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Supplemental Reload Licensing Report
for
Vermont Yankee Nuclear Power Station
Reload 24 Cycle 25
(with Extended Power Uprate)

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Reporter/Clerk MAC

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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 GE Energy - NSA personnel. The Supplemental Reload Licensing Report was prepared by L. A. Leatherwood. 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

Appendix A: Analysis Conditions
Appendix B: Decrease in Core Coolant Temperature Events
Appendix C: ARTS Power and Flow Operating Limits Adjustments
Appendix D: Implementation of Extended Power Uprate (EPU)
Appendix E: Stability Solution Option 1-D Exclusion and Buffer Regions at EPU Condition
Appendix F: List of Acronyms

2. Reload Fuel Bundles

Fuel Type	Cycle Loaded	Number
Irradiated:		
GE14-P10DNAB394-7G5.0/6G4.0-100T-150-T6-2566 (GE14C)	23	92
GE14-P10DNAB394-8G5.0/6G4.0-100T-150-T6-2595 (GE14C)	23	16
GE14-P10DNAB394-12G5.0-100T-150-T6-2596 (GE14C)	23	20
GE14-P10DNAB426-16G6.0-100T-150-T6-2682 (GE14C)	24	32
GE14-P10DNAB390-14GZ-100T-150-T6-2683 (GE14C)	24	44
GE14-P10DNAB388-17GZ-100T-150-T6-2684 (GE14C)	24	40
New:		
GE14-P10DNAB383-17G6.0-100T-150-T6-2865 (GE14C)	25	16
GE14-P10DNAB383-13G6.0-100T-150-T6-2863 (GE14C)	25	28
GE14-P10DNAB383-14G6.0-100T-150-T6-2864 (GE14C)	25	32
GE14-P10DNAB422-16GZ-100T-150-T6-2862 (GE14C)	25	48
Total:		**368**

3. Reference Core Loading Pattern

	Core Average Exposure	Cycle Average Exposure
Nominal previous end-of-cycle exposure:	27305 MWd/MT (24771 MWd/ST)	12153 MWd/MT (11025 MWd/ST)
Minimum previous end-of-cycle exposure (for cold shutdown considerations):	26976 MWd/MT (24472 MWd/ST)	11823 MWd/MT (10726 MWd/ST)
Assumed reload beginning-of-cycle exposure:	14829 MWd/MT (13453 MWd/ST)	0 MWd/MT (0 MWd/ST)
Assumed reload end-of-cycle exposure (rated conditions):	29093 MWd/MT (26393 MWd/ST)	14264 MWd/MT (12940 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	1.118
Fully controlled	0.953
Strongest control rod out	0.988
R, Maximum increase in strongest rod out reactivity during the cycle (Δk)	0.0001
Cycle average exposure at which R occurs	14264 MWd/MT (12940 MWd/ST)

5. Standby Liquid Control System Shutdown Capability

Boron (ppm) (at 20°C)	Shutdown Margin (Δk) (at 160°C, Xenon Free)	
	Analytical Requirement	Achieved
800	≥0.010	0.037

6. Reload Unique GETAB Anticipated Operational Occurrences (AOO) Analysis Initial Condition Parameters [1]

Operating domain: ICF (HBB) Exposure range : BOC to MOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.43	1.29	1.040	7.244	110.6	1.35

Operating domain: ICF (HBB) Exposure range : MOC to EOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.42	1.31	1.040	7.159	111.9	1.34

Operating domain: MELLLA (HBB) Exposure range : BOC to MOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.41	1.28	1.040	7.125	102.0	1.33

Operating domain: MELLLA (HBB) Exposure range : MOC to EOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.40	1.30	1.040	7.054	103.0	1.33

[1] Exposure range designation is defined in Table 7-1. Application condition number is defined in Section 11.

Operating domain: ICF (UB) Exposure range : MOC to EOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.49	1.31	1.040	7.556	107.5	1.34

Operating domain: MELLLA (UB) Exposure range : MOC to EOC (Application Condition: 1)							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.49	1.42	1.040	7.518	98.3	1.31

7. Selected Margin Improvement Options [2]

Recirculation pump trip:	No
Rod withdrawal limiter:	No
Thermal power monitor:	No
Improved scram time:	Yes (ODYN Option B)
Measured scram time:	No
Exposure dependent limits:	Yes
Exposure points analyzed:	2

Table 7-1 Cycle Exposure Range Designation

Name	Exposure Range [3]
BOC to MOC	BOC25 to EOR25-1213 MWd/MT (1100 MWd/ST)
MOC to EOC	EOR25-1213 MWd/MT (1100 MWd/ST) to EOC25
BOC to EOC	BOC25 to EOC25

[2] Refer to GESTAR for those margin improvement options that are referenced and supported within GESTAR.
[3] End of Rated (EOR) is defined as the cycle average exposure corresponding to all rods out, 100% power/100% flow, and normal feedwater temperature.

8. Operating Flexibility Options [4]

The following information presents the operational domains and flexibility options which are supported by the reload licensing analysis. Inclusion of these results in this report is not meant to imply that these domains and options have been fully licensed and approved for operation.

Extended Operating Domain (EOD):	Yes
EOD type: Maximum Extended Load Line Limit (MELLLA)	
Minimum core flow at rated power:	99.0 %
Increased Core Flow:	Yes
Flow point analyzed throughout cycle:	107.0 %
Feedwater Temperature Reduction:	No
ARTS Program:	Yes
Single Loop Operation:	Yes
Equipment Out of Service:	
Safety/relief valves Out of Service: (credit taken for 3 of 4 relief valves (1 RV OOS))	Yes

9. Core-wide AOO Analysis Results [5]

Methods used: GEMINI, GEXL-PLUS

Operating domain: ICF (HBB)
Exposure range : BOC to MOC (Application Condition: 1)

			Uncorrected ΔCPR	
Event	**Flux (%rated)**	**Q/A (%rated)**	**GE14C**	**Fig.**
FW Controller Failure	354	121	0.26	2
Load Rejection w/o Bypass	382	119	0.28	3
Turbine Trip w/o Bypass	372	118	0.27	4
Inadvertent HPCI /L8	347	123	0.27	5

[4] Refer to GESTAR for those operating flexibility options that are referenced and supported within GESTAR.
[5] Exposure range designation is defined in Table 7-1. Application condition number is defined in Section 11.

Operating domain: ICF (HBB)
Exposure range : MOC to EOC (Application Condition: 1)

Event	Flux (%rated)	Q/A (%rated)	Uncorrected ΔCPR GE14C	Fig.
FW Controller Failure	379	123	0.26	6
Load Rejection w/o Bypass	400	120	0.27	7
Turbine Trip w/o Bypass	395	120	0.27	8
Inadvertent HPCI /L8	372	125	0.27	9

Operating domain: MELLLA (HBB)
Exposure range : BOC to MOC (Application Condition: 1)

Event	Flux (%rated)	Q/A (%rated)	Uncorrected ΔCPR GE14C	Fig.
FW Controller Failure	314	119	0.25	10
Load Rejection w/o Bypass	328	116	0.26	11
Turbine Trip w/o Bypass	331	116	0.25	12
Inadvertent HPCI /L8	306	121	0.25	13

Operating domain: MELLLA (HBB)
Exposure range : MOC to EOC (Application Condition: 1)

Event	Flux (%rated)	Q/A (%rated)	Uncorrected ΔCPR GE14C	Fig.
FW Controller Failure	328	120	0.25	14
Load Rejection w/o Bypass	337	117	0.26	15
Turbine Trip w/o Bypass	340	117	0.25	16
Inadvertent HPCI /L8	324	122	0.26	17

Operating domain: ICF (UB) Exposure range : MOC to EOC (Application Condition: 1)				
			Uncorrected ΔCPR	
Event	Flux (%rated)	Q/A (%rated)	GE14C	Fig.
FW Controller Failure	250	115	0.25	18
Load Rejection w/o Bypass	301	114	0.27	19
Turbine Trip w/o Bypass	278	114	0.26	20
Inadvertent HPCI /L8	247	118	0.26	21

Operating domain: MELLLA (UB) Exposure range : MOC to EOC (Application Condition: 1)				
			Uncorrected ΔCPR	
Event	Flux (%rated)	Q/A (%rated)	GE14C	Fig.
FW Controller Failure	213	113	0.22	22
Load Rejection w/o Bypass	260	111	0.24	23
Turbine Trip w/o Bypass	238	112	0.24	24
Inadvertent HPCI /L8	207	115	0.23	25

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

Rod withdrawal error (RWE) limits with ARTS are reported in *Vermont Yankee Nuclear Power Station APRM/RBM/Technical Specifications / Maximum Extended Load Line Limit Analysis (ARTS/MELLLA)*, NEDC-33089P, March 2003. A statistically based RWE limit of 1.40 is established in the *Statistically Based Rod Withdrawal Error Analysis for Vermont Yankee Nuclear Power Station*, GE-NE-0000-0016-3451-R0, July 2003.

A cycle specific analysis was performed for Vermont Yankee Cycle 25 to determine the MCPR corresponding to full withdrawal. (RBM was not credited in this analysis.) For the exposure range from BOC25 to EOC25, it is concluded that the statistically based RWE analysis value of 1.40 bounds the Cycle 25 specific analysis value. Therefore, it is the statistically based value that is reported in Section 11 of the SRLR.

The RBM operability requirements specified in Section 3.4 of ARTS Report NEDC-33089P 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 unblocked RWE event.

11. Cycle MCPR Values [6] [7] [8]

Two loop operation safety limit:	1.07
Single loop operation safety limit:	1.09
Stability MCPR Design Basis:	See Section 15
ECCS MCPR Design Basis:	See Section 16 (Initial MCPR)

Non-pressurization events:

Exposure range: BOC to EOC	
	GE14C
Loss of Feedwater Heating (See Appendix B)	1.20
Rod Withdrawal Error (full withdrawal)	1.40
Fuel Loading Error (misoriented)	1.28

Limiting Pressurization Events OLMCPR Summary Table: [9]

Appl. Cond.	Exposure Range	Option A	Option B
		GE14C	**GE14C**
1	**Normal Operation (w/ equipment in-service)**		
	BOC to MOC	1.47	1.36
	MOC to EOC	1.57	1.40

[6] The two loop and single loop Safety Limit values include a 0.02 additional bundle uncertainty at the EPU condition as required by NRC and documented in *VY Cycle 25 Extended Power Uprate (EPU) Safety Limit Minimum Critical Power Ratio (SLMCPR)*, Letter, B. Vita (VY) to C. Collins (GNF), NEA-05-067, November 30, 2005. This restriction will remain in place until such time that NRC removes it.
[7] Exposure range designation is defined in Table 7-1.
[8] For single loop operation, the MCPR operating limit is 0.02 greater than the two loop value.
[9] Each application condition (Appl. Cond.) covers the entire range of licensed flow and feedwater temperature unless specified otherwise. The OLMCPR values presented apply to rated power operation based on the two loop operation safety limit MCPR.

Pressurization events: [10]

Operating domain: ICF (HBB) **Exposure range : BOC to MOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.46	1.35
Load Rejection w/o Bypass	1.47	1.36
Turbine Trip w/o Bypass	1.46	1.35
Inadvertent HPCI /L8	1.47	1.36

Operating domain: ICF (HBB) **Exposure range : MOC to EOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.56	1.39
Load Rejection w/o Bypass	1.57	1.40
Turbine Trip w/o Bypass	1.56	1.39
Inadvertent HPCI /L8	1.57	1.40

Operating domain: MELLLA (HBB) **Exposure range : BOC to MOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.44	1.33
Load Rejection w/o Bypass	1.46	1.35
Turbine Trip w/o Bypass	1.45	1.34
Inadvertent HPCI /L8	1.45	1.34

[10] Application condition numbers shown for each of the following pressurization events represent the application conditions for which this event contributed in the determination of the limiting OLMCPR value.

Operating domain: MELLLA (HBB) **Exposure range : MOC to EOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.54	1.37
Load Rejection w/o Bypass	1.55	1.38
Turbine Trip w/o Bypass	1.55	1.38
Inadvertent HPCI /L8	1.55	1.38

Operating domain: ICF (UB) **Exposure range : MOC to EOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.54	1.37
Load Rejection w/o Bypass	1.57	1.40
Turbine Trip w/o Bypass	1.56	1.39
Inadvertent HPCI /L8	1.55	1.38

Operating domain: MELLLA (UB) **Exposure range : MOC to EOC (Application Condition: 1)**		
	Option A	**Option B**
	GE14C	**GE14C**
FW Controller Failure	1.51	1.34
Load Rejection w/o Bypass	1.53	1.36
Turbine Trip w/o Bypass	1.53	1.36
Inadvertent HPCI /L8	1.52	1.35

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pdome (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram) - ICF (HBB)	1302	1303	1328	Figure 26
MSIV Closure (Flux Scram) - MELLLA (HBB)	1299	1300	1324	Figure 27

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes[11]

Misoriented Fuel Bundle	ΔCPR
GE14-P10DNAB426-16G6.0-100T-150-T6-2682 (GE14C)	0.07
GE14-P10DNAB390-14GZ-100T-150-T6-2683 (GE14C)	0.20
GE14-P10DNAB422-16GZ-100T-150-T6-2862 (GE14C)	0.07
GE14-P10DNAB383-14G6.0-100T-150-T6-2864 (GE14C)	0.09
GE14-P10DNAB388-17GZ-100T-150-T6-2684 (GE14C)	0.21
GE14-P10DNAB383-13G6.0-100T-150-T6-2863 (GE14C)	0.08
GE14-P10DNAB383-17G6.0-100T-150-T6-2865 (GE14C)	0.08

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

Vermont Yankee has implemented the Option I-D solution documented in Reference 15.1. The NRC approved ODYSY methodology (Reference 15.2) has been applied to this reload. ODYSY applications offer the benefit of more accurate simulations of BWR stability events and conditions. Option I-D has (1) "prevention" elements (Exclusion and Buffer Regions) and (2) a "detect & suppress" element (MCPR safety limit (MCPRSL) protection provided by the flow-biased APRM flux trip for the dominant core-wide mode of coupled thermal-hydraulic/neutronic reactor instability). Core and hot channel decay ratio calculations (Reference 15.3) to determine the Exclusion Region and additional bases demonstrate that core-wide is the predominant reactor instability mode for Vermont Yankee. The detect and suppress calculation (Reference 15.4) consists of (A) calculation of a 95% probability/95% confidence level statistically-based hot channel oscillation magnitude for anticipated core-wide mode reactor instability and (B) calculation of the stability-based Operating Limit MCPR (OLMCPR) which provides 95/95 MCPRSL protection.

The detect and suppress calculation requires the use of the Delta CPR over Initial MCPR Versus the Oscillation Magnitude (DIVOM) curve. Recent TRACG evaluations by GE have shown that the generic core-wide DIVOM curve specified in Reference 15.5 may not be conservative for current plant operating conditions for plants that have implemented Stability Option I-D. Specifically, a non-conservative deficiency has been identified for high power-to-flow ratios in the generic core-wide mode DIVOM

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

curve. The deficiency results in a non-conservative slope of the associated core-wide DIVOM curve so that the APRM flux trip setpoint is too high. GE had made a Part 21 Notification on this issue. For Option I-D plants, the applicability of the core-wide mode DIVOM curve may be determined by comparing the core average power-to-flow ratio following a simulated flow runback on the rated rod line to approximately 30% of rated core flow to a value of 66 (MWt/Mlbm/hr) (Reference 15.6). If the core average power-to-flow ratio exceeds this value, then the generic core-wide mode DIVOM curve is not applicable and appropriate corrective actions should be taken. For Vermont Yankee, the calculated core average power-to-flow ratio is 71.7 (MWt/Mlbm/hr) for Cycle 25 EPU conditions, which confirms that the core-wide mode generic DIVOM slope value of 0.175 is not applicable. Therefore, a conservative DIVOM slope of 0.35 (twice the generic DIVOM slope of 0.175) was selected for Cycle 25 EPU operation.

(1) The Exclusion Region and Buffer Region were calculated for Cycle 25 operation. The regions are based on Reference 15.3 and are provided in Appendix E for EPU conditions.

(2A) The hot channel oscillation magnitudes at natural circulation, 45% rated core flow, and 55% rated core flow were determined for Cycle 25 EPU conditions. Revised values for 45% rated core flow and 55% rated core flow are used in the calculation of the stability-based OLMCPR.

(2B) The stability-based OLMCPR was calculated for Cycle 25 EPU conditions. The calculation demonstrated that reactor stability does not produce the limiting OLMCPR for Cycle 25 EPU operation. It is shown that the rated OLMCPR, OLMCPR(100%P/100%F), is greater than the OLMCPR for a two-pump trip scenario, OLMCPR(2PT), the OLMCPR at 100% rod line and 45% rated core flow, OLMCPR(100%RL/45%F), is greater than the OLMCPR at steady state, OLMCPR(SS,45%F), and that the OLMCPR at 100% rod line and 55% rated core flow, OLMCPR(100%RL/55%F), is greater than the OLMCPR at steady state, OLMCPR(SS,55%F). For this analysis, the rated OLMCPR, OLMCPR(100%RL/45%F), and OLMCPR(100%RL/55%F) values are used for comparison (Reference 15.4). For all scenarios considered, the criteria are met at EPU conditions.

OLMCPR(100%P/100%F) > OLMCPR(2PT)

OLMCPR(100%RL/45%F) > OLMCPR(SS,45%F)

OLMCPR(100%RL/55%F) > OLMCPR(SS,55%F)

References:

15.1 *Application of the "Regional Exclusion with Flow-Biased APRM Neutron Flux Scram" Stability Solution (Option I-D) to the Vermont Yankee Nuclear Power Plant, Licensing Topical Report,* GENE-637-018-0793, July 1993.

15.2 *ODYSY Application for Stability Licensing Calculations, Licensing Topical Report,* NEDC-32992P-A, July 2001.

15.3 *Vermont Yankee Cycle 25 Option I-D Stability Exclusion Region Analysis (EPU),* GE-NE-0000-0043-5771-R0, December 2005.

15.4 *Vermont Yankee Cycle 25 Option I-D Stability Detect and Suppress Analysis (EPU)*, GE-NE-0000-0044-5878-R0, December 2005.

15.5 *Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Applications, Licensing Topical Report*, NEDO-32465-A, August 1996.

15.6 *Determination of Figure of Merit for Stability DIVOM Curve Applicability*, OG01-0228-001, July 16, 2001.

16. Loss-of-Coolant Accident Results

16.1 10CFR50.46 Licensing Results

The ECCS-LOCA analysis is based on the SAFER/GESTR-LOCA methodology. The licensing results applicable to all fuel types 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	1960	< 3.00	< 0.10

The SAFER/GESTR-LOCA analysis results for GE14C fuel type are documented in Section 16.4, Reference 1.

16.2 10CFR50.46 Error Evaluation

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

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

10CFR50.46 Error Notifications		
Number	**Subject**	**PCT Impact (°F)**
2003-05	Impact of postulated hydrogen-oxygen recombination on PCT.	0
	Total PCT Adder (°F)	0

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

16.3 ECCS-LOCA Operating Limits

The ECCS MAPLHGR operating limits for the fuel bundles in this cycle are shown in the tables below.

Table 16.3-1 MAPLHGR Limits

Bundle Type: GE14-P10DNAB426-16G6.0-100T-150-T6-2682 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	**GWd/ST**	**kW/ft**
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-2 MAPLHGR Limits

Bundle Type: GE14-P10DNAB390-14GZ-100T-150-T6-2683 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	**GWd/ST**	**kW/ft**
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-3 MAPLHGR Limits

Bundle Type: GE14-P10DNAB422-16GZ-100T-150-T6-2862 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-4 MAPLHGR Limits

Bundle Type: GE14-P10DNAB383-14G6.0-100T-150-T6-2864 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-5 MAPLHGR Limits

Bundle Type: GE14-P10DNAB388-17GZ-100T-150-T6-2684 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-6 MAPLHGR Limits

Bundle Type: GE14-P10DNAB383-13G6.0-100T-150-T6-2863 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-7 MAPLHGR Limits

Bundle Type: GE14-P10DNAB383-17G6.0-100T-150-T6-2865 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-8 MAPLHGR Limits

Bundle Type: GE14-P10DNAB394-7G5.0/6G4.0-100T-150-T6-2566 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-9 MAPLHGR Limits

Bundle Type: GE14-P10DNAB394-8G5.0/6G4.0-100T-150-T6-2595 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-10 MAPLHGR Limits

Bundle Type: GE14-P10DNAB394-12G5.0-100T-150-T6-2596 (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
21.08	19.12	12.82
63.50	57.61	8.00
70.00	63.50	5.00

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

Table 16.3-5 Initial MCPR and Single Loop Operation PLHGR and MAPLHGR Multiplier

Fuel Type	Initial MCPR	Single Loop Operation PLHGR and MAPLHGR Multiplier
GE14C	1.275	0.82

16.4 References

The SAFER/GESTR-LOCA analysis report applicable to the new cycle core is listed below for each fuel type. The report is based on a power level of 1912 MWt. ECCS-LOCA results at this power level bound any lower power levels.

References for GE14C

1. *Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station - Extended Power Uprate ECCS-LOCA SAFER/GESTR*, GE-NE-0000-0015-5477-01, July 2003.

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43
44									H	H	H	H	H	H								
42								I	H	A	C	C	A	H	I							
40					H	H	J	H	A	C	E	E	C	A	H	J	H	H				
38				H	J	A	C	A	C	H	D	D	H	C	A	C	A	J	H			
36			H	J	F	C	I	C	E	F	E	E	F	E	C	I	C	F	J	H		
34			H	A	C	B	F	E	D	B	G	G	B	D	E	F	B	C	A	H		
32			I	C	I	F	H	D	B	H	B	B	H	B	D	H	F	I	C	I		
30		J	H	A	C	E	D	B	F	E	G	G	E	F	B	D	E	C	A	H	J	
28	J	H	A	C	E	D	B	F	B	H	B	B	H	B	F	B	D	E	C	A	H	J
26	H	A	C	H	F	B	H	E	H	H	D	D	H	H	E	H	B	F	H	C	A	H
24	H	C	E	D	E	G	B	G	B	D	H	H	D	B	G	B	G	E	D	E	C	H
22	H	C	E	D	E	G	B	G	B	D	H	H	D	B	G	B	G	E	D	E	C	H
20	H	A	C	H	F	B	H	E	H	H	D	D	H	H	E	H	B	F	H	C	A	H
18	J	H	A	C	E	D	B	F	B	H	B	B	H	B	F	B	D	E	C	A	H	J
16		J	H	A	C	E	D	B	F	E	G	G	E	F	B	D	E	C	A	H	J	
14			I	C	I	F	H	D	B	H	B	B	H	B	D	H	F	I	C	I		
12			H	A	C	B	F	E	D	B	G	G	B	D	E	F	B	C	A	H		
10			H	J	F	C	I	C	E	F	E	E	F	E	C	I	C	F	J	H		
8				H	J	A	C	A	C	H	D	D	H	C	A	C	A	J	H			
6					H	H	J	H	A	C	E	E	C	A	H	J	H	H				
4								I	H	A	C	C	A	H	I							
2									H	H	H	H	H	H								

Fuel Type			
A=GE14-P10DNAB426-16G6.0-100T-150-T6-2682	(Cycle 24)	F=GE14-P10DNAB383-13G6.0-100T-150-T6-2863	(Cycle 25)
B=GE14-P10DNAB390-14GZ-100T-150-T6-2683	(Cycle 24)	G=GE14-P10DNAB383-17G6.0-100T-150-T6-2865	(Cycle 25)
C=GE14-P10DNAB422-16GZ-100T-150-T6-2862	(Cycle 25)	H=GE14-P10DNAB394-7G5.0/6G4.0-100T-150-T6-2566	(Cycle 23)
D=GE14-P10DNAB383-14G6.0-100T-150-T6-2864	(Cycle 25)	I=GE14-P10DNAB394-8G5.0/6G4.0-100T-150-T6-2595	(Cycle 23)
E=GE14-P10DNAB388-17GZ-100T-150-T6-2684	(Cycle 24)	J=GE14-P10DNAB394-12G5.0-100T-150-T6-2596	(Cycle 23)

Figure 1 Reference Core Loading Pattern

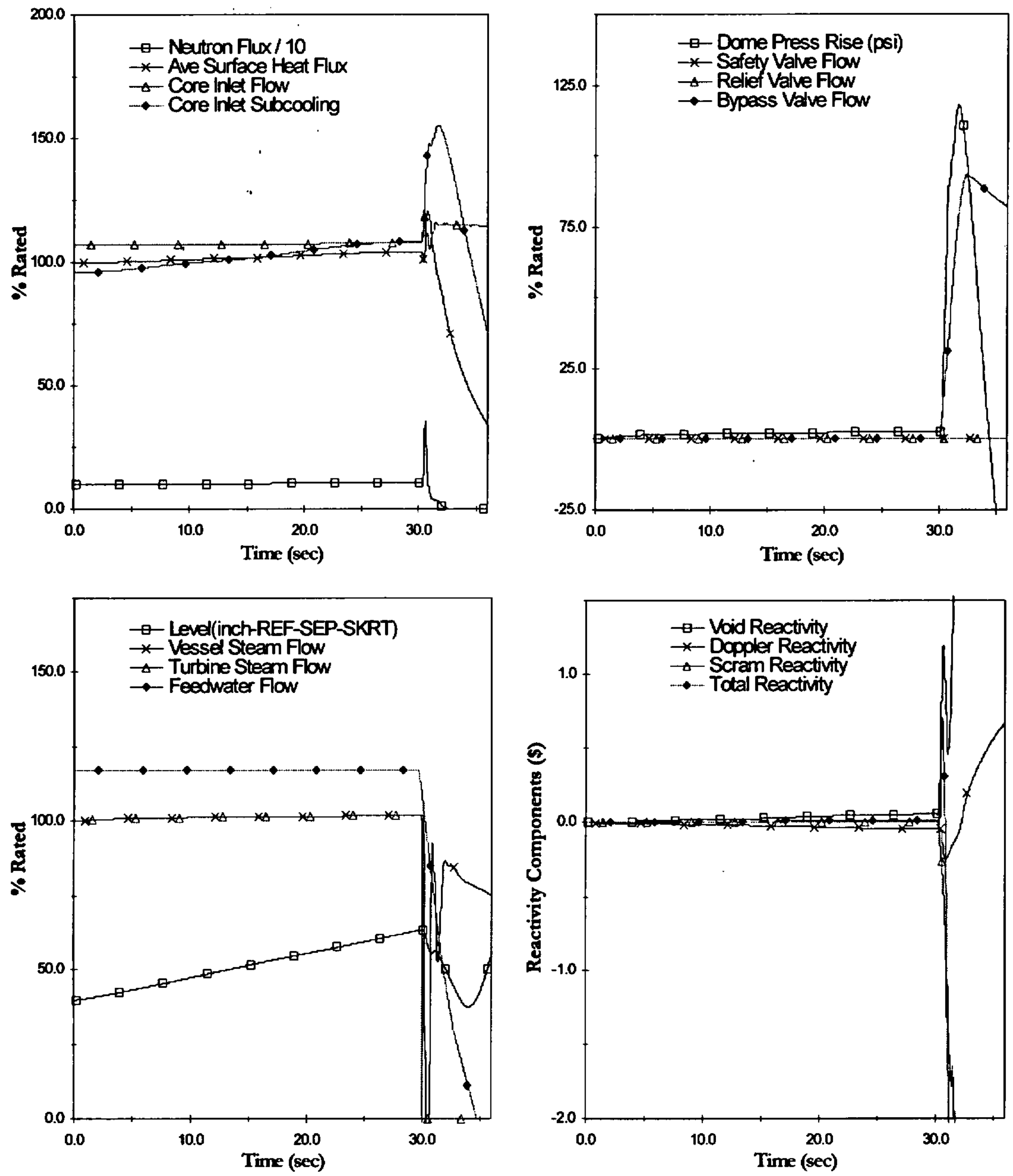

Figure 2 Plant Response to FW Controller Failure
(MOC ICF (HBB))

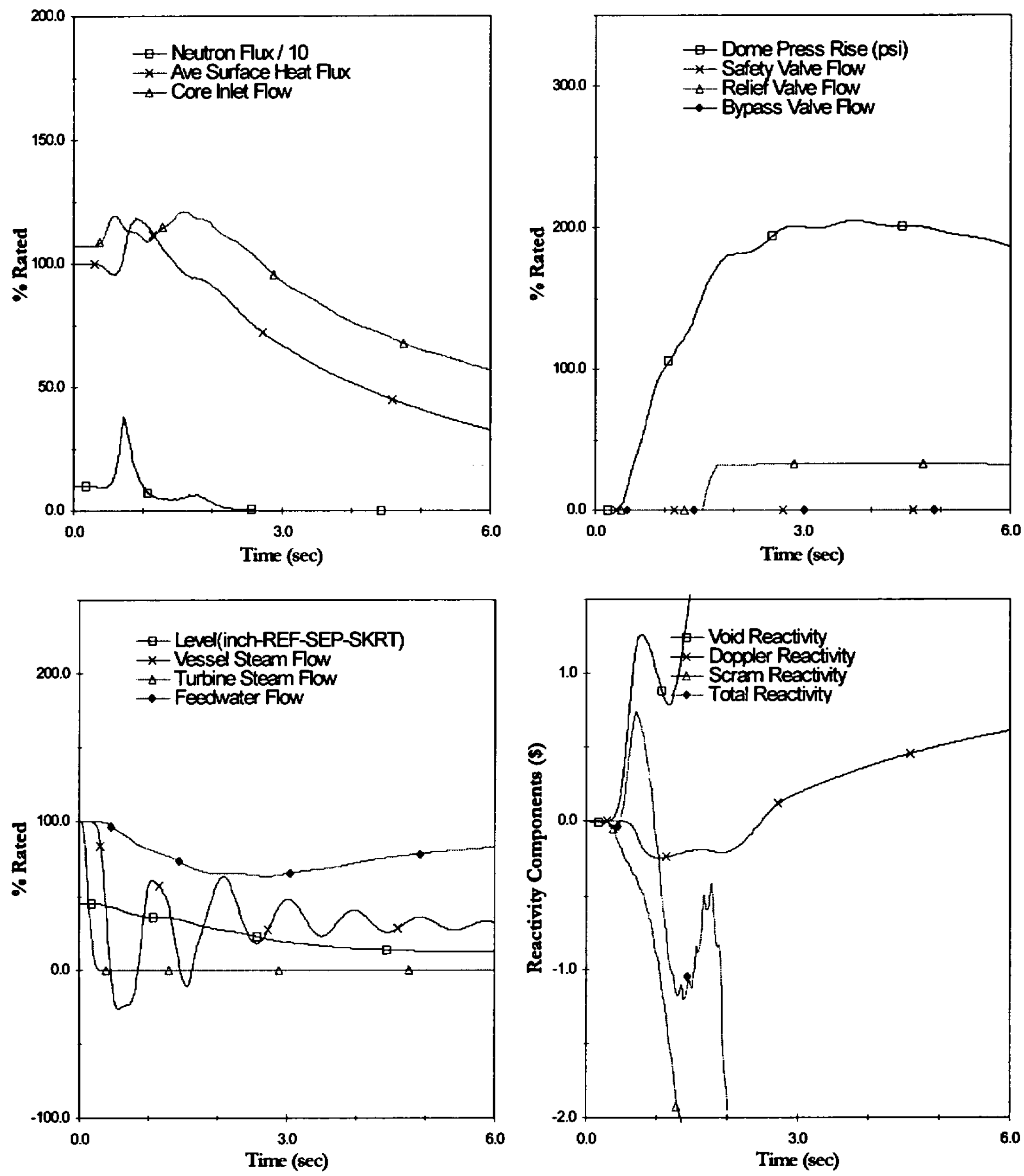

Figure 3 Plant Response to Load Rejection w/o Bypass
(MOC ICF (HBB))

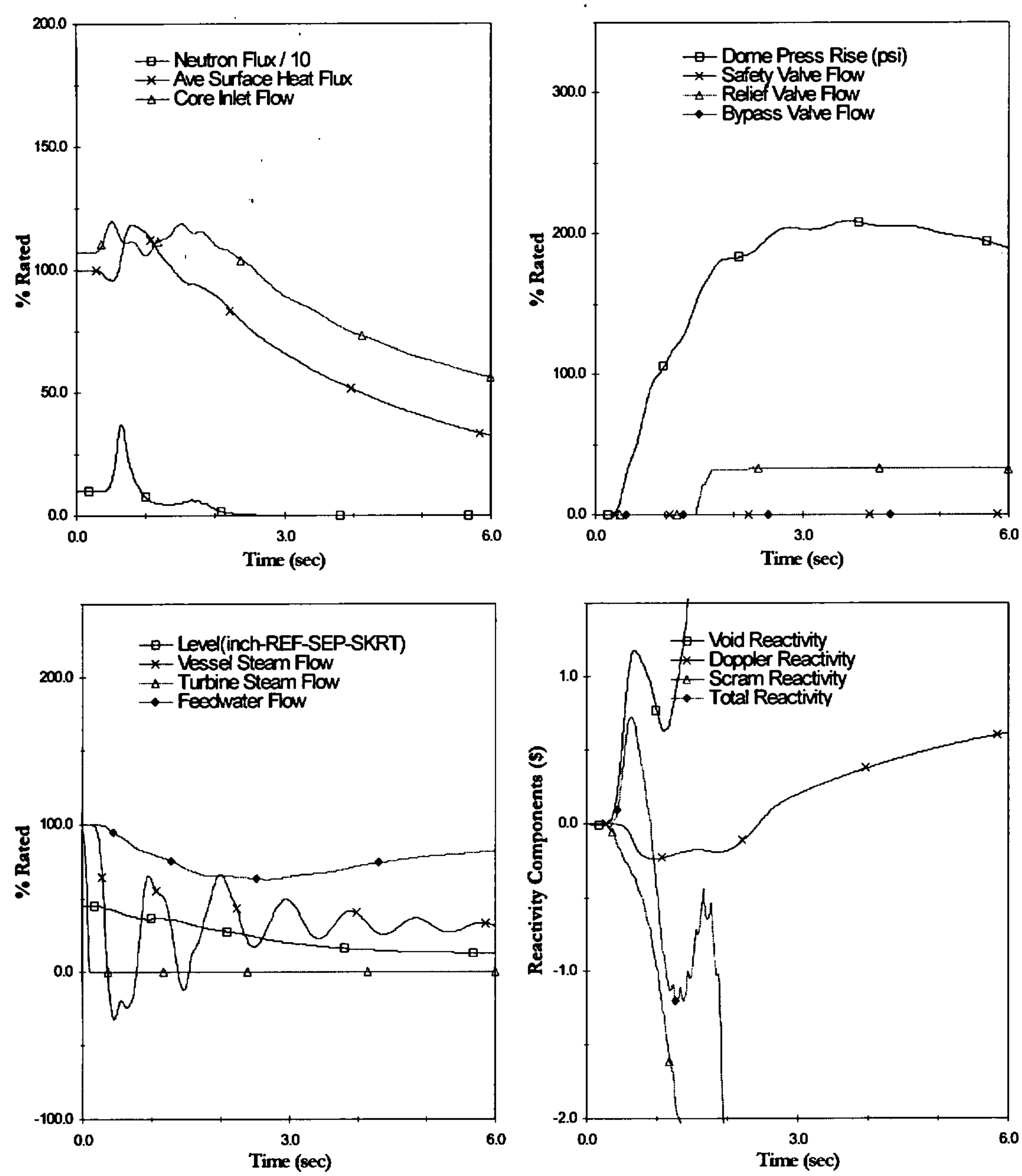

Figure 4 Plant Response to Turbine Trip w/o Bypass
(MOC ICF (HBB))

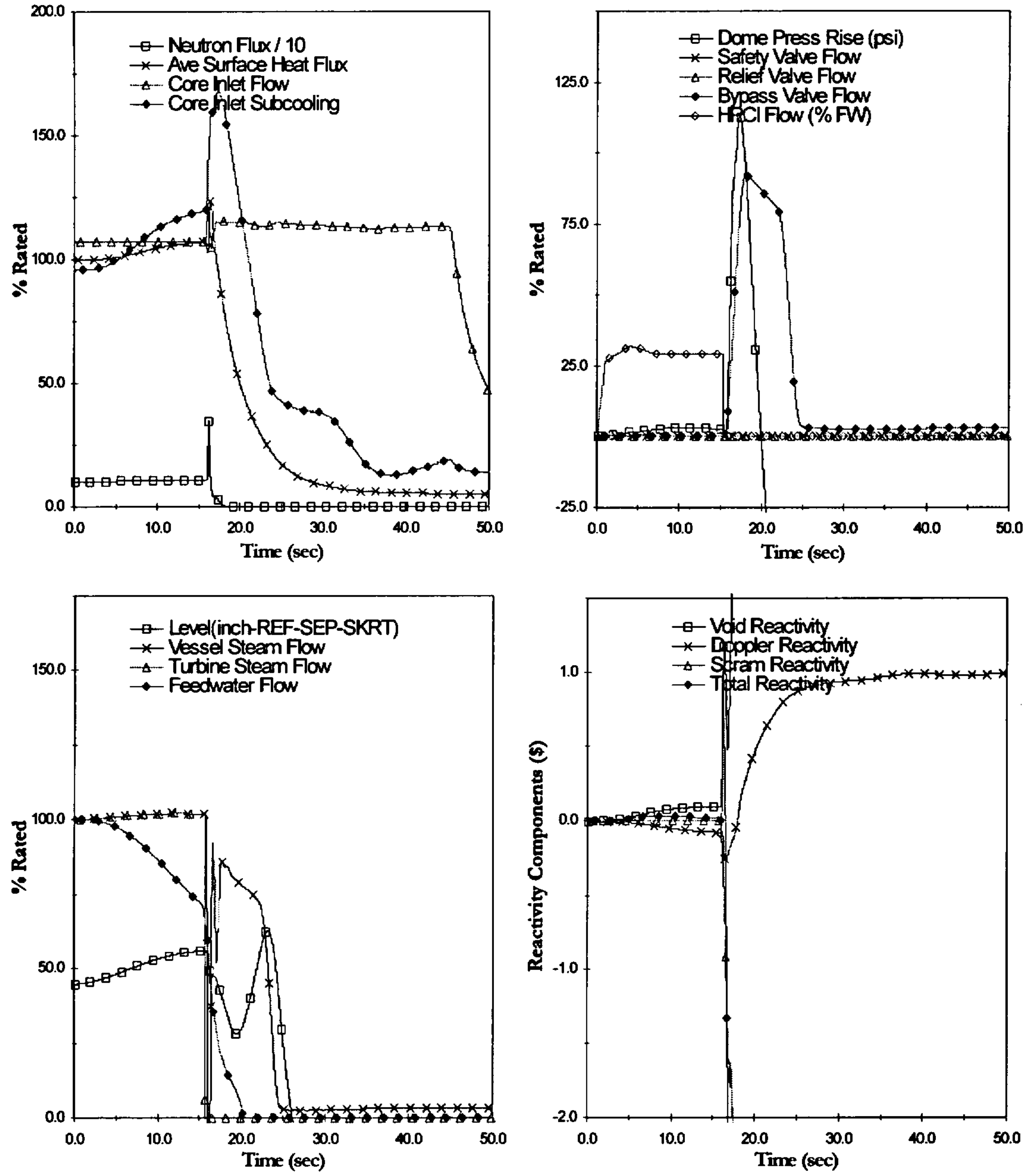

Figure 5 Plant Response to Inadvertent HPCI /L8
(MOC ICF (HBB))

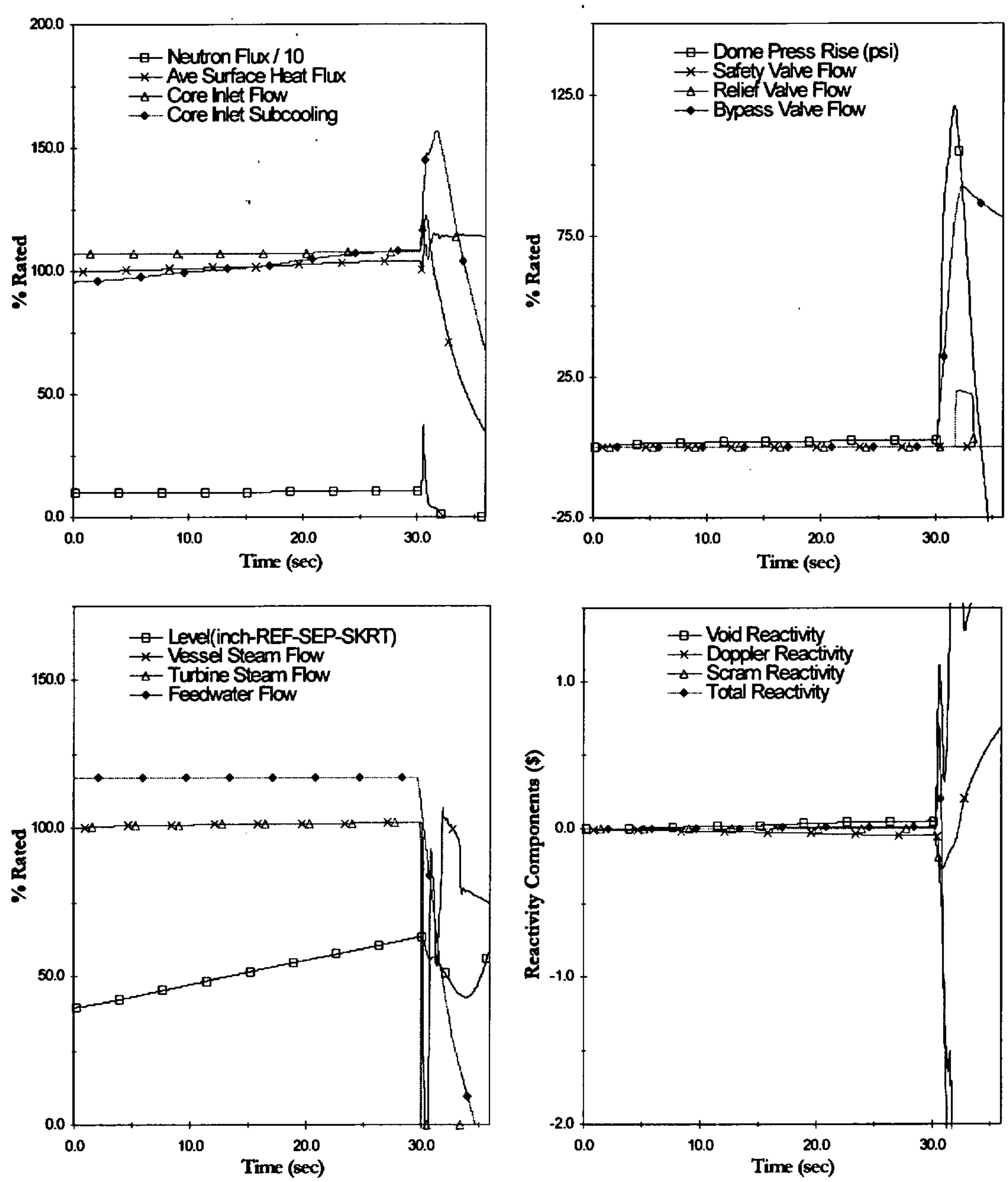

Figure 6 Plant Response to FW Controller Failure
(EOC ICF (HBB))

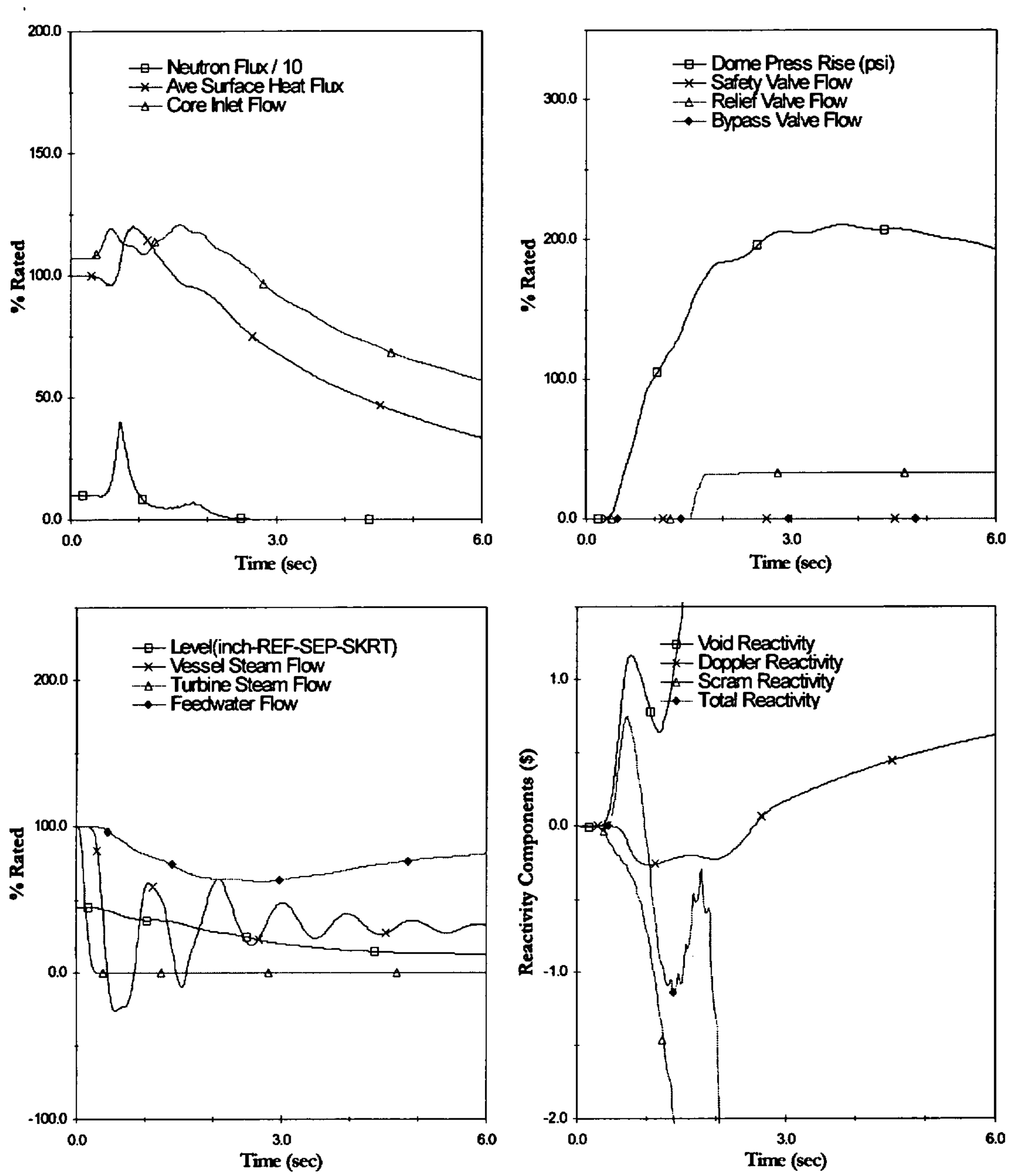

Figure 7 Plant Response to Load Rejection w/o Bypass
(EOC ICF (HBB))

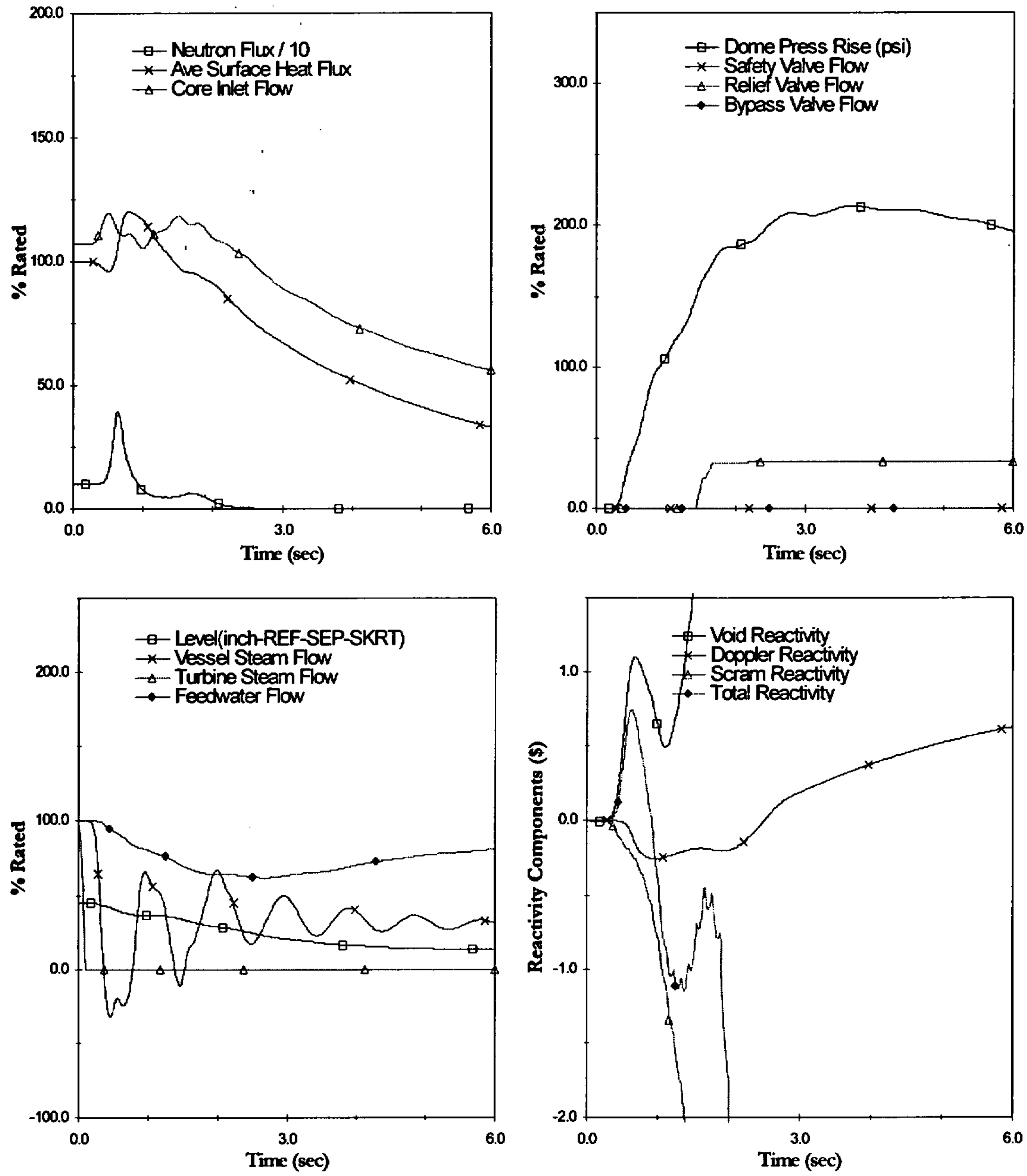

Figure 8 Plant Response to Turbine Trip w/o Bypass
(EOC ICF (HBB))

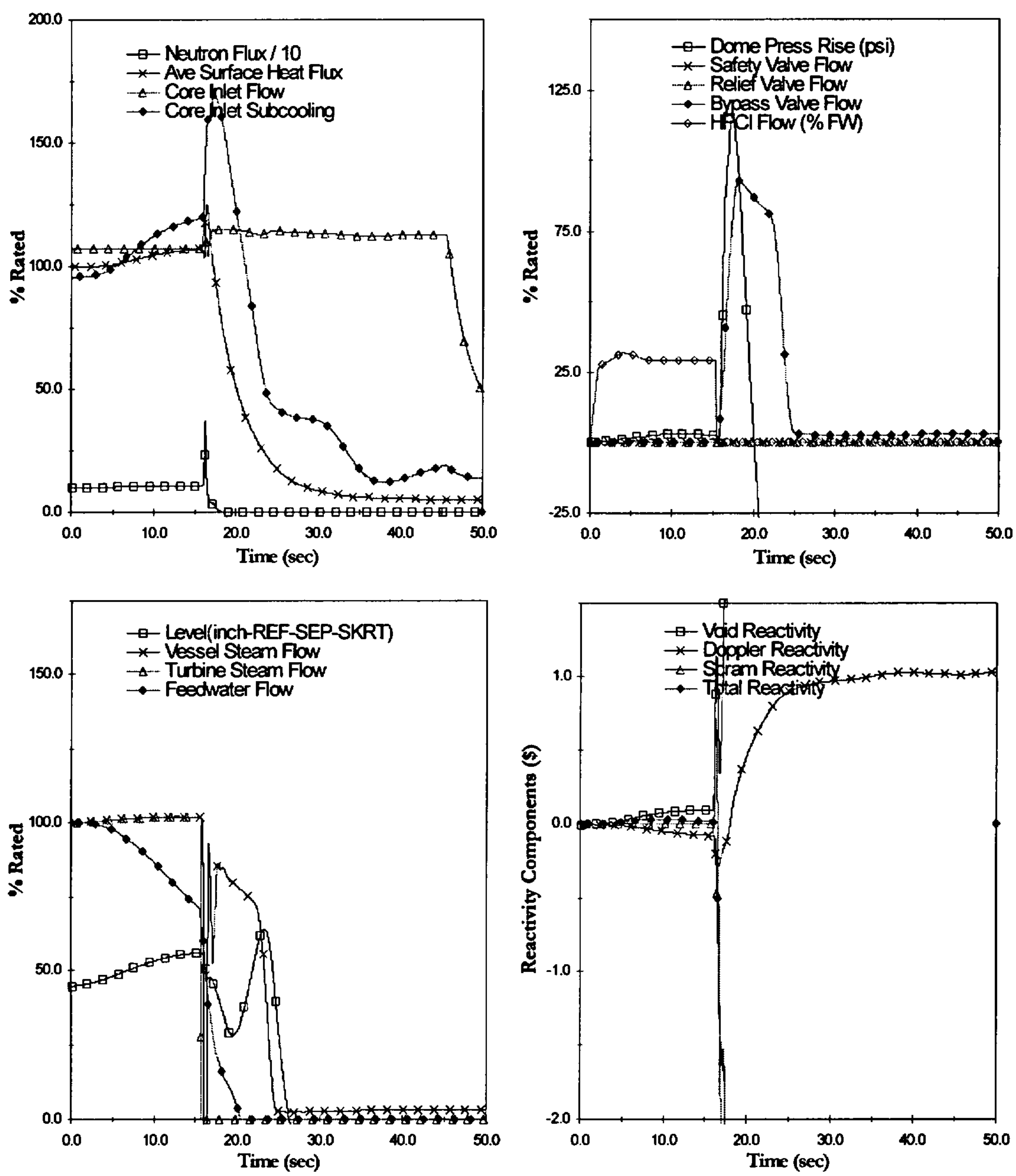

Figure 9 Plant Response to Inadvertent HPCI /L8
(EOC ICF (HBB))

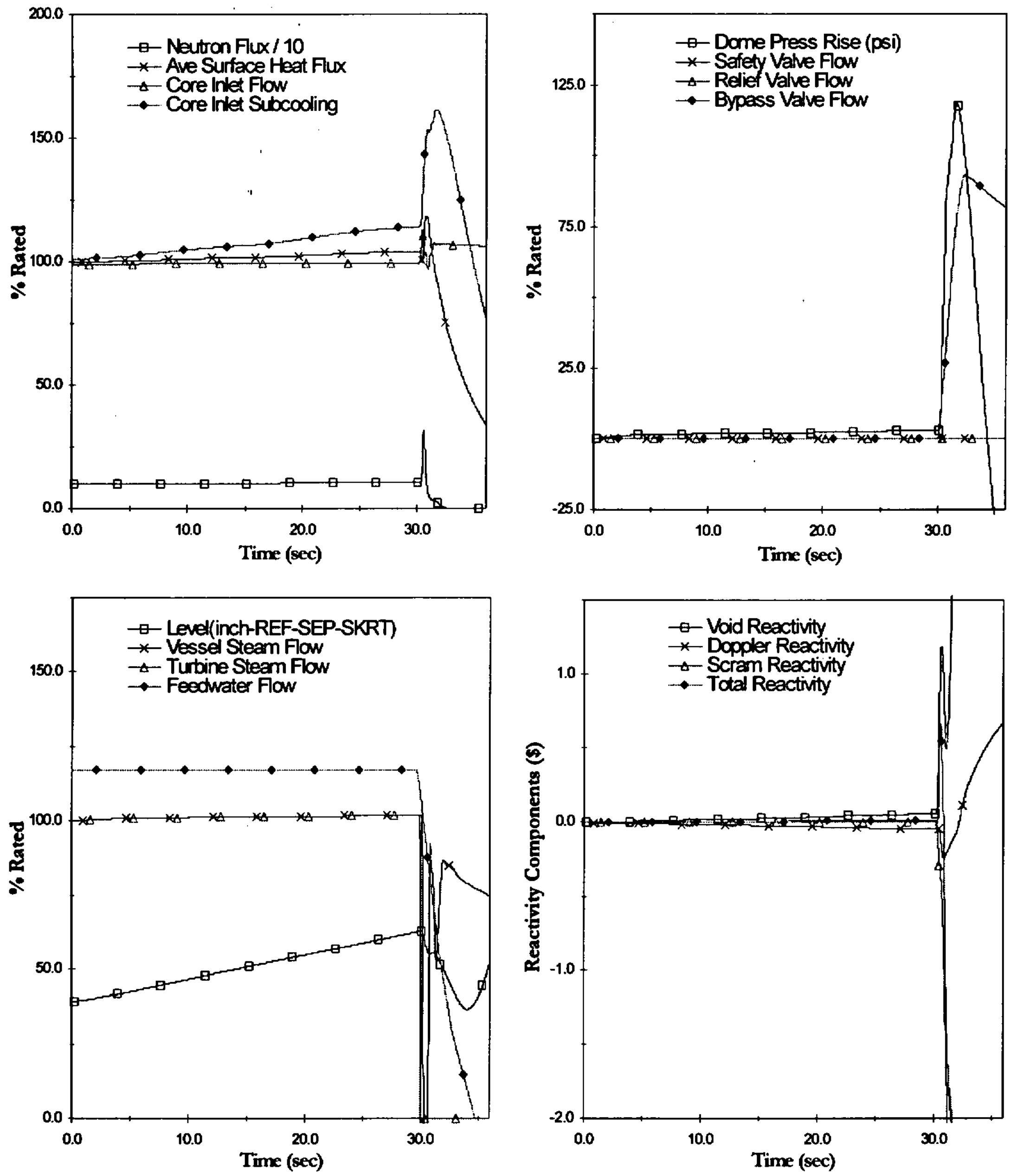

Figure 10 Plant Response to FW Controller Failure
(MOC MELLLA (HBB))

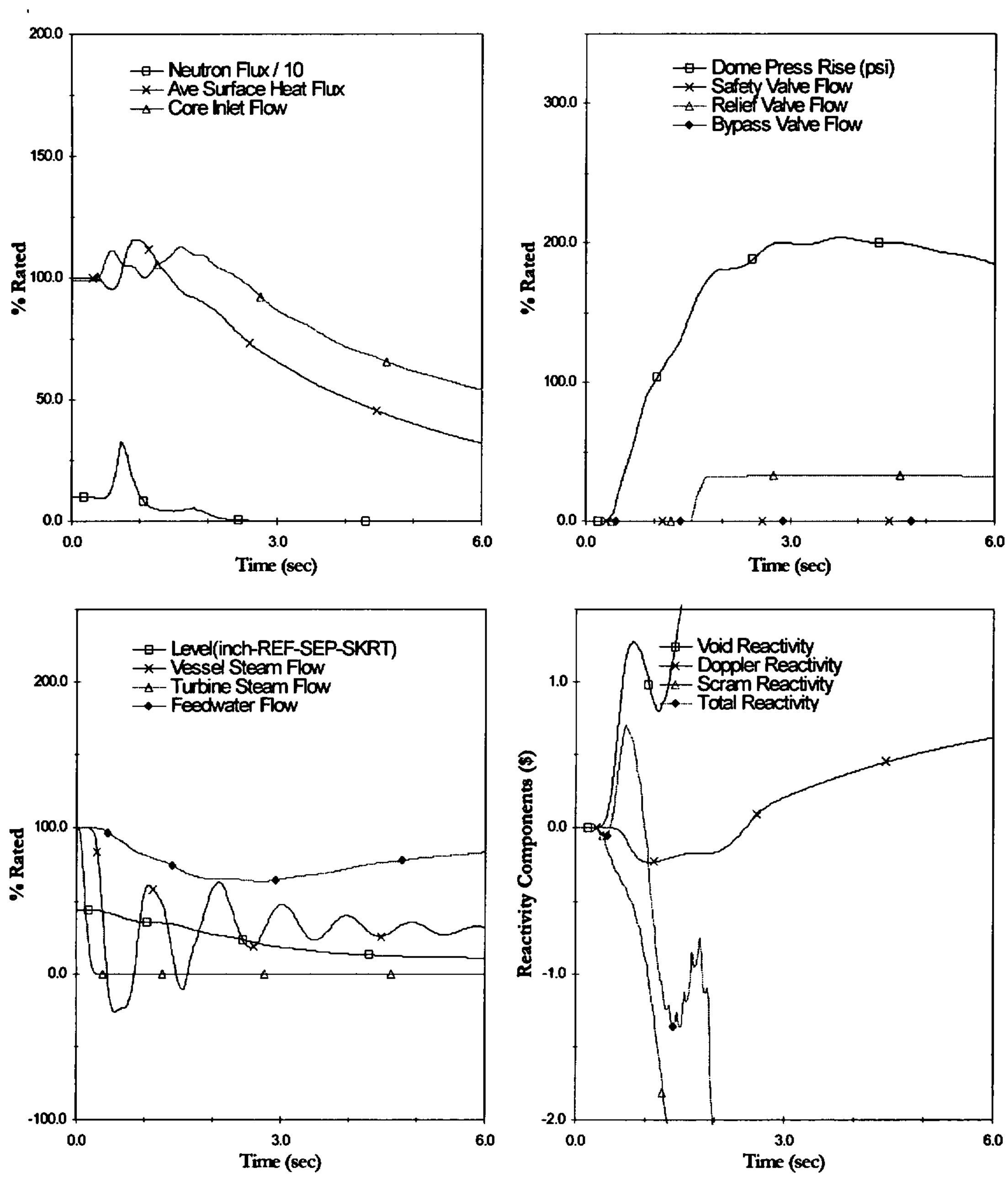

Figure 11 Plant Response to Load Rejection w/o Bypass
(MOC MELLLA (HBB))

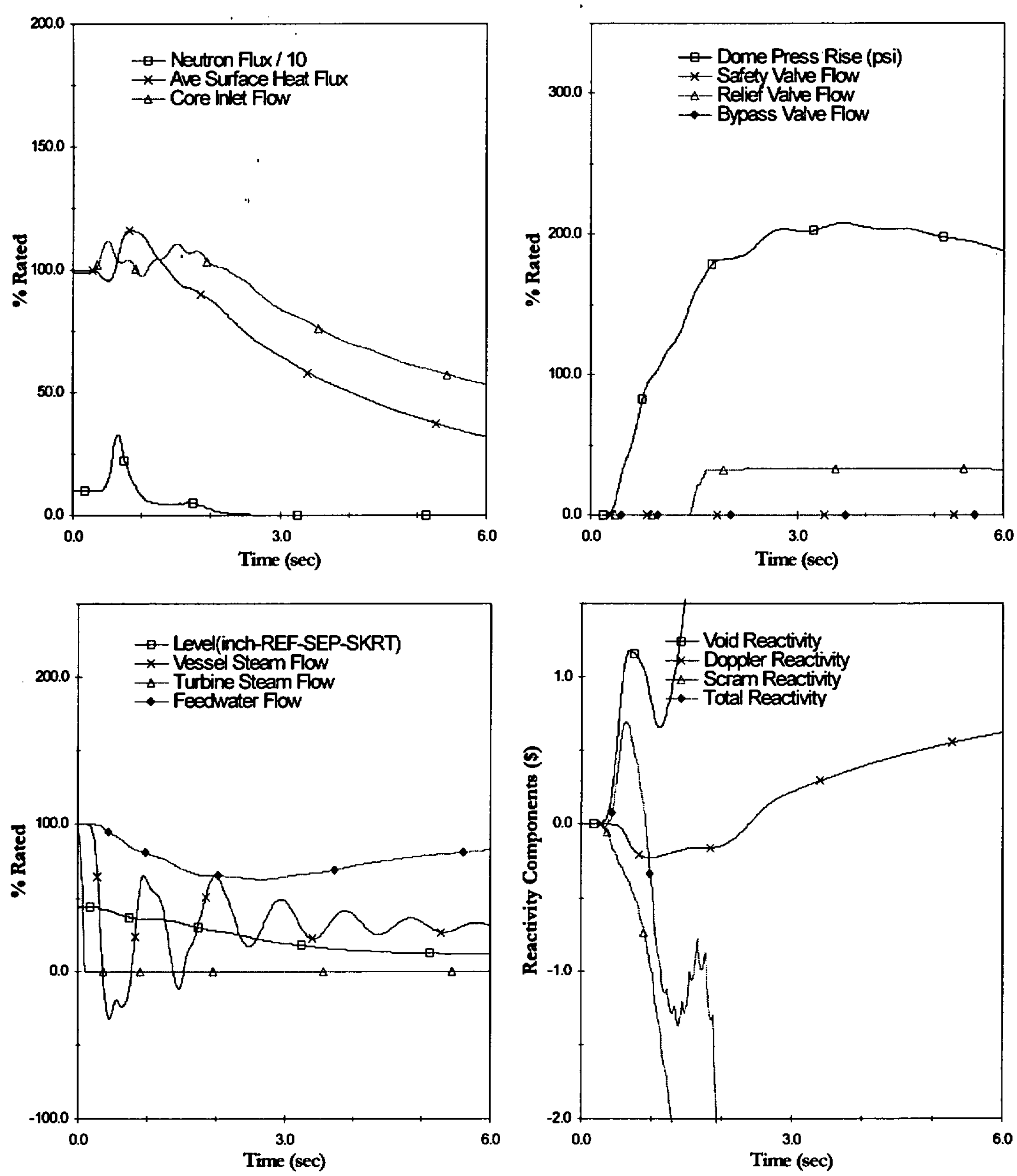

Figure 12 Plant Response to Turbine Trip w/o Bypass
(MOC MELLLA (HBB))

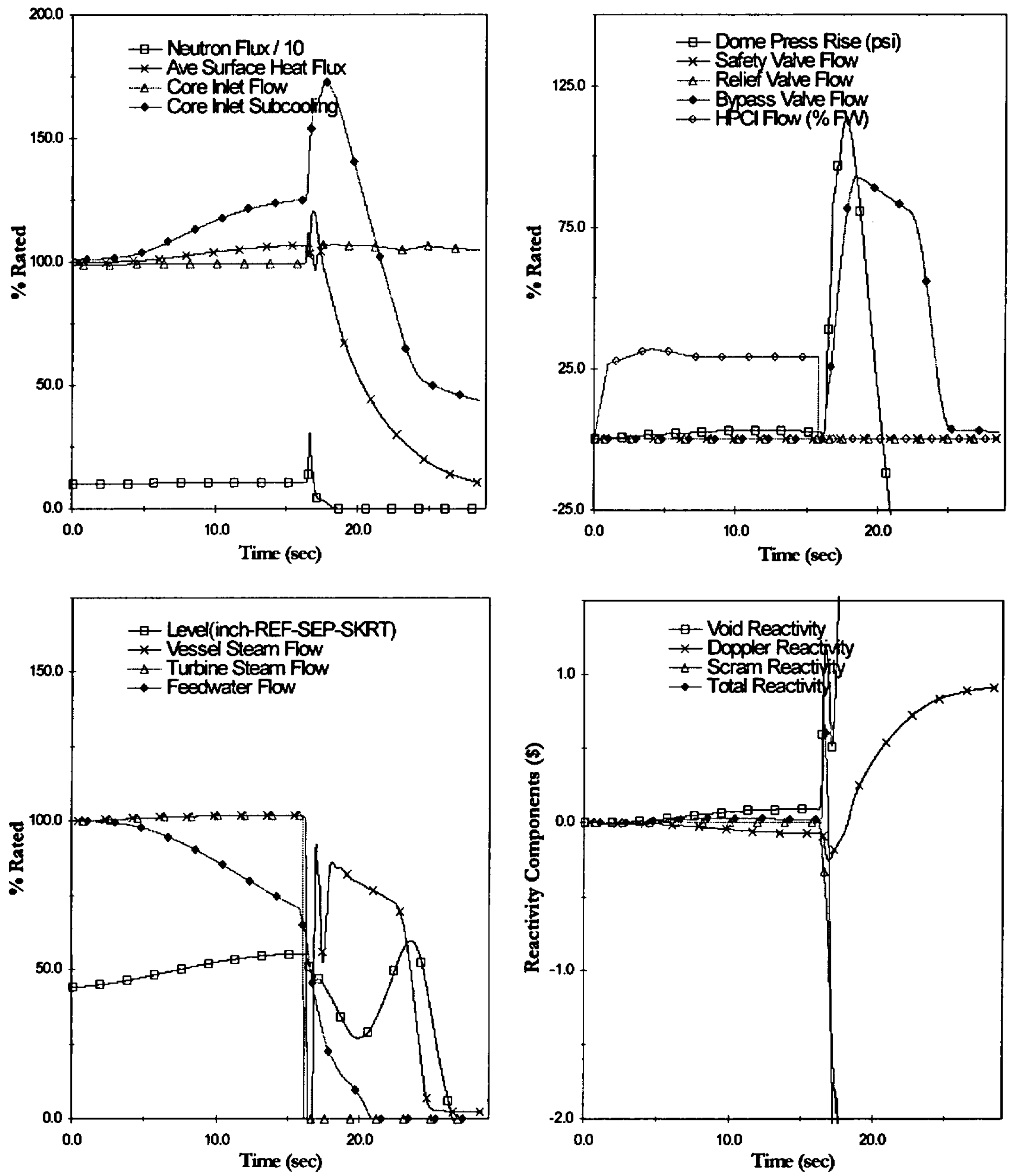

Figure 13 Plant Response to Inadvertent HPCI /L8
(MOC MELLLA (HBB))

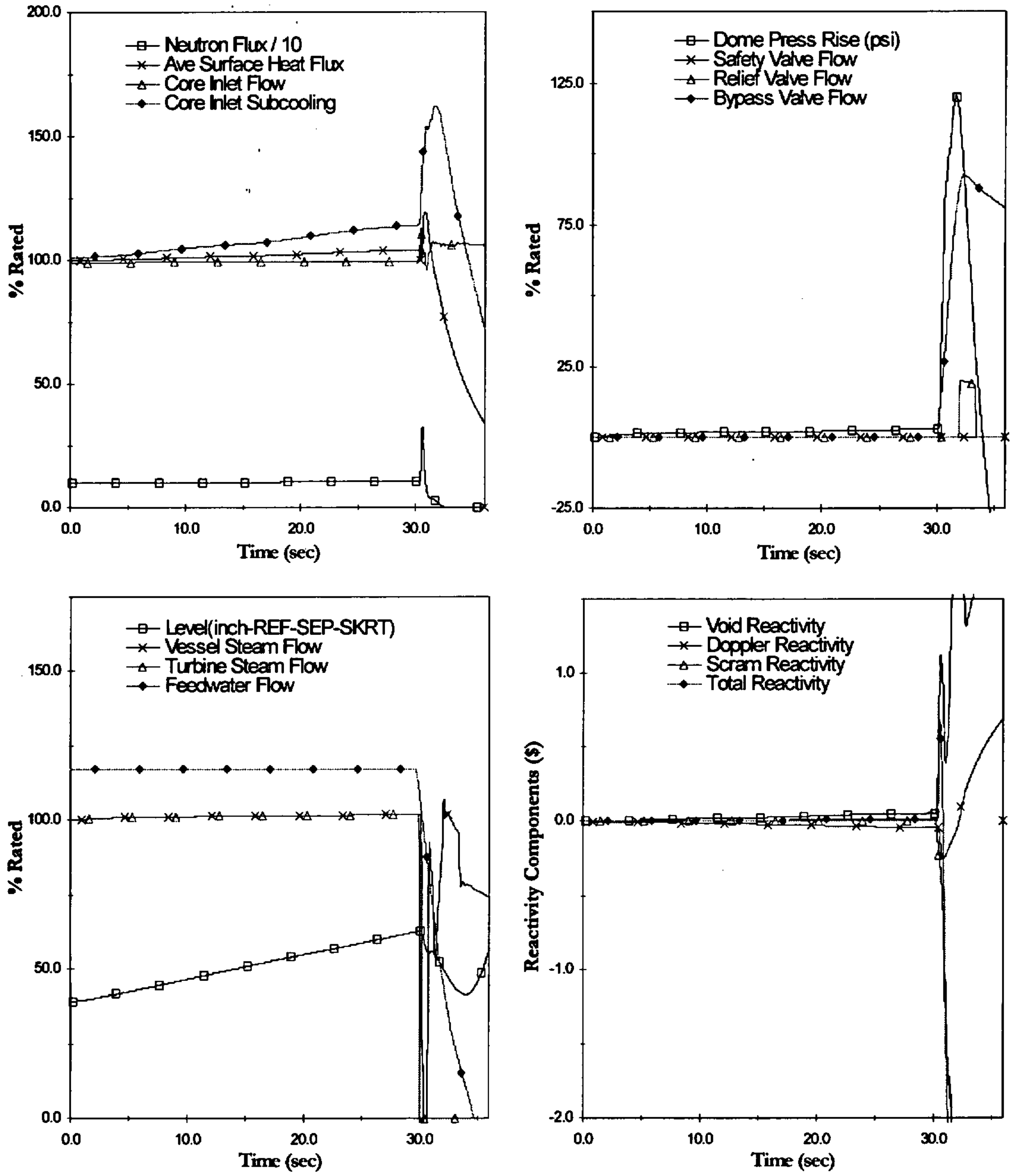

Figure 14 Plant Response to FW Controller Failure
(EOC MELLLA (HBB))

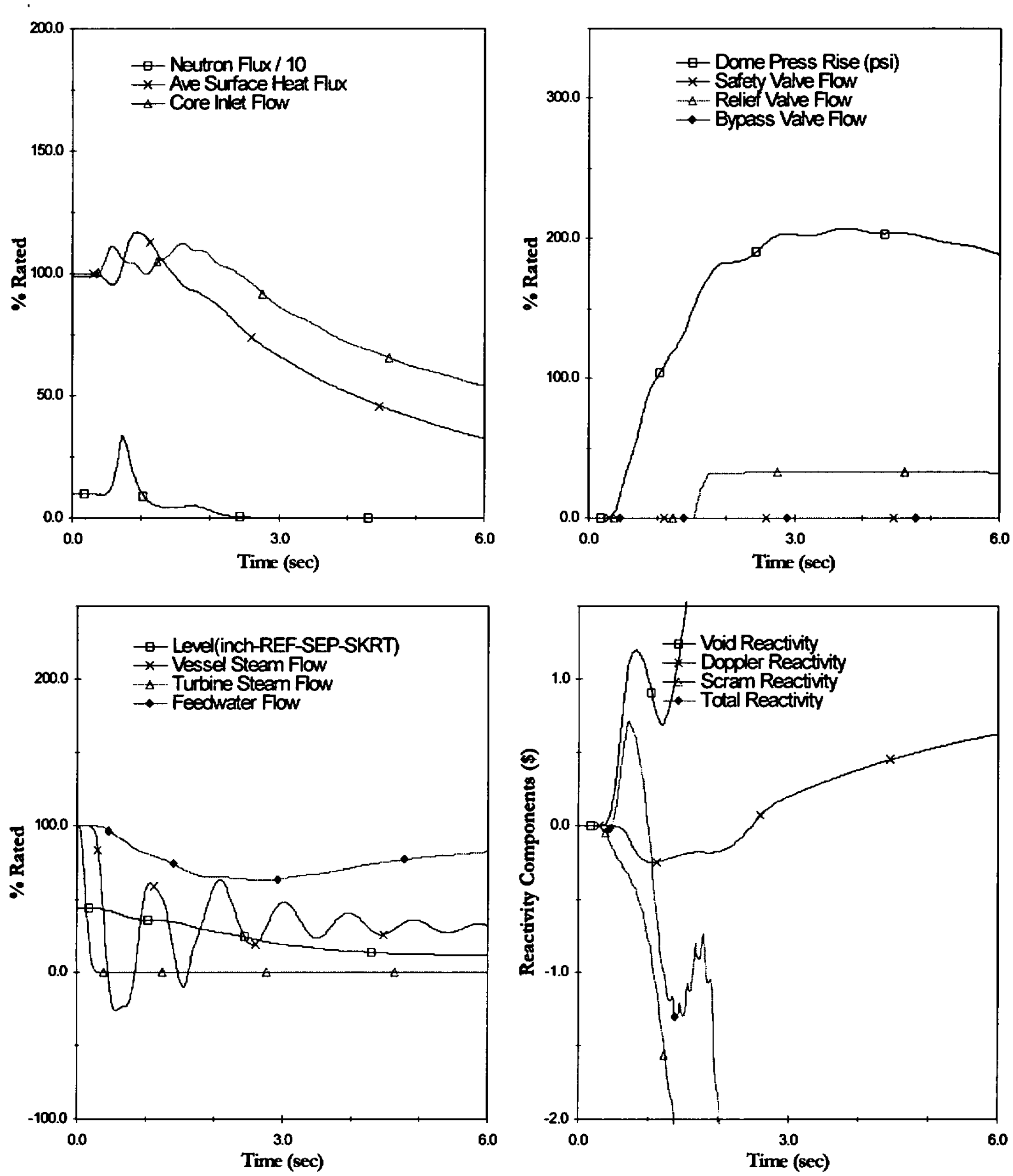

Figure 15 Plant Response to Load Rejection w/o Bypass
(EOC MELLLA (HBB))

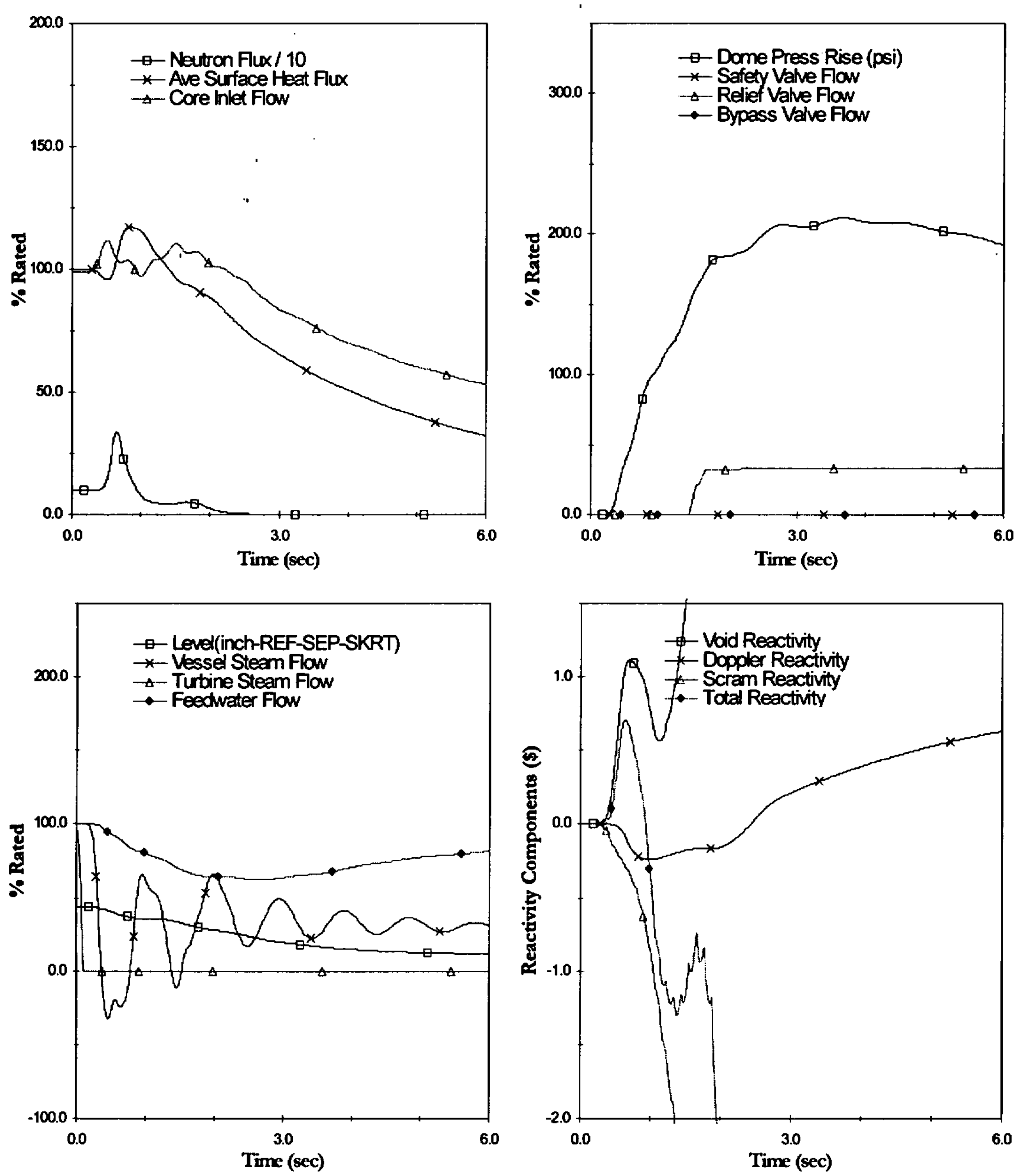

Figure 16 Plant Response to Turbine Trip w/o Bypass
(EOC MELLLA (HBB))

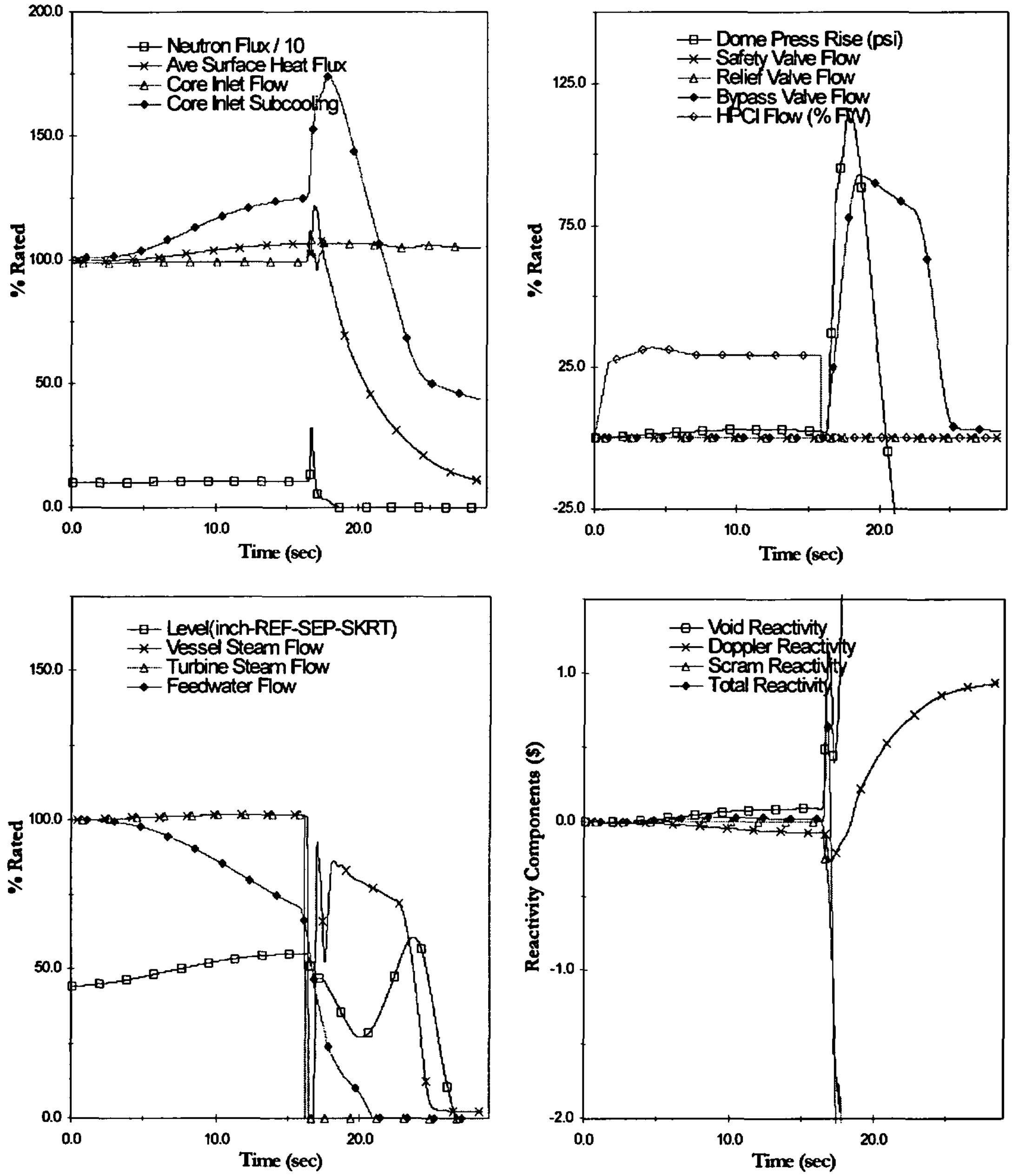

Figure 17 Plant Response to Inadvertent HPCI /L8
(EOC MELLLA (HBB))

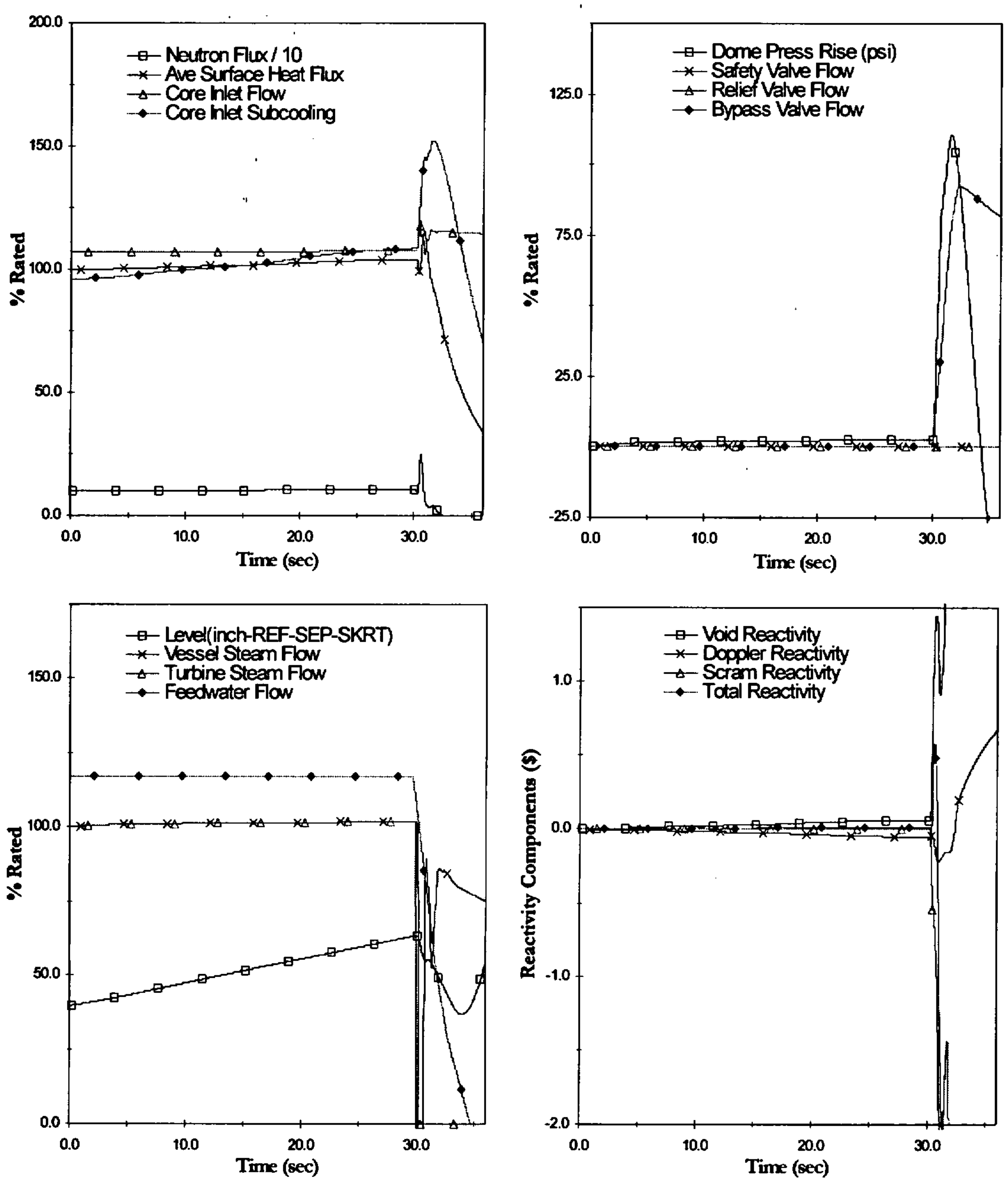

Figure 18 Plant Response to FW Controller Failure
(EOC ICF (UB))

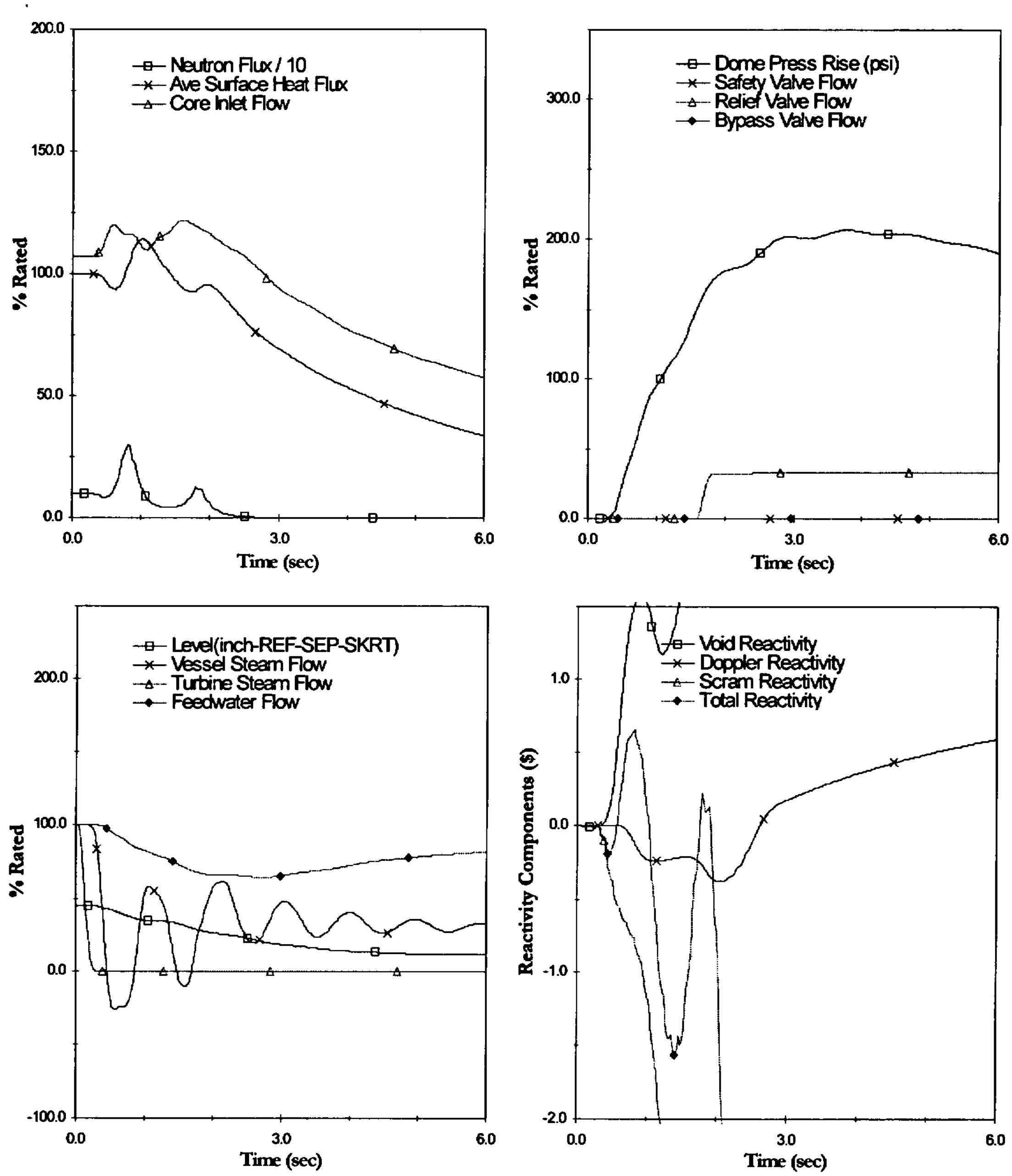

Figure 19 Plant Response to Load Rejection w/o Bypass
(EOC ICF (UB))

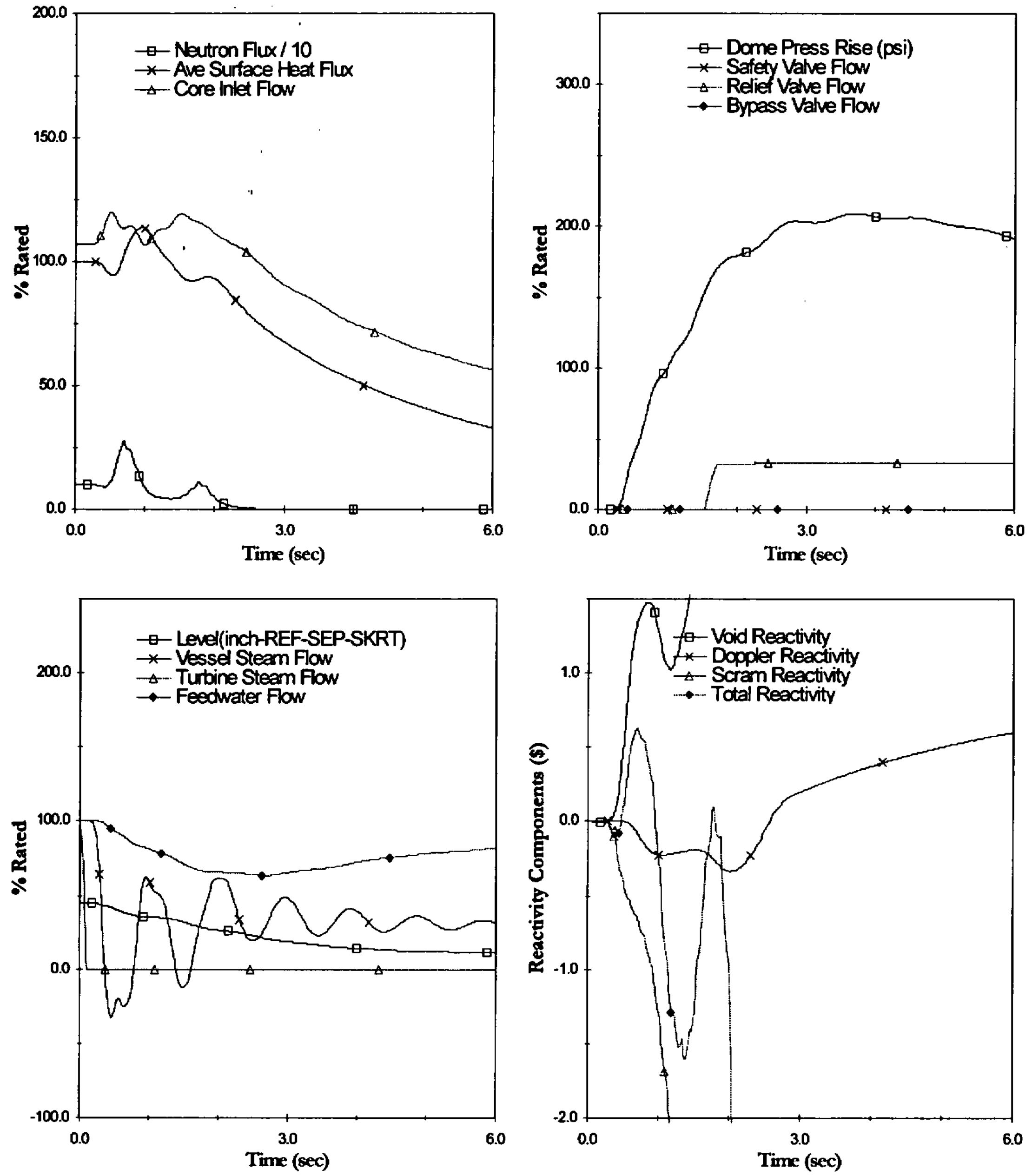

Figure 20 Plant Response to Turbine Trip w/o Bypass
(EOC ICF (UB))

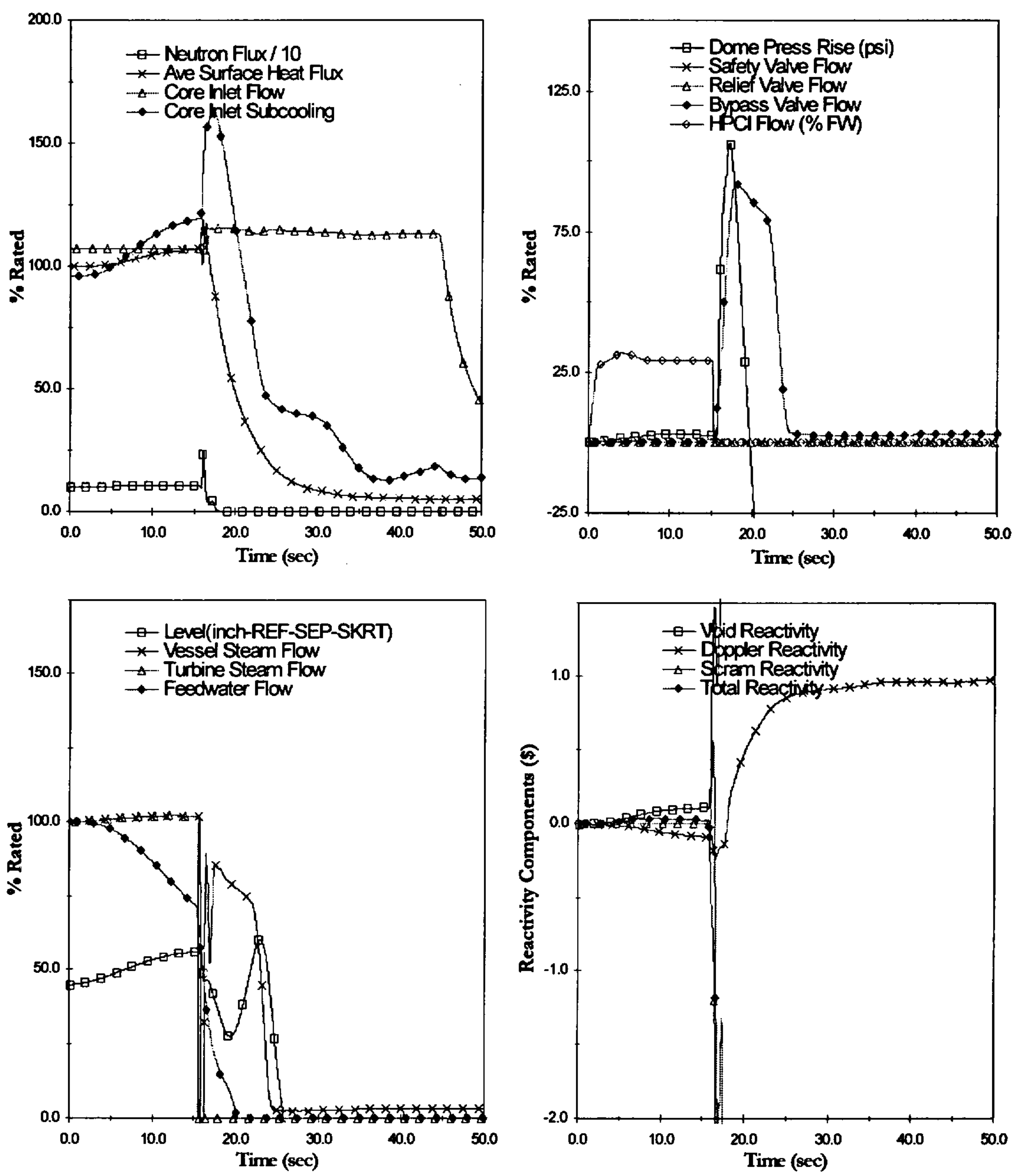

Figure 21 Plant Response to Inadvertent HPCI /L8
(EOC ICF (UB))

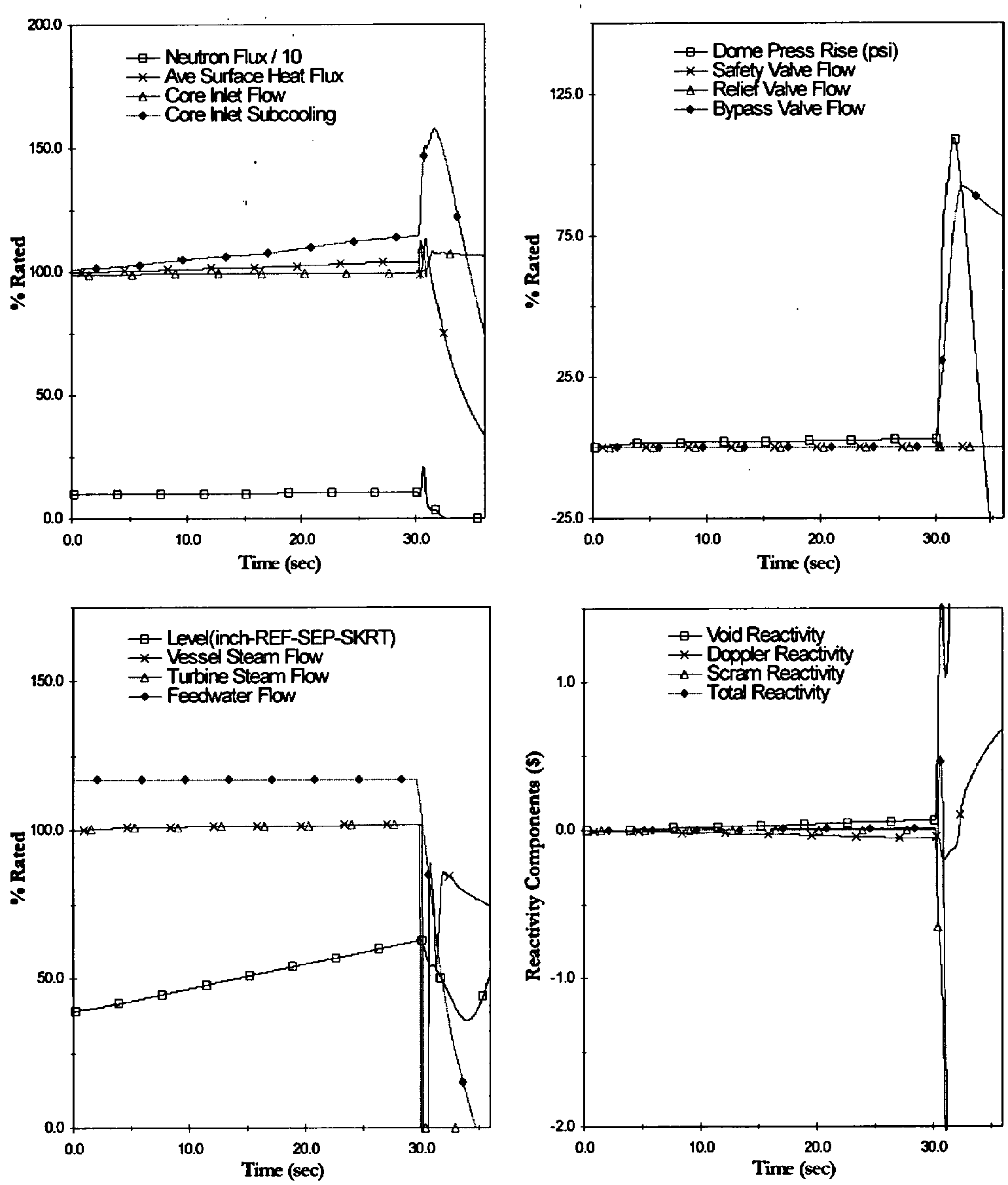

Figure 22 Plant Response to FW Controller Failure
(EOC MELLLA (UB))

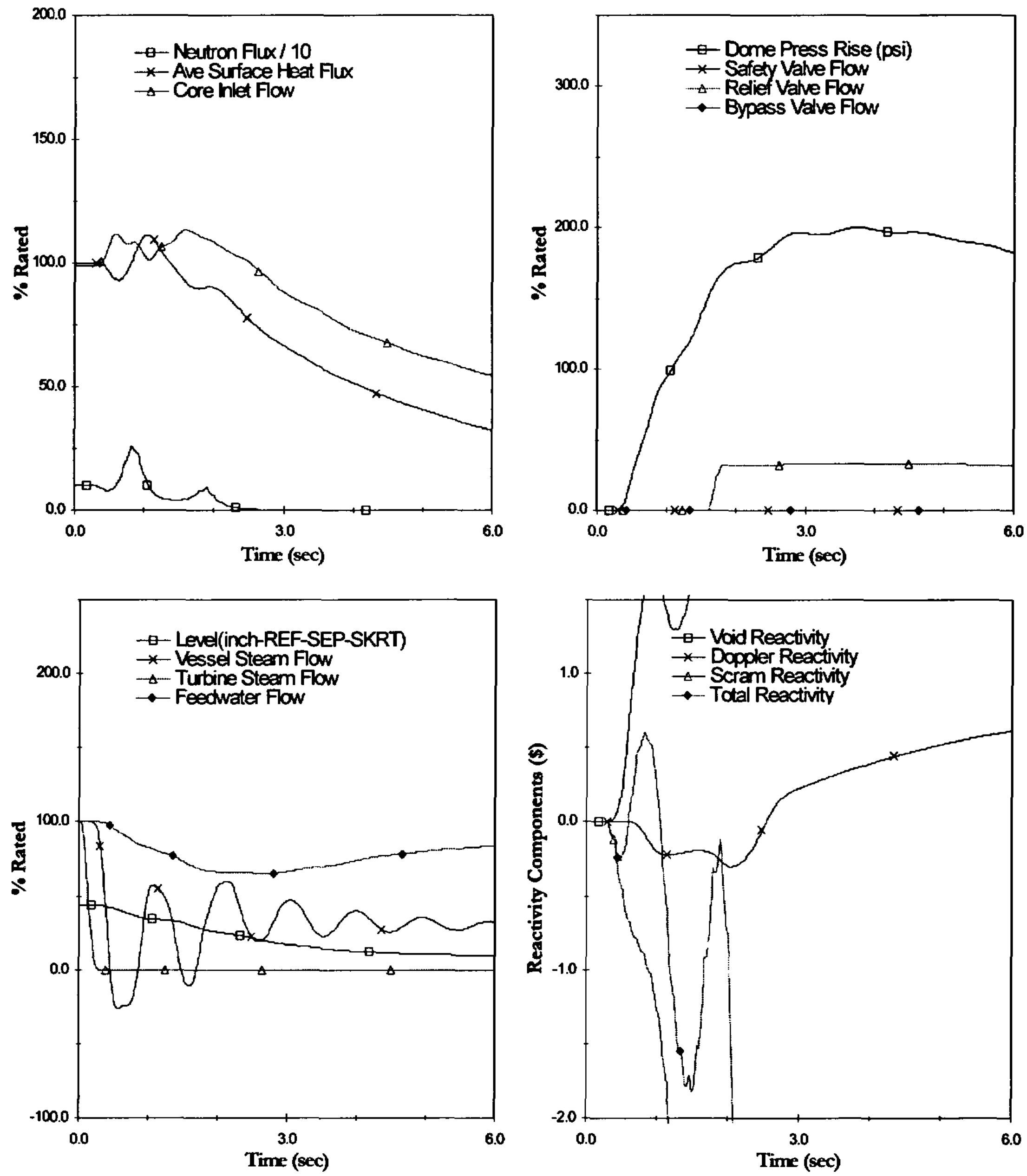

Figure 23 Plant Response to Load Rejection w/o Bypass
(EOC MELLLA (UB))

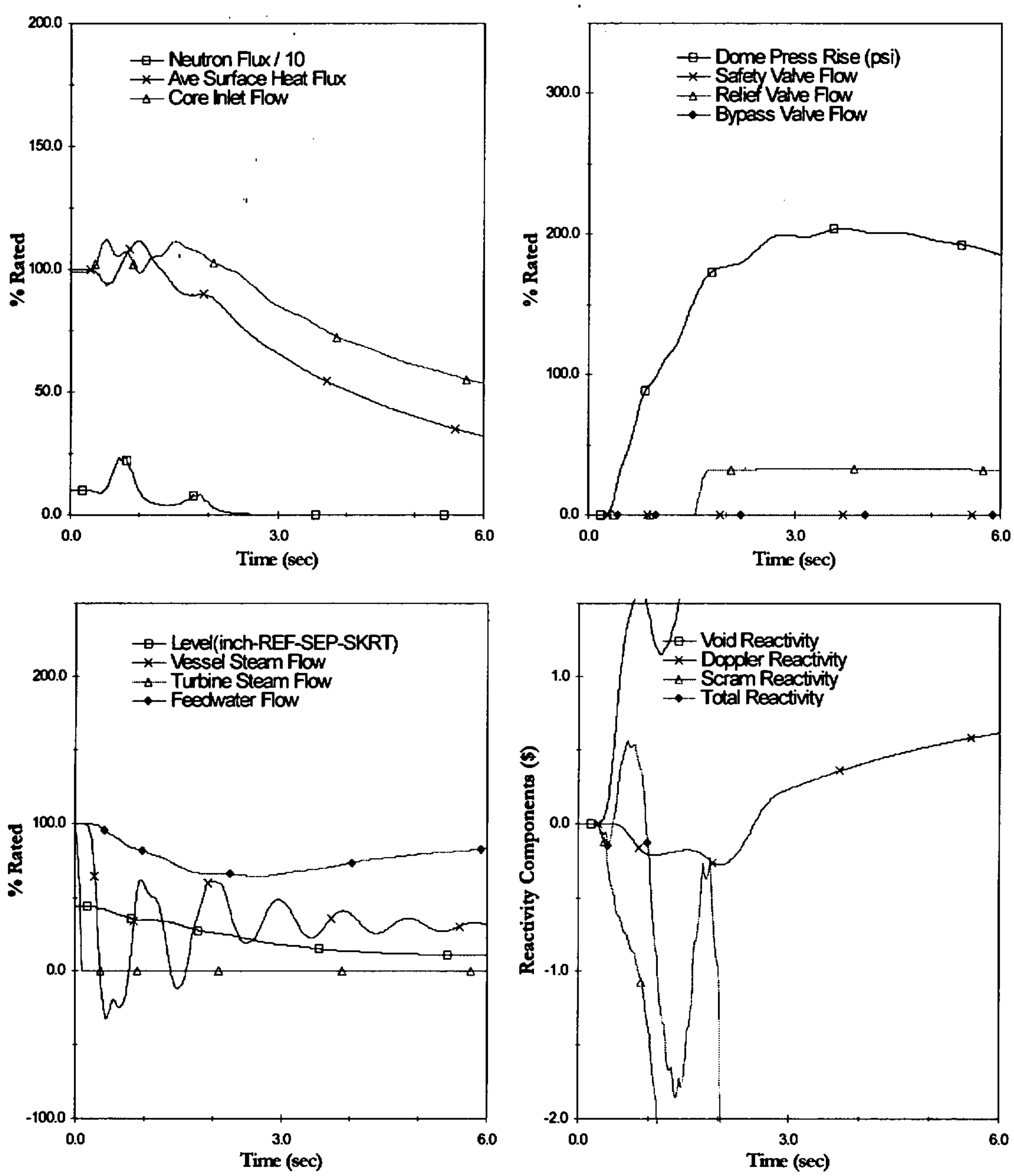

Figure 24 Plant Response to Turbine Trip w/o Bypass
(EOC MELLLA (UB))

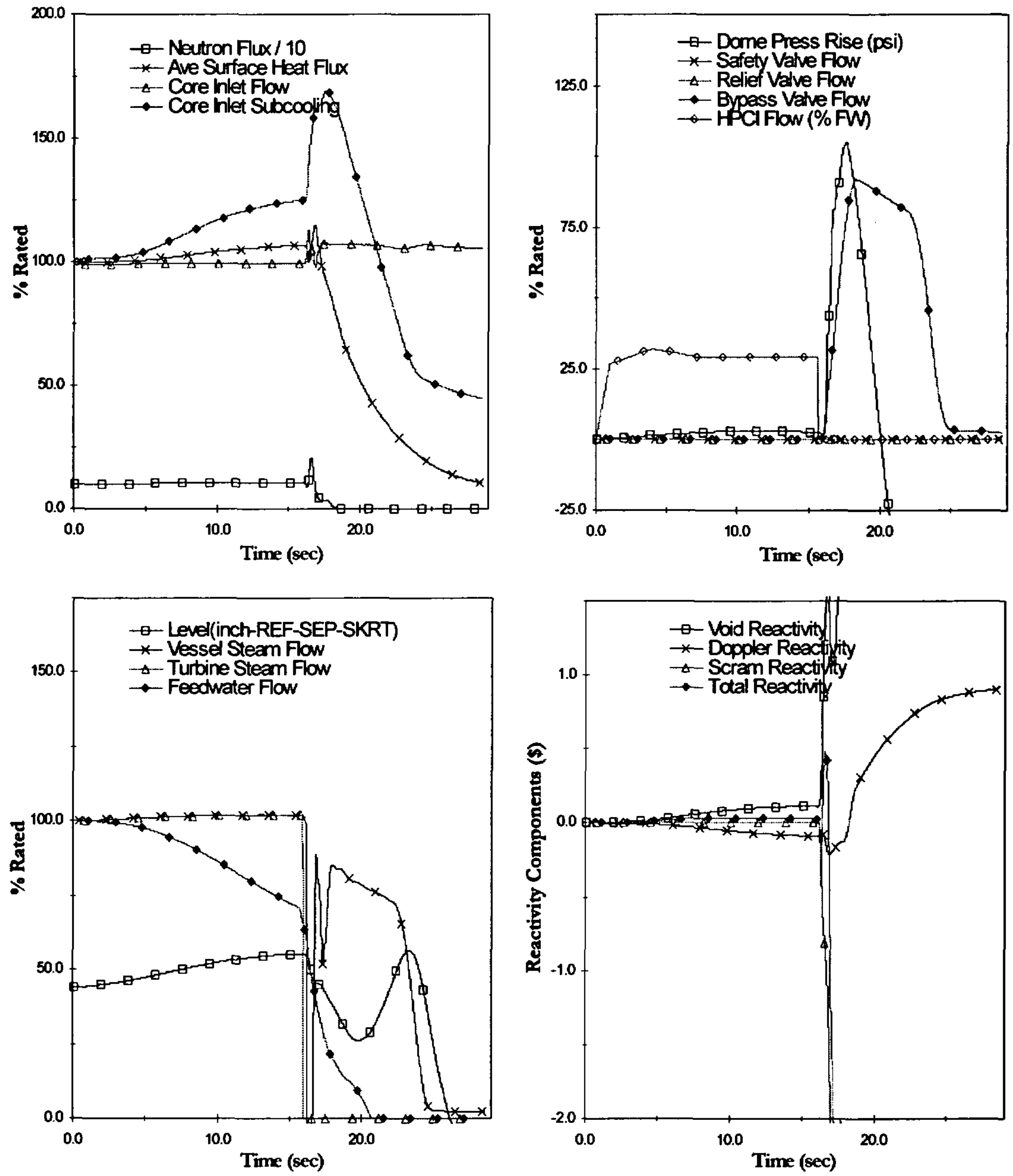

Figure 25 Plant Response to Inadvertent HPCI /L8
(EOC MELLLA (UB))

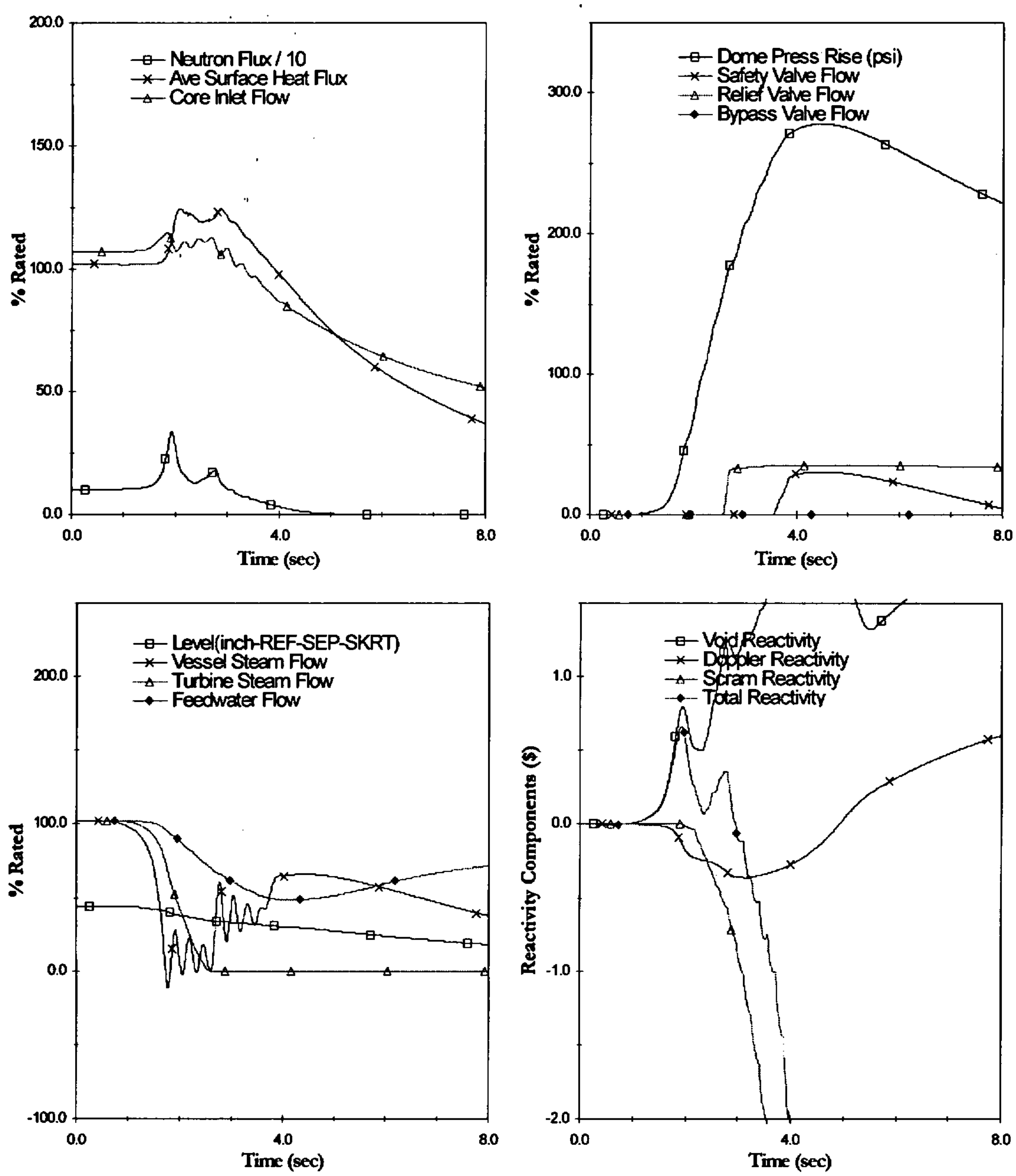

Figure 26 Plant Response to MSIV Closure (Flux Scram) - ICF (HBB)

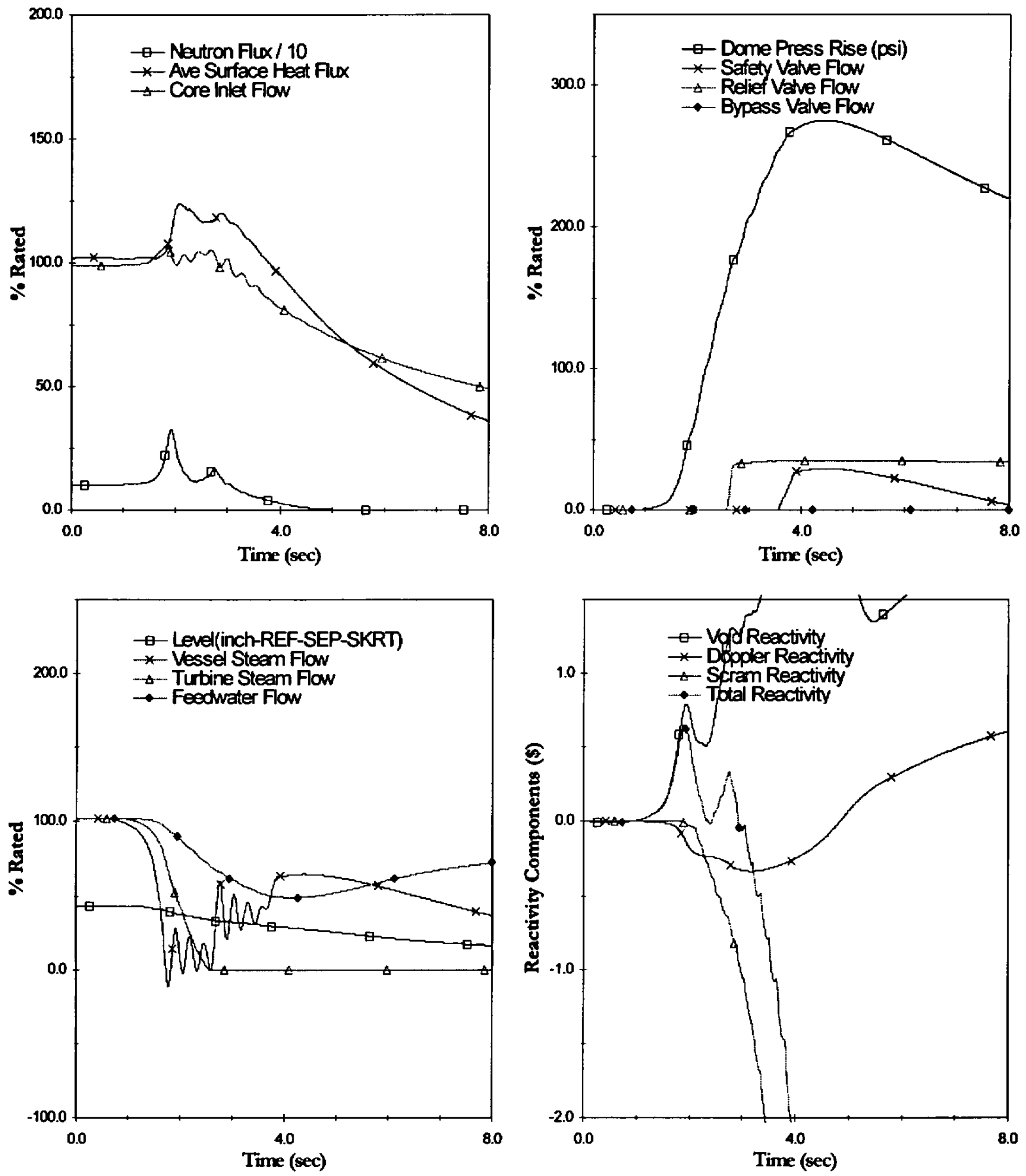

Figure 27 Plant Response to MSIV Closure (Flux Scram) - MELLLA (HBB)

Appendix A
Analysis Conditions

The reactor operating conditions and the pressure relief and safety valve configuration used in the reload licensing analysis for this plant and cycle are presented in Tables A-1 and A-2 below.

Table A-1 Reactor Operating Conditions

Parameter	Analysis Value	
	ICF NFWT	LCF NFWT
Thermal power, MWt	1912.0	1912.0
Core flow, Mlb/hr	51.4	47.5
Reactor pressure (core mid-plane), psia	1041.4	1039.8
Inlet enthalpy, Btu/lb	520.9	518.6
Non-fuel power fraction	0.036	0.036
Steam flow, Mlb/hr	7.92	7.91
Dome pressure, psig	1010.0	1010.0
Turbine pressure, psig	946.4	946.5

Table A-2 Pressure Relief and Safety Valve Configuration

Valve Type	Number of Valves	Lowest Setpoint (psig)
Safety/Relief Valve	4	1113.0
Spring Safety Valve	3	1277.0

Appendix B
Decrease in Core Coolant Temperature Events

The Loss of Feedwater Heating (LFWH) event and Inadvertent High Pressure Coolant Injection (HPCI) Startup event are the only cold water injection AOOs checked on a cycle-by-cycle basis.

The Loss-of-Feedwater Heating event was analyzed at the EPU power level (1912 MWt) 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.

An ODYN analysis has been performed for the inadvertent High Pressure Coolant Injection (HPCI) Startup event as part of the reload licensing analysis. Therefore, inadvertent HPCI calculations assuming a L8 trip were performed. The OLMCPR results are shown in Section 11.

Appendix C
ARTS Power and Flow Operating Limits Adjustments

The Vermont Yankee plant uses the PANAC11 methodology, so it does not have thermal-mechanical MAPLHGR limits. This plant requires the use of LHGRFAC multipliers (power and flow dependent multipliers on LHGR) to ensure that off-rated AOO thermal-mechanical criteria are met. The LHGRFAC multipliers also provide adequate protection for the off-rated LOCA conditions since a constant local peaking factor is used in the LOCA evaluation. Off-rated MAPLHGR multipliers are not required.

The ARTS power and flow dependent operating limits for all operating flexibility options are provided in References C-1, C-2 and C-3. Due to Cycle 25 having no plant specific changes, including no safety limit change from that assumed in Cycle 24, no adjustments were made to the MCPR(p) and MCPR(f) limits curves. Figures C-1 through C-4 provide the power and flow dependent limits for VY Cycle 25 at EPU conditions.

References

C-1 *Vermont Yankee Nuclear Power Station APRM/RBM/Technical Specifications / Maximum Extended Load line Limit Analysis (ARTS/MELLLA),* NEDC-33089P, March 2003.

C-2 *Entergy Nuclear Operations Incorporated Vermont Yankee Nuclear Power Station Extended Power Uprate*, GE-NE-0000-0011-7129-01, Rev. 0, Project Task Report, Task T0900, July 2003.

C-3 *Statistically Based Rod Withdrawal Error Analysis for Vermont Yankee Nuclear Power Station,* GE-NE-0000-0016-3451-R0, July 2003.

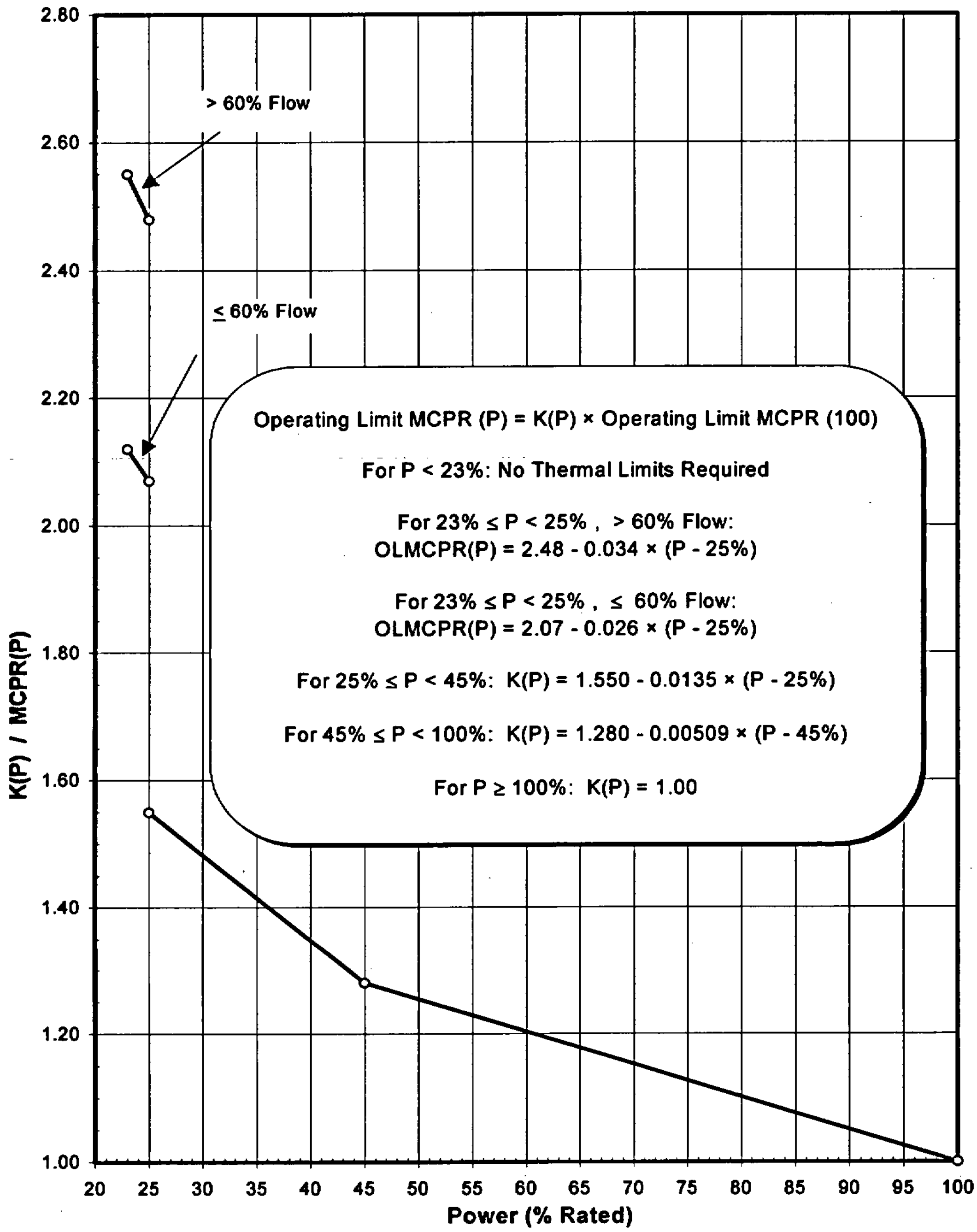

Figure C-1 Power Dependent K(P) / MCPR(P) Limits For EPU

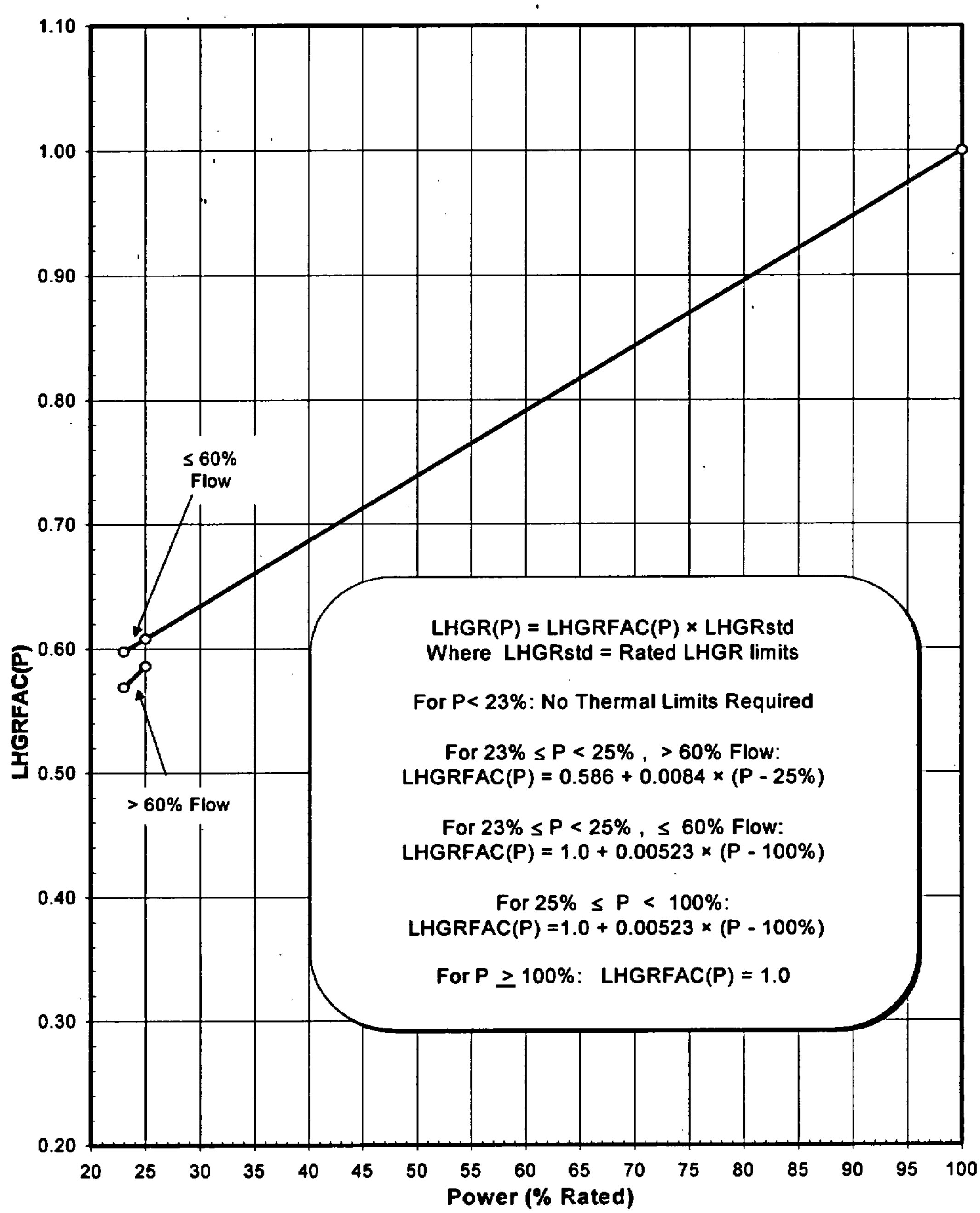

Figure C-2 Power Dependent LHGRFAC(P) Multiplier for EPU

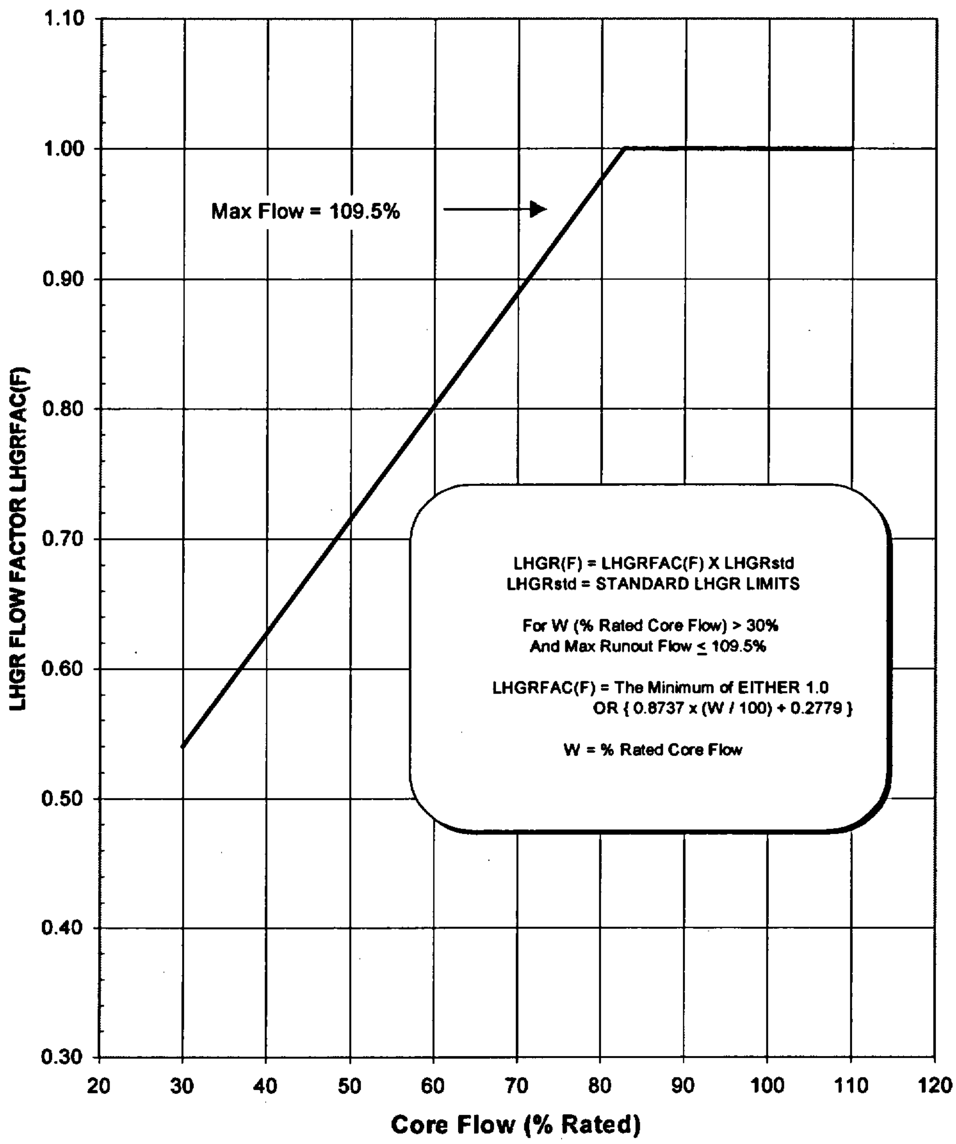

Figure C-3 LHGR Flow Factor LHGRFAC(F) for EPU

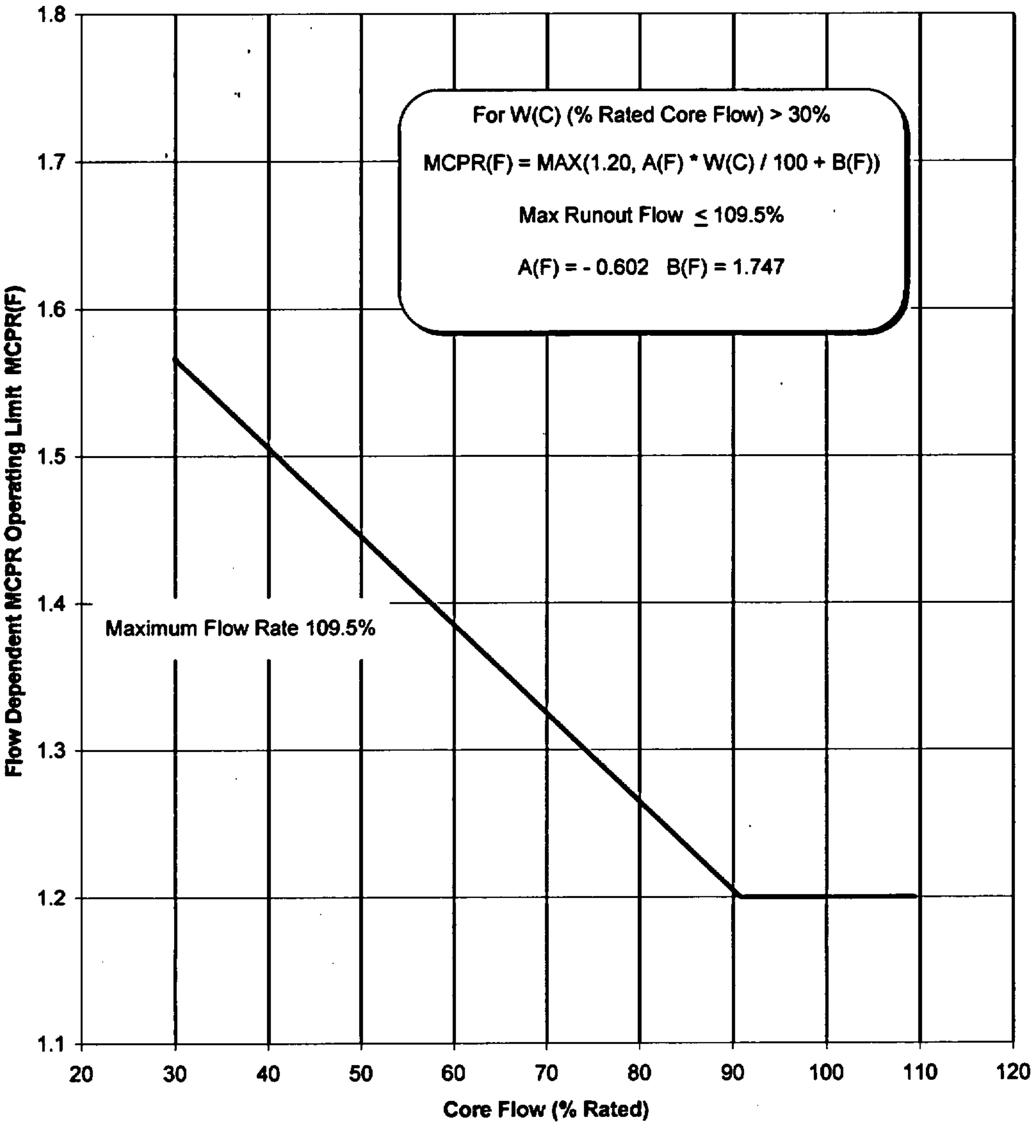

Figure C-4 Flow Dependent MCPR Operating Limit MCPR(F) for EPU

Appendix D
Implementation of Extended Power Uprate (EPU)

To provide the Vermont Yankee Nuclear Power Station (VYNPS) with operating improvements, analyses were performed to increase the rated power from 1593 MWt to 1912 MWt. Reference D-1 provides the basis for operation of VYNPS at Extended Power Uprate (EPU), i. e., 1912 MWt conditions. The required OLMCPRs are provided in Section 11.

References

D-1 *Safety Analysis Report for Vermont Yankee Nuclear Power Station Constant Pressure Power Uprate*, NEDC-33090P, Rev. 0, September 2003.

Appendix E
Stability Solution Option 1-D Exclusion and Buffer Regions at EPU Condition

The stability Option I-D Exclusion Region and Buffer Region were calculated for Vermont Yankee Cycle 25 operation at the EPU (Extended Power Uprate) conditions. The endpoints of the regions are defined in Table E-1. The region boundaries are defined using the Generic Shape Function (GSF), Equation E-1. The regions are shown on the Vermont Yankee Cycle 25 power/flow map in Figure E-1. These regions are valid up to an end of cycle exposure of 13,930 MWd/ST.

Table E-1: Exclusion and Buffer Region Endpoints[1]

Exclusion Region	Power (% rated)[2]	Flow (% rated)[3]
A	66.26	52.25
B	35.69	31.27
Buffer Region	**Power (% rated)[2]**	**Flow (% rated)[3]**
A	70.10	57.25
B	30.69	31.17

1. Point "A" is on the High Flow Control Line (HFCL) and point "B" is on the Natural Circulation Line (NCL). For Vermont Yankee Cycle 25, the HFCL is the Maximum Extended Load Line Limit Analysis (MELLLA) boundary.

2. Rated core power is 1912 MWt.

3. Rated core flow is 48 Mlb/hr.

Equation E-1: Generic Shape Function

$$P = P_B\left(\frac{P_A}{P_B}\right)^{\frac{1}{2}\left[\frac{W-W_B}{W_A-W_B}+\left(\frac{W-W_B}{W_A-W_B}\right)^2\right]}$$

where,
P = a core thermal power value on the region boundary (% of rated),
W = the core flow rate corresponding to power, P, on the region boundary (% of rated),

P_A = core thermal power at point A (% of rated),
P_B = core thermal power at point B (% of rated),
W_A = core flow rate at point A (% of rated), and
W_B = core flow rate at point B (% of rated).

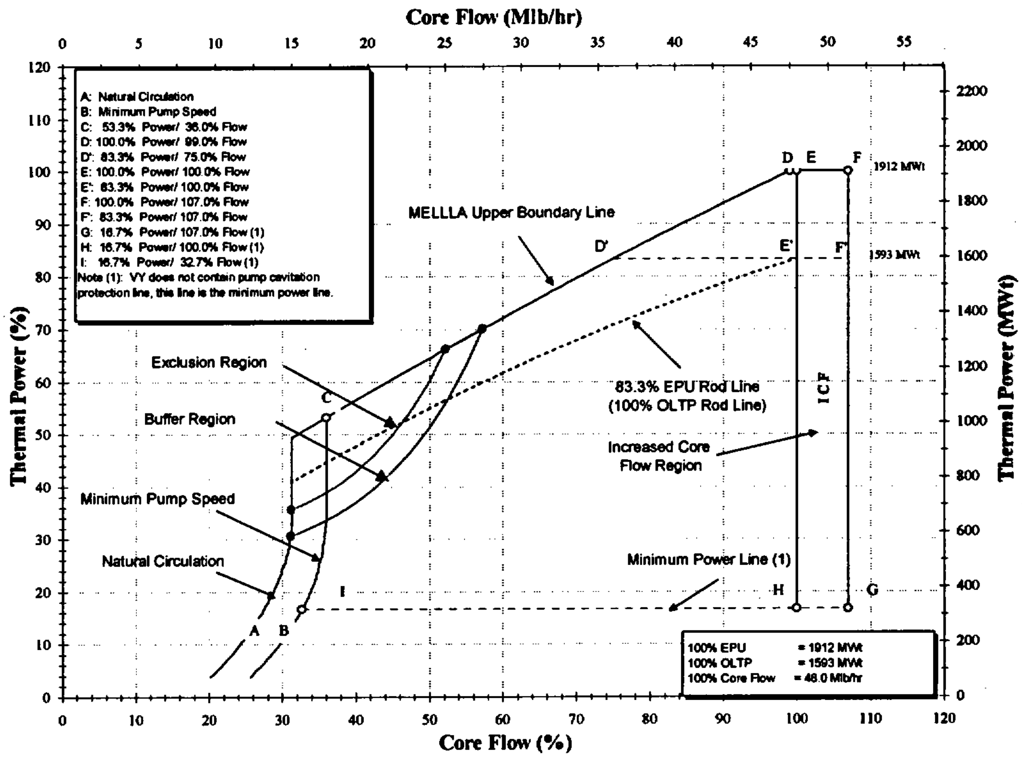

Figure E-1: Exclusion and Buffer Regions on the EPU Power/Flow Map

Appendix F
List of Acronyms

Acronym	Description
ΔCPR	Delta Critical Power Ratio
Δk	Delta k-effective
2RPT	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
Btu	British thermal unit
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
DS/RV	Dual Mode Safety/Relief Valve
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 / NFWT)
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
GESTAR	General Electric Standard Application for Reactor Fuel
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
HPCI	High Pressure Coolant Injection

Acronym	Description
ICA	Interim Corrective Action
ICF	Increased Core Flow
IMCPR	Initial MCPR
IVM	Initial Validation Matrix
L8	Turbine Trip on high water level (Level 8)
LCF	Low Core Flow
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
RCF	Rated Core Flow

Acronym	Description
RFWT	Reduced Feedwater Temperature
RPS	Reactor Protection System
RPT	Recirculation Pump Trip
RPTOOS	Recirculation Pump Trip Out of Service
RV	Relief Valve
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
S/RV	Safety/Relief Valve
SRVOOS	Safety/Relief Valve(s) Out of Service
SS	Steady State
SSV	Spring Safety Valve
STU	Short Tons (or Standard Tons) of Uranium
TBV	Turbine Bypass Valve
TBVOOS	Turbine Bypass Valves Out of Service
TCV	Turbine Control Valve
TCVOOS	Turbine Control Valve Out of Service
TCVSC	Turbine Control Valve Slow Closure
TLO	Two Loop Operation
TRF	Trip Reference Function
TSIP	Technical Specifications Improvement Program
TTHBP	Turbine Trip with Half Bypass
TTNBP	Turbine Trip without Bypass
UB	Under Burn