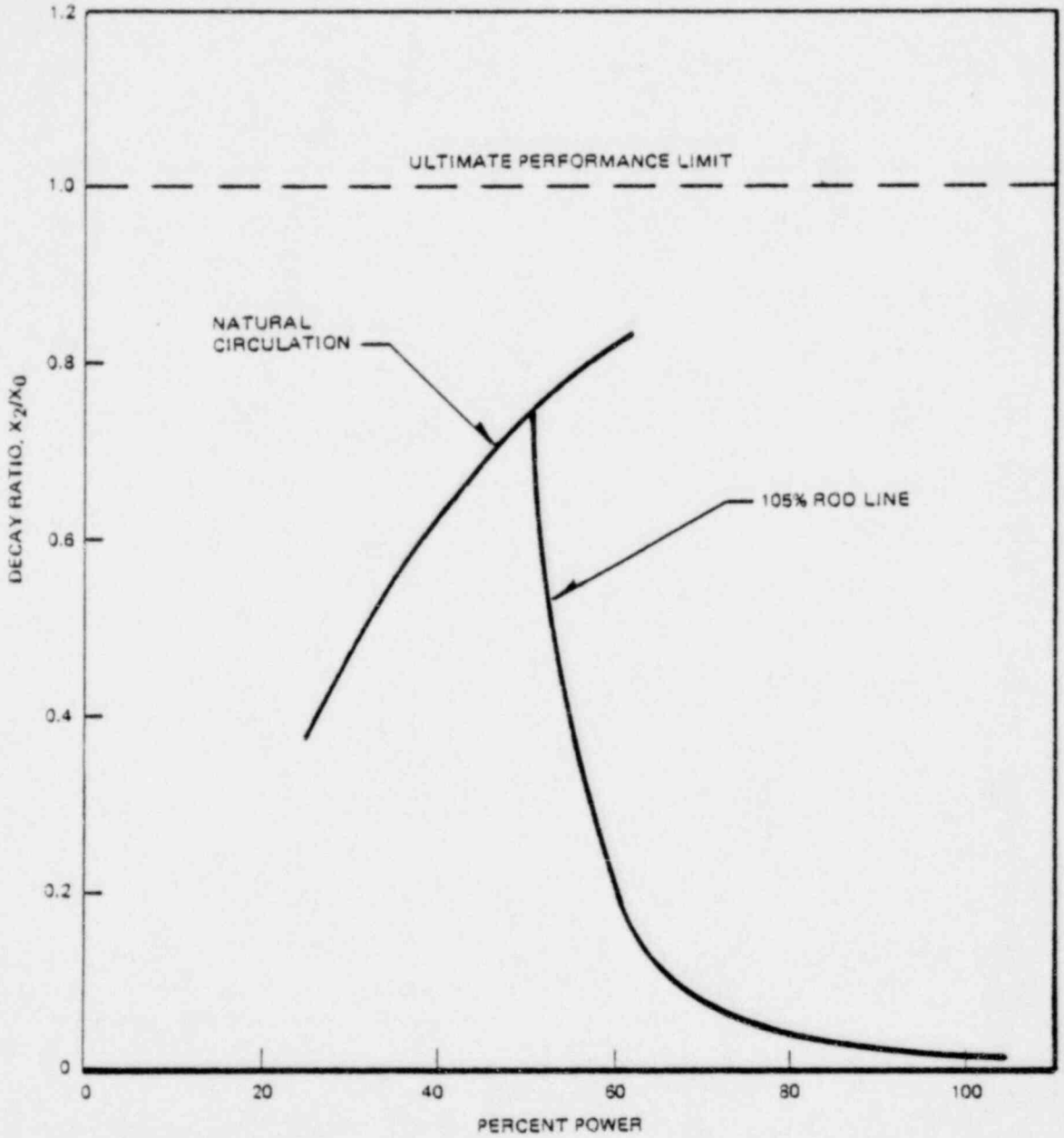


Figure 8. Decay Ratio

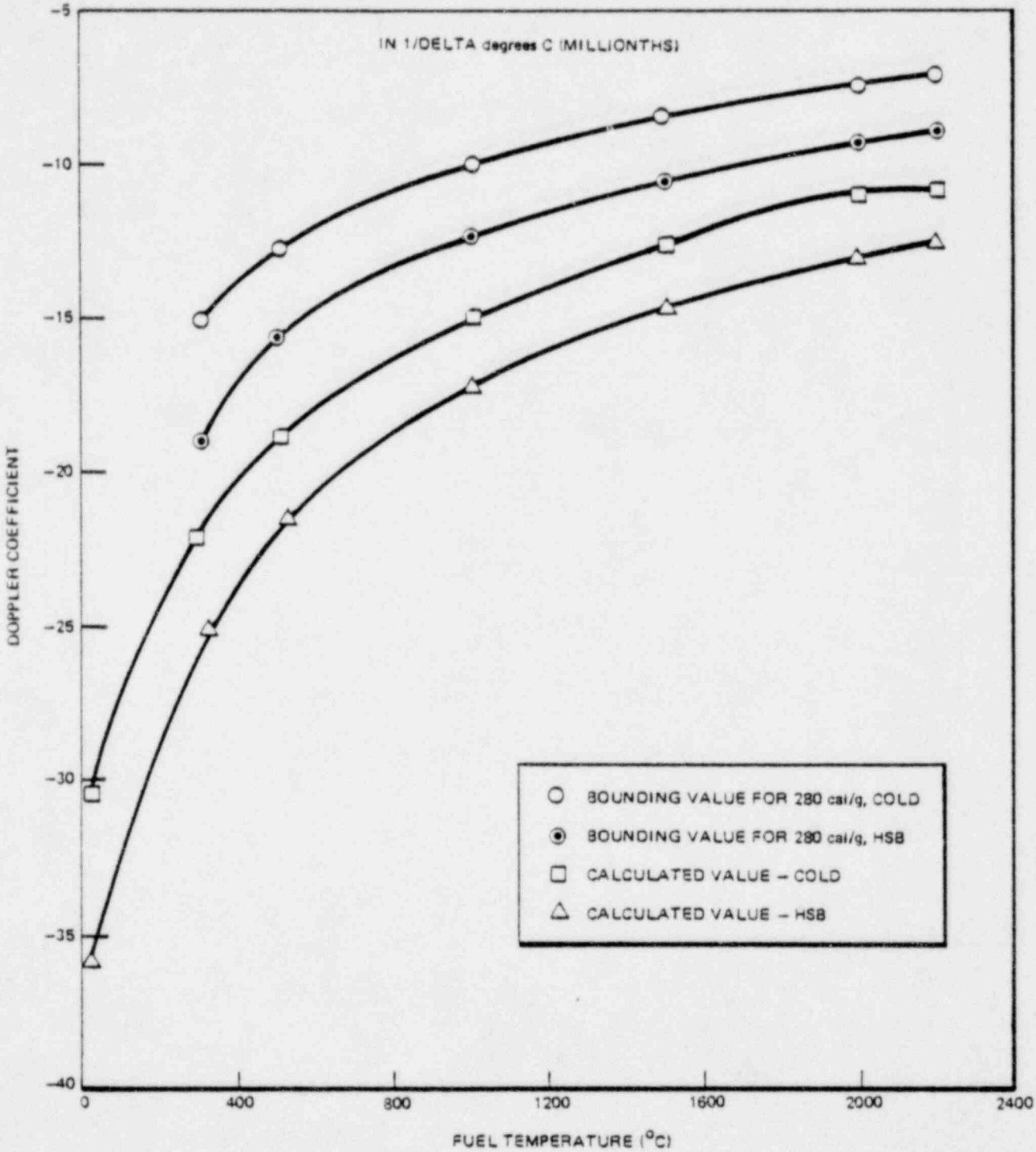


Figure 9. Doppler Reactivity Coefficient Comparison for RDA

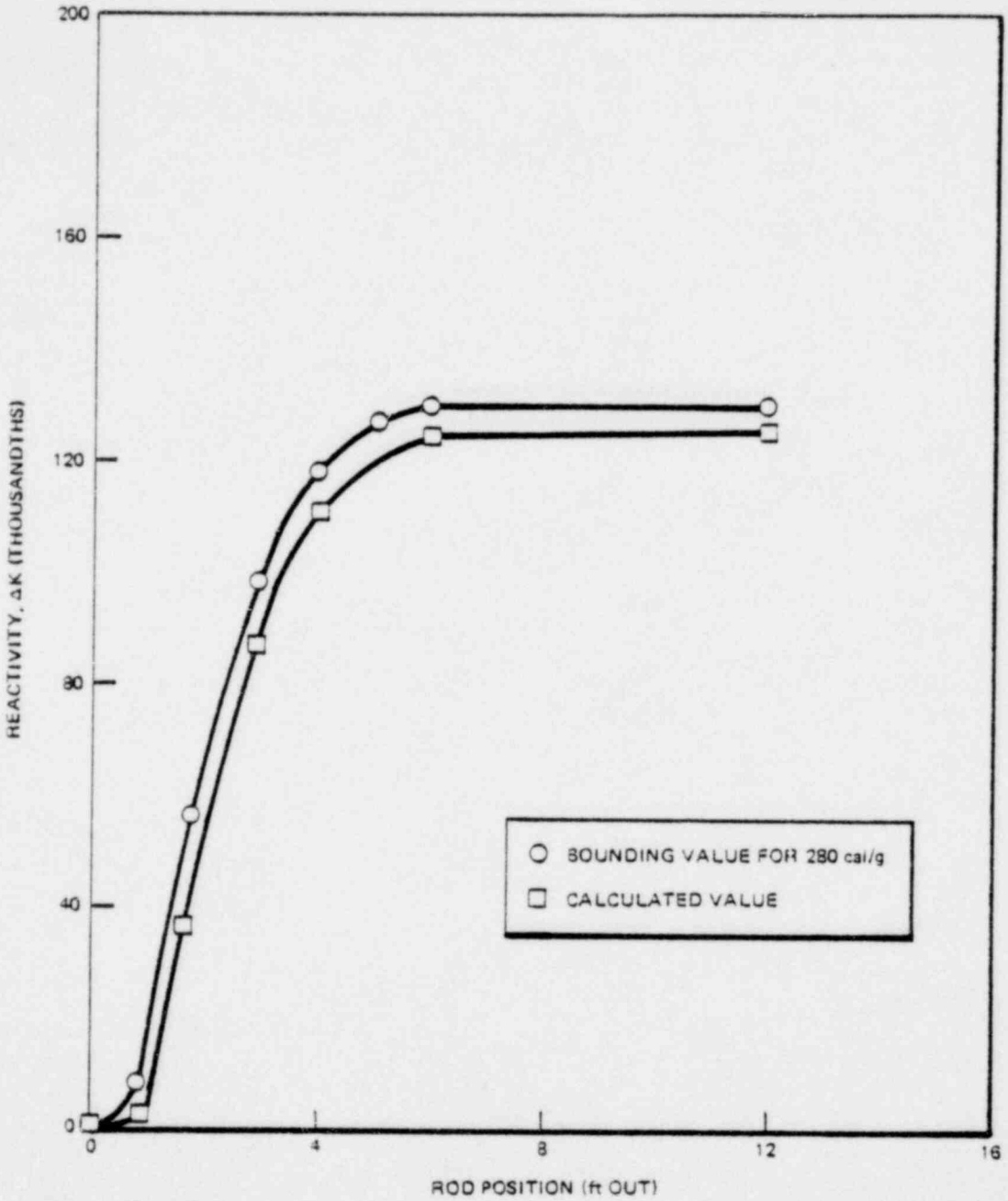


Figure 10. RDA Reactivity Shape Function at 20°C

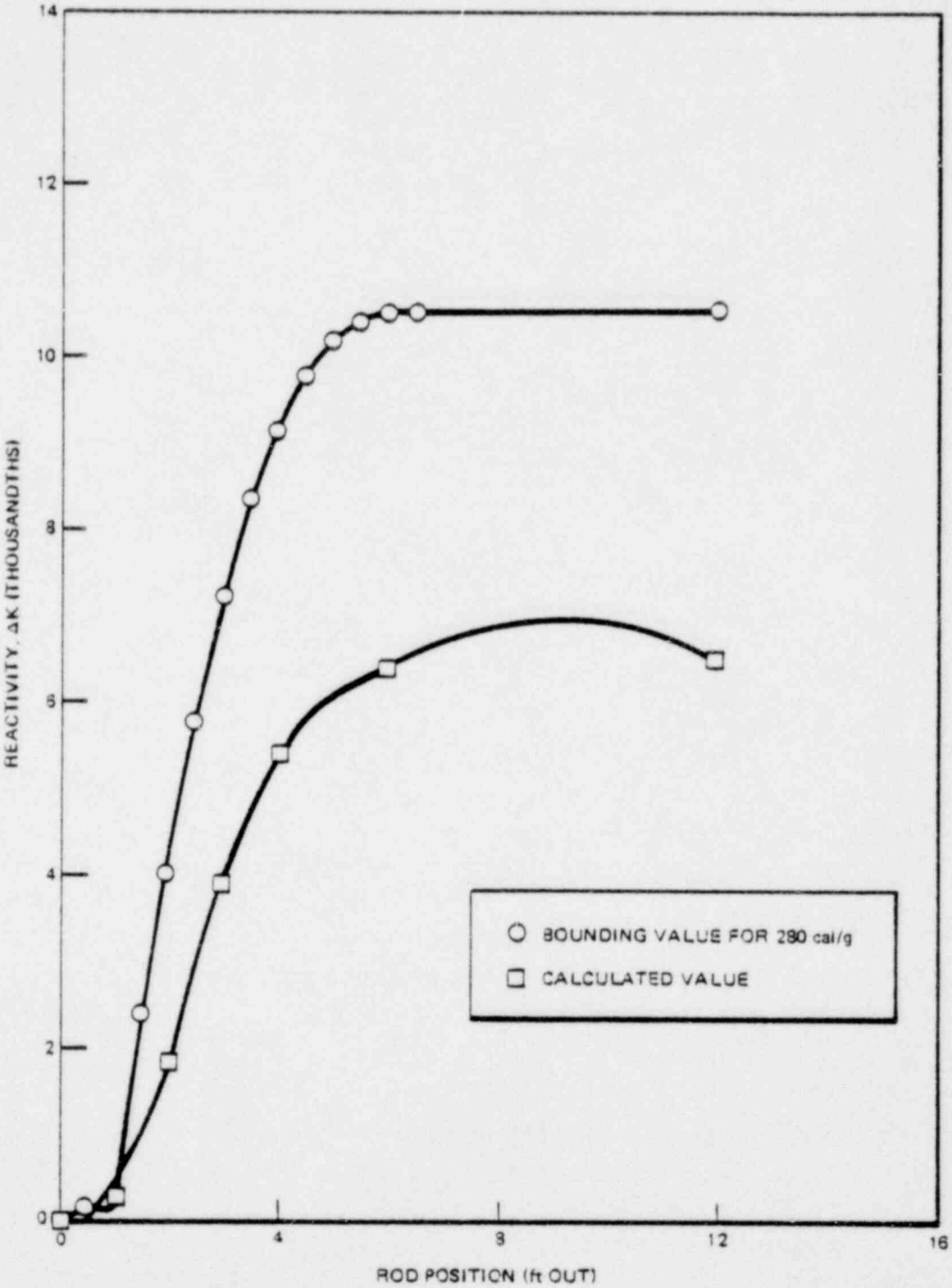


Figure 11. RDA Reactivity Shape Function at 286°C

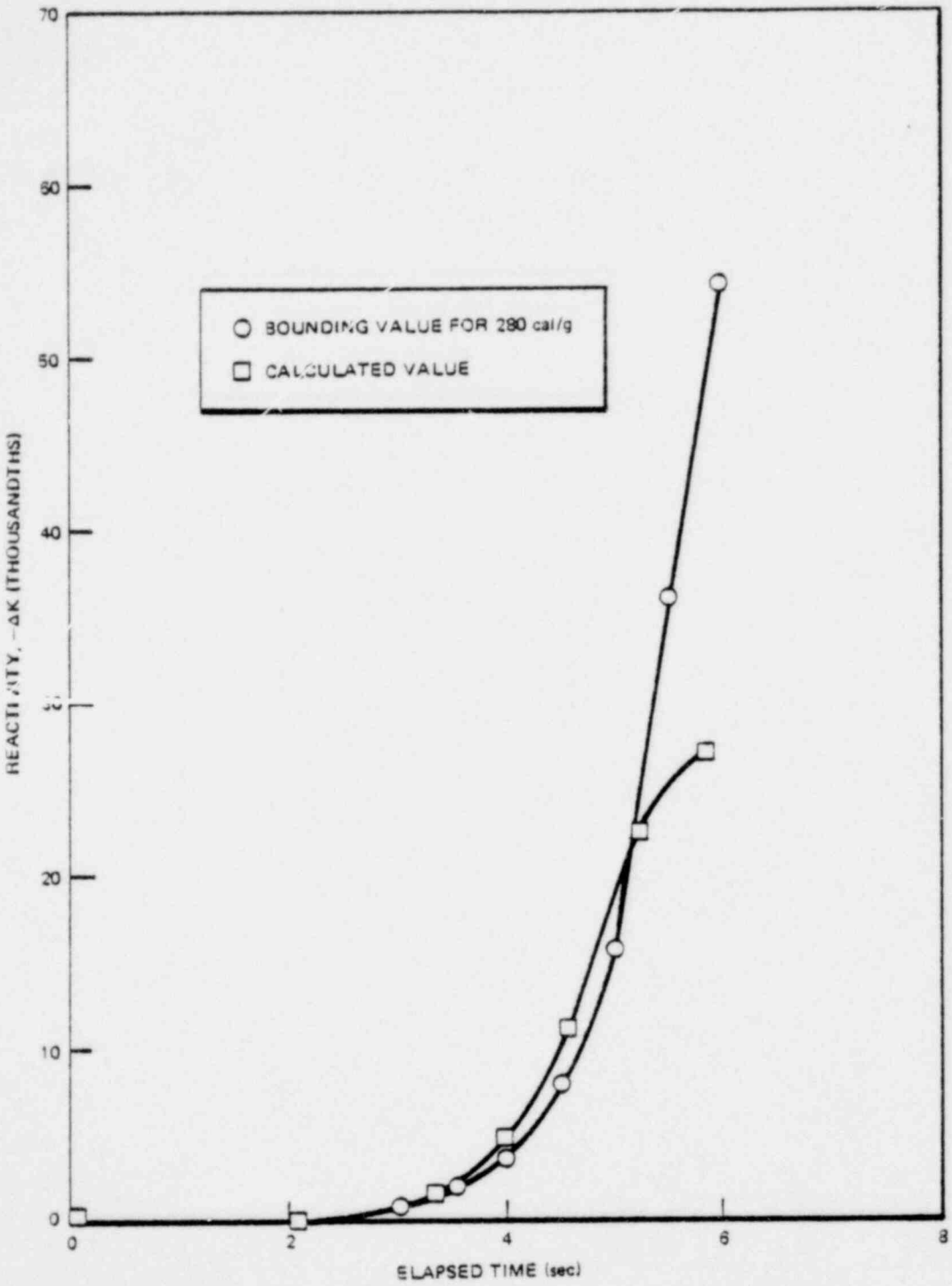


Figure 12. RDA Scram Reactivity Function at 20°C

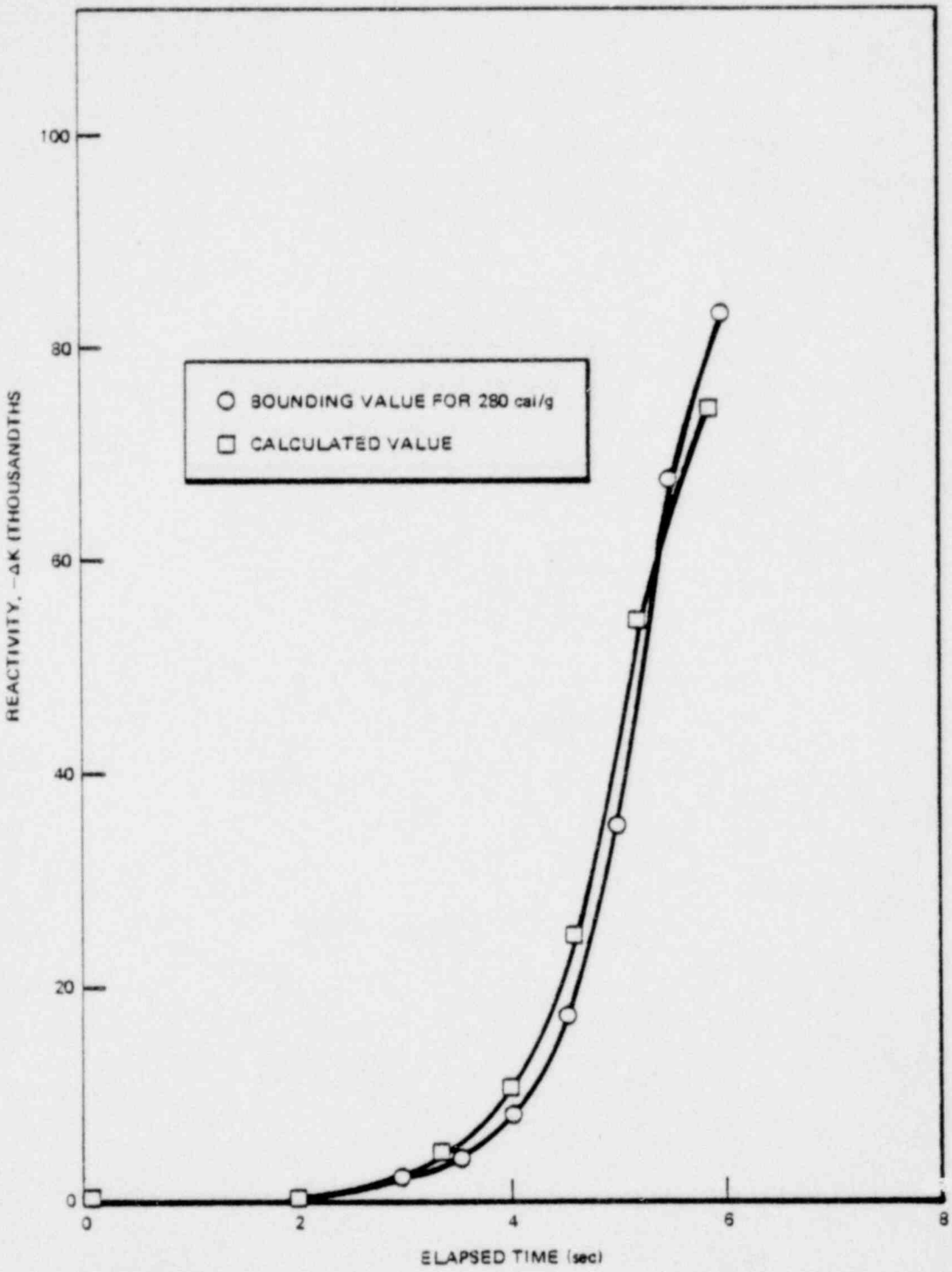


Figure 13. RDA Scram Reactivity Function at 286°C

APPENDIX A

NOT USED

APPENDIX B

TRANSIENT ANALYSIS INITIAL CONDITIONS

S/RV Lowest Setpoint (psig)	1105 ± 1%
S/RV Capacity (%)	87.4
Turbine Pressure (psig)	975.1

APPENDIX C

NOT USED

APPENDIX D

NEW BUNDLE LOADING ERROR EVENT ANALYSES PROCEDURES

The bundle loading error analyses results presented in Section 15 in this supplement are based on new analyses procedures for both the rotated bundle and the mislocated bundle loading error events. The use of these new analysis procedures is discussed below.

NEW ANALYSIS PROCEDURE FOR THE ROTATED BUNDLE LOADING ERROR EVENT

The rotated bundle loading error analysis results presented in this supplement are based on the new analysis procedure described and approved in Reference D-1. This new method of performing the analysis is based on a more accurate detailed analytical model.

The principal difference between the previous analysis procedure and the new analysis procedure is the modeling of the water gap along the axial length of the bundle. The previous analysis used a uniform water gap, whereas the new analysis utilizes a variable water gap which is more representative of the actual condition, since the interfacing between the top guide and the fuel spacer buttons, caused by misorientation, causes the bundle to lean. The effect of the variable water gap is to reduce the power peaking and the R-factor in the upper regions of the limiting fuel rod. This results in the calculation of a reduced CPR for the rotated bundle. The calculation was performed using the same analytical models as were previously used. The only change is in the simulation of the water gap, which more accurately represents the actual geometry.

NEW ANALYSIS PROCEDURE FOR THE MISLOCATED BUNDLE LOADING ERROR EVENT

The mislocated bundle loading error event analyses results presented in this supplement are based on the new analysis procedure described in Reference D-1. This new method of performing the analysis employs a statistically corrected Haling procedure and analyzes every bundle in the core.

The use of the statistically corrected Haling analyses procedure indicates that the minimum CPR for mislocated bundles is greater than the safety limit (1.07) for all exposures throughout the cycle.

REFERENCES

D-1. Safety Evaluation Report (letter), D.G. Eisenhut (NRC) to R.E. Engel (GE), MFN-200-78, dated May 8, 1978.

APPENDIX E

LINEAR HEAT GENERATION RATE FOR BUNDLE LOADING ERROR

16.8 kW/ft

APPENDIX F

DENSIFICATION POWER SPIKING

Reference F-1 documents the NRC staff position that ". . . it (is) acceptable to remove the 8x8 and 8x8R spiking penalty factor from the plant Technical Specification for those operating BWR's for which it can be shown that the predicted worst case maximum transient LHGR's, when augmented by the power spike penalty, do not violate the exposure-dependent safety limit LHGR's."

The BSEP-2 Reload-3 submittal contains the required information to demonstrate that the stated criterion is met for BSEP-2, Reload 3. Section 10, Rod Withdrawal Error, and Appendix E (Linear Heat Generation Rate for Bundle Loading Error) include the densification effect in the calculated LHGR of the 8x8 fuels.

REFERENCE

F-1 "Safety Evaluation of the General Electric Methods for the Consideration of Power Spiking Due to Densification Effects in BWR 8x8 Fuel Design and Performance," Reactor Safety Branch, DOR, May 1978.

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