Attachment 4

LR-N05-0330
LCR H05-01

0000-0031-9433-MCAR, Rev. 0
Mixed Core Analysis Report (MCAR) for Hope Creek Extended Power Uprate

GNF
Global Nuclear Fuel
A Joint Venture of GE, Toshiba, & Hitachi

0000-0031-9433-MCAR
Revision 0
April 2005

0000-0031-9433-MCAR, Rev. 0

Mixed Core Analysis Report (MCAR)
for
Hope Creek
Extended Power Uprate

Approved: M. E. Harding
M. E. Harding, Manager
Fuel Engineering Services

Approved: Rick Kingston
R. E. Kingston
Customer Account Leader

Proprietary Information Notice

This document is the GNF non-proprietary version of the GNF proprietary report. From the GNF proprietary version, the information denoted as GNF proprietary (enclosed in double brackets) was deleted to generate this version.

Important Notice Regarding Contents of This Report

Please Read Carefully

This report was prepared by Global Nuclear Fuel - Americas, LLC (GNF-A) solely for PSEG Nuclear, LLC. The information contained in this report is believed by GNF-A to be an accurate and true representation of the facts known, obtained or provided to GNF-A at the time this report was prepared.

The only undertakings of GNF-A respecting information in this document are contained in the Contract between PSEG Nuclear, LLC, Global Nuclear Fuel - Americas, LLC and General Electric Company for Fuel Fabrication and Related Components and Services for Hope Creek Generating Station, 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 GNF-A 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.

Table of Contents

1.0 Introduction and Summary **1**
- 1.1 REFERENCES 2

2.0 Lattice Physics Comparison **3**
- 2.1 REFERENCES 3

3.0 CPPU Base Point Determination **4**
- 3.1 CYCLE 13 SIMULATION 4
- 3.2 REFERENCES 4

4.0 Fuel Rod Thermal-Mechanical Compliance **7**
- 4.1 LIMITING THERMAL AND MECHANICAL OVERPOWERS AT OFF-RATED CONDITIONS 7
- 4.2 REFERENCES 10

5.0 GE14 / SVEA 96+ Demonstration Cycle Analysis Description at the CPPU Condition **13**
- 5.1 RELOAD BUNDLE DESIGN DESCRIPTION 13
- 5.2 CPPU CORE DESIGN DESCRIPTION 14
  - *5.2.1 Core Configuration Description* *14*
  - *5.2.2 Design Limits and Targets* *14*
- 5.3 CPPU PERFORMANCE SUMMARY 15
- 5.4 REFERENCES 15

6.0 Safety Limit Minimum Critical Power Ratio (SLMCPR) **35**
- 6.1 DISCUSSION 35
- 6.2 SUMMARY 37
- 6.3 REFERENCES 37

7.0 Supplemental Reload Licensing Report (SRLR) at CPPU Condition **42**

List Of Tables

TABLE 4.1 – THERMAL OVERPOWER SUMMARY FOR AOO'S 11
TABLE 4.2 – MECHANICAL OVERPOWER SUMMARY FOR AOO'S 12
TABLE 5.1 - CORE DESIGN LIMITS 16
TABLE 5.2 - CORE DESIGN MARGIN TARGETS 16
TABLE 5.3 - CPPU RLP SUMMARY OF ROD PATTERN RESULTS 17
TABLE 5.4 - CPPU RLP HOT EXCESS REACTIVITY 18
TABLE 5.5 - CPPU RLP COLD SHUTDOWN REACTIVITY MARGIN 19
TABLE 5.6 - CPPU RLP STANDBY LIQUID CONTROL SHUTDOWN MARGIN 20
TABLE 6.1 - COMPARISON OF THE HOPE CREEK GENERATING STATION CPPU AND CYCLE 13 SLMCPR 38
TABLE 6.2 - STANDARD UNCERTAINTIES 39
TABLE 6.3 - EXCEPTIONS TO THE STANDARD UNCERTAINTIES USED IN HOPE CREEK CPPU AND CYCLE 13 39

List Of Figures

FIGURE 3.1 – HOT CRITICAL EIGENVALUE TRENDS 5
FIGURE 3.2 - COLD CRITICAL EIGENVALUE TRENDS 5
FIGURE 3.3 - CYCLE 13 RLP ROD PATTERN THERMAL DESIGN RATIO RESULTS 6
FIGURE 5.1 - FRESH GE14 RELOAD BUNDLE 2830 CONFIGURATION 22
FIGURE 5.2 - CPPU CORE LOADING (QUARTER CORE) 23
FIGURE 5.3 - CPPU REFERENCE LOADING PATTERN CONTROL ROD OPERATING SEQUENCE 24
FIGURE 5.4 - CPPU RLP ROD PATTERN THERMAL DESIGN RATIO RESULTS 33
FIGURE 5.5 - CPPU RLP HOT EXCESS REACTIVITY 33
FIGURE 5.6 - CPPU RLP COLD SHUTDOWN MARGIN 34
FIGURE 5.7 - CPPU RLP STANDBY LIQUID CONTROL SYSTEM SHUTDOWN MARGIN 34
FIGURE 6.1 – CCPU REFERENCE CORE LOADING PATTERN 40
FIGURE 6.2 - REFERENCE CORE LOADING PATTERN – CYCLE 13 41

PSEG Hope Creek
Mixed Core Analysis Report

1.0 Introduction and Summary

The implementation of a new fuel design for a General Electric (GE) Boiling Water Reactor (BWR) follows a two-step process. First, the new fuel design is submitted to and approved by the Nuclear Regulatory Commission (NRC) [[{3}]] via the GESTAR II Amendment 22 process. Then, plant-specific analyses are performed to justify use of the new fuel design in an upcoming plant reload. The [[{3}]] analyses consist of one-time [[{3}]] analyses and [[{3}]] analyses.

This report summarizes the results of the [[{3}]] analyses and evaluations for the HCGS Constant Pressure Power Uprate (CPPU) mixed core of GE14 and SVEA 96+ fuel. HCGS will be loading GE14 fuel at a CPPU condition of 115% of the Current Licensed Thermal Power (CLTP), i.e., CPPU Rated Thermal Power (RTP) of 3840 MWt. The CPPU mixed core described in this report consists of approximately 50% GE14 and 50% SVEA 96+ fuel. The [[{3}]] analyses are documented in the plant and cycle unique Supplemental Reload Licensing Report (SRLR), which is included in this report as Section 7.0. The following information is provided in the SRLR:

- Plant-unique Items
- Reload Fuel Bundles
- Reference Core Loading Pattern
- Calculated Core Effective Multiplication and Control System Worth
- Standby Liquid Control System Shutdown Capability
- Reload Unique GETAB Anticipated Operational Occurrences (AOO) Analysis Initial Condition Parameters
- Selected Margin Improvement Options
- Operating Flexibility Options
- Core-wide AOO Analysis Results
- Local Rod Withdrawal Error AOO Summary
- Cycle MCPR Values
- Overpressurization Analysis Summary
- Loading Error Results
- Control Rod Drop Analysis
- Stability Analysis Results
- Loss-of-Coolant Accident Results

In addition to the SRLR, this report also presents the following information that supports the analyses:

- CPPU Base Point Determination
- Fuel Rod Thermal Mechanical Performance Summary for GE14 and SVEA 96+ at CPPU conditions
- CPPU Mixed Core Reload Bundle Design, Core Design and Performance Summary
- CPPU Safety Limit Minimum Critical Power Ratio Summary

The Mixed Core Analysis Report for Hope Creek Reload 12 Cycle 13[3] included a lattice physics comparison section and a benchmark of previous operating cycles section. These sections are not being repeated in this report; however, the codes and methods topic will be addressed in a codes and methods supplement of this report.

[[(3)]] analyses have been performed and documented in the Fuel Transition Report for Hope Creek Generating Station.[1,2]

The fuel rod thermal-mechanical performance limits for SVEA-96+ and GE14 have been established and are applicable for CPPU RTP operation. The results of the fuel rod thermal-mechanical Anticipated Operational Occurrence evaluations for CPPU RTP are acceptable and demonstrate that compliance with fuel rod thermal-mechanical design and licensing limits will be maintained for CPPU RTP operation.

The CPPU mixed core reload bundle and core design has been completed. As indicated by the performance summary, all core operating and design margins have been dispositioned to be acceptable based on the CPPU reload bundle and core design.

The CPPU SLMCPR calculations, including a comparison to the SLMCPR calculated for Cycle 13 using GNF methods, have been completed. The calculated CPPU SLMCPR values of 1.07 for dual loop operation and 1.09 for single loop operation are appropriate for the Hope Creek CPPU mixed core.

The results presented in the SRLR have been determined using NRC approved methods in accordance with the basis provided in *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. The results of the analyses and evaluations contained in the SRLR support the conclusion that HCGS can safely load and operate using GE14 fuel with SVEA 96+ fuel in the CPPU condition.

1.1 References

1. *Fuel Transition Report For Hope Creek Generating Station*, NEDC-33158P, Revision 4, March 2005.
2. *Fuel Transition Report For Hope Creek Generating Station Supplement 1*, NEDC-33158P, Revision 0, March 2005.
3. *Mixed Core Analysis Report (MCAR) for Hope Creek Reload 12 Cycle 13*, 0000-0029-7705-MCAR, Revision 0, April 2005.

2.0 Lattice Physics Comparison

The Mixed Core Analysis Report for Hope Creek Reload 12 Cycle 13[1] included a lattice physics comparison section. This section is not being repeated in this report; however, the codes and methods topic will be addressed in a codes and methods supplement of this report.

2.1 References

1. *Mixed Core Analysis Report (MCAR) for Hope Creek Reload 12 Cycle 13*, 0000-0029-7705-MCAR, Revision 0, April 2005.

3.0 CPPU Base Point Determination

The operating history of the Hope Creek reactor is tracked by the 3D simulator (PANAC11). The results of this tracking are used to determine appropriate hot and cold eigenvalues for core design work as well as to evaluate thermal margin biases, which may exist between the simulator and the process computer. The tracking simulations also provide the base point (starting point) for core design work for the CPPU cycle. Benchmark comparisons from the previous cycles were reported in Section 3 of the Mixed Core Analysis Report for Cycle 13[1] and are not repeated here; however, the benchmark comparisons are still applicable for the selection of the CPPU base point.

3.1 Cycle 13 Simulation

This section contains several figures summarizing the results for the current operating cycle, Cycle 13, which is the first loading of GE14 fuel. Figures 3.1 and 3.2 summarize the hot and cold design basis eigenvalues for Cycle 13 and CPPU.

The hot eigenvalue selected as Cycle 13 design basis is based on a combination of the data for previous cycles at Hope Creek as well as GNF's methods experience with similar size and power BWRs. The eigenvalue data for previous cycles is well behaved and relatively tightly packed. GNF would expect the eigenvalue to behave as shown by the "GE14 Equilibrium" curve as the fraction of GE14 fuel is increased in future cycles.

The cold eigenvalue selected as the Cycle 13 and CPPU design bases are again based on a combination of cold critical measurements in the previous cycles as well as GNF's method experience with its BWR fleet. Generally the cold eigenvalue basis is selected to conservatively bound the measured data rather than fit through the data as with the hot eigenvalue.

Figure 3.3 shows the simulation of MFLCPR, MFLPD, and MAPRAT for Cycle 13. Table 5.2 shows the design basis margin for these thermal limits.

3.2 References

1. *Mixed Core Analysis Report (MCAR) for Hope Creek Reload 12 Cycle 13*, 0000-0029-7705-MCAR, Revision 0, April 2005.

[[

$^{\{3\}}$]]

Figure 3.1 – Hot Critical Eigenvalue Trends

[[

$^{\{3\}}$]]

Figure 3.2 - Cold Critical Eigenvalue Trends

[[

{3}]]

Figure 3.3 - Cycle 13 RLP Rod Pattern Thermal Design Ratio Results

4.0 Fuel Rod Thermal-Mechanical Compliance

The fuel rod thermal-mechanical performance limits for the SVEA 96+ and GE14C fuel designs for application in the Hope Creek Generating Station were established in the Cycle 13 MCAR[1]. The fuel rod thermal-mechanical performance limits established in Reference [1] are applicable to CPPU RTP operation at HCGS with one addition. HCGS has implemented the ARTS/MELLLA bases as a prerequisite of the CPPU. Consequently, the ARTS based off-rated LHGR or MAPLHGR limits have been incorporated into HCGS's design and licensing basis (off-rated limits required to replace the APRM trip setdown requirement which was deleted as part of licensing and implementation of ARTS/MELLLA at HCGS[2]). Therefore, Section 4.1 defines the limiting thermal and mechanical overpowers at off-rated conditions based on the ARTS off-rated limits.

The reference loading pattern (RLP) of the CPPU demonstration cycle shown in Section 5 must meet the criteria specified in Section 4.1 and in Reference [1]. Tables 4.1 and 4.2 provide a summary of overpower results based on the CPPU mixed core of SVEA 96+ and GE14 at CPPU RTP conditions including a comparison to the Cycle 13 mixed core results at CLTP. All acceptance criteria are met and compliance with the fuel rod thermal-mechanical design and licensing limits is ensured.

4.1 Limiting Thermal and Mechanical Overpowers at Off-Rated Conditions

The method for determining thermal and mechanical overpowers defined in Section 4.2.2 of Reference [1] and the limits defined in Tables 4.4, 4.5, 4.6 and 4.7 of Reference [1] apply to evaluations of rated events. For off-rated events, the same basic limits apply, i.e., the fuel shall not experience fuel centerline melting and the cladding plastic strain during the event shall not exceed 1%. For the ARTS/MELLLA bases, these criteria are met by limiting the initial steady-state power from which the off-rated event can be initiated. With the removal of the APRM trip setdown requirement, steady-state operating limits for off-rated conditions are defined through the use of a reduction factor applied to the rated power fuel thermal-mechanical limits. These reduction factors are presented as a function of reactor power and flow. If the plant fuel thermal-mechanical bases are protected with the MAPLHGR, then the $MAPFAC_P$ and $MAPFAC_F$ reduction factors are used. If the plant fuel thermal-mechanical bases are protected with the LHGR, then $LHGRFAC_P$ and $LHGRFAC_F$ reduction factors are used. The resulting $MAPLHGR_P/MAPLHGR_F$ or $LHGR_P/LHGR_F$ limits are set such that an AOO initiated from the off-rated condition will not result in fuel melt or 1% cladding plastic strain.

The following expressions and definitions for determining the reduction factors assume protection is provided by the MAPLHGR. If the fuel thermal-mechanical basis is protected by the LHGR, the expressions and definitions are the same substituting $LHGRFAC_P$ and $LHGRFAC_F$ for $MAPFAC_P$ and $MAPFAC_F$, respectively.

The thermal and mechanical overpowers for the events are defined in Section 4.2.2 of Reference [1]. The required thermal and mechanical MAPLHGR reduction factors are then determined from:

For $P>P_{BYP}$ versus power:

$$\mathrm{MAPFAC}_P^{Th} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_P^{Th}+100}\right] \tag{4.1}$$

$$\mathrm{MAPFAC}_P^{Me} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Me}}{OP_P^{Me}}\right] \tag{4.2}$$

For $P>P_{BYP}$ versus flow:

$$\mathrm{MAPFAC}_F^{Th} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_F^{Th}+100}\right] \tag{4.3}$$

$$\mathrm{MAPFAC}_F^{Me} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Me}}{OP_F^{Me}}\right] \tag{4.4}$$

where:

P_{BYP} = The reactor power level below which the turbine stop valve position scram is bypassed.

MAPFAC_P^{Th} = The MAPLHGR reduction factor versus power due to thermal overpower during the event for a particular fuel type.

MAPFAC_P^{Me} = The MAPLHGR reduction factor versus power due to mechanical overpower during the event for a particular fuel type.

MAPFAC_F^{Th} = The MAPLHGR reduction factor versus flow due to thermal overpower during the event for a particular fuel type.

MAPFAC_F^{Me} = The MAPLHGR reduction factor versus flow due to mechanical overpower during the event for a particular fuel type.

OP_{limit}^{Th} = The limit for thermal overpower for the event from Tables 4.4, 4.5, 4.6 or 4.7 of Reference [1] depending on the event being evaluated.

OP_P^{Th} = The thermal overpower for the event at reactor power P for a particular fuel type.

OP_{limit}^{Me} = The limit for mechanical overpower for the event from Tables 4.4, 4.5, 4.6 or 4.7 of Reference [1] depending on the event being evaluated.

OP_P^{Me} = The mechanical overpower for the event at reactor power P for a particular fuel type.

OP_F^{Th} = The thermal overpower for the event at reactor flow F for a particular fuel type.

OP_F^{Me} = The mechanical overpower for the event at reactor flow F for a particular fuel type.

Different equations for $MAPFAC_P^{Th}$ and $MAPFAC_F^{Th}$ are defined for $P \le P_{BYP}$. Since the scram is bypassed under these conditions, the resulting transient is significantly different than would occur for the same event at rated conditions. Therefore, the off-rated basis for $P \le P_{BYP}$ is to assure conformance to the absolute fuel rod thermal-mechanical limits rather than to assure that the off-rated transient is no more severe than the transient at rated conditions. Furthermore, it is unlikely that operation at this low power condition will extend for the long time periods required to adversely impact the overpower to 1% plastic strain. Therefore, conformance to thermal overpower limit assures conformance to the mechanical overpower limit and $MAPFAC^{Me}$ equals $MAPFAC^{Th}$ for $P \le P_{BYP}$. Also, for $P \le P_{BYP}$, the limit for thermal overpower is taken as the thermal overpower limit for slow events from Tables 4.4 and 4.5 of Reference [1] for all events, since the event characteristics for fast events are different with the scram bypassed and the limits defined in Tables 4.6 and 4.7 of Reference [1] are not applicable.

For $P \le P_{BYP}$ versus power:

$$MAPFAC_P^{Th} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_P^{Th}+100}\right] \tag{4.5}$$

$$MAPFAC_P^{Me} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_P^{Th}+100}\right] \tag{4.6}$$

For $P \le P_{BYP}$ versus flow:

$$MAPFAC_F^{Th} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_F^{Th}+100}\right] \tag{4.7}$$

$$MAPFAC_F^{Me} = \mathrm{Min}\left[1.0, \frac{OP_{limit}^{Th}+100}{OP_F^{Th}+100}\right] \tag{4.8}$$

where:

OP_{limit}^{Th} = The limit for thermal overpower from Table 4.4 and Table 4.5 of Reference [1].

At each core power and flow point, the limiting initial steady-state MAPLHGR reduction factor is then determined from:

$$\mathrm{MAPFAC_P} = \mathrm{Min}\left[\mathrm{MAPFAC_P^{Th}}, \mathrm{MAPFAC_P^{Mc}}\right] \tag{4.9}$$

from power dependent transient evaluations, and

$$\mathrm{MAPFAC_F} = \mathrm{Min}\left[\mathrm{MAPFAC_F^{Th}}, \mathrm{MAPFAC_F^{Mc}}\right] \tag{4.10}$$

from flow dependent transient evaluations.

4.2 References

1. *Mixed Core Analysis Report (MCAR) for Hope Creek Reload 12 Cycle 13*, 0000-0029-7705-MCAR, Revision 0, April 2005.
2. *Hope Creek Generating Station APRM/RBM/Technical Specifications / Maximum Extended Load Line Limit Analysis (ARTS/MELLLA)*, NEDC-33066P, Revision 2, February 2005.

Table 4.1 – Thermal Overpower Summary for AOO's

[[

{3}]]

Table 4.2 – Mechanical Overpower Summary for AOO's

[[

{3}]]

5.0 GE14 / SVEA 96+ Demonstration Cycle Analysis Description at the CPPU Condition

This section of the MCAR provides the results of the Reference Loading Pattern (RLP) core operation simulation of the CPPU RTP mixed core of GE14 and SVEA 96+ fuel. The RLP is developed to meet all design bases set for the CPPU cycle. The RLP is the basis for the licensing calculations that are documented in the Supplemental Reload Licensing Report (SRLR) that is reported in Section 7.0 of this report.

5.1 Reload Bundle Design Description

The reload bundle nuclear design process is closely coupled with the core nuclear design process in demonstrating compliance with safety and performance criteria. An iterative process was used between bundle design and core design to obtain an optimal balance among performance objectives while satisfying all safety criteria.

This process resulted in a one-stream GE14 reload design strategy using a GE14 bundle with axial and radial isotopic configurations shown in Figure 5.1. The average content and specific distributions of gadolinium and enriched uranium used for the GE14 bundle design was selected to accomplish the following goals:

1. Meet PSEG specified cycle energy and operating strategy for an 18-month operating cycle. The average enrichment of the fuel bundle was 3.96 wt% U235. The gadolinium loading of 4.0 and 6.0 wt% Gd_2O_3 was chosen to compensate for the natural decrease in hot excess reactivity of the legacy fuel resulting in a relatively flat overall core hot excess reactivity throughout the majority of the operating cycle and to control radial and axial power shapes without leaving significant amounts of undepleted gadolinium at the end of the cycle.
2. Maintain adequate thermal margins. Lattice enrichment and gadolinium distributions were optimized to obtain desired relative rod-to-rod thermal performance. This included analysis of the local power peaking factors used to calculate linear heat generation rates and the bundle R-factors used to calculate critical power ratios. These parameters were minimized, consistent with other goals, throughout the bundle exposure range associated with expected high power operation for these GE14 designs. Relative powers for gadolinia rods were suppressed to provide adequate margin to meet thermal-mechanical design requirements.
3. Maintain adequate reactivity margins. To demonstrate one stuck rod sub-criticality, design margin to criticality is calculated with the 3D simulator (PANACEA) in conjunction with critical eigenvalue determinations at the reactor during plant startup. Reactivity control of the fresh fuel is accomplished through the choice of gadolinia design. Cold shutdown margin at beginning of cycle is influenced primarily by the number of gadolinia rods used, while cold shutdown margin later in the cycle is influenced primarily by the concentration of gadolinia used.
4. Provide a realistic SVEA 96+ / GE14 mixed core design basis at CPPU RTP that can be compared to the equilibrium GE14 core that was established as the core design basis for the HCGS Power Uprate Safety Analysis Report[1]. The fuel bundle design and target rod pattern specifications have been validated in accordance with GNF Technical Design Procedures to be acceptable for actual use in a mixed core reload. In addition, the fuel bundle design and target rod pattern specifications are comparable to the GE14 equilibrium fuel cycle that was utilized in Reference [1].

5.2 CPPU Core Design Description

5.2.1 Core Configuration Description

Changing the design of the fuel utilized in a nuclear power reactor requires a wide range of analyses to support acceptance relative to operational and safety requirements. The purpose of the core design analysis is to demonstrate feasibility of operation, assure compliance with safety limits and provide operating state points for further safety analyses.

Hot operating analyses with projected control rod patterns were performed at different burn-up points through the CPPU cycle to demonstrate that the specified operating strategies can be supported and that all operating limits can be satisfied. These analysis conditions also provide the beginning state points for other safety analyses. Cold shutdown calculations have been performed throughout the cycle to demonstrate compliance with the stuck control rod criteria.

5.2.2 Design Limits and Targets

The target core flow range is 97.0 – 105.0% rated flow. The critical k_{eff} design target for hot, rated operation is shown in Figure 3.1. The distributed critical k_{eff} design target for cold shutdown evaluations is shown in Figure 3.2. Core design limits are provided in Table 5.1 and parameters for tracking the core design limits are provided in Table 5.2.

The cold critical k_{eff} values are based on the local, cold, critical k_{eff} predicted for CPPU operation. The local cold critical k_{eff} = (distributed cold critical k_{eff}) - 0.003, where the distributed cold, critical k_{eff} are based on observed plant data from in-sequence cold critical cases.

MCPR margin is tracked via the parameter MFLCPR; MLHGR (pellet power margin) is tracked via the parameter MFLPD; and, nodal power margin is tracked via the parameter MAPRAT, where:

$$\text{MFLCPR} = \frac{\text{MCPR Operating Limit}}{\text{MCPR}} \tag{5.1}$$

$$\text{MFLPD} = \frac{\text{Peak LHGR}}{\text{LHGR Operating Limit}} \tag{5.2}$$

$$\text{MAPRAT} = \frac{\text{Maximum Average Planar LHGR}}{\text{MAPLHGR Operating Limit}} \tag{5.3}$$

5.3 CPPU Performance Summary

The resultant CPPU RLP for the upper left quarter core loading configuration is provided in Figure 5.2[a]. The table below Figure 5.2 lists all fuel types and how many of each type are included in the CPPU core configuration.

Table 5.3 compares the calculated thermal limit core performance parameters to the Table 5.2 thermal limit design margin targets. Table 5.4 provides hot excess reactivity vs. cycle exposure. Tables 5.5 and 5.6 compare cold shutdown and standby liquid control system (SLCS) reactivity performance parameters, respectively, to the Table 5.2 reactivity limit design margin targets.

Figure 5.3 provides the CPPU cycle core control blade configuration for the upper left quadrant[b], calculated thermal margins[c] and k_{eff} eigenvalue as a function of cycle exposure. Figure 5.4 plots the thermal limit parameters vs. cycle exposure. Figure 5.5 plots core hot excess reactivity vs. cycle exposure. Figures 5.6 and 5.7 plot cold shutdown and SLCS reactivity margins, respectively, versus cycle exposure.

As is seen in the above referenced tables and figures, all core operating and design margins are met by the CPPU RLP, except for MFLPD at BOC and for the 4500-7500 MWD/ST exposure range. The MFLPD exceptions have been dispositioned to be acceptable based on the previous cycle benchmark comparison for MFLPD at these exposure points.

5.4 References

1. *Safety Analysis Report for Hope Creek Constant Pressure Power Uprate,* NEDC-33076P, Class III (Proprietary), March 2005.

---

[a] The RLP was evaluated on a quarter-core basis.

[b] All control blade patterns are quarter-core mirror symmetric.

[c] Minimum margin in quarter-core reported.

Table 5.1 - Core Design Limits

Minimum Critical Power Ratio (MCPR) - Design operating limit for RLP core design (Actual operating limits as determined by reload analyses are presented in Section 7.0)	GE14 [[{3}]] BOC to 10 GWd/ST [[{3}]] after 10 GWd/ST
	SVEA 96+ [[{3}]] BOC to 10 GWd/ST [[{3}]] after 10 GWd/ST
Maximum Linear Heat Generation Rate (MLHGR)	Fuel Dependent Limit in kW/ft [[{3}]] kW/ft (GE14) [[{3}]] kW/ft (SVEA 96+)
Cold Shutdown Margin - One Stuck Control Rod	1.0% Δk
Boron Injection Shutdown Margin	1.0% Δk
Peak Pellet Exposure	[[{3}]] GWd/MTU (GE14) [[{3}]] GWd/MTU (SVEA 96+)

Table 5.2 - Core Design Margin Targets

MFLCPR	0.93
MFLPD	0.85
MAPRAT	0.89
Cold Shutdown Margin - One Stuck Control Rod	1.3% Δk
Boron Injection Shutdown Margin	1.0% Δk
Peak Pellet Exposure	[[{3}]] GWd/MTU (GE14) [[{3}]] GWd/MTU (SVEA 96+)

Table 5.3 - CPPU RLP Summary of Rod Pattern Results

[[

{3}]]

Table 5.4 - CPPU RLP Hot Excess Reactivity

[[

{3}]]

Table 5.5 - CPPU RLP Cold Shutdown Reactivity Margin

*** CARI AND SDM RESULTS ***

CASE CONVERGENCE: PASSED
DESIGN CRITERIA: MET

[[

{3}]]

Table 5.6 - CPPU RLP Standby Liquid Control Shutdown Margin

SLCS ANALYSIS - PANACEA SLCS RESULTS

PLANT NAME : HOPE CREEK 1
EIS CODE : KT1
CYCLE NUMBER : 14
METHOD TYPE : II
PANACEA VERSION : PANAC11V
ANALYSIS TYPE : STATEPOINT
SDM REQUIREMENT : 0.010

[[

(3)]]

Table 5.6 - CPPU RLP Standby Liquid Control Shutdown Margin

SDM REQUIREMENT (MOST RESTRICTIVE VALUE): 0.010
SDM REQUIREMENT USED (DTA OVERLAY) : 0.010
[[

{3}]]

[[

$^{\{3\}}$]]

Figure 5.1 - Fresh GE14 Reload Bundle 2830 Configuration

[[

{3}]]

Figure 5.2 - CPPU Core Loading (Quarter Core)

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence
[[{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence
[[{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence

[[

{3}]]

Figure 5.3 - CPPU Reference Loading Pattern Control Rod Operating Sequence
[[[3]]]

[[

$^{\{3\}}$]]

Figure 5.4 - CPPU RLP Rod Pattern Thermal Design Ratio Results

[[

$^{\{3\}}$]]

Figure 5.5 - CPPU RLP Hot Excess Reactivity

[[

{3}]]

Figure 5.6 - CPPU RLP Cold Shutdown Margin

[[

{3}]]

Figure 5.7 - CPPU RLP Standby Liquid Control System Shutdown Margin

6.0 Safety Limit Minimum Critical Power Ratio (SLMCPR)

This section of the MCAR provides the results of the SLMCPR evaluation of the Reference Loading Pattern that represents the CPPU RTP mixed core of GE14 and SVEA 96+ fuel, as reported in Section 5.0 of this report. The purpose of the evaluation is to determine the minimum allowable MCPR during the most limiting full core transients under which at least 99.9% of the rods in the core would be expected to avoid boiling transition. The minimum allowable MCPR established in this way is defined as the safety limit minimum critical power ratio (SLMCPR).

6.1 Discussion

The Safety Limit Minimum Critical Power Ratio (SLMCPR) evaluations for the Hope Creek CPPU cycle were performed using NRC approved methodology and uncertainties. [1] Table 6.1 summarizes the relevant input parameters and results for CPPU operation. Additional information is provided in response to NRC questions related to similar submittals regarding changes in Technical Specification values of SLMCPR. NRC questions pertaining to how GE14 applications satisfy the conditions of the NRC SER[1] have been addressed in Reference [2]. Other generically applicable questions related to application of the GEXL14 correlation, and to the applicable range for the R-factor methodology, are addressed in Reference [3]. Items that require a plant/cycle specific response are presented below.

Previously, the SLMCPR was calculated on the upper boundary of the power/flow operating map only at 100% flow / 100% power (rated flow/rated power) with limiting control blade patterns developed at the rated flow/rated power point. This approach had been shown in NEDC-32601P-A to result in conservative SLMCPR evaluation values. As reported in Reference [4], recent SLMCPR evaluations performed by GNF have shown that limiting control blade patterns developed for less than rated flow at the rated power condition sometimes yield more limiting bundle-by-bundle MCPR distributions and/or more limiting bundle axial power shapes than the limiting control blade patterns developed at the rated flow/rated power evaluation point. Consequently, in addition to the rated flow/rated power evaluation point, an SLMCPR calculation has been performed for Hope Creek at a lower flow/rated power evaluation point. The assumed Hope Creek Cycle 13 minimum allowable core flow at rated power is 76.6% rated flow. However, to account for future operation at lower flow/CPPU conditions, SLMCPR evaluations were performed at a reduced core flow rate of 94.8% rated flow at the CPPU condition for the same exposure points calculated for the rated flow/CPPU evaluations.

The core loading information for Hope Creek CPPU is provided in Figure 6.1. The actual core loading information for Hope Creek Cycle 13 is provided in Figure 6.2.

In general, the calculated safety limit is dominated by two key parameters: (1) flatness of the core bundle-by-bundle MCPR distributions, and (2) flatness of the bundle pin-by-pin power/ R-factor distributions. Greater flatness in either parameter yields more rods susceptible to boiling transition and thus a higher calculated SLMCPR. The value of these parameters for Hope Creek CPPU is summarized in Table 6.1 as the MIP (MCPR Importance Parameter) and the RIP (R-factor Importance Parameter), respectively.

The impact of the fuel loading pattern differences on the calculated SLMCPR is correlated to the values of MIP and RIP. The calculated MIP value for the Hope Creek CPPU core at EOR using a limiting rod pattern is [[{3}]]

Pin-by-pin power distributions are characterized in terms of R-factors using the NRC approved methodology.[5] For the Hope Creek CPPU cycle limiting case analyzed at EOR, the weighted RIP value, considering the participation of the contributing bundles, was calculated to be [[{3}]]

The revised power distribution methodology was used for the Hope Creek CPPU analysis. This methodology has been justified, reviewed and approved by the NRC (reference NEDC-32601P-A). When applying the revised model to calculate a lower SLMCPR, the conservatism that remains was reviewed, approved and documented by the USNRC. It was noted on page A-24 of NEDC-32601P-A [[

{3}]]

The SLMCPR was calculated for the Hope Creek CPPU condition using the reduced power distribution uncertainties described in Reference [1].

Table 6.1 summarizes the relevant input parameters and results of CPPU operation evaluated at the condition of 94.8% rated flow/rated power. The SLMCPR values were calculated for Hope Creek using uncertainties that have been previously reviewed and approved by the NRC as listed in Table 6.2 and described in Reference [1] and, where warranted, higher plant-cycle-specific uncertainties as listed in Table 6.3. A [[
{3}]] consistent with current GNF fuel operation. For the Hope Creek CPPU lower flow evaluations, the Core Flow Rate and Random effective TIP reading uncertainties were [[

{3}]]

These calculations use the GEXL14 correlation for GE14 fuel and GEXL80 correlation for SVEA 96+ fuel (Reference [6]). [[

{3}]]

The Two Loop and SLO SLMCPR values calculated for the Hope Creek CCPU cycle are shown in Table 6.1. The calculated SLO SLMCPR is 1.09.

6.2 Summary

The calculated 1.07 SLMCPR and 1.09 SLO SLMCPR for Hope Creek CPPU operation are consistent with expectations given the ratios for MIP and RIP that have been calculated and the use of the reduced uncertainties described in Reference [1]. Correlations of MIP and RIP directly to the calculated SLMCPR have been performed for this plant/cycle which show that these values are appropriate when the approved methodology and the reduced uncertainties given in NEDC-32601P-A and NEDC-32694P-A are used.

Based on all of the information and discussion presented above, it is concluded that a 1.07 SLMCPR and 1.09 SLO SLMCPR for the Hope Creek CPPU core are appropriate for the cycle operation.

6.3 References

1. Letter, Frank Akstulewicz (NRC) to Glen A. Watford (GE), "Acceptance for Referencing of Licensing Topical Reports NEDC-32601P, *Methodology and Uncertainties for Safety Limit MCPR Evaluations;* NEDC-32694P, *Power Distribution Uncertainties for Safety Limit MCPR Evaluation;* and Amendment 25 to NEDE-24011-P-A on Cycle Specific Safety Limit MCPR," (TAC Nos. M97490, M99069 and M97491), March 11, 1999.
2. Letter, Glen A. Watford (GNF-A) to U. S. Nuclear Regulatory Commission Document Control Desk with attention to R. Pulsifer (NRC), "Confirmation of 10x10 Fuel Design Applicability to Improved SLMCPR, Power Distribution and R-Factor Methodologies", FLN-2001-016, September 24, 2001.
3. Letter, Glen A. Watford (GNF-A) to U. S. Nuclear Regulatory Commission Document Control Desk with attention to J. Donoghue (NRC), "Confirmation of the Applicability of the GEXL14 Correlation and Associated R-Factor Methodology for Calculating SLMCPR Values in Cores Containing GE14 Fuel", FLN-2001-017, October 1, 2001.
4. Letter, Jason S. Post (GE Energy) to U.S. Nuclear Regulatory Commission Document Control Desk, "Part 21 Reportable Condition and 60-Day Interim Report Notification: Non-conservative SLMCPR", MFN-04-081, August 24, 2004.
5. Letter, Thomas H. Essig (NRC) to Glen A. Watford (GE), "Acceptance for Referencing of Licensing Topical Report NEDC-32505P, Revision 1, *R-Factor Calculation Method for GE11, GE12 and GE13 Fuel,*" (TAC Nos. M99070 and M95081), January 11, 1999.
6. *GEXL80 Correlation for SVEA 96+ Fuel,* NEDC-33107P, Revision 0, Class III, September 2003.
7. Letter, Glen A. Watford (GNF-A) to U. S. Nuclear Regulatory Commission Document Control Desk with attention to J. Donoghue (NRC), "Final Presentation Material for GEXL Presentation – February 11, 2002", FLN-2002-004, February 12, 2002.

Table 6.1 - Comparison of the Hope Creek Generating Station CPPU and Cycle 13 SLMCPR

DESCRIPTION	Hope Creek Cycle 13	Hope Creek Cycle 13	Hope Creek CPPU	Hope Creek CPPU
Number of Bundles in Core	764	764	764	764
Limiting Cycle Exposure Point[a]	EOR	EOR	EOR	EOR
Cycle Exposure at Limiting Point (MWd/MTU)	10472 (EOR-1467)	10472 (EOR-1467)	12125 (EOR-1102)	12125 (EOR-1102)
Core Flow, % Rated	100.0	76.6	100.0	94.8
Reload Fuel Type	GE14	GE14	GE14	GE14
Latest Reload Batch Fraction, %	21.5	21.5	33.0	33.0
Latest Reload Average Batch Weight % Enrichment	4.02	4.02	3.96	3.96
Core Fuel Fraction for GE14 (%)	21.5	21.5	54.5	54.5
Core Fuel Fraction for SVEA 96+ (%)	78.5	78.5	45.5	45.5
Core Average Weight % Enrichment	3.63	3.63	3.81	3.81
Core MCPR (for limiting rod pattern)	1.42	1.38	1.40	1.42
MCPR Importance Parameter, MIP	[[			{3}]]
R-factor Importance Parameter, RIP	[[			{3}]]
MIPRIP	[[			{3}]]
Power distribution methodology	Revised NEDC-32601P-A		Revised NEDC-32601P-A	
Power distribution uncertainty	Reduced NEDC-32694P-A		Reduced NEDC-32694P-A	
Non-power distribution uncertainty	Revised NEDC-32601P-A		Revised NEDC-32601P-A	
Calculated Safety Limit MCPR (Two Loop)	1.05	1.06	1.06	1.07
Calculated Safety Limit MCPR (SLO)	1.06	1.07	1.09	1.09

---

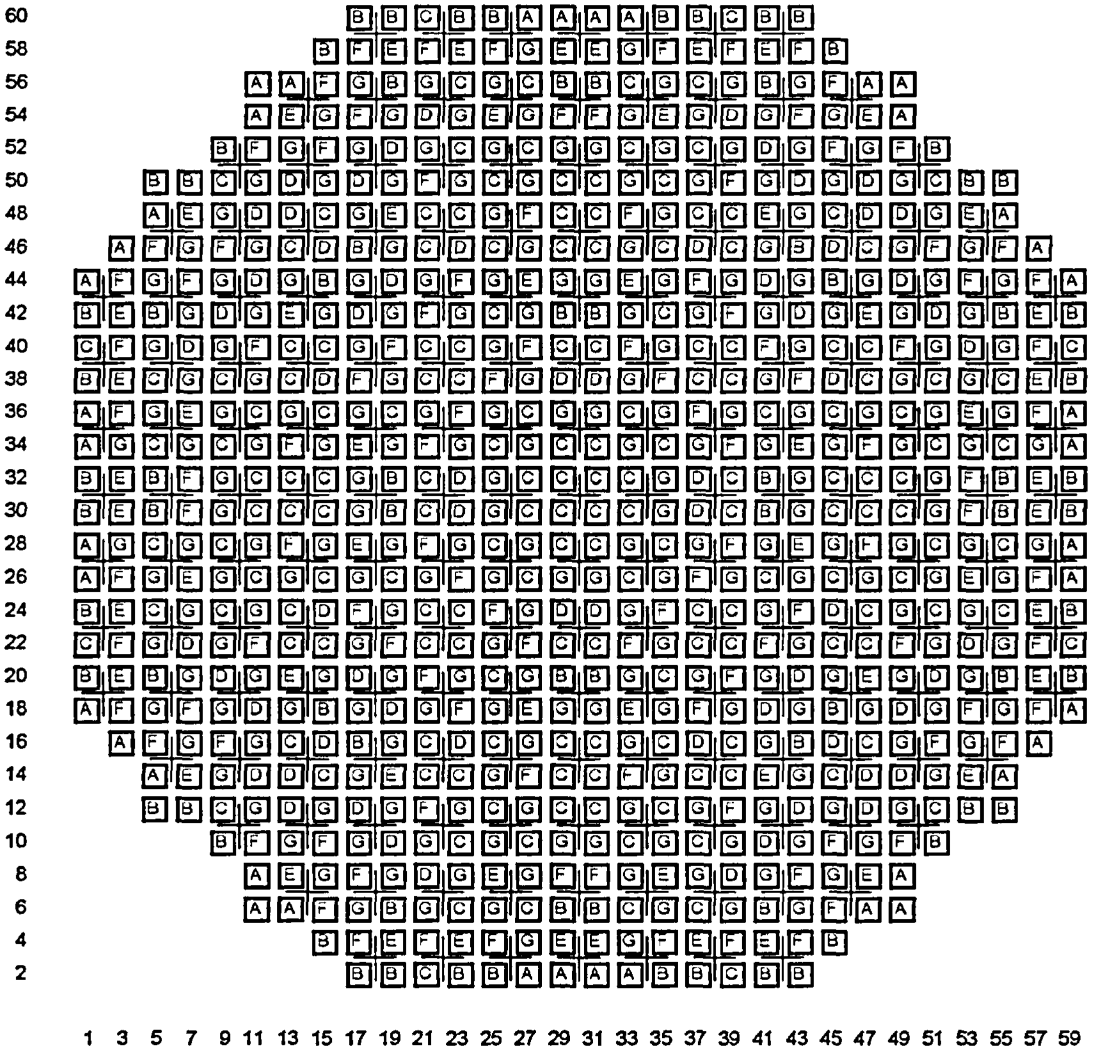
[a] End of Rated (EOR) is defined as end-of-cycle all rods out, 100% power / 100% flow and normal feedwater temperature. The actual analysis is performed prior to EOR in order to have sufficient control rod density to force some bundles near to the OLMCPR.

Table 6.2 - Standard Uncertainties

DESCRIPTION	Hope Creek Cycle 13 100% Flow	Hope Creek Cycle 13 76.6% Flow	Hope Creek CPPU 100% Flow	Hope Creek CPPU 94.8% Flow
Non-power Distribution Uncertainties	**Revised NEDC-32601P-A**	**Revised NEDC-32601P-A**	**Revised NEDC-32601P-A**	**Revised NEDC-32601P-A**
Core flow rate (derived from pressure drop)	2.5 Two Loop 6.0 SLO	2.5 Two Loop 6.0 SLO	2.5 Two Loop 6.0 SLO	2.5 Two Loop 6.0 SLO
Individual channel flow area	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Individual channel friction factor	5.0	5.0	5.0	5.0
Friction factor multiplier	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Reactor pressure	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Core inlet temperature	0.2	0.2	0.2	0.2
Feedwater temperature	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Feedwater flow rate	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Power Distribution Uncertainties	Reduced NEDC-32694P-A	Reduced NEDC-32694P-A	Reduced NEDC-32694P-A	Reduced NEDC-32694P-A
GEXL R-factor	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Random effective TIP reading	1.2 Two Loop 2.85 SLO	1.2 Two Loop 2.85 SLO	1.2 Two Loop 2.85 SLO	1.2 Two Loop 2.85 SLO
Systematic effective TIP reading	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Integrated effective TIP reading	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Bundle power	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]
Effective total bundle power uncertainty	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]

Table 6.3 - Exceptions to the Standard Uncertainties Used in Hope Creek CPPU and Cycle 13

Reactor pressure	2.04	2.04	2.04	2.04
Core Flow Rate	--	[[$^{\{3\}}$]]	--	[[$^{\{3\}}$]]
Random Effective TIP Reading	--	[[$^{\{3\}}$]]	--	[[$^{\{3\}}$]]
GEXL R-factor	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]	[[$^{\{3\}}$]]



Code	Bundle Name	Number Loaded	Cycle Loaded
A	SVEA96-P10CASB360-12GZ-568U-4WR-150-T6-2656	40	11
B	SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657	76	11
C	SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658	168	12
D	SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659	64	12
E	GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757	56	13
F	GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758	108	13
G	GE14-P10CNAB396-16GZ-100T-150-T6-2830-LICENSING	252	14

Figure 6.1 – CCPU Reference Core Loading Pattern

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59
60									A	A	A	A	A	A	A	A	A	A	A	A	A	A								
58								A	B	E	E	F	F	F	F	F	F	F	F	E	E	J	A							
56						A	C	C	B	C	E	B	C	F	C	C	F	C	B	E	C	B	C	C	A					
54						B	E	E	C	E	C	F	E	G	C	C	G	E	F	C	E	C	E	E	B					
52					A	A	C	E	G	E	G	E	H	C	H	H	D	H	E	G	E	G	E	C	A	A				
50			A	A	A	G	C	G	D	H	C	H	C	F	C	C	F	C	H	C	H	D	G	C	G	A	A	A		
48			A	E	C	C	E	D	H	E	E	C	G	D	E	E	D	G	C	E	E	H	D	E	C	C	E	A		
46		A	C	E	L	G	D	D	C	H	C	E	F	G	D	D	G	F	E	C	H	C	D	D	G	E	E	C	I	
44	A	B	B	C	G	C	H	C	G	C	H	D	H	B	H	H	B	H	C	H	C	G	C	H	C	G	C	B	B	A
42	A	E	K	E	E	H	E	H	B	E	E	H	C	E	B	B	E	D	H	E	E	C	H	E	H	E	E	C	E	A
40	A	L	E	C	G	C	E	C	H	E	D	C	H	D	E	E	D	H	C	D	E	H	C	E	C	G	C	E	E	A
38	A	F	B	F	E	H	C	E	D	H	C	D	E	H	C	C	H	E	D	C	H	C	E	C	H	E	F	B	F	A
36	B	F	C	E	H	D	G	F	H	D	H	E	H	E	H	H	E	H	E	H	D	H	F	G	C	H	E	C	F	B
34	A	F	F	G	D	F	D	G	C	E	D	H	E	C	E	E	C	E	H	D	E	C	G	D	F	C	G	F	F	A
32	A	F	D	C	H	C	E	D	H	C	E	C	H	E	C	C	E	H	C	E	C	H	D	E	C	H	C	D	F	A
30	A	F	D	C	H	C	E	D	H	C	E	C	H	E	C	C	E	H	C	E	C	H	D	E	C	H	C	D	F	A
28	A	F	F	G	C	F	D	G	C	E	D	H	E	C	E	E	C	E	H	D	E	C	G	D	F	D	G	F	F	A
26	B	M	C	E	H	C	G	F	H	D	H	E	H	E	H	H	E	H	E	H	D	H	F	G	D	H	E	C	F	B
24	A	F	B	F	E	H	C	E	D	H	C	D	E	H	C	C	H	E	D	C	H	C	E	C	H	E	F	B	F	A
22	A	E	E	C	G	C	E	C	H	E	D	C	H	D	E	E	D	H	C	D	E	H	C	E	C	G	C	E	E	A
20	A	E	C	E	E	H	E	H	C	E	E	H	D	E	B	B	E	C	H	E	E	C	H	E	H	E	E	C	E	A
18	A	B	B	C	G	C	H	C	G	C	H	D	H	B	H	H	B	H	D	H	C	G	C	H	C	G	C	B	B	A
16		A	C	E	E	G	D	D	C	H	C	E	F	G	D	D	G	F	E	C	H	C	D	D	G	L	L	A	A	
14			A	E	C	C	E	D	H	E	E	C	G	D	E	E	D	G	C	E	E	H	D	E	C	C	E	A		
12			A	A	A	G	C	G	D	H	C	H	C	F	C	C	F	C	H	C	H	D	G	C	G	A	A	A		
10					A	A	C	E	G	E	G	E	H	D	H	H	C	H	E	G	E	G	E	C	A	I				
8						B	E	E	C	E	C	F	E	G	C	C	G	E	F	C	E	C	E	E	A					
6						A	C	C	B	C	E	B	C	F	C	C	F	C	B	E	K	B	C	A	A					
4								A	J	E	E	F	M	F	F	F	F	F	F	E	E	B	A							
2									A	A	A	A	A	A	A	A	A	A	A	A	A	A								

Code	Bundle Name	Number Loaded	Cycle Loaded
A	SVEA96-P10CASB326-11GZ-568U-4WR-150-T6-2654	89	10
B	SVEA96-P10CASB326-11G4.5-568U-4WR-150-T6-2655	38	10
C	SVEA96-P10CASB360-12GZ-568U-4WR-150-T6-2656	166	11
D	SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657	69	11
E	SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658	164	12
F	SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659	62	12
G	GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757	56	13
H	GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758	108	13
I	SVEA96-P10CASB326-11GZ-568U-4WR-150-T6-2654	2	10
J	SVEA96-P10CASB326-11G4.5-568U-4WR-150-T6-2655	2	10
K	SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657	2	11
L	SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658	4	12
M	SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659	2	12

Figure 6.2 - Reference Core Loading Pattern – Cycle 13

7.0 Supplemental Reload Licensing Report (SRLR) at CPPU Condition

A copy of the CPPU SRLR follows this analysis. The SRLR sections, tables, figures, appendices and page numbering are self contained as in the original report and therefore have not been modified to be consistent with Sections 1.0 – 7.0 of the MCAR. Accordingly, individual SRLR sections, tables and figures are not contained in the MCAR Table of Contents, List of Tables or List of Figures. The CPPU operation cycle in the SRLR is referred to as Cycle 14.

GNF
Global Nuclear Fuel
A Joint Venture of GE, Toshiba, & Hitachi

0000-0031-9425-MCAR-SRLR
Revision 0
Class I
April 2005

0000-0031-9425-MCAR-SRLR, Rev. 0

Mixed Core Analysis Report
Supplemental Reload Licensing Report

for
Hope Creek Unit 1

Reload 13 Cycle 14

Extended Power Uprate

Approved: M. E. Harding
M. E. Harding, Manager
Fuel Engineering Services

Approved: Rick Kingston
R. E. Kingston
Customer Account Leader

Important Notice Regarding Contents of This Report
Please Read Carefully

The analyses in this document are not intended for the reload licensing of the actual Hope Creek Generating Station Unit 1 Cycle 14, and thus is not represented as fully conforming to the GESTAR-II analysis bases.

This report was prepared by Global Nuclear Fuel - Americas, LLC (GNF-A) solely for PSEG Nuclear LLC (PSEG) and the U.S. Nuclear Regulatory Commission (USNRC). The information contained in this report is believed by GNF-A to be an accurate and true representation of the facts known, obtained or provided to GNF-A at the time this report was prepared.

The only undertakings of GNF-A respecting information in this document are contained in the contract between PSEG and GNF-A for nuclear fuel and related services for the nuclear system for Hope Creek Generating Station 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 GNF-A nor any of the contributors to this document makes any representation or warranty (express or implied) as to the completeness, accuracy or usefulness of 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

'Nuclear Fuel Engineering' and 'Nuclear and Safety Analysis' groups performed the engineering and reload licensing analyses, which form the technical basis of this Supplemental Reload Licensing Report. Jin Su prepared this Supplemental Reload Licensing Report, and J. Rea was the verifier of this document.

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:	List of Acronyms
Appendix C:	Decrease In Core Coolant Temperature Events
Appendix D:	Reactor Recirculation Pump Seizure Event
Appendix E:	Power and Flow Dependent Limits

2. Reload Fuel Bundles

Fuel Type	**Cycle Loaded**	**Number**
Irradiated:		
SVEA96-P10CASB360-12GZ-568U-4WR-150-T6-2656	11	40
SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657	11	76
SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658	12	168
SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659	12	64
GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757 (GE14C)	13	56
GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758 (GE14C)	13	108
New:		
GE14-P10CNAB396-16GZ-100T-150-T6-2830-LICENSING (GE14C)	14	252
Total:		764

3. Reference Core Loading Pattern

Nominal previous cycle core average exposure at end of cycle:	29646 MWd/MT (26895 MWd/ST)
Minimum previous cycle core average exposure at end of cycle from cold shutdown considerations:	29646 MWd/MT (26895 MWd/ST)
Assumed reload cycle core average exposure at beginning of cycle:	16290 MWd/MT (14778 MWd/ST)
Assumed reload cycle core average exposure at end of cycle (rated conditions):	29518 MWd/MT (26778 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	1.106
Fully controlled	0.945
Strongest control rod out	0.984
R, Maximum increase in cold core reactivity with exposure into cycle, Δk	0.003

5. Standby Liquid Control System Shutdown Capability

Boron (ppm) (at 20°C)	Shutdown Margin (Δk) (at 160°C, Xenon Free)
660	0.032

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

[1]Operating domain: ICF (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.44	1.24	1.040	7.049	105.3	1.33
SVEA96+	1.45	1.50	1.24	0.990	7.327	102.3	1.32

Operating domain: ICF (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.38	1.34	1.040	6.775	108.9	1.33
SVEA96+	1.45	1.43	1.34	0.990	7.008	105.5	1.34

---

[1] End of Rated (EOR) is defined as end-of-cycle all rods out, 100% power/100% flow, and normal feedwater temperature.

Operating domain: MELLLA (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.40	1.22	1.040	6.854	95.4	1.33
SVEA96+	1.45	1.45	1.22	0.990	7.088	92.3	1.33

Operating domain: MELLLA (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.35	1.30	1.040	6.613	98.3	1.34
SVEA96+	1.45	1.39	1.30	0.990	6.810	94.8	1.35

Operating domain: ICF (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.42	1.22	1.040	6.950	106.5	1.34
SVEA96+	1.45	1.46	1.22	0.990	7.176	103.7	1.35

Operating domain: MELLLA (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.39	1.21	1.040	6.822	95.8	1.33
SVEA96+	1.45	1.44	1.21	0.990	7.044	92.7	1.33

Operating domain: ICF & MFWT[2] (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.49	1.24	1.040	7.294	103.5	1.29
SVEA96+	1.45	1.53	1.24	0.990	7.510	100.6	1.30

Operating domain: ICF & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.42	1.33	1.040	6.977	107.5	1.30
SVEA96+	1.45	1.47	1.33	0.990	7.182	103.9	1.32

Operating domain: MELLLA & MFWT (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.45	1.23	1.040	7.094	93.7	1.29
SVEA96+	1.45	1.50	1.23	0.990	7.322	90.4	1.29

Operating domain: MELLLA & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14							
	Peaking Factors						
Fuel Design	Local	Radial	Axial	R-Factor	Bundle Power (MWt)	Bundle Flow (1000 lb/hr)	Initial MCPR
GE14C	1.45	1.39	1.30	1.040	6.810	97.1	1.30
SVEA96+	1.45	1.43	1.30	0.990	7.015	93.2	1.31

---

[2] MFWT, minimum feedwater temperature, is allowed by plant Technical Specifications as low as 409 °F at rated power.

Operating domain: ICF & MFWT (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.46	1.23	1.040	7.150	105.1	1.31
SVEA96+	1.45	1.51	1.23	0.990	7.371	102.0	1.31

Operating domain: MELLLA & MFWT (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.44	1.22	1.040	7.049	94.4	1.29
SVEA96+	1.45	1.48	1.22	0.990	7.254	91.1	1.30

Operating domain: ICF with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.41	1.24	1.040	6.904	106.3	1.36
SVEA96+	1.45	1.46	1.24	0.990	7.159	103.4	1.36

Operating domain: ICF with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.35	1.34	1.040	6.645	109.7	1.37
SVEA96+	1.45	1.41	1.34	0.990	6.896	106.3	1.37

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.37	1.22	1.040	6.739	96.1	1.35
SVEA96+	1.45	1.42	1.22	0.990	6.962	93.1	1.35

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.34	1.30	1.040	6.564	98.6	1.35
SVEA96+	1.45	1.38	1.30	0.990	6.747	95.2	1.36

Operating domain: ICF with RPTOOS (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.38	1.22	1.040	6.791	107.6	1.38
SVEA96+	1.45	1.43	1.22	0.990	7.024	104.8	1.38

Operating domain: MELLLA with RPTOOS (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.37	1.21	1.040	6.716	96.5	1.36
SVEA96+	1.45	1.41	1.21	0.990	6.919	93.6	1.36

Operating domain: ICF & MFWT with RPTOOS (HBB) **Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)**							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.45	1.24	1.040	7.122	104.6	1.33
SVEA96+	1.45	1.51	1.24	0.990	7.377	101.5	1.33

Operating domain: ICF & MFWT with RPTOOS (HBB) **Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14**							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.40	1.33	1.040	6.848	108.4	1.33
SVEA96+	1.45	1.44	1.33	0.990	7.070	104.7	1.34

Operating domain: MELLLA & MFWT with RPTOOS (HBB) **Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)**							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.43	1.23	1.040	6.999	94.3	1.31
SVEA96+	1.45	1.48	1.23	0.990	7.219	91.0	1.31

Operating domain: MELLLA & MFWT with RPTOOS (HBB) **Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14**							
	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.37	1.30	1.040	6.734	97.6	1.32
SVEA96+	1.45	1.42	1.30	0.990	6.947	93.6	1.33

Operating domain: ICF & MFWT with RPTOOS (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.44	1.23	1.040	7.036	105.9	1.34
SVEA96+	1.45	1.48	1.23	0.990	7.262	102.7	1.34

Operating domain: MELLLA & MFWT with RPTOOS (UB)
Exposure range : BOC14 to EOC14

	Peaking Factors						
Fuel Design	**Local**	**Radial**	**Axial**	**R-Factor**	**Bundle Power (MWt)**	**Bundle Flow (1000 lb/hr)**	**Initial MCPR**
GE14C	1.45	1.42	1.22	1.040	6.937	95.1	1.32
SVEA96+	1.45	1.46	1.22	0.990	7.120	91.9	1.33

7. Selected Margin Improvement Options[3]

Recirculation pump trip:	Yes
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

---

[3] Refer to GESTAR for those margin improvement options that are referenced and supported within GESTAR.

8. Operating Flexibility Options [4]

Extended Operating Domain (EOD): Yes

EOD type: Maximum Extended Load Line Limit (MELLLA)

Minimum core flow at rated power: 94.8 %

Increased Core Flow: Yes

Flow point analyzed throughout cycle: 105.0 %

Feedwater Temperature Reduction: No

ARTS Program: ~~No~~ Yes TgS 5/6/05*

Single-loop operation: Yes

Equipment Out of Service:

Safety/relief valves Out of Service: Yes
(credit taken for 13 of 14 valves)

RPTOOS Yes

9. Core-wide AOO Analysis Results

Methods used: GEMINI; GEXL-PLUS

Operating domain: ICF (HBB) **Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)**					
			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	218	112	0.22	0.22	2
Turbine Trip w/o Bypass	284	112	0.26	0.26	3
Load Reject w/o Bypass	281	112	0.26	0.25	4

---

[4] Refer to GESTAR for those operating flexibility options that are referenced and supported within GESTAR.

* Option confirmed to be "Yes" by GNF 5/6/05.

Operating domain: MELLLA (UB) Exposure range : BOC14 to EOC14					
			Uncorrected ΔCPR		
Event	Flux (% NBR)	Q/A (% NBR)	GE14C	SVEA96+	Fig.
FW Controller Failure	201	110	0.22	0.22	17
Turbine Trip w/o Bypass	258	111	0.26	0.26	18
Load Reject w/o Bypass	254	110	0.26	0.26	19

Operating domain: ICF & MFWT (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)					
			Uncorrected ΔCPR		
Event	Flux (% NBR)	Q/A (% NBR)	GE14C	SVEA96+	Fig.
FW Controller Failure	219	113	0.22	0.23	20

Operating domain: ICF & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14					
			Uncorrected ΔCPR		
Event	Flux (% NBR)	Q/A (% NBR)	GE14C	SVEA96+	Fig.
FW Controller Failure	305	120	0.24	0.25	21

Operating domain: MELLLA & MFWT (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)					
			Uncorrected ΔCPR		
Event	Flux (% NBR)	Q/A (% NBR)	GE14C	SVEA96+	Fig.
FW Controller Failure	198	110	0.21	0.22	22

Operating domain: MELLLA & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14					
			Uncorrected ΔCPR		
Event	Flux (% NBR)	Q/A (% NBR)	GE14C	SVEA96+	Fig.
FW Controller Failure	271	117	0.23	0.25	23

Operating domain: ICF & MFWT (UB)
Exposure range : BOC14 to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	248	115	0.24	0.24	24

Operating domain: MELLLA & MFWT (UB)
Exposure range : BOC14 to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	210	111	0.22	0.23	25

Operating domain: ICF with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	246	115	0.25	0.25	26
Turbine Trip w/o Bypass	328	116	0.29	0.29	27
Load Reject w/o Bypass	334	115	0.29	0.28	28

Operating domain: ICF with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	325	121	0.26	0.27	29
Turbine Trip w/o Bypass	405	122	0.29	0.30	30
Load Reject w/o Bypass	395	122	0.29	0.30	31

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	218	112	0.24	0.24	32
Turbine Trip w/o Bypass	290	114	0.28	0.28	33
Load Reject w/o Bypass	289	113	0.28	0.27	34

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	278	118	0.25	0.26	35
Turbine Trip w/o Bypass	345	119	0.28	0.29	36
Load Reject w/o Bypass	350	119	0.28	0.29	37

Operating domain: ICF with RPTOOS (UB)
Exposure range : BOC14 to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	269	117	0.27	0.27	38
Turbine Trip w/o Bypass	356	119	0.31	0.31	39
Load Reject w/o Bypass	364	118	0.31	0.30	40

Operating domain: MELLLA with RPTOOS (UB)
Exposure range : BOC14 to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	221	113	0.24	0.24	41
Turbine Trip w/o Bypass	292	114	0.29	0.29	42
Load Reject w/o Bypass	290	114	0.28	0.28	43

Operating domain: ICF & MFWT with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	246	116	0.26	0.25	44

Operating domain: ICF & MFWT with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	337	123	0.26	0.27	45

Operating domain: MELLLA & MFWT with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	218	112	0.24	0.24	46

Operating domain: MELLLA & MFWT with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	292	119	0.25	0.26	47

Operating domain: ICF & MFWT with RPTOOS (UB)
Exposure range : BOC14 to EOC14

			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	278	118	0.27	0.27	48

Operating domain: MELLLA & MFWT with RPTOOS (UB) **Exposure range : BOC14 to EOC14**					
			Uncorrected ΔCPR		
Event	**Flux (% NBR)**	**Q/A (% NBR)**	**GE14C**	**SVEA96+**	**Fig.**
FW Controller Failure	232	114	0.25	0.25	49

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

Assuming the worst channel response and 50% availability of the LPRMs yields a ΔCPR of 0.21 for all RBM setpoints including the unblocked response.

11. Cycle MCPR Values [5]

Safety limit:	1.07
Single loop operation safety limit:	1.09
ECCS OLMCPR Design Basis:	See Section 16 (Initial MCPR)

Non-pressurization events:

Exposure range: BOC14 to EOC14		
	GE14C	SVEA96+
Loss of Feedwater Heating (110°F)	1.21	1.21
Control Rod Withdrawal Error (unblocked)	1.28	1.28
Fuel Loading Error (misoriented)	1.19	1.29

---

[5] For single-loop operation, the MCPR operating limit is 0.02 greater than the two-loop value.

Limiting Pressurization Events OLMCPR Summary Table: [6]

Appl. Cond.[7]	Exposure Range	Option A		Option B	
		GE14C	SVEA96+	GE14C	SVEA96+
1	EQUIPMENT IN SERVICE				
	BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)	1.46	1.45	1.35	1.34
	EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14	1.57	1.58	1.40	1.41
2	RPTOOS				
	BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)	1.49	1.49	1.38	1.38
	EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14	1.60	1.61	1.43	1.44

Pressurization events: [8]

Operating domain: ICF (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.42	1.41	1.31	1.30
Turbine Trip w/o Bypass	1.46	1.45	1.35	1.34
Load Reject w/o Bypass	1.45	1.45	1.34	1.34

Operating domain: ICF (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.52	1.54	1.35	1.37
Turbine Trip w/o Bypass	1.56	1.58	1.39	1.41
Load Reject w/o Bypass	1.56	1.57	1.39	1.40

---

[6] 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.
[7] One SRV out-of-service allowed.
[8] The application condition number(s) shown for each of the following pressurization events represents the application condition(s) for which this event contributed in the determination of the limiting OLMCPR value.

Operating domain: MELLLA (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.41	1.41	1.30	1.30
Turbine Trip w/o Bypass	1.45	1.45	1.34	1.34
Load Reject w/o Bypass	1.45	1.45	1.34	1.34

Operating domain: MELLLA (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.52	1.54	1.35	1.37
Load Reject w/o Bypass	1.56	1.58	1.39	1.41
Turbine Trip w/o Bypass	1.55	1.58	1.38	1.41

Operating domain: ICF (UB)
Exposure range : BOC14 to EOC14
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.53	1.53	1.36	1.36
Turbine Trip w/o Bypass	1.57	1.58	1.40	1.41
Load Reject w/o Bypass	1.57	1.57	1.40	1.40

Operating domain: MELLLA (UB)
Exposure range : BOC14 to EOC14
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.51	1.52	1.34	1.35
Turbine Trip w/o Bypass	1.55	1.56	1.38	1.39
Load Reject w/o Bypass	1.55	1.56	1.38	1.39

Operating domain: ICF & MFWT (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) Application condition: 1, 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.42	1.42	1.31	1.31

Operating domain: ICF & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 Application condition: 1, 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.53	1.55	1.36	1.38

Operating domain: MELLLA & MFWT (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) Application condition: 1, 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.41	1.41	1.30	1.30

Operating domain: MELLLA & MFWT (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 Application condition: 1, 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.52	1.55	1.35	1.38

Operating domain: ICF & MFWT (UB) Exposure range : BOC14 to EOC14 Application condition: 1, 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.53	1.54	1.36	1.37

Operating domain: MELLLA & MFWT (UB)
Exposure range : BOC14 to EOC14
Application condition: 1, 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.51	1.53	1.34	1.36

Operating domain: ICF with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)
Application condition: 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.45	1.45	1.34	1.34
Turbine Trip w/o Bypass	1.49	1.49	1.38	1.38
Load Reject w/o Bypass	1.49	1.48	1.38	1.37

Operating domain: ICF with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14
Application condition: 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.55	1.57	1.38	1.40
Turbine Trip w/o Bypass	1.59	1.60	1.42	1.43
Load Reject w/o Bypass	1.58	1.60	1.41	1.43

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)
Application condition: 2

	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.43	1.43	1.32	1.32
Turbine Trip w/o Bypass	1.48	1.48	1.37	1.37
Load Reject w/o Bypass	1.47	1.47	1.36	1.36

Operating domain: MELLLA with RPTOOS (HBB)
Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14
Application condition: 2

	Option A		Option B	
	GE14C	**SVEA96+**	**GE14C**	**SVEA96+**
FW Controller Failure	1.54	1.56	1.37	1.39
Turbine Trip w/o Bypass	1.58	1.59	1.41	1.42
Load Reject w/o Bypass	1.58	1.59	1.41	1.42

Operating domain: ICF with RPTOOS (UB)
Exposure range : BOC14 to EOC14
Application condition: 2

	Option A		Option B	
	GE14C	**SVEA96+**	**GE14C**	**SVEA96+**
FW Controller Failure	1.56	1.57	1.39	1.40
Turbine Trip w/o Bypass	1.60	1.61	1.43	1.44
Load Reject w/o Bypass	1.60	1.61	1.43	1.44

Operating domain: MELLLA with RPTOOS (UB)
Exposure range : BOC14 to EOC14
Application condition: 2

	Option A		Option B	
	GE14C	**SVEA96+**	**GE14C**	**SVEA96+**
FW Controller Failure	1.53	1.54	1.36	1.37
Turbine Trip w/o Bypass	1.58	1.59	1.41	1.42
Load Reject w/o Bypass	1.58	1.58	1.41	1.41

Operating domain: ICF & MFWT with RPTOOS (HBB)
Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST)
Application condition: 2

	Option A		Option B	
	GE14C	**SVEA96+**	**GE14C**	**SVEA96+**
FW Controller Failure	1.45	1.45	1.34	1.34

Operating domain: ICF & MFWT with RPTOOS (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 Application condition: 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.55	1.57	1.38	1.40

Operating domain: MELLLA & MFWT with RPTOOS (HBB) Exposure range : BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) Application condition: 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.43	1.44	1.32	1.33

Operating domain: MELLLA & MFWT with RPTOOS (HBB) Exposure range : EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 Application condition: 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.54	1.56	1.37	1.39

Operating domain: ICF & MFWT with RPTOOS (UB) Exposure range : BOC14 to EOC14 Application condition: 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.56	1.57	1.39	1.40

Operating domain: MELLLA & MFWT with RPTOOS (UB) Exposure range : BOC14 to EOC14 Application condition: 2				
	Option A		Option B	
	GE14C	SVEA96+	GE14C	SVEA96+
FW Controller Failure	1.54	1.55	1.37	1.38

12. Overpressurization Analysis Summary

Event	Psl (psig)	Pdome (psig)	Pv (psig)	Plant Response
MSIV Closure (Flux Scram) (ICF)	1258	1263	1284	Figure 50
MSIV Closure (Flux Scram) (MELLLA)	1258	1264	1284	Figure 51

13. Loading Error Results

Variable water gap misoriented bundle analysis: Yes [9]

Misoriented Fuel Bundle	ΔCPR
GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757 (GE14C)	0.08
GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758 (GE14C)	0.12
GE14-P10CNAB396-16GZ-100T-150-T6-2830-LICENSING (GE14C)	0.12

14. Control Rod Drop Analysis Results

Banked Position Withdrawal Sequence is utilized at Hope Creek Generating Station Unit 1, therefore, the control rod drop accident analysis is not required. NRC approval is documented in NEDE-24011-P-A-US.

15. Stability Analysis Results

15.1 Introduction

Hope Creek has implemented BWROG Long Term Stability Solution Option III (Oscillation Power Range Monitor-OPRM) as described in Reference 1 in Section 15.4. Plant specific analysis incorporating the Option III hardware is described in Reference 2 in Section 15.4.

Should the Option III OPRM system be declared inoperable, the Backup Stability Protection (BSP) solution will constitute the stability licensing basis for Hope Creek Cycle 14 operation.

15.2 Stability Option III

Reload validation has been performed in accordance with the licensing basis methodology described in Reference 3 in Section 15.4. The stability based MCPR Operating Limit is provided for two conditions as a function of OPRM amplitude setpoint in the following table. The two conditions evaluated are for a postulated oscillation at 45% rated core flow steady state operation (SS) and following a two recirculation pump trip (2PT) from the limiting full power operation state point. Current power and flow dependent limits provide adequate protection against violation of the Safety Limit MCPR for postulated reactor

---

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

instability as long as the operating limit is greater than or equal to the specified value for the selected OPRM setpoint.

The BWROG Plant-Specific Regional Mode DIVOM Procedure Guideline (Reference 4 in Section 15.4) recommends that a plant specific DIVOM slope be used for Option III OPRM setpoint determination. The stability-based OLMCPR was calculated for Cycle 14 based on the plant-specific DIVOM slope of 0.802 (Reference 5 in Section 15.4). The Option III reload validation calculation demonstrated that reactor stability does not produce the limiting OLMCPR for Cycle 14 as long as the selected OPRM setpoint produces values for OLMCPR(SS) and OLMCPR(2PT) which are less than the corresponding acceptance criteria.

Two sets of OPRM setpoints are provided. Table 15.2-1 assumes a 1.0 Hz corner frequency in the conditioning filter while Table 15.2-2 assumes a 1.5 Hz corner frequency for the conditioning filter.

Table 15.2-1 OLMCPR Results as a Function of OPRM Setpoint

(1.0 Hz Corner Frequency, DIVOM Slope = 0.802)

OPRM Setpoint	Δ_i[10]	1 Hz Corner Frequency OLMCPR(SS)	1 Hz Corner Frequency OLMCPR(2PT)
1.05	0.200	1.274	1.145
1.06	0.238	1.322	1.188
1.07	0.276	1.374	1.235
1.08	0.315	1.432	1.286
1.09	0.353	1.493	1.341
1.10	0.391	1.559	1.401
1.11	0.428	1.629	1.464
1.12	0.465	1.706	1.533
1.13	0.502	1.791	1.609
1.14	0.539	1.885	1.693
1.15	0.576	1.989	1.787
Acceptance Criteria		Off-rated OLMCPR @ 45% flow[11]	Rated Power OLMCPR

---

[10] Δ_i is the licensing basis HCOM with 1.5 Hz corner frequency filtering effect for OPRM setpoint i, in accordance with Reference 2 of Section 15.4.

[11] The off-rated OLMCPR is the maximum of the K_p adjusted MCPR or the $MCPR_f$ at 45% core flow.

Table 15.2-2 OLMCPR Results as a Function of OPRM Setpoint

(1.5 Hz Corner Frequency, DIVOM Slope = 0.802)

OPRM Setpoint	Δ_i[12]	1.5 Hz Corner Frequency OLMCPR(SS)	1.5 Hz Corner Frequency OLMCPR(2PT)
1.05	0.189	1.261	1.133
1.06	0.225	1.306	1.173
1.07	0.261	1.353	1.216
1.08	0.297	1.405	1.262
1.09	0.333	1.460	1.312
1.10	0.369	1.520	1.365
1.11	0.404	1.583	1.422
1.12	0.439	1.651	1.484
1.13	0.474	1.726	1.551
1.14	0.509	1.808	1.625
1.15	0.544	1.898	1.705
Acceptance Criteria		Off-rated OLMCPR @ 45% flow[13]	Rated Power OLMCPR

---

[12] Δ_i is the licensing basis HCOM with 1.5 Hz corner frequency filtering effect for OPRM setpoint i, in accordance with Reference 2 of Section 15.4.

[13] The off-rated OLMCPR is the maximum of the K_p adjusted MCPR or the $MCPR_f$ at 45% core flow.

15.3 Backup Stability Protection

GE SIL-380 recommendations, *BWROG Interim Corrective Actions* (Reference 6 in Section 15.4) and *Backup Stability Protection for Inoperable Option III Solution* (Reference 7 in Section 15.4) have been included in the Hope Creek Cycle 14 operating procedures. Regions of restricted operation defined in Attachment 1 to NRC Bulletin No. 88-07, Supplement 1, (Reference 8 in Section 15.4) and expanded in Reference 6 in Section 15.4 and Reference 7 in Section 15.4 are used for Hope Creek Cycle 14 backup stability protection evaluation (Reference 9 in Section 15.4). The standard ICA stability regions are expanded as appropriate to offer stability protection as described in Reference 7 in Section 15.4 and Reference 10 in Section 15.4 for Hope Creek Cycle 14 MELLLA operation. The Hope Creek Cycle 14 stability analyses discussed above are applicable to the MELLLA operation domain as specified in Reference 9 in Section 15.4.

15.4 References

1. *BWR Owners' Group Long-Term Stability Solutions Licensing Methodology*, NEDO-31960-A, November 1995.
2. *Licensing Basis Hot Channel Oscillation Magnitude for Hope Creek*, GENE-A13-00381-04, Revision 1, September 2004.
3. *Reactor Stability Detect and Suppress Solutions Licensing Basis Methodology for Reload Application*, NEDO-32465-A, August 1996.
4. *Plant-Specific Regional Mode DIVOM Guideline*, GE-NE-0000-0028-9714-R0, June 2004.
5. *MELLLA Option III Stability Evaluation for Hope Creek at CPPU Conditions*, GE-NE-0000-0038-6654-R0, April 2005.
6. *BWR Owners' Group Guideline for Stability Interim Corrective Action*, BWROG-94079, June 6, 1994.
7. *Backup Stability Protection (BSP) for Inoperable Option III Solution, GE to BWR Owners' Group Detect and Suppress II Committee*, OG 02-0119-260, July 17, 2002.
8. *Power Oscillations in Boiling Water Reactors*, NRC Bulletin 88-07, Supplement 1, December 30, 1988.
9. *MELLLA Backup Stability Protection Evaluation for Hope Creek Cycle 14 at CPPU Conditions*, NEDC-33179P-R1, March 2005.
10. *Review of BWR Owners' Group Guidelines for Stability Interim Corrective Action*, BWROG-02072, November 20, 2002.

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 each fuel type 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 (%)
SVEA96+	1540	< 1.00	< 0.10
GE14C	1380	< 1.00	< 0.10

The SAFER/GESTR-LOCA analysis results for SVEA96+ fuel are documented in Section 5 of Reference 1 for SVEA96+ in Section 16.4.

The SAFER/GESTR-LOCA analysis results for GE14C fuel are documented in Section 5 of Reference 1 for GE14C in Section 16.4.

16.2 10CFR50.46 Error Evaluation

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

Table 16.2-1 Impact on Licensing Basis Peak Cladding Temperature for SVEA96+

10CFR50.46 Error Notifications		
Number	**Subject**	**PCT Impact (°F)**
-	No Errors	0
	Total PCT Adder (°F)	0

There are no 10CFR50.46 errors associated with the SVEA96+ Reference 1 analysis. Therefore, no changes to the Licensing Basis PCT for SVEA96+ are necessary.

Table 16.2-2 Impact on Licensing Basis Peak Cladding Temperature for GE14C

10CFR50.46 Error Notifications		
Number	**Subject**	**PCT Impact (°F)**
-	No Errors	0
	Total PCT Adder (°F)	0

There are no 10CFR50.46 errors associated with the GE14C Reference 1 analysis. Therefore, no changes to the Licensing Basis PCT for GE14C are necessary.

16.3 ECCS-LOCA Operating Limits

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

Table 16.3-1 MAPLHGR Limits for GE14C

Bundle Type: GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757 (GE14C)
GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758 (GE14C)
GE14-P10CNAB396-16GZ-100T-150-T6-2830-LICENSING (GE14C)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.82
16.00	14.51	12.82
21.09	19.13	12.82
63.50	57.61	8.00
70.00	63.50	5.00

Table 16.3-2 MAPLHGR Limits for SVEA96+

Bundle Types: SVEA96-P10CASB360-12GZ-568U-4WR-150-T6-2656 (SVEA96+)
SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657 (SVEA96+)
SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658 (SVEA96+)
SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659 (SVEA96+)

Average Planar Exposure		MAPLHGR Limit
GWd/MT	GWd/ST	kW/ft
0.00	0.00	12.85
3.68	3.34	12.85
16.00	14.51	10.97
65.00	58.97	7.24

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

Table 16.3-3 Initial MCPR and Single Loop Operation PLHGR and MAPLHGR Multiplier

Fuel Type	Initial MCPR	Single Loop Operation PLHGR and MAPLHGR Multiplier
SVEA96+	1.250	0.80
GE14C	1.250	0.80

16.4 References

The SAFER/GESTR-LOCA analysis base reports applicable to the new cycle core are listed below.

References for SVEA96+ and GE14C

SAFER/GESTR-LOCA Loss of Coolant Accident Analysis for Hope Creek Generating Station at Power Up-rate, NEDC-33172P, March 2005.

60									B	B	C	B	B	A	A	A	A	B	B	C	B	B								
58								B	F	E	F	E	F	G	E	E	G	F	E	F	E	F	B							
56						A	A	F	G	B	G	C	G	C	B	B	C	G	C	G	B	G	F	A	A					
54						A	E	G	F	G	D	G	E	G	F	F	G	E	G	D	G	F	G	E	A					
52					B	F	G	F	G	D	G	C	G	C	G	G	C	G	C	G	D	G	F	G	F	B				
50			B	B	C	G	D	G	D	G	F	G	C	G	C	C	G	C	G	F	G	D	G	D	G	C	B	B		
48			A	E	G	D	D	C	G	E	C	C	G	F	C	C	F	G	C	C	E	G	C	D	D	G	E	A		
46		A	F	G	F	G	C	D	B	G	C	D	C	G	C	C	G	C	D	C	G	B	D	C	G	F	G	F	A	
44	A	F	G	F	G	D	G	B	G	D	G	F	G	E	G	G	E	G	F	G	D	G	B	G	D	G	F	G	F	A
42	B	E	B	G	D	G	E	G	D	G	F	G	C	G	B	B	G	C	G	F	G	D	G	E	G	D	G	B	E	B
40	C	F	G	D	G	F	C	C	G	F	C	C	G	F	C	C	F	G	C	C	F	G	C	C	F	G	D	G	F	C
38	B	E	C	G	C	G	C	D	F	G	C	C	F	G	D	D	G	F	C	C	G	F	D	C	G	C	G	C	E	B
36	A	F	G	E	G	C	G	C	G	C	G	F	G	C	G	G	C	G	F	G	C	G	C	G	C	G	E	G	F	A
34	A	G	C	G	C	G	F	G	E	G	F	G	C	G	C	C	G	C	G	F	G	E	G	F	G	C	G	C	G	A
32	B	E	B	F	G	C	C	C	G	B	C	D	G	C	C	C	C	G	D	C	B	G	C	C	C	G	F	B	E	B
30	B	E	B	F	G	C	C	C	G	B	C	D	G	C	C	C	C	G	D	C	B	G	C	C	C	G	F	B	E	B
28	A	G	C	G	C	G	F	G	E	G	F	G	C	G	C	C	G	C	G	F	G	E	G	F	G	C	G	C	G	A
26	A	F	G	E	G	C	G	C	G	C	G	F	G	C	G	G	C	G	F	G	C	G	C	G	C	G	E	G	F	A
24	B	E	C	G	C	G	C	D	F	G	C	C	F	G	D	D	G	F	C	C	G	F	D	C	G	C	G	C	E	B
22	C	F	G	D	G	F	C	C	G	F	C	C	G	F	C	C	F	G	C	C	F	G	C	C	F	G	D	G	F	C
20	B	E	B	G	D	G	E	G	D	G	F	G	C	G	B	B	G	C	G	F	G	D	G	E	G	D	G	B	E	B
18	A	F	G	F	G	D	G	B	G	D	G	F	G	E	G	G	E	G	F	G	D	G	B	G	D	G	F	G	F	A
16		A	F	G	F	G	C	D	B	G	C	D	C	G	C	C	G	C	D	C	G	B	D	C	G	F	G	F	A	
14			A	E	G	D	D	C	G	E	C	C	G	F	C	C	F	G	C	C	E	G	C	D	D	G	E	A		
12			B	B	C	G	D	G	D	G	F	G	C	G	C	C	G	C	G	F	G	D	G	D	G	C	B	B		
10					B	F	G	F	G	D	G	C	G	C	G	G	C	G	C	G	D	G	F	G	F	B				
8						A	E	G	F	G	D	G	E	G	F	F	G	E	G	D	G	F	G	E	A					
6						A	A	F	G	B	G	C	G	C	B	B	C	G	C	G	B	G	F	A	A					
4								B	F	E	F	E	F	G	E	E	G	F	E	F	E	F	B							
2									B	B	C	B	B	A	A	A	A	B	B	C	B	B								
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59

Fuel Type			
A	=	SVEA96-P10CASB360-12GZ-568U-4WR-150-T6-2656	(Cycle 11)
B	=	SVEA96-P10CASB360-12G5.0-568U-4WR-150-T6-2657	(Cycle 11)
C	=	SVEA96-P10CASB361-14GZ-568U-4WR-150-T6-2658	(Cycle 12)
D	=	SVEA96-P10CASB360-12G5.5/2G2.5-568U-4WR-150-T6-2659	(Cycle 12)
E	=	GE14-P10CNAB402-4G6.0/16G4.0-100T-150-T6-2757	(Cycle 13)
F	=	GE14-P10CNAB402-5G6.0/14G4.0-100T-150-T6-2758	(Cycle 13)
G	=	GE14-P10CNAB396-16GZ-100T-150-T6-2830-LICENSING	(Cycle 14)

Figure 1 Reference Core Loading Pattern

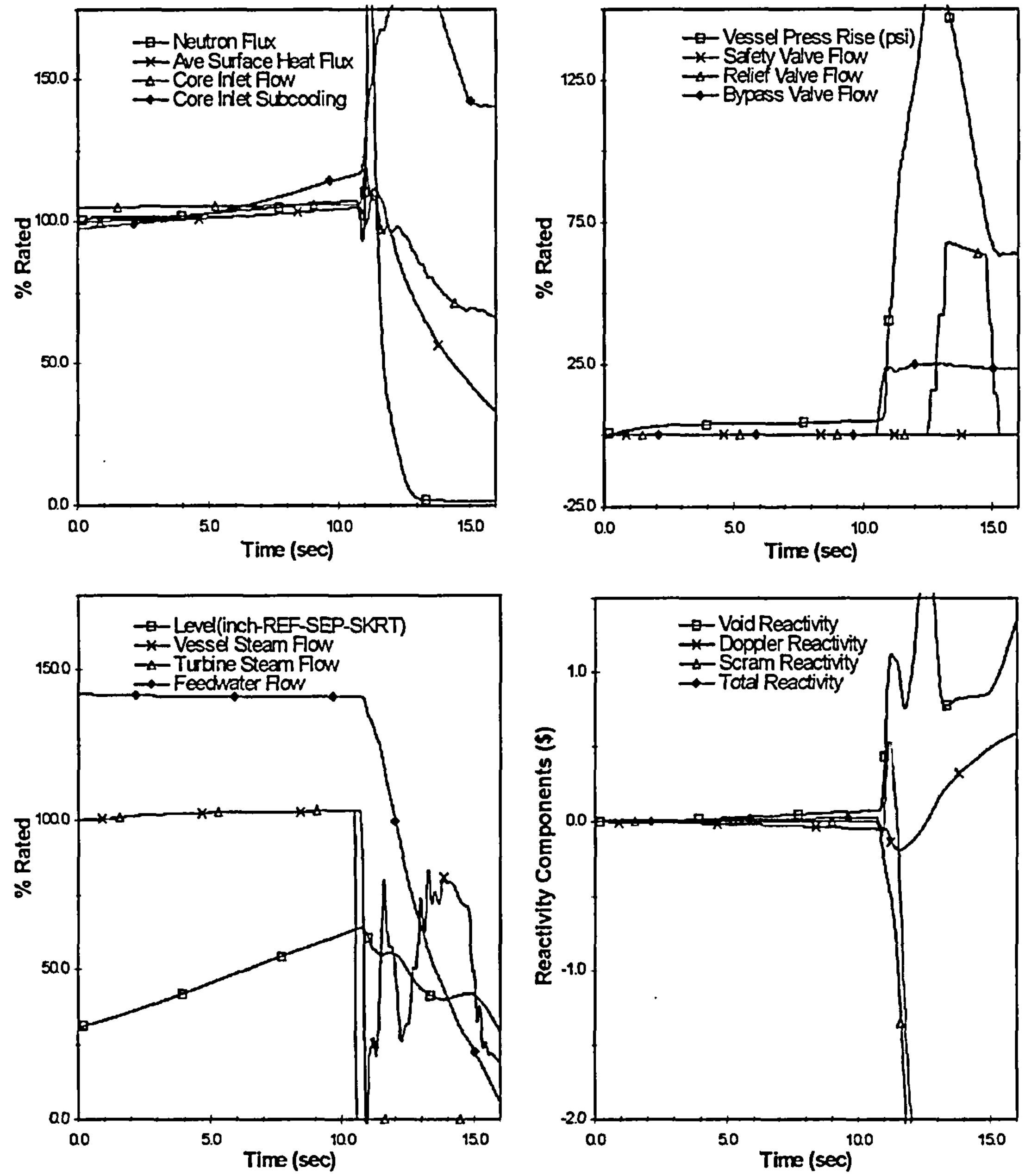


Figure 2 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF (HBB))

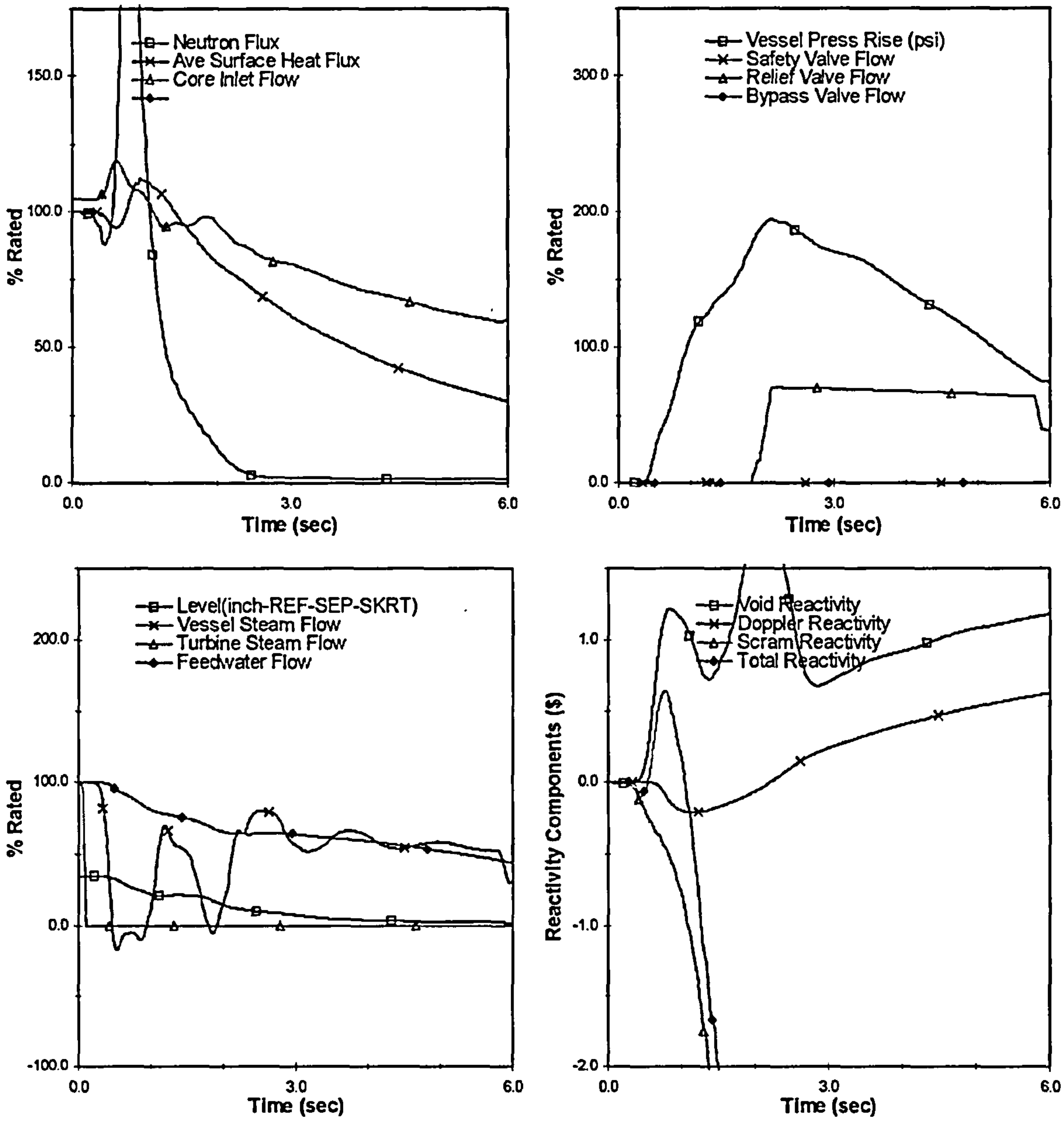


Figure 3 Plant Response to Turbine Trip w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF (HBB))

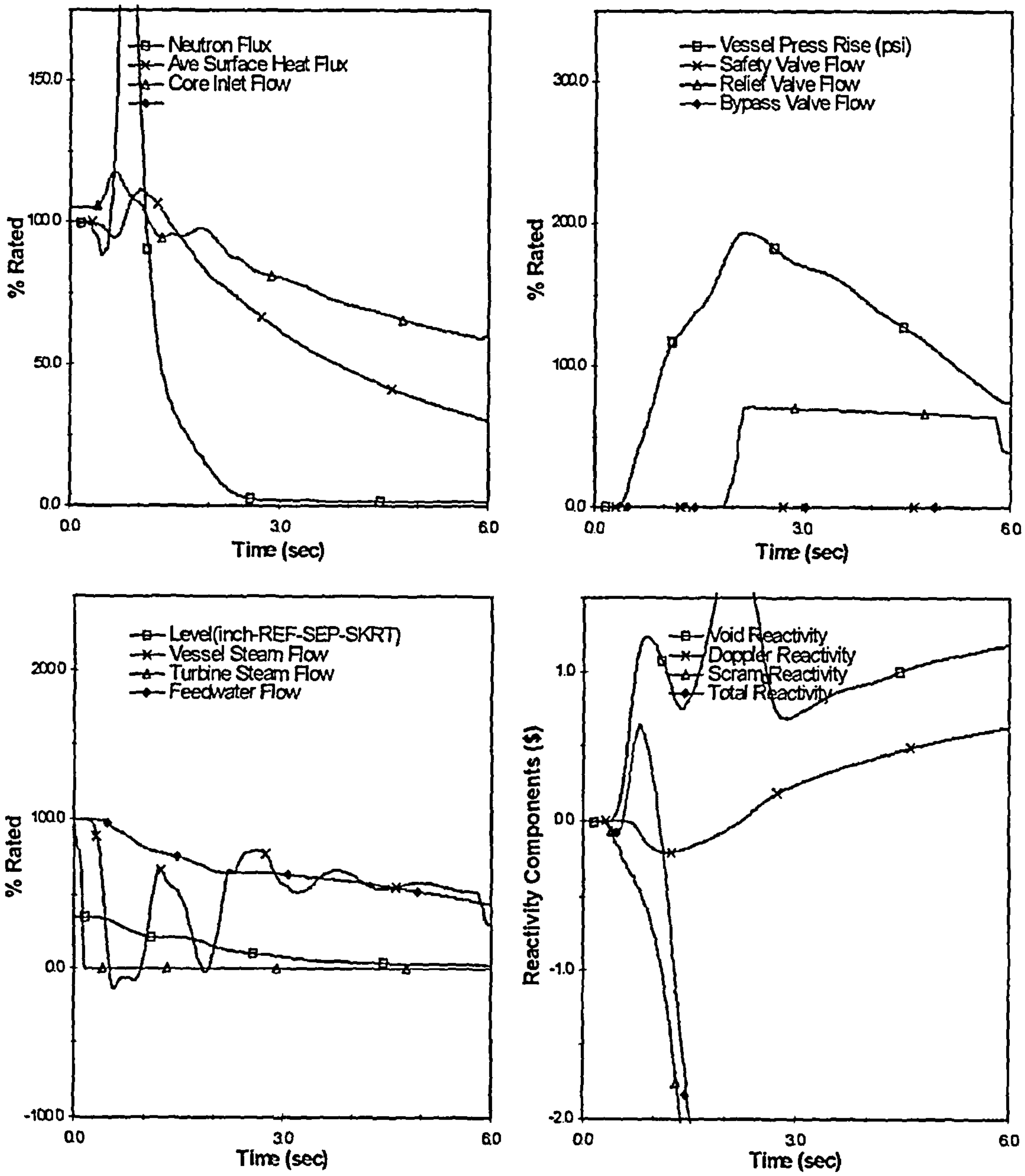


Figure 4 Plant Response to Load Reject w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF (HBB))

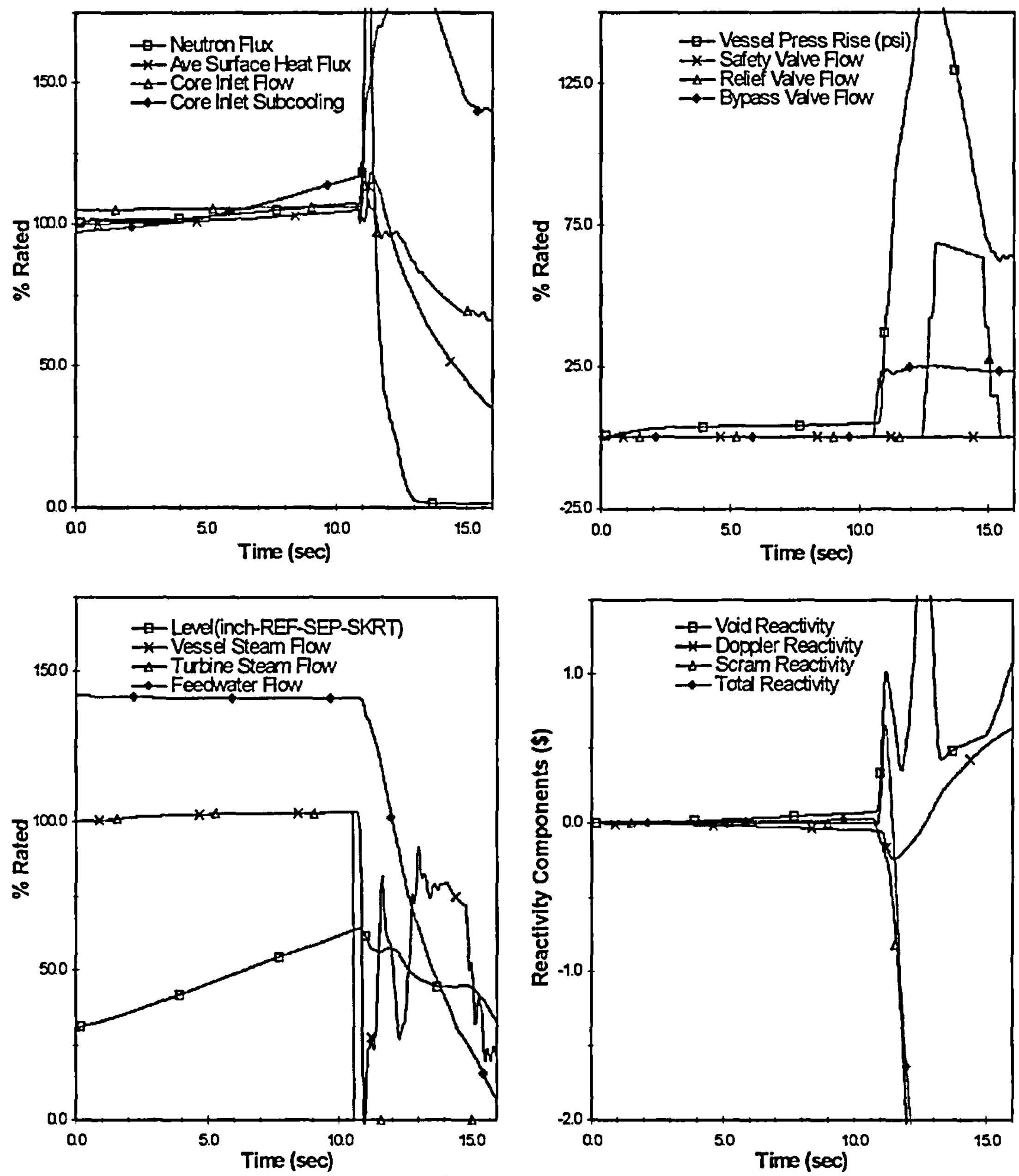


Figure 5 Plant Response to FW Controller Failure (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF (HBB))

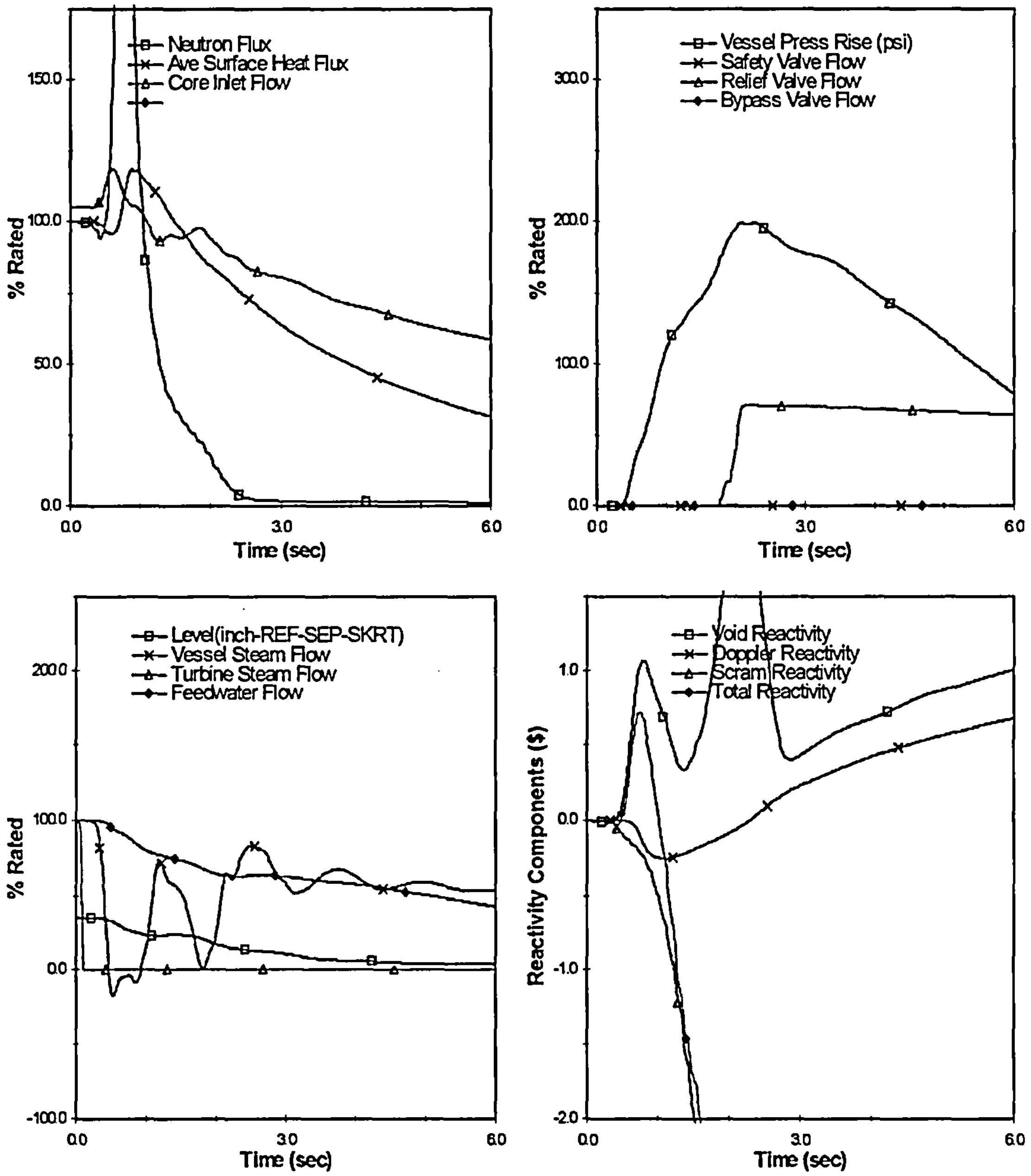


Figure 6 Plant Response to Turbine Trip w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF (HBB))

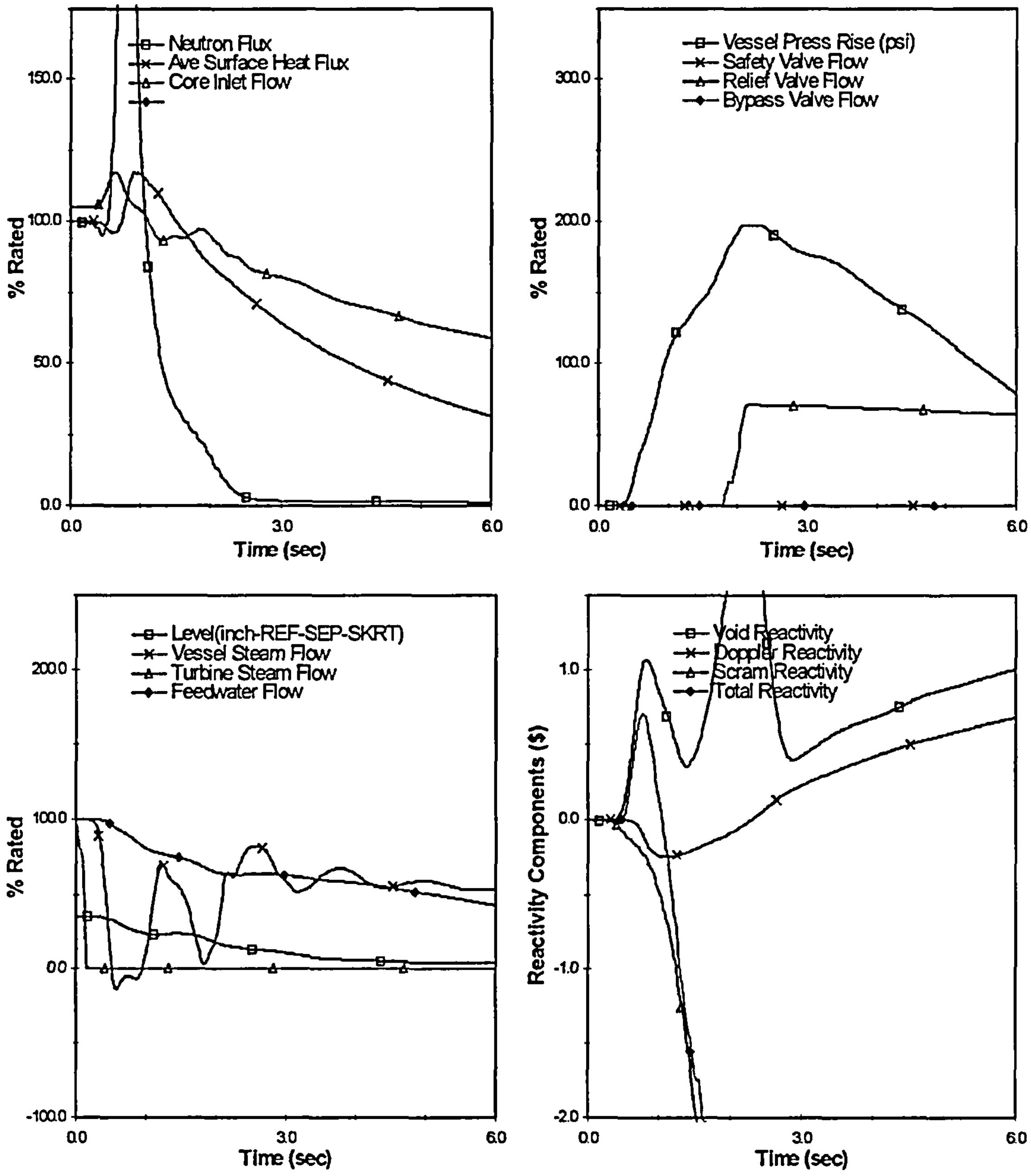


Figure 7 Plant Response to Load Reject w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF (HBB))

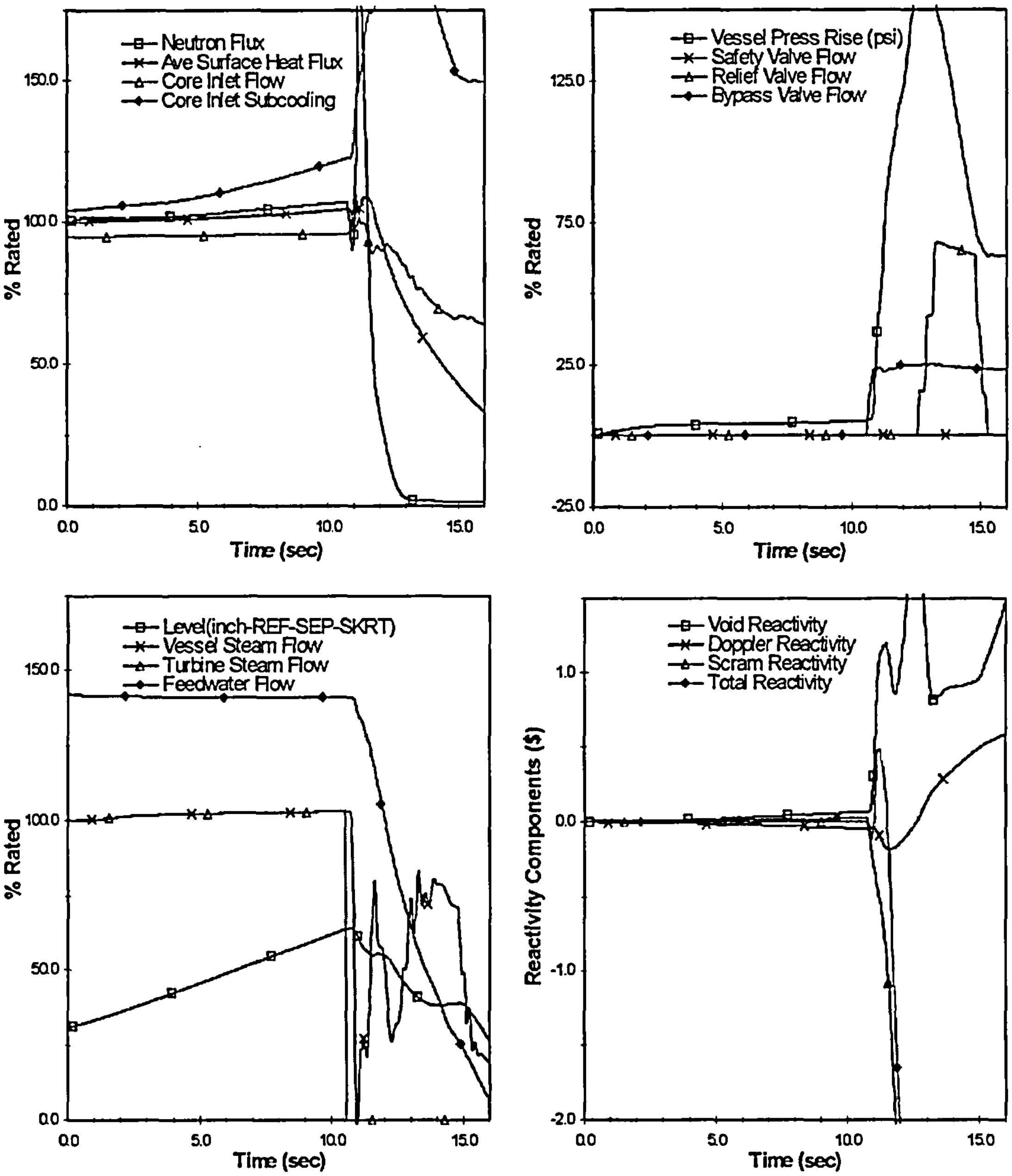


Figure 8 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA (HBB))

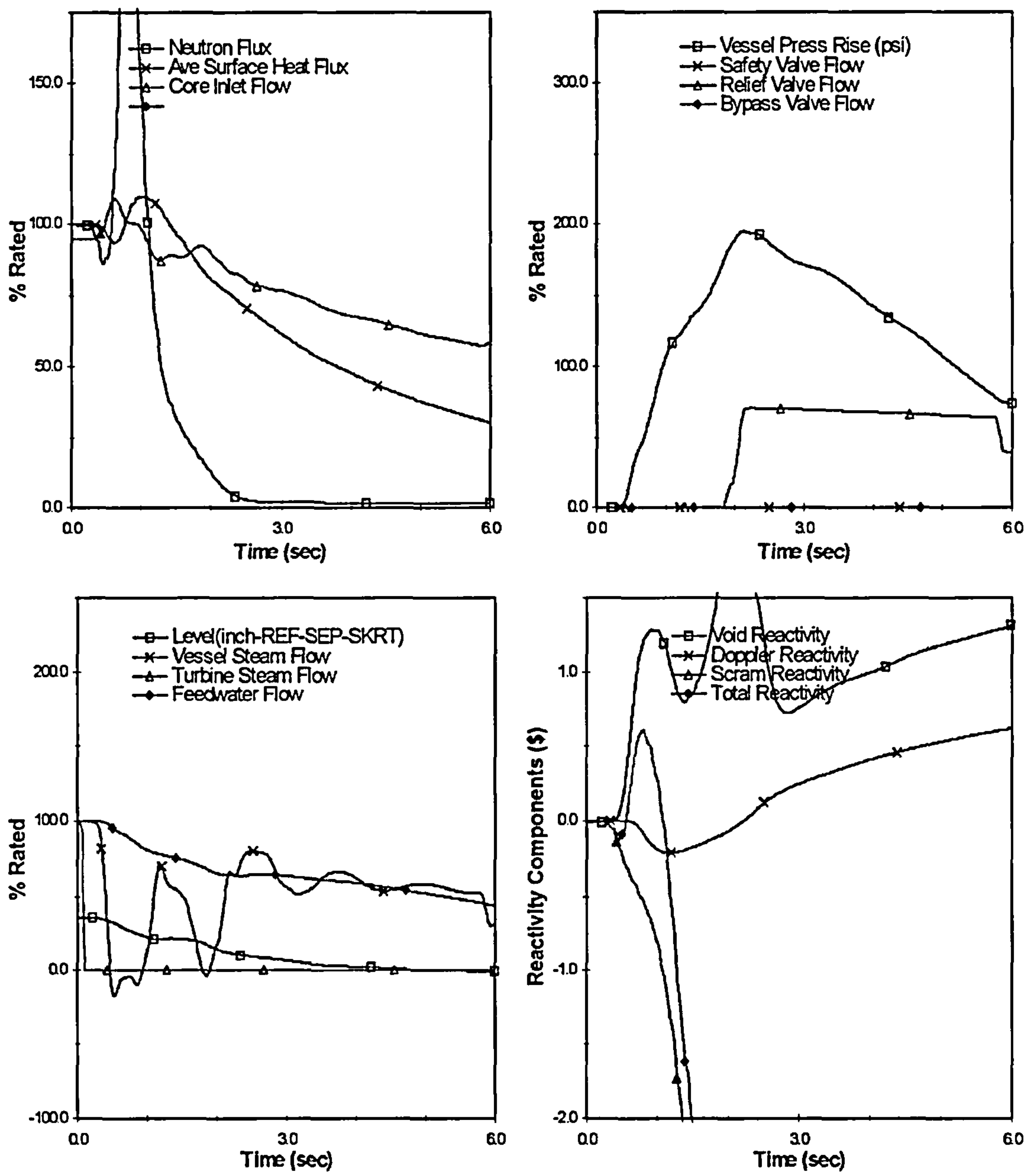


Figure 9 Plant Response to Turbine Trip w/o Bypass (BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA (HBB))

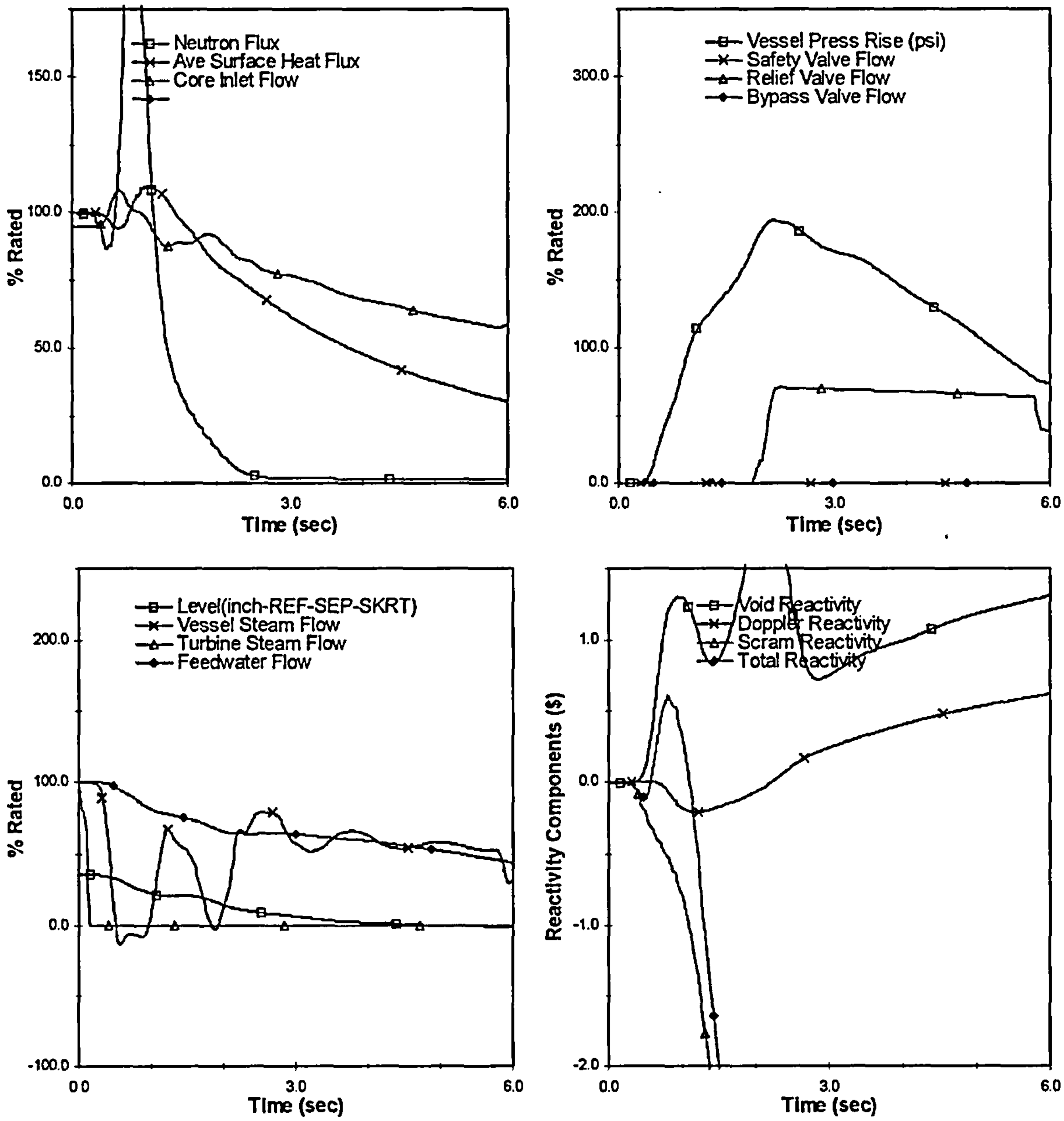


Figure 10 Plant Response to Load Reject w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA (HBB))

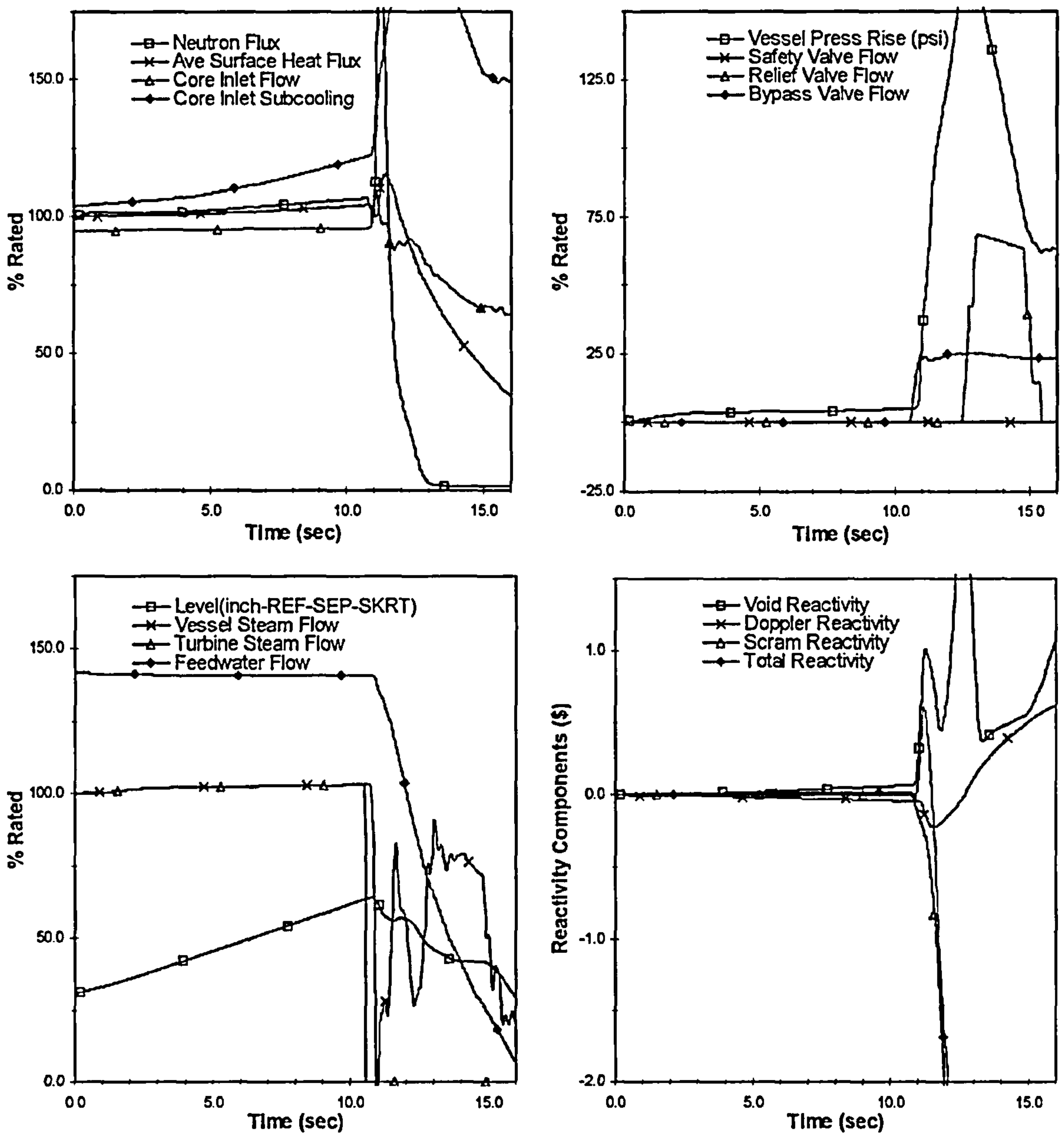


Figure 11 Plant Response to FW Controller Failure
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA (HBB))

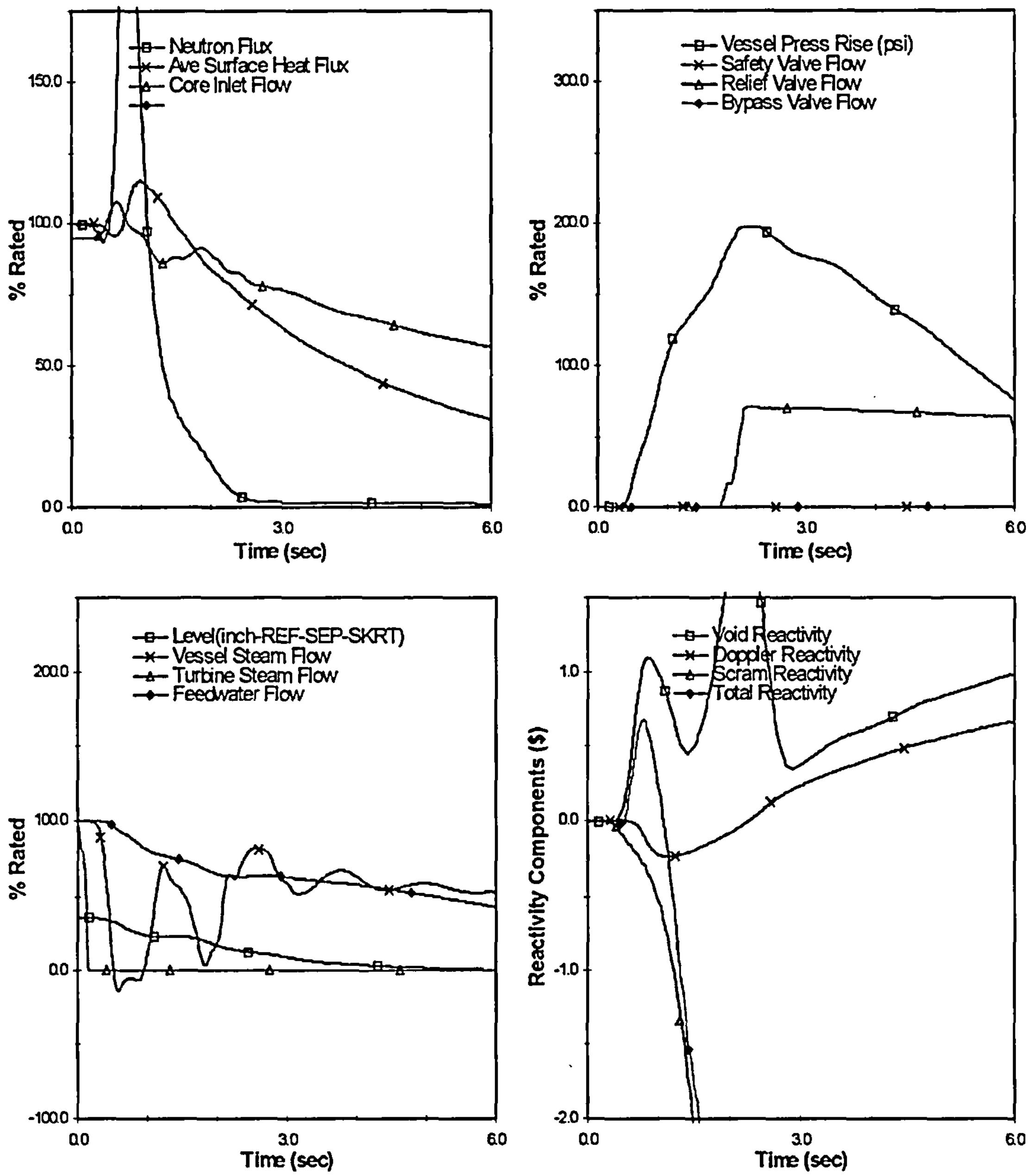


Figure 12 Plant Response to Load Reject w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA (HBB))

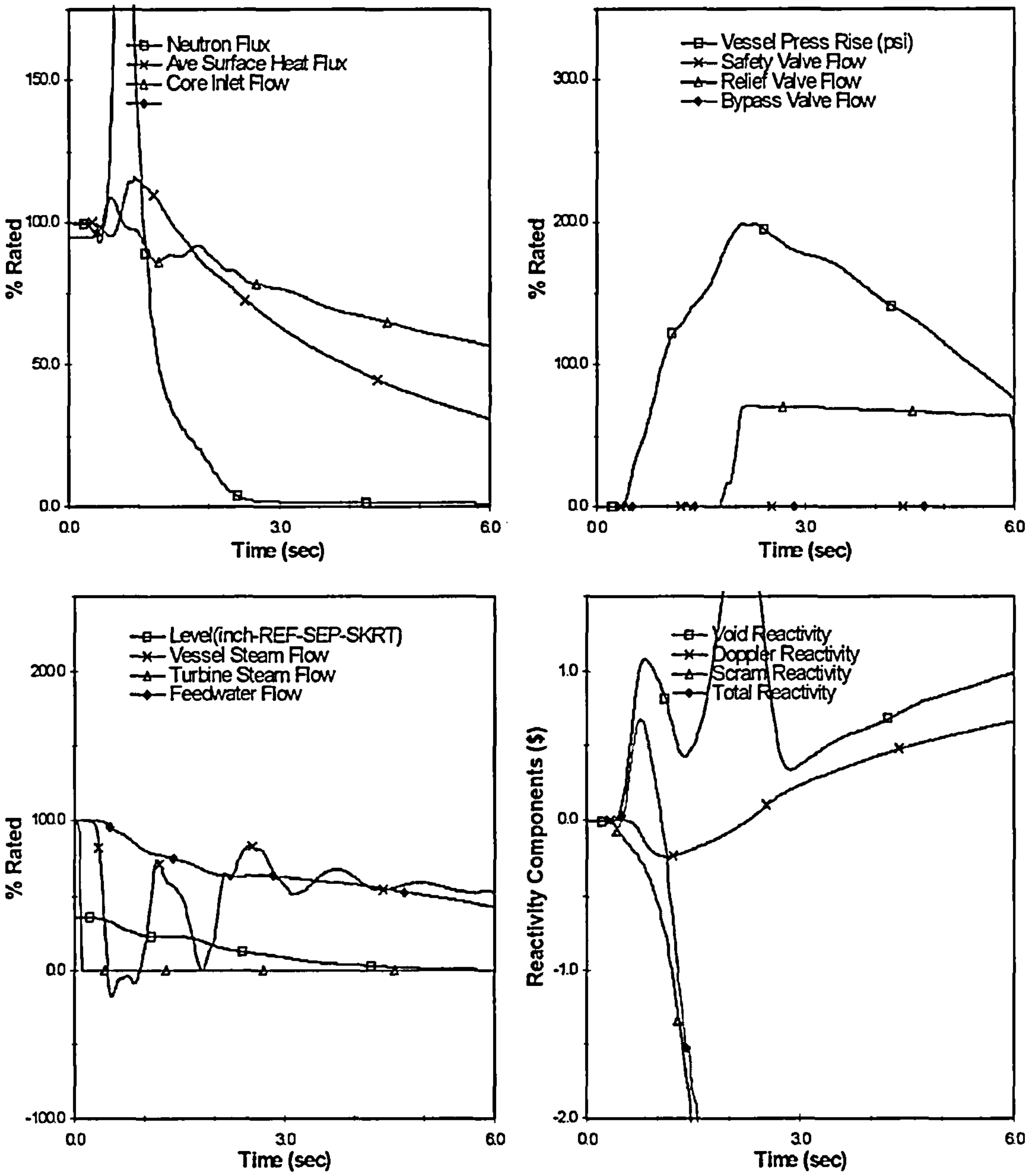


**Figure 13 Plant Response to Turbine Trip w/o Bypass
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA (HBB))**

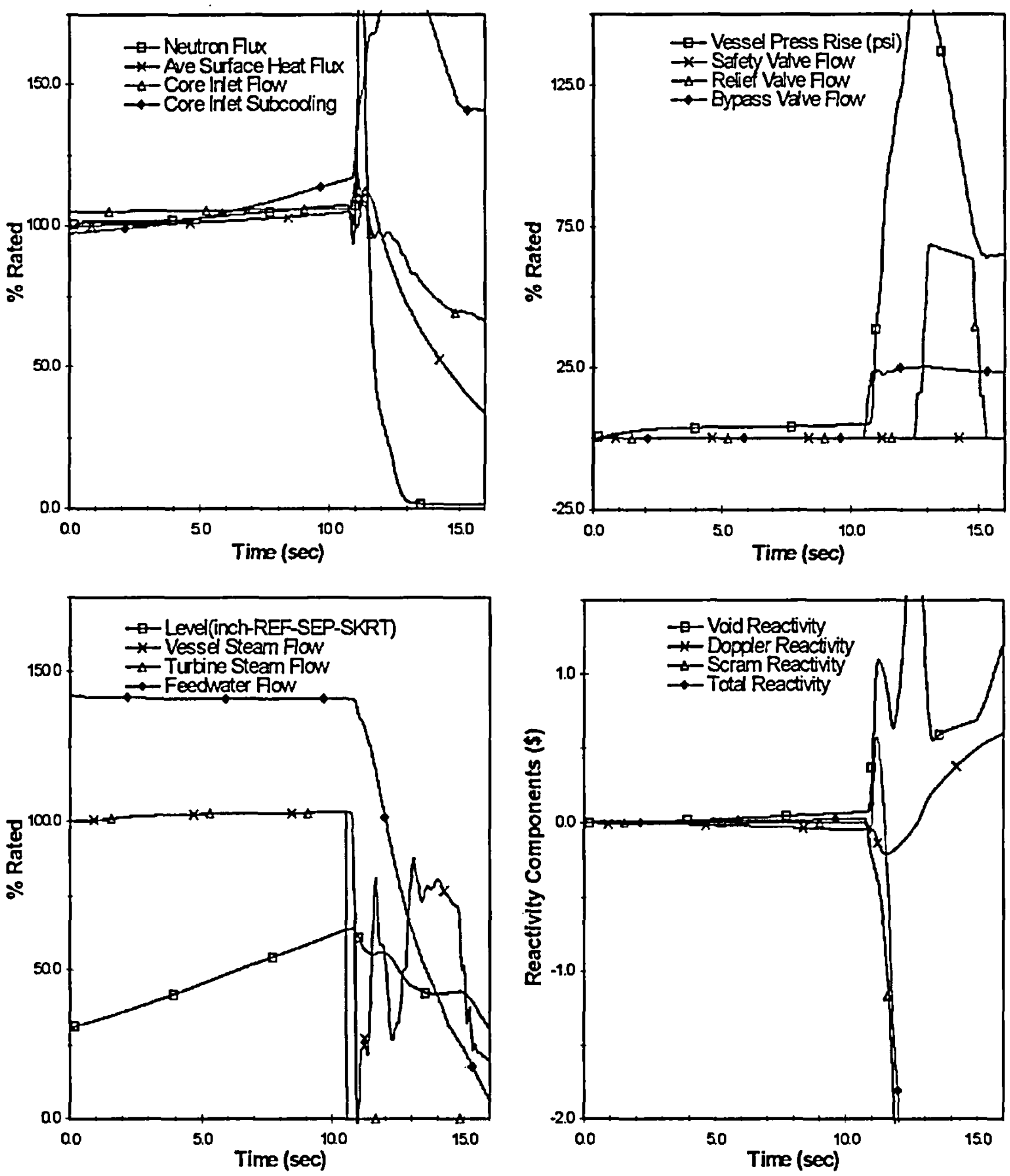


Figure 14 Plant Response to FW Controller Failure
(BOC14 to EOC14 ICF (UB))

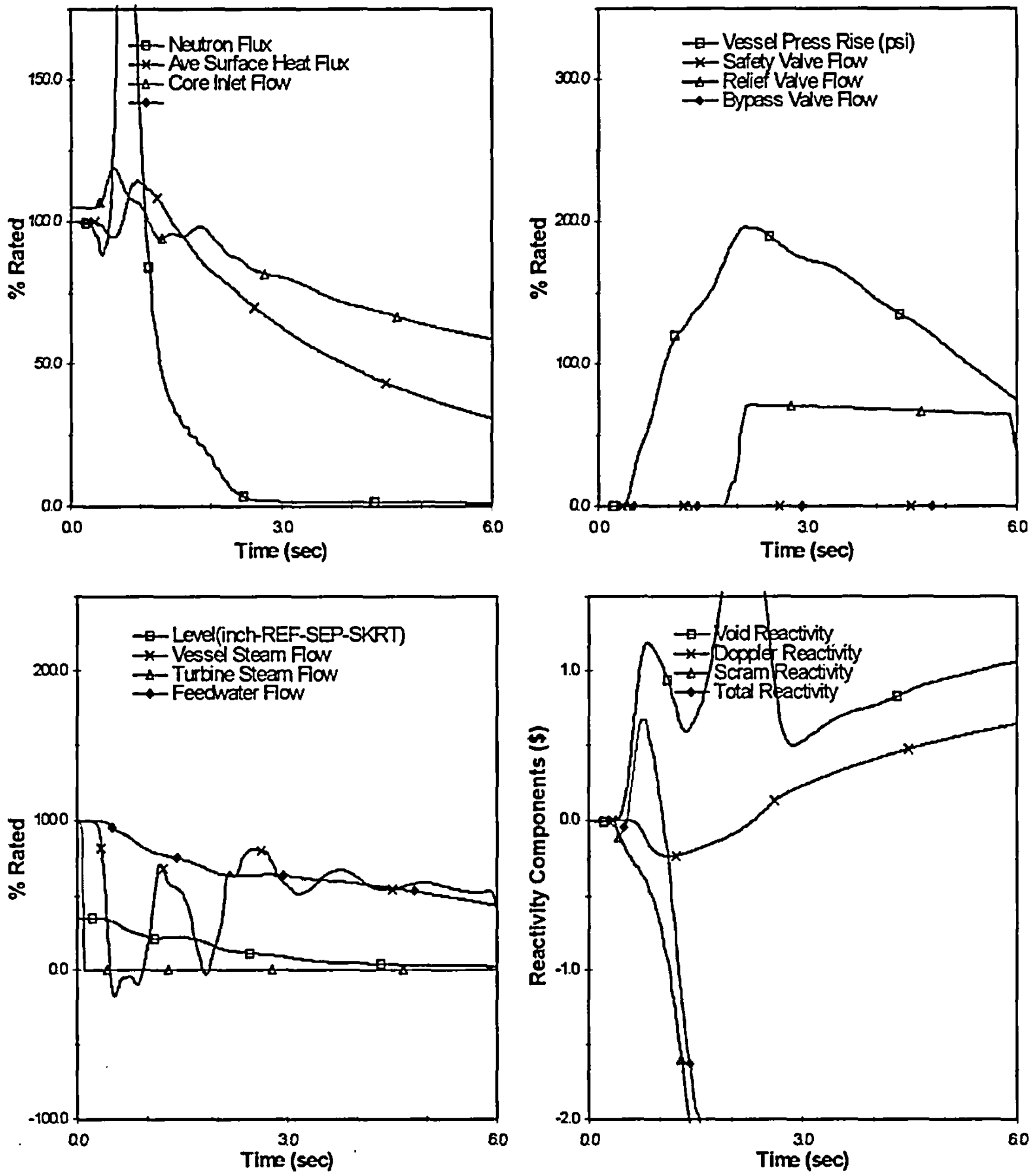


Figure 15 Plant Response to Turbine Trip w/o Bypass (BOC14 to EOC14 ICF (UB))

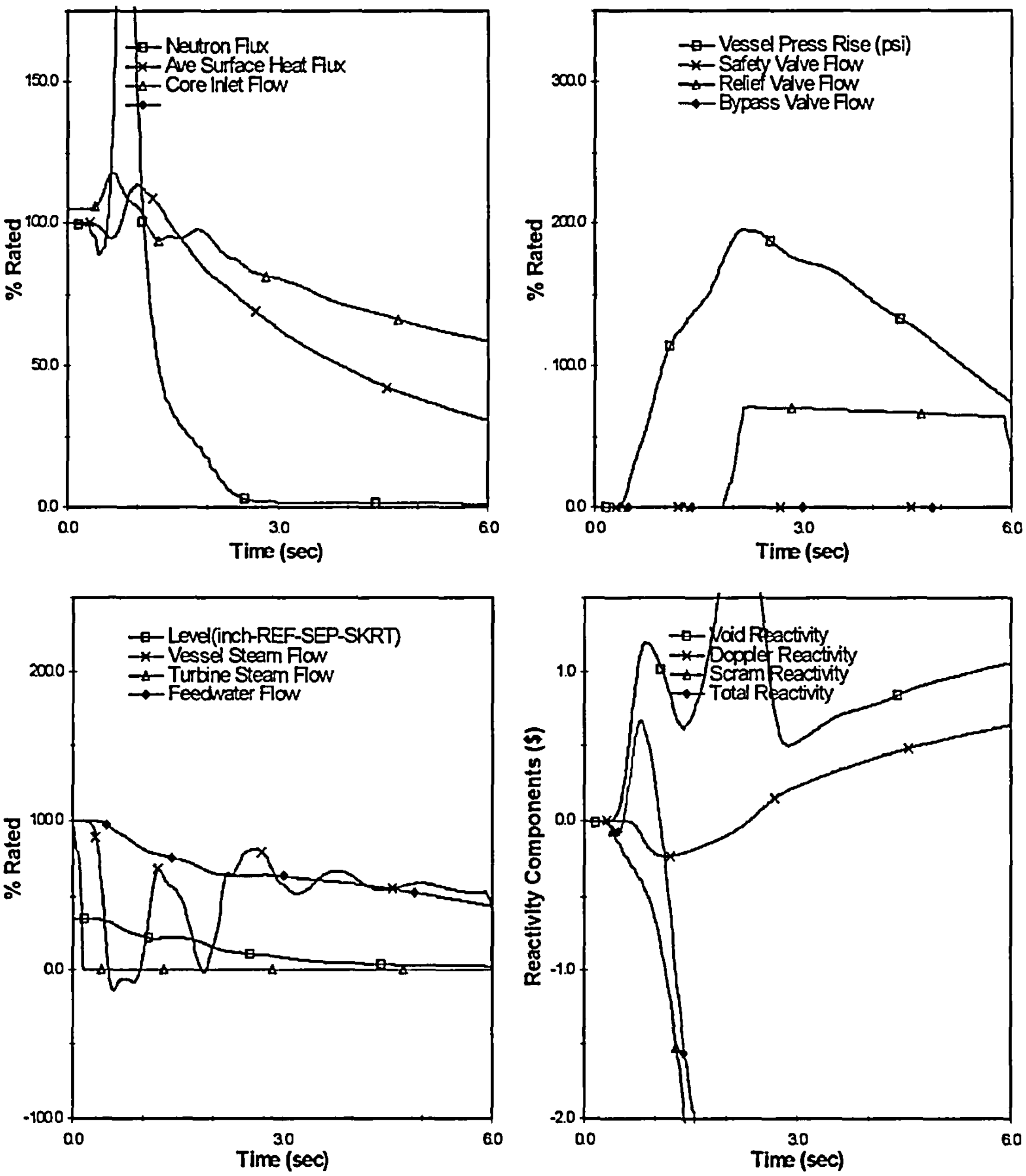


Figure 16 Plant Response to Load Reject w/o Bypass (BOC14 to EOC14 ICF (UB))

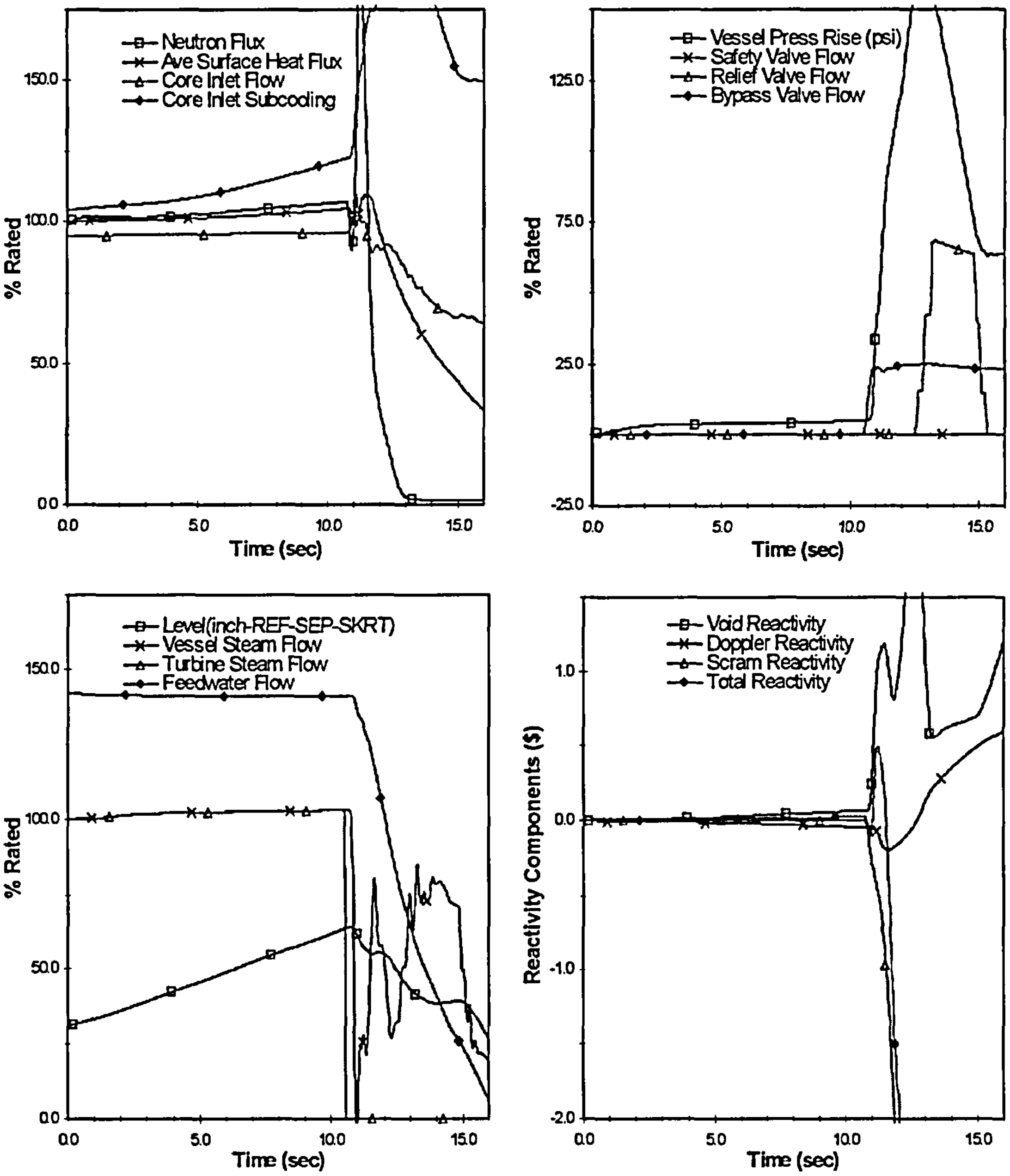


Figure 17 Plant Response to FW Controller Failure
(BOC14 to EOC14 MELLLA (UB))

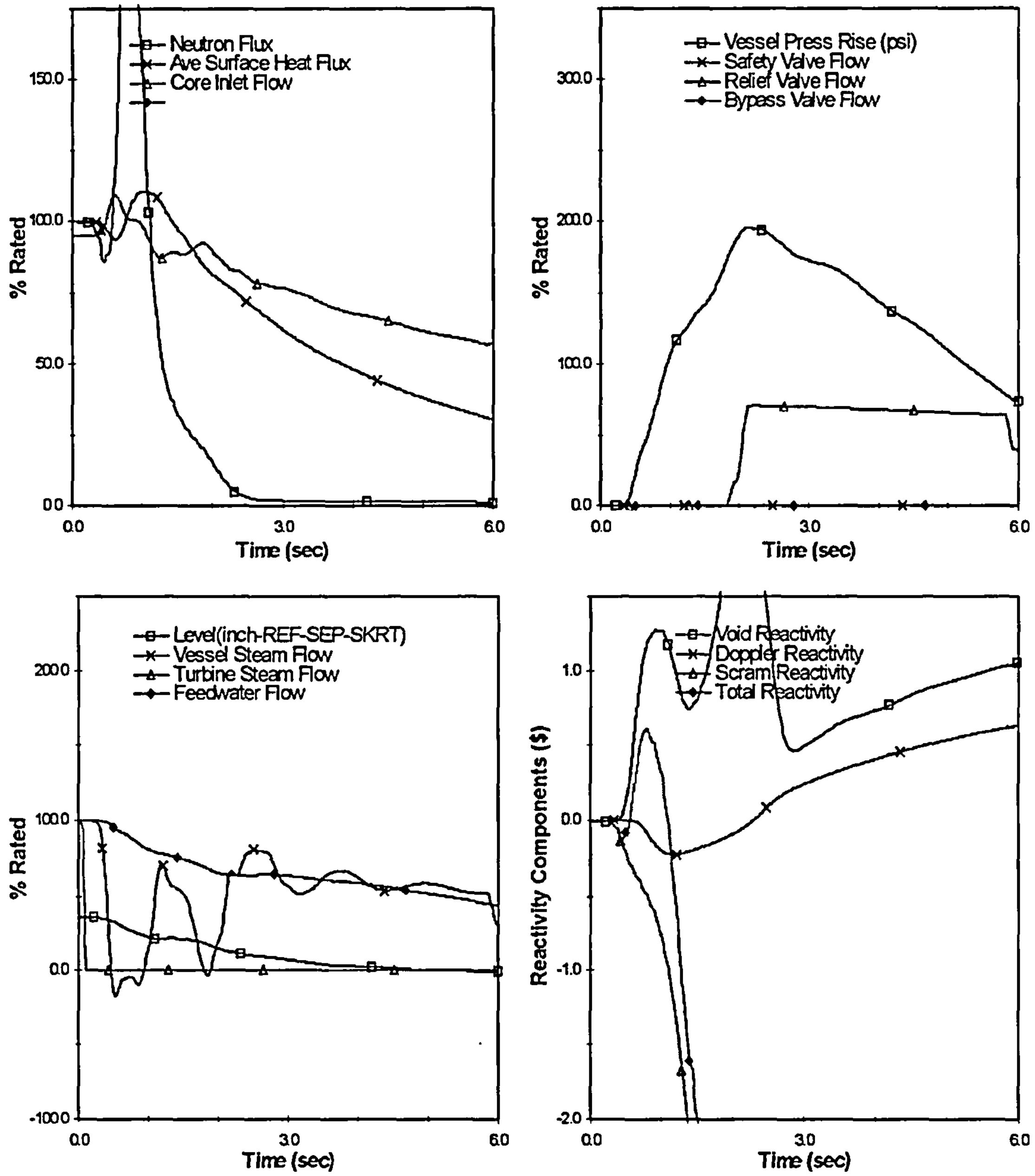


Figure 18 Plant Response to Turbine Trip w/o Bypass (BOC14 to EOC14 MELLLA (UB))

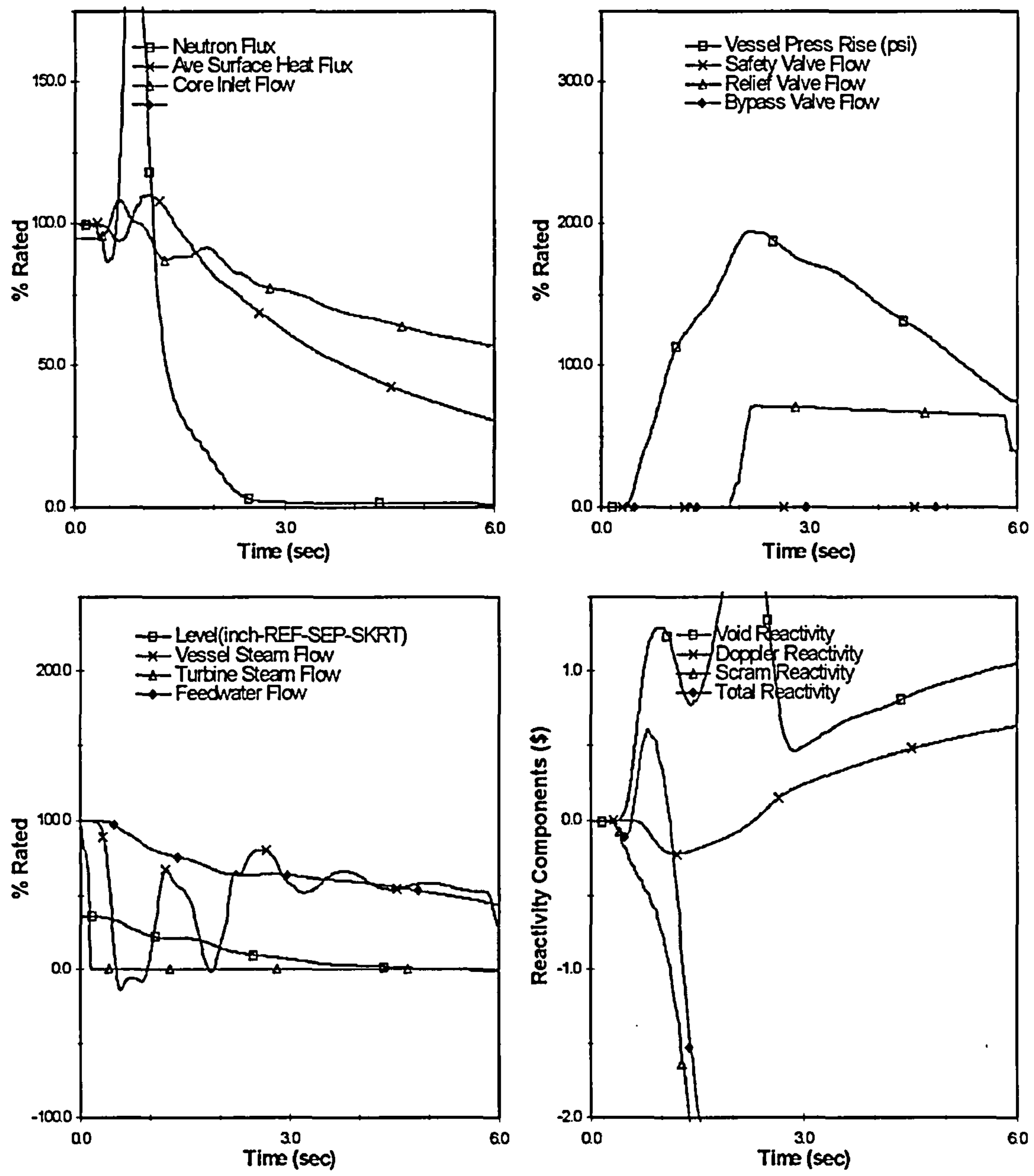


Figure 19 Plant Response to Load Reject w/o Bypass (BOC14 to EOC14 MELLLA (UB))

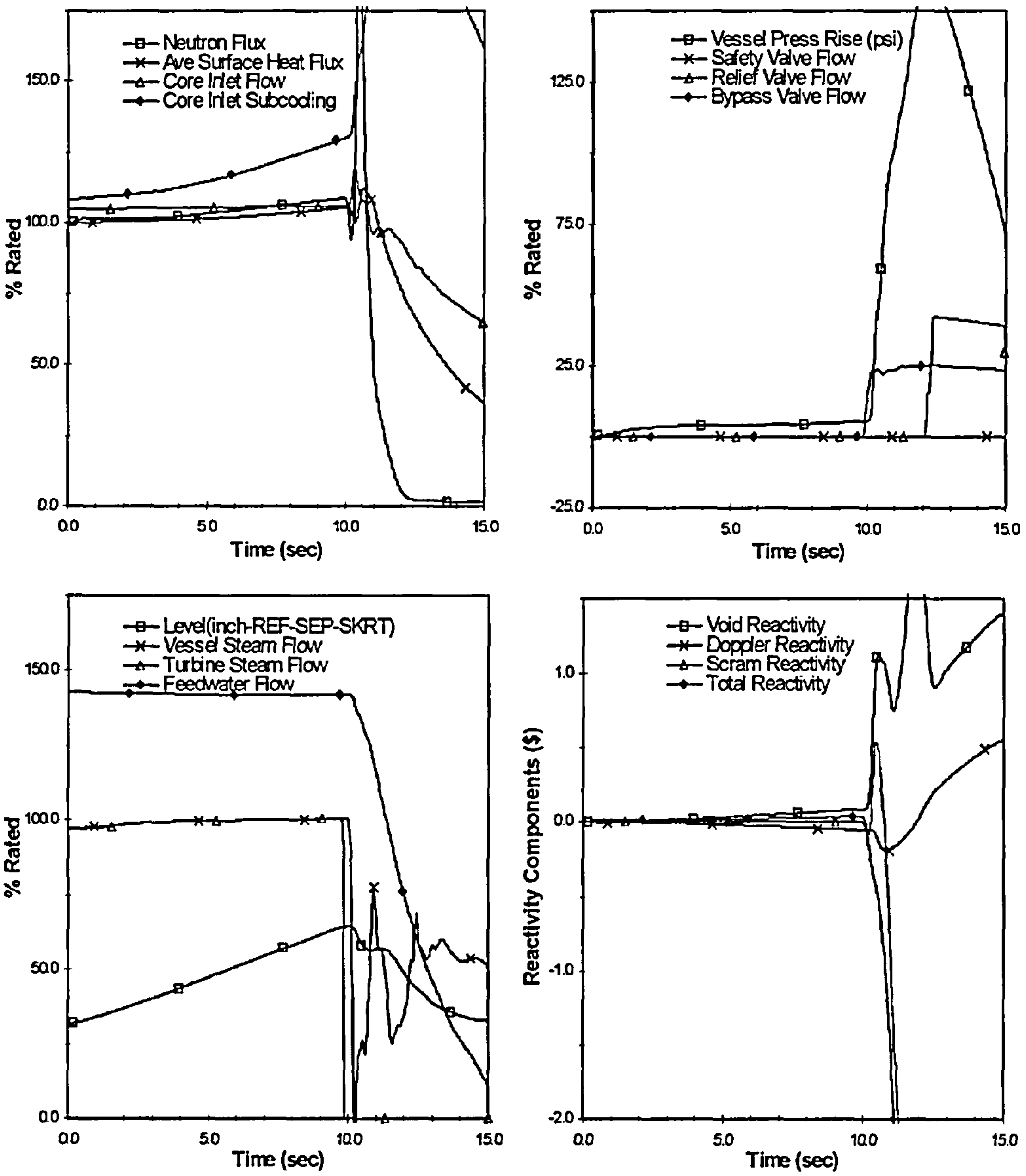


Figure 20 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF & MFWT (HBB))

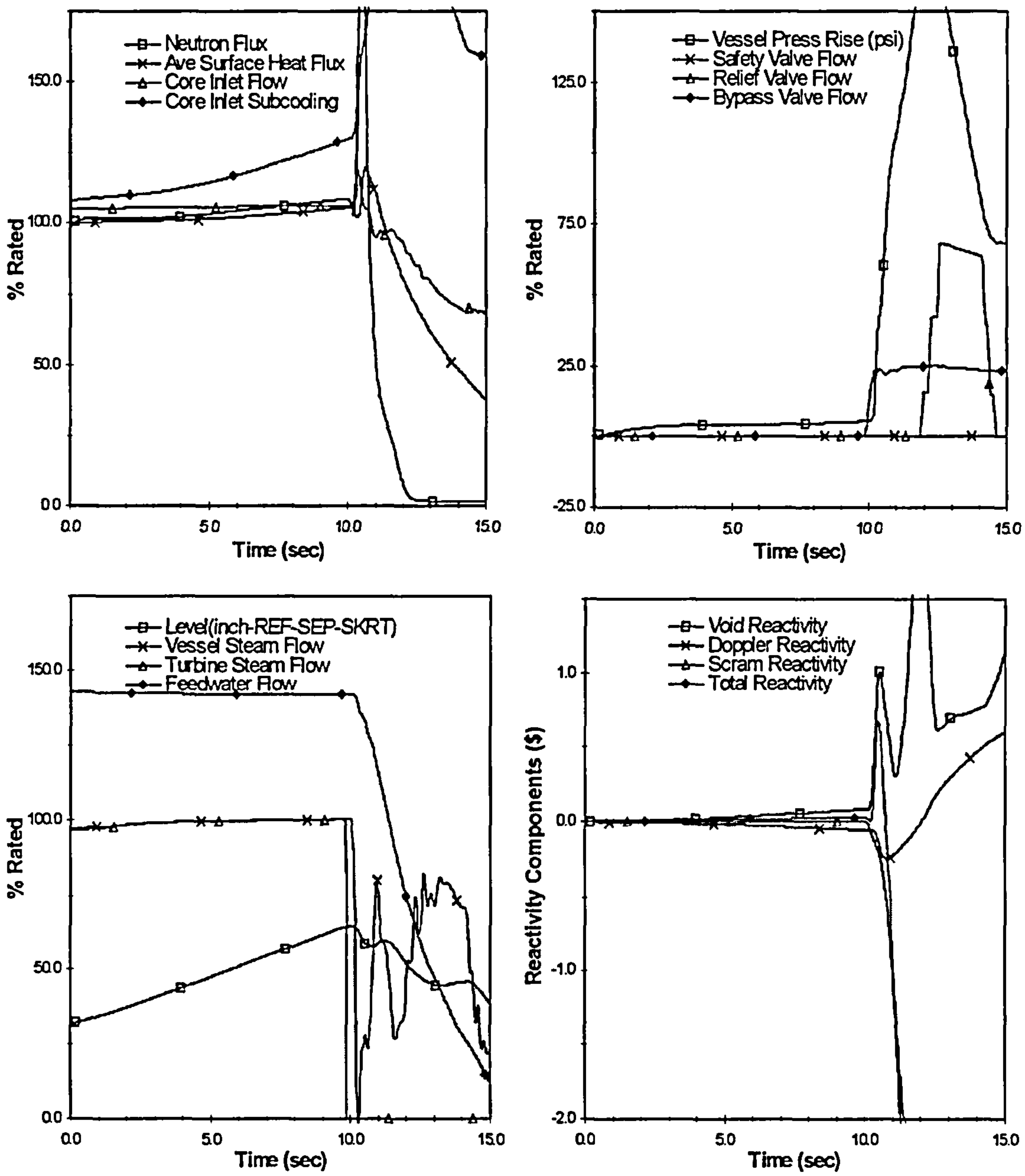


Figure 21 Plant Response to FW Controller Failure
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF & MFWT (HBB))

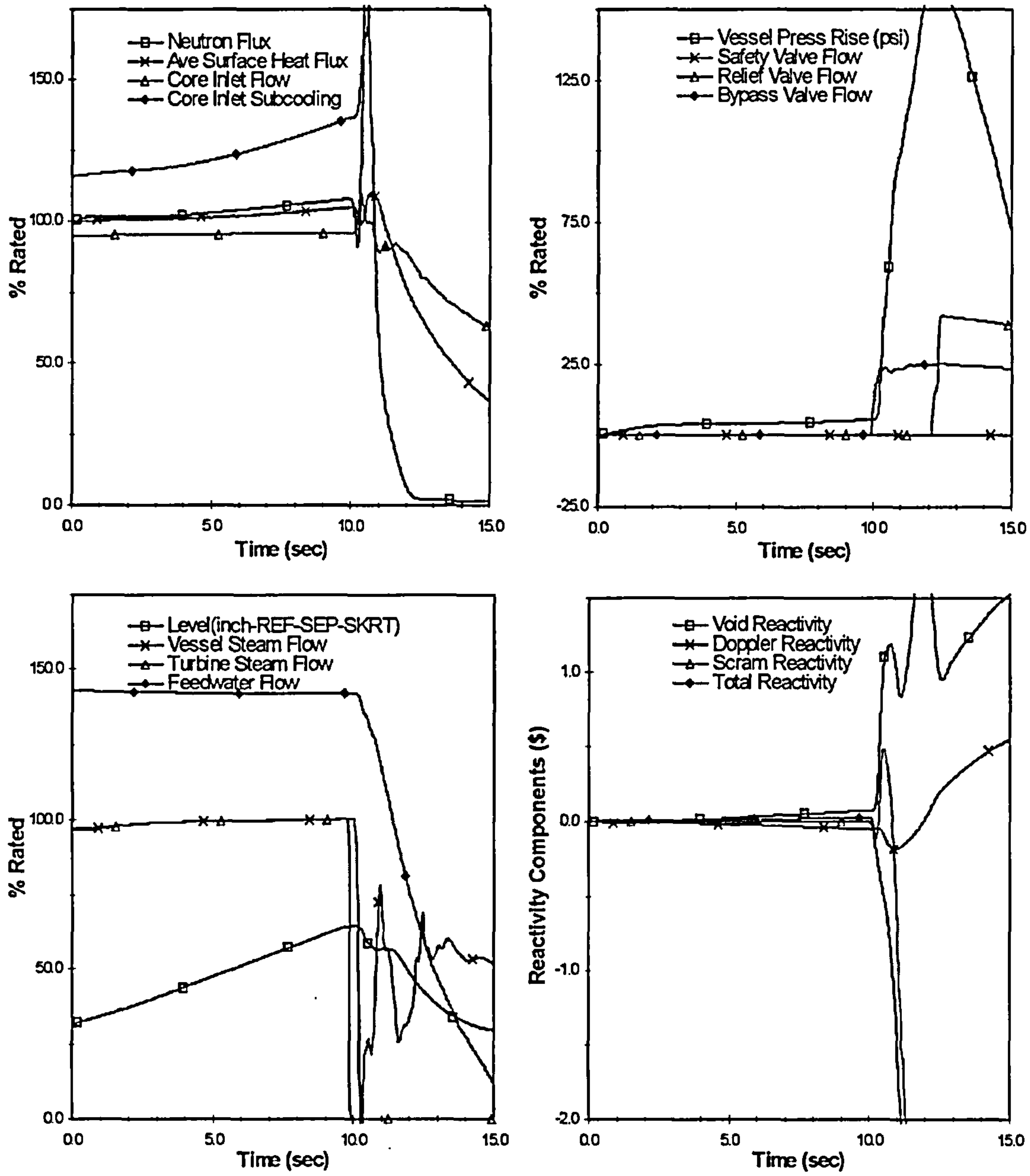


Figure 22 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA & MFWT (HBB))

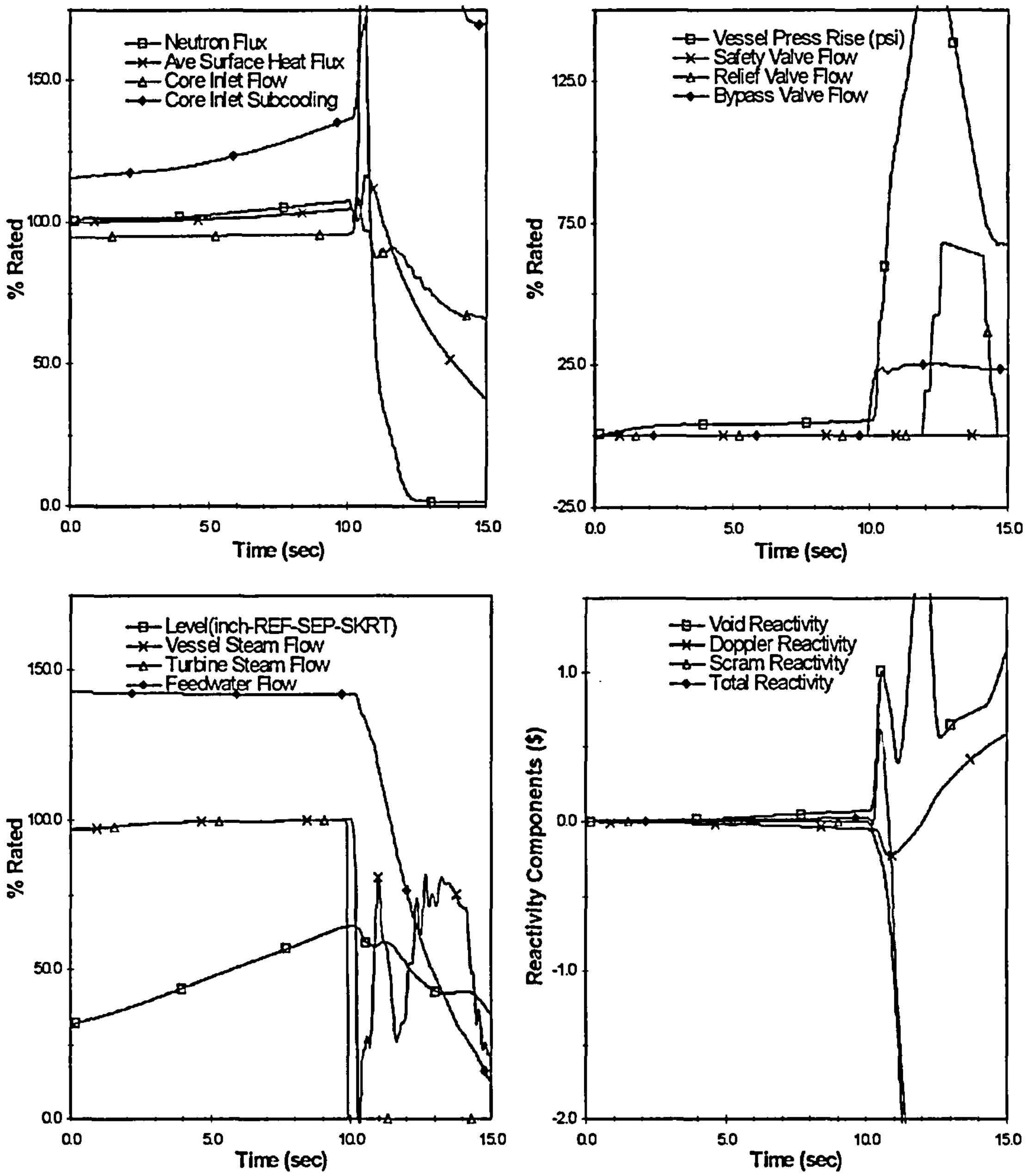


Figure 23 Plant Response to FW Controller Failure (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA & MFWT (HBB))

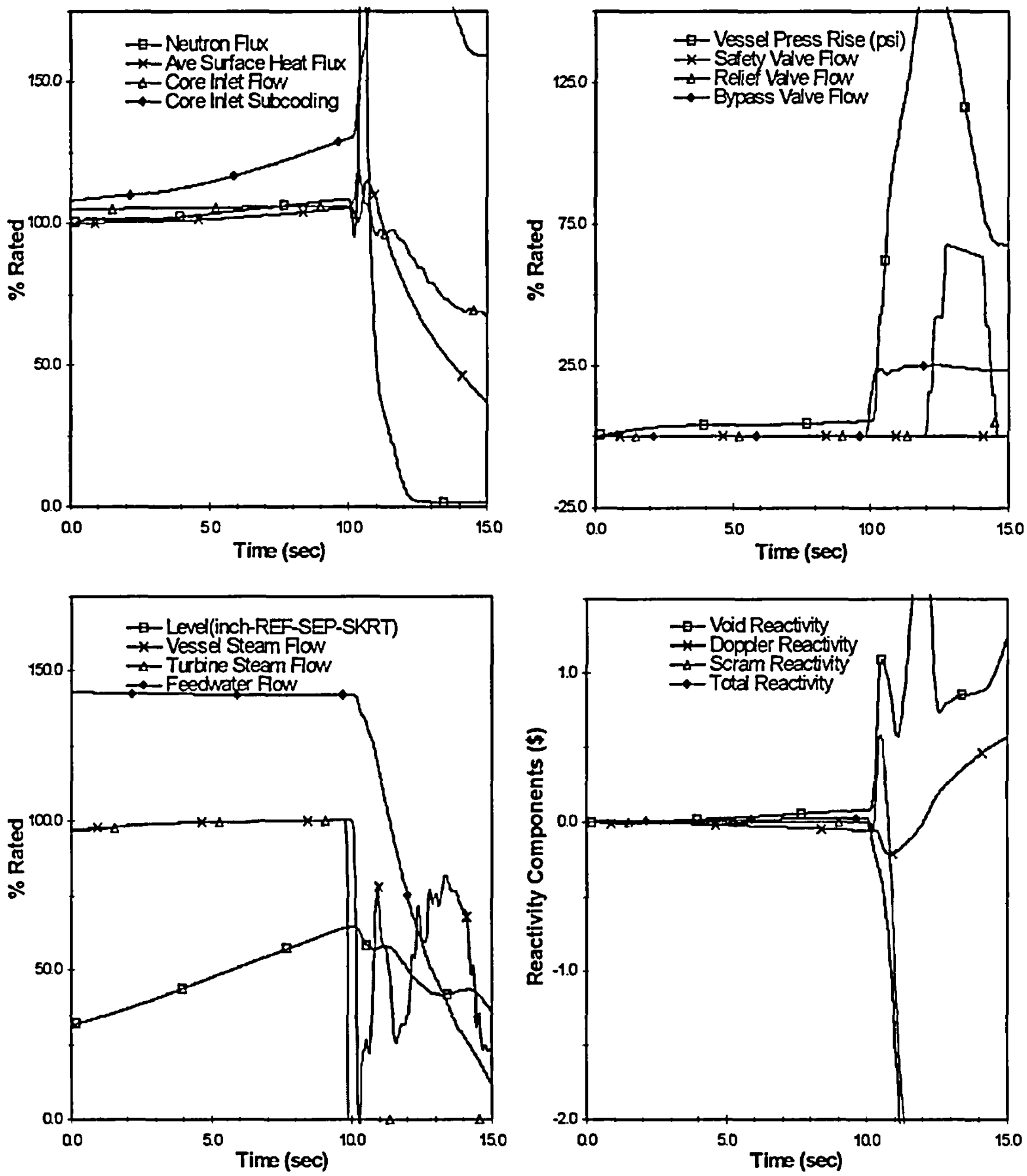


Figure 24 Plant Response to FW Controller Failure (BOC14 to EOC14 ICF & MFWT (UB))

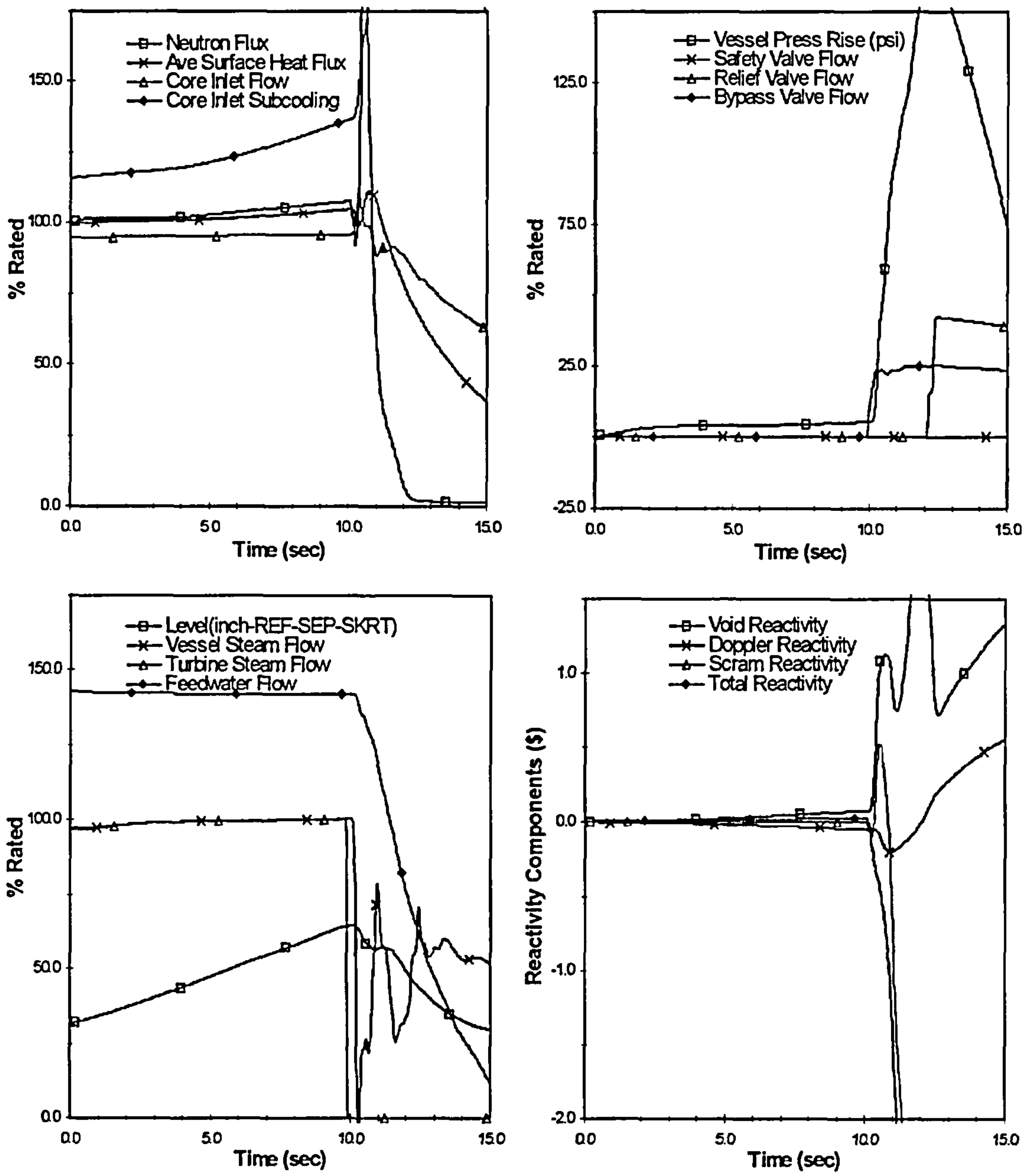


Figure 25 Plant Response to FW Controller Failure (BOC14 to EOC14 MELLLA & MFWT (UB))

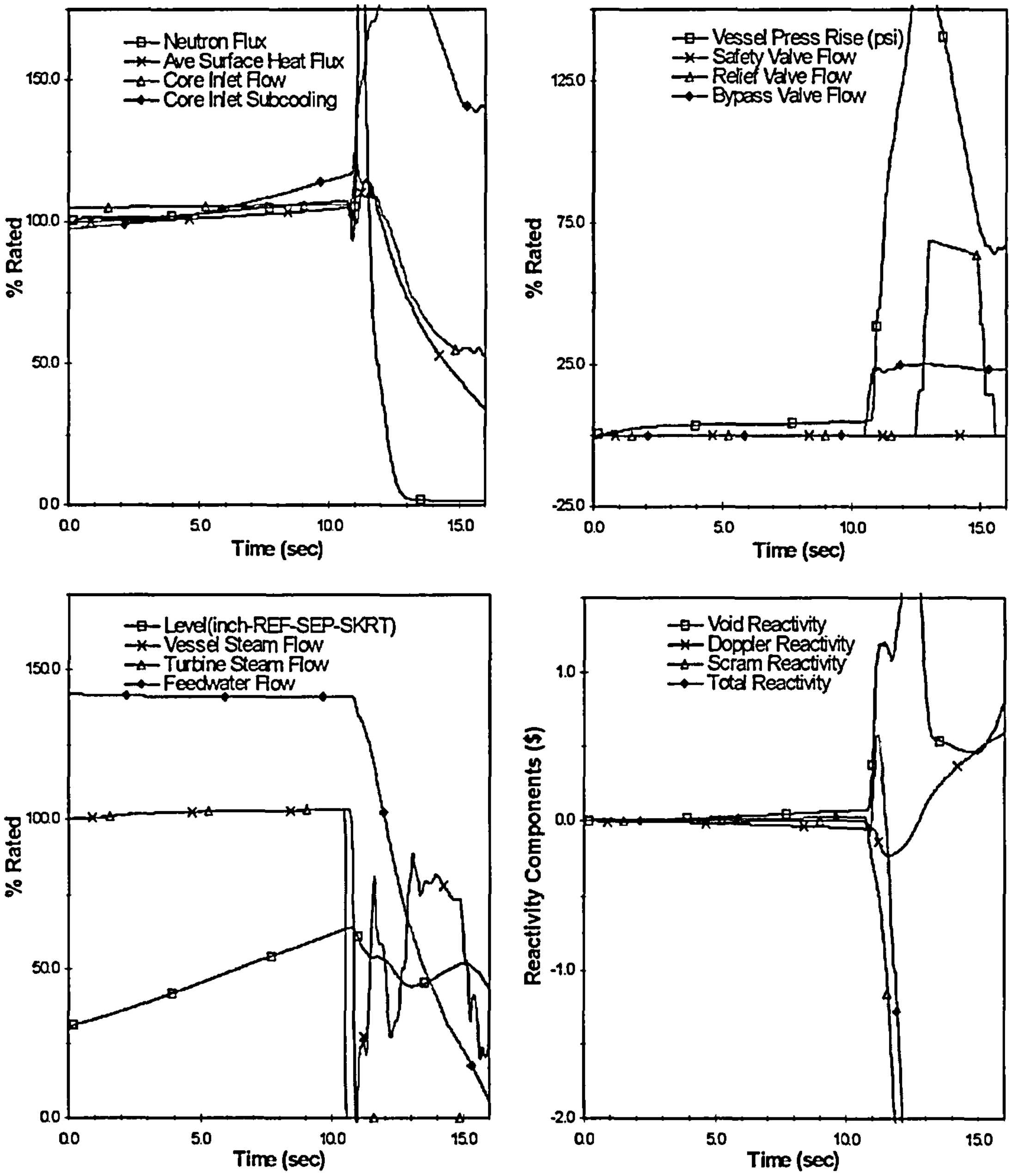


Figure 26 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF with RPTOOS (HBB))

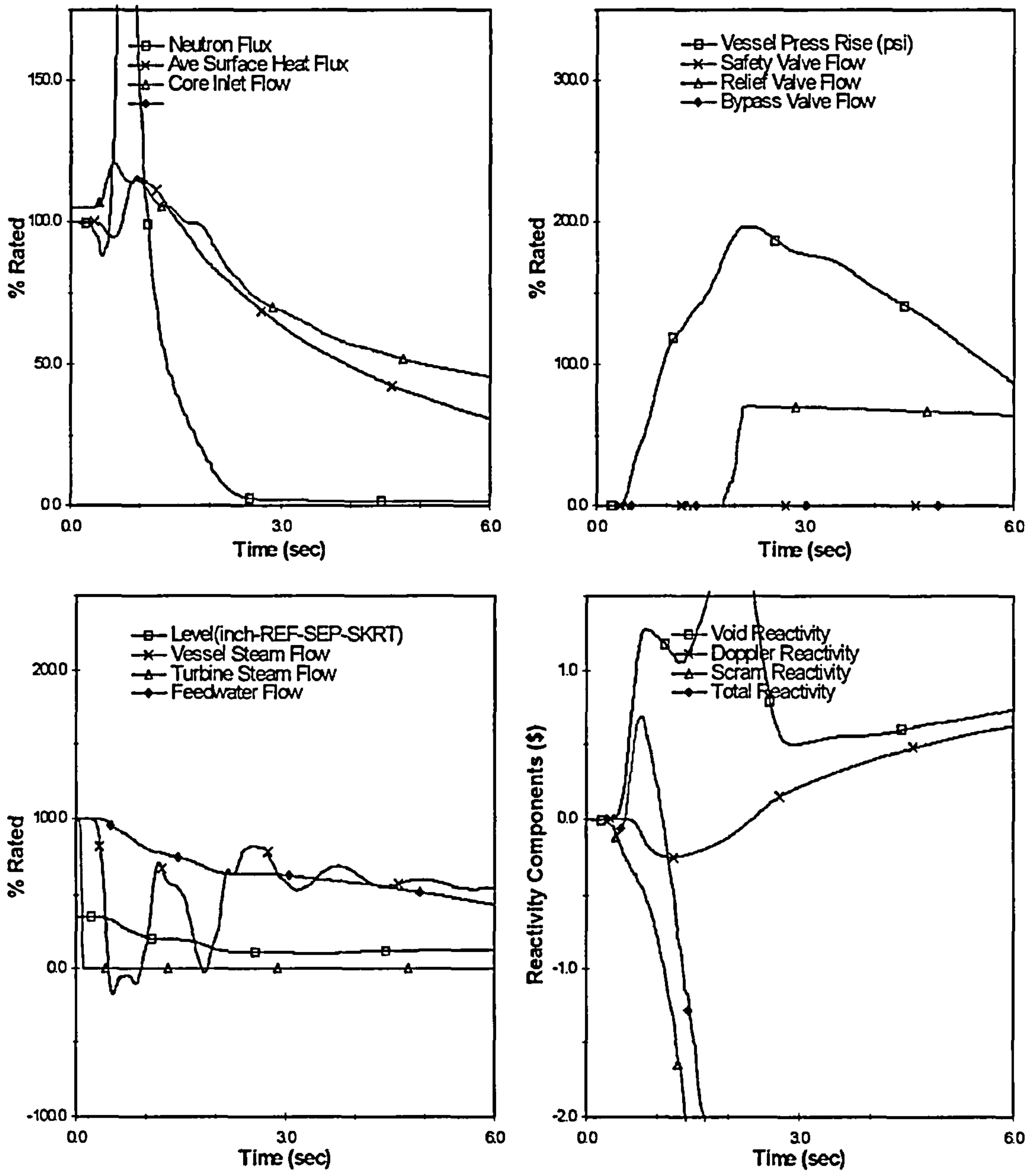


Figure 27 Plant Response to Turbine Trip w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF with RPTOOS (HBB))

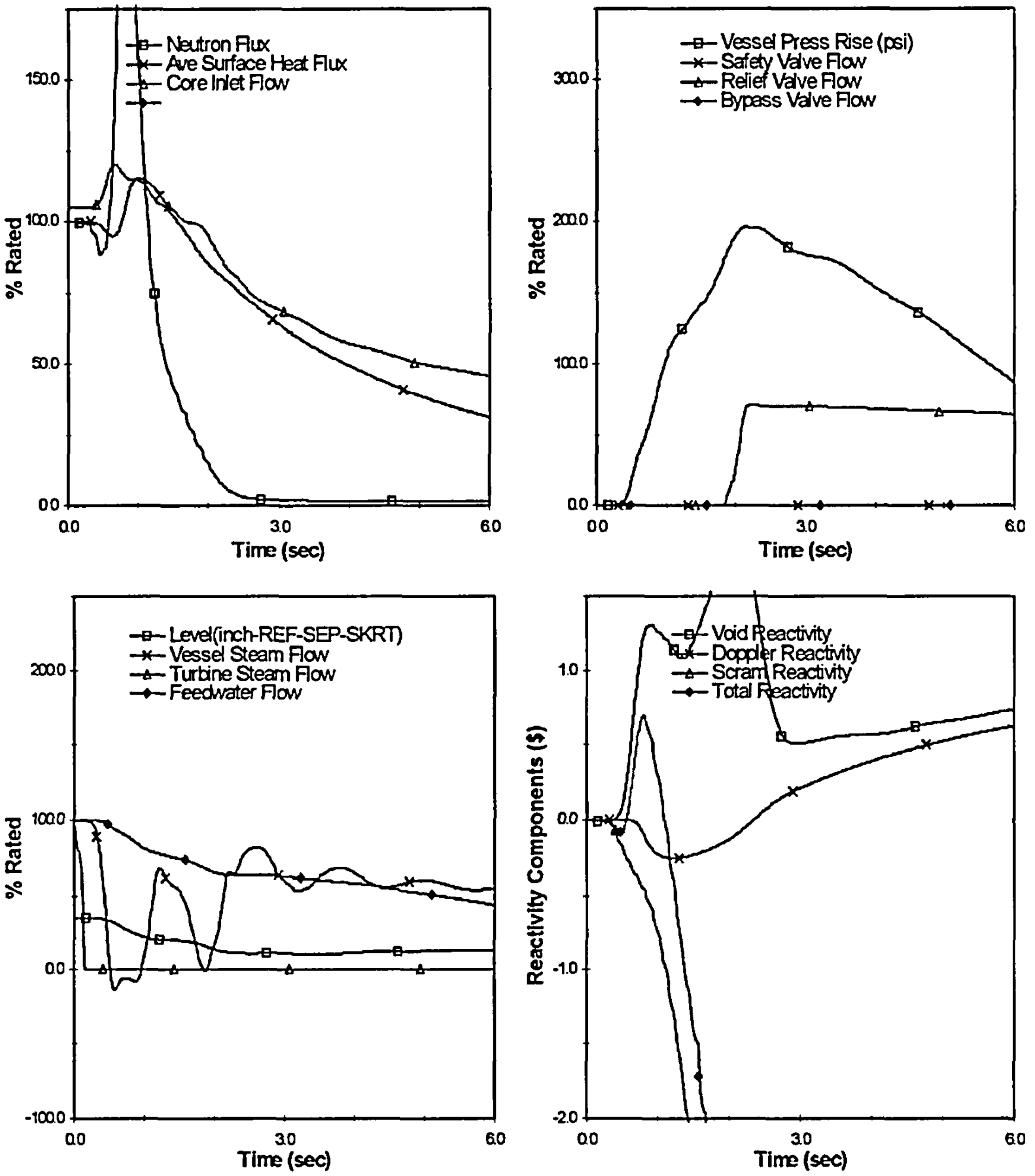


Figure 28 Plant Response to Load Reject w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF with RPTOOS (HBB))

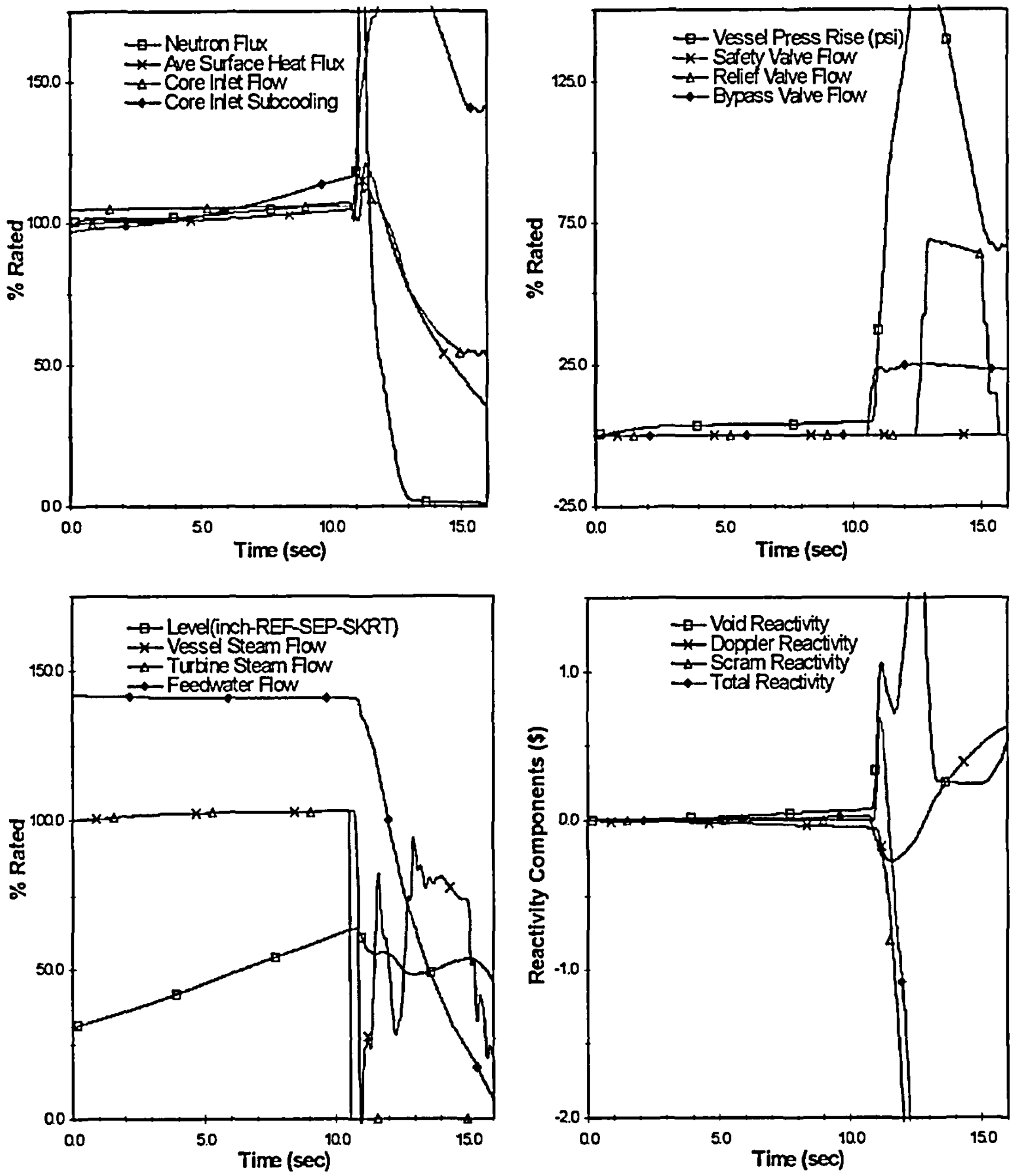


Figure 29 Plant Response to FW Controller Failure (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF with RPTOOS (HBB))

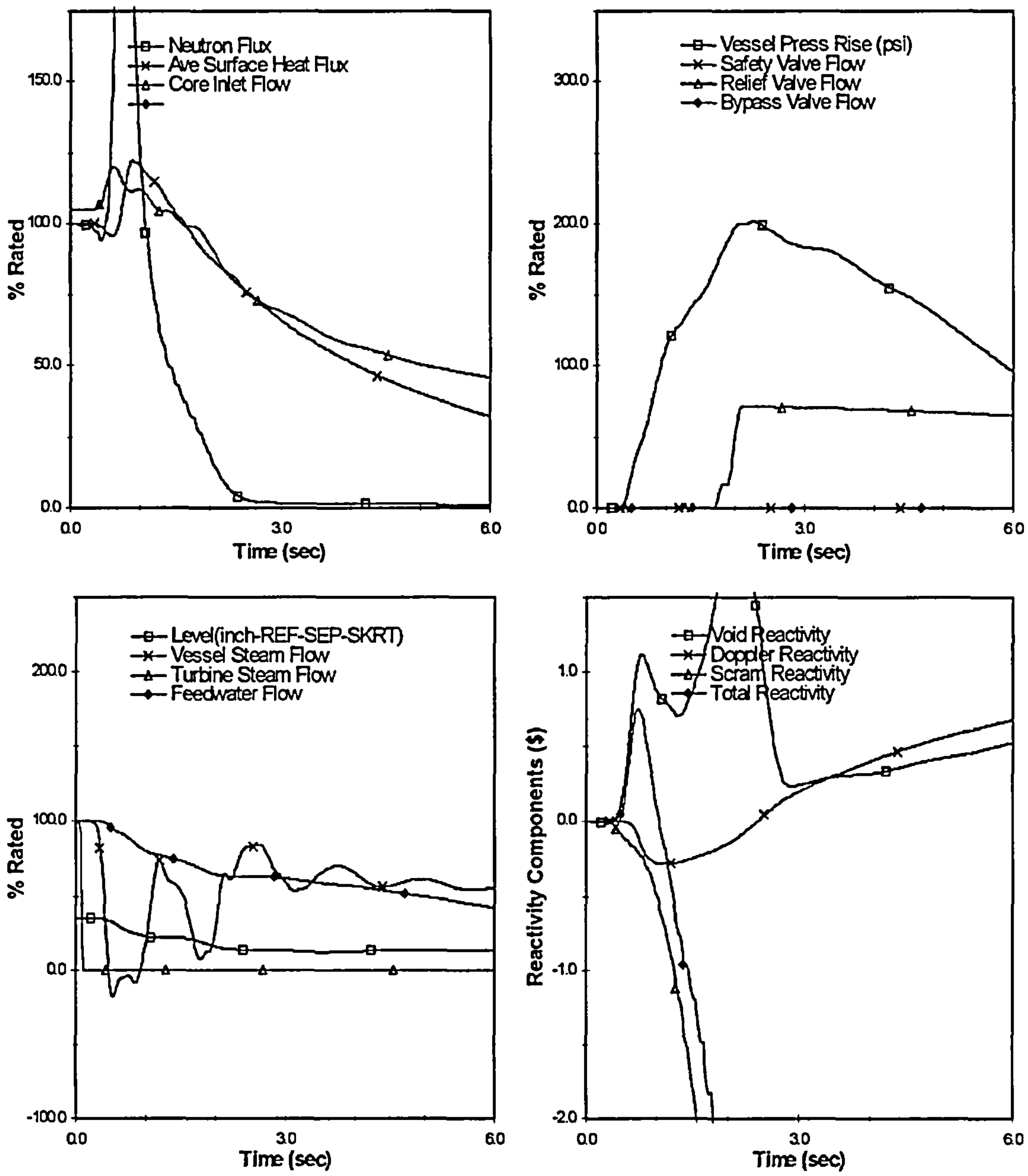


Figure 30 Plant Response to Turbine Trip w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF with RPTOOS (HBB))

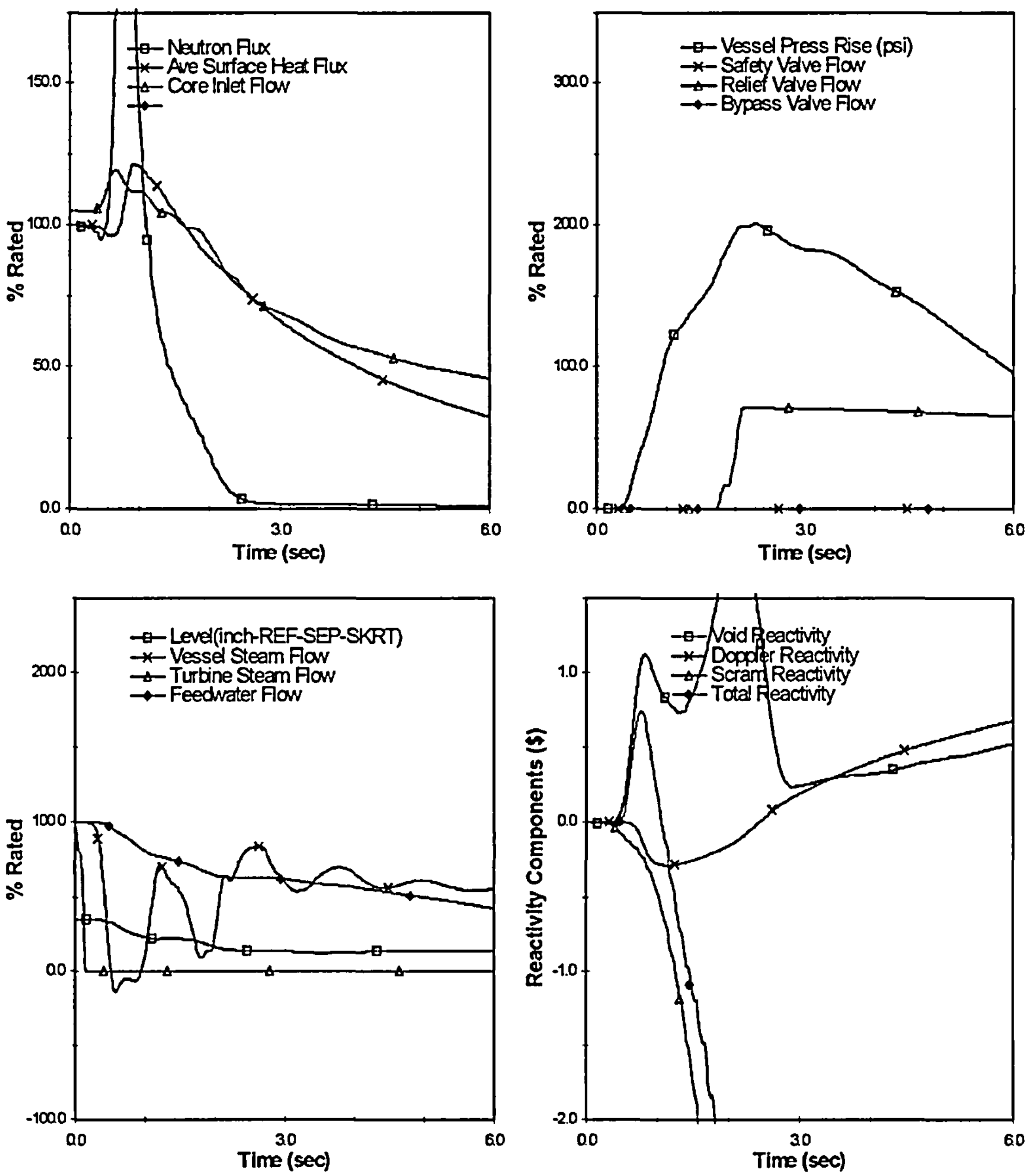


**Figure 31 Plant Response to Load Reject w/o Bypass
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF with RPTOOS (HBB))**

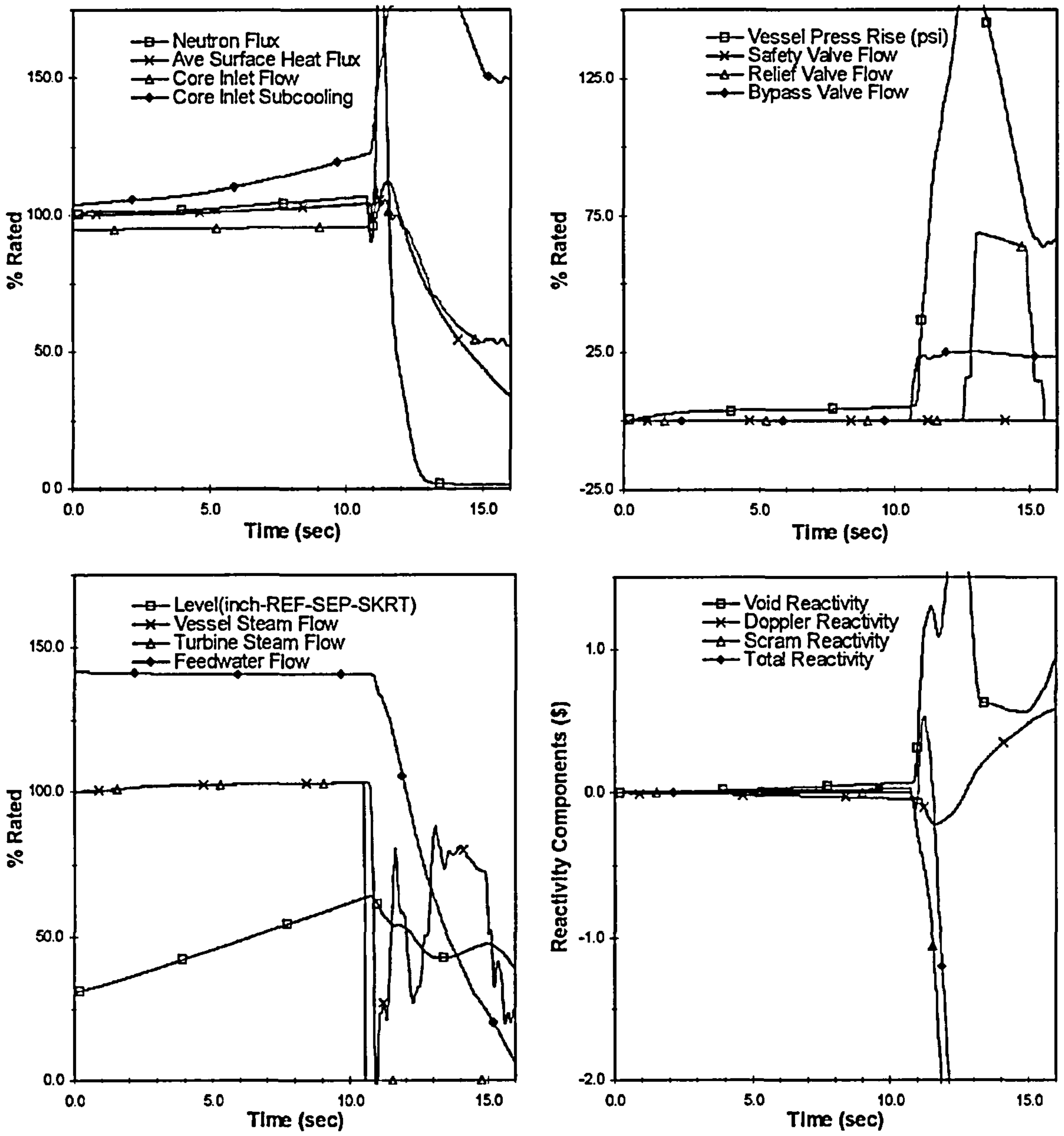


Figure 32 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA with RPTOOS (HBB))

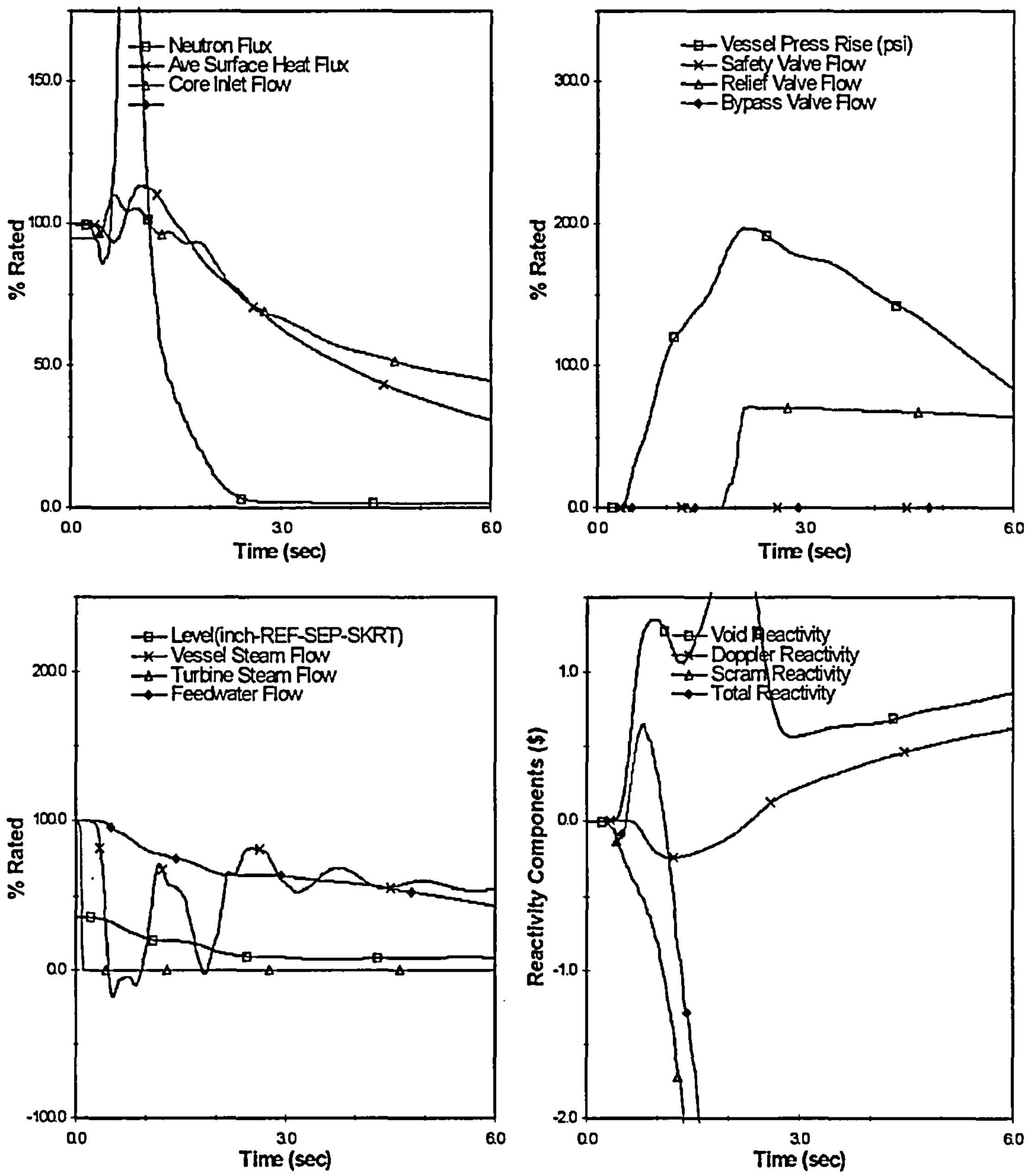


Figure 33 Plant Response to Turbine Trip w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA with RPTOOS (HBB))

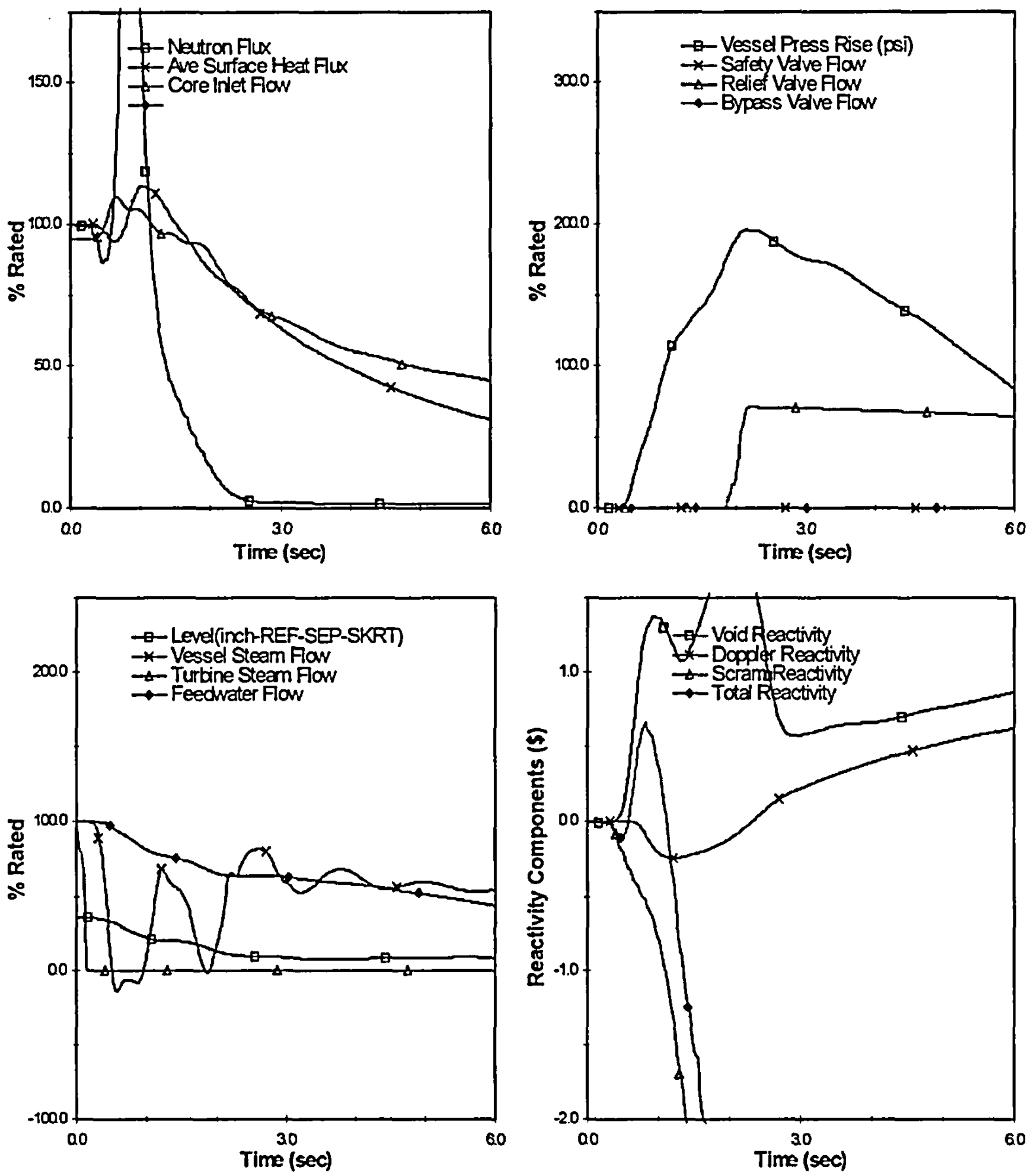


Figure 34 Plant Response to Load Reject w/o Bypass
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA with RPTOOS (HBB))

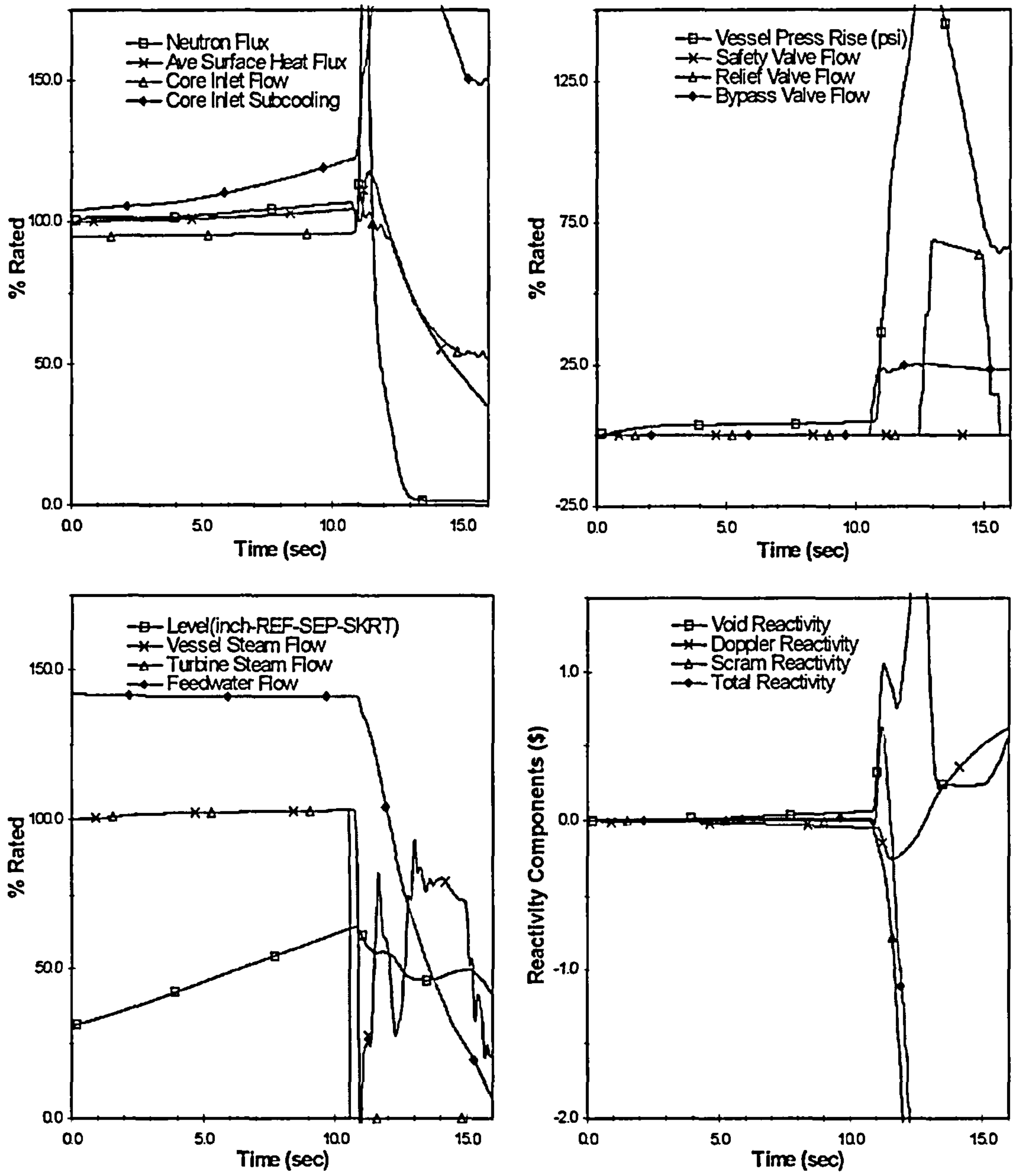


**Figure 35 Plant Response to FW Controller Failure
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA with RPTOOS (HBB))**

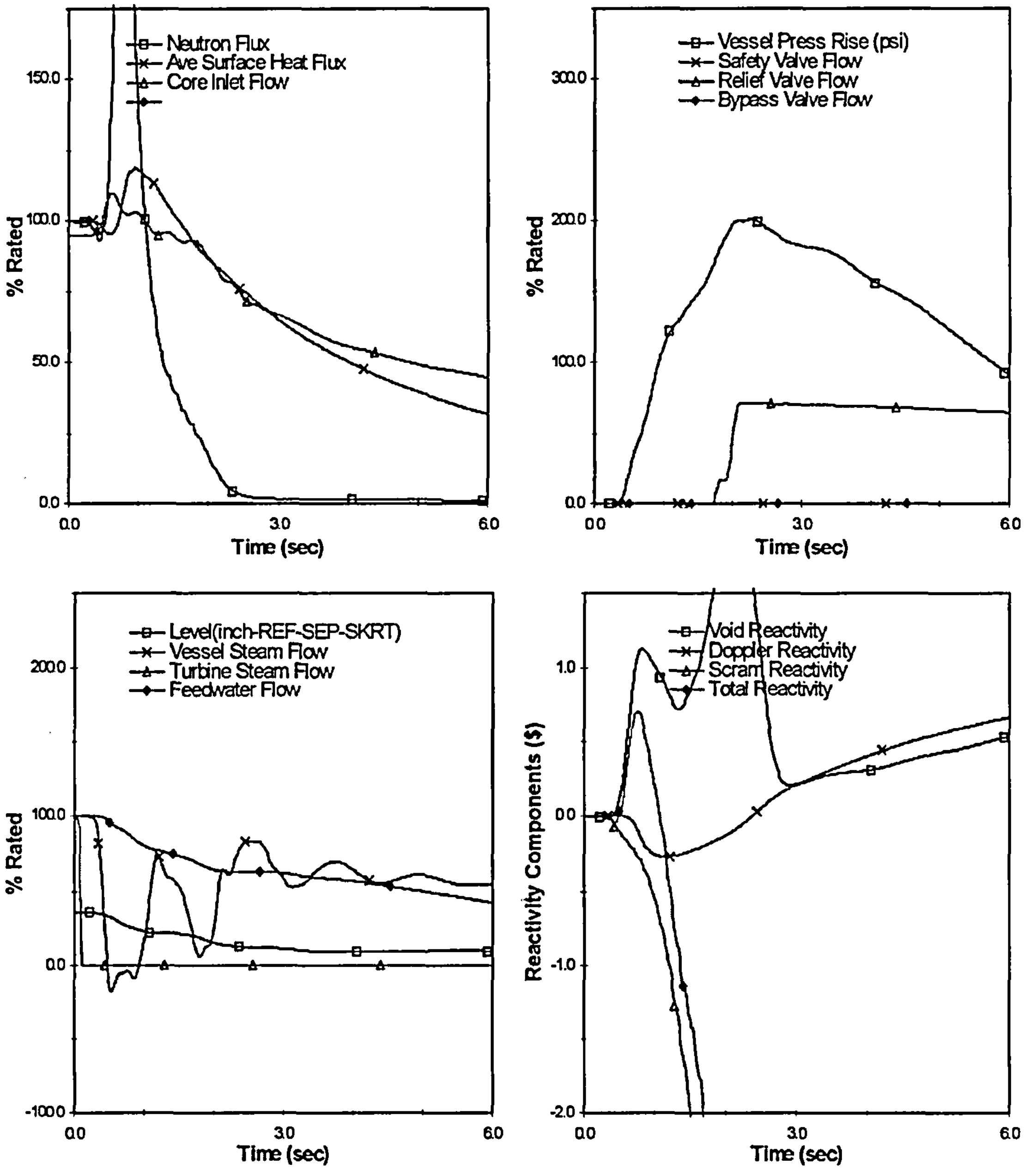


Figure 36 Plant Response to Turbine Trip w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA with RPTOOS (HBB))

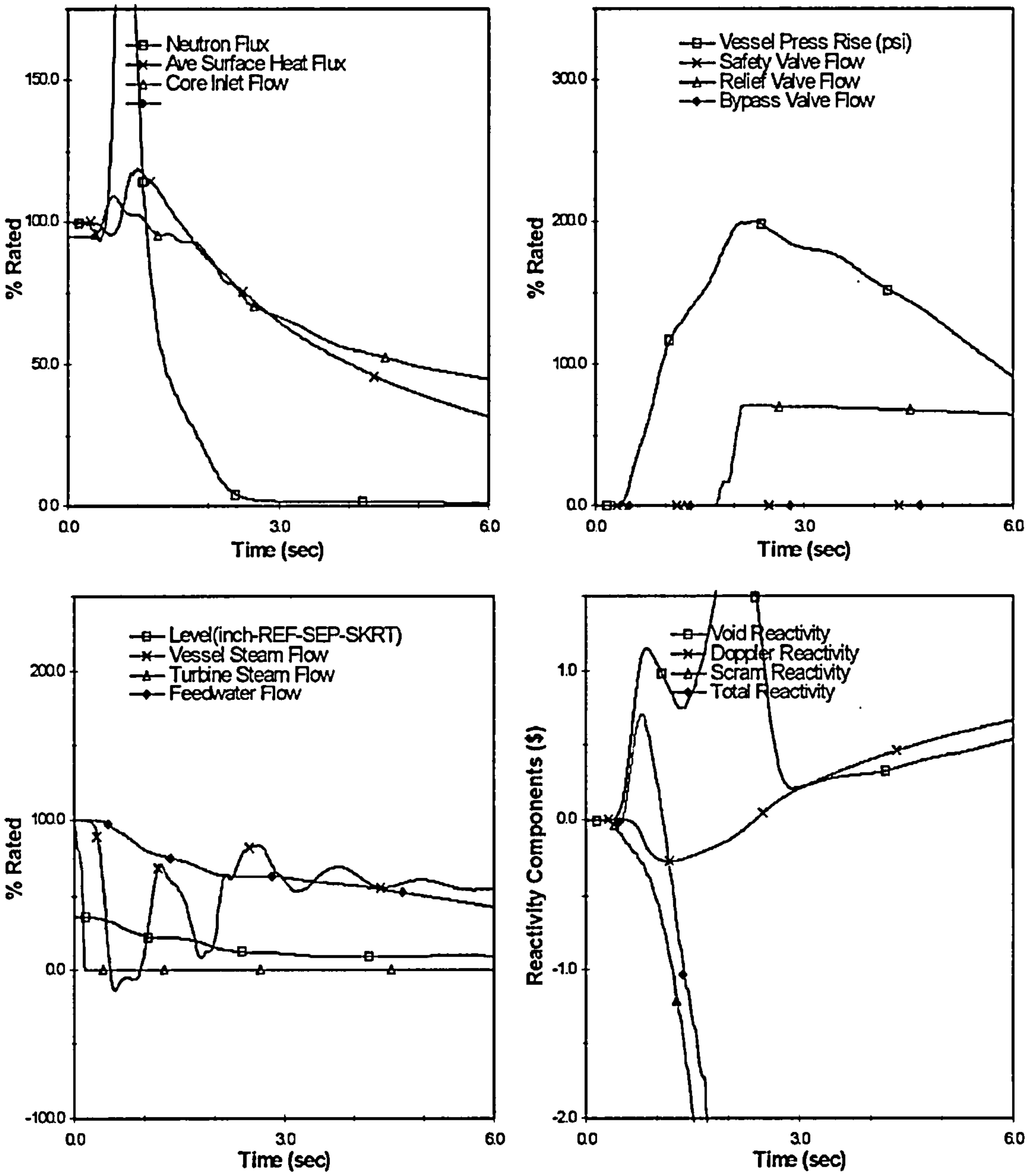


Figure 37 Plant Response to Load Reject w/o Bypass (EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA with RPTOOS (HBB))

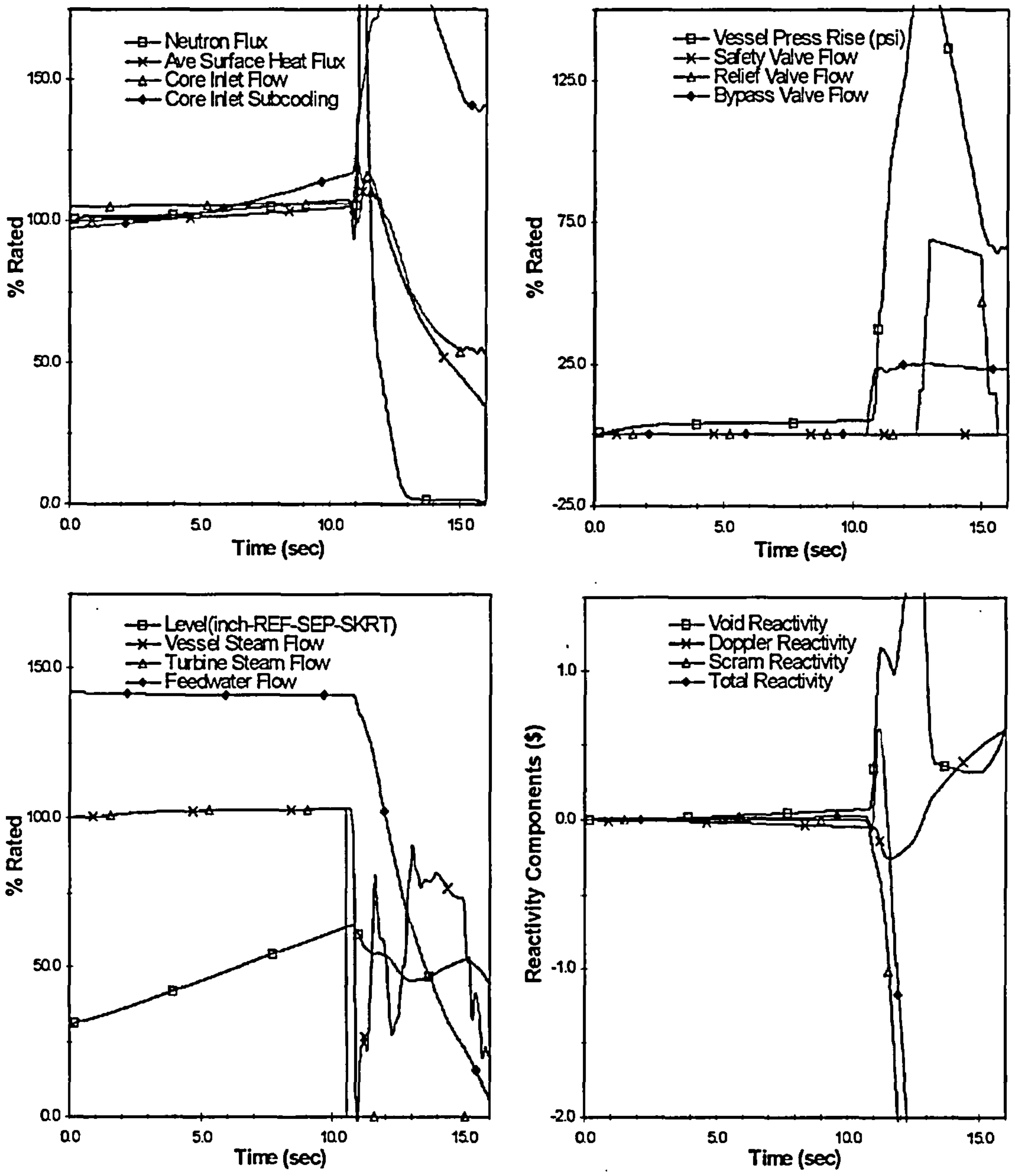


**Figure 38 Plant Response to FW Controller Failure
(BOC14 to EOC14 ICF with RPTOOS (UB))**

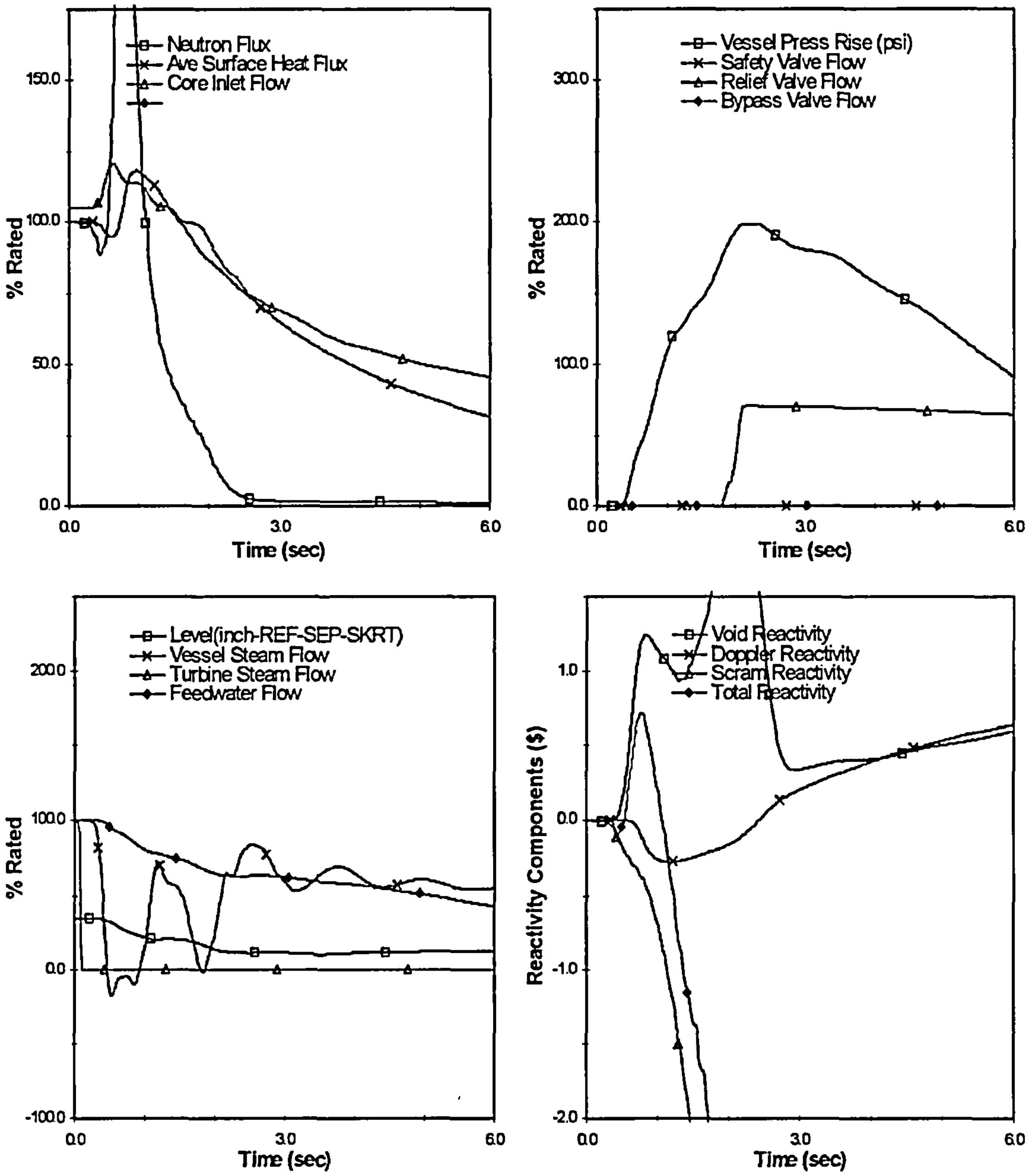


Figure 39 Plant Response to Turbine Trip w/o Bypass (BOC14 to EOC14 ICF with RPTOOS (UB))

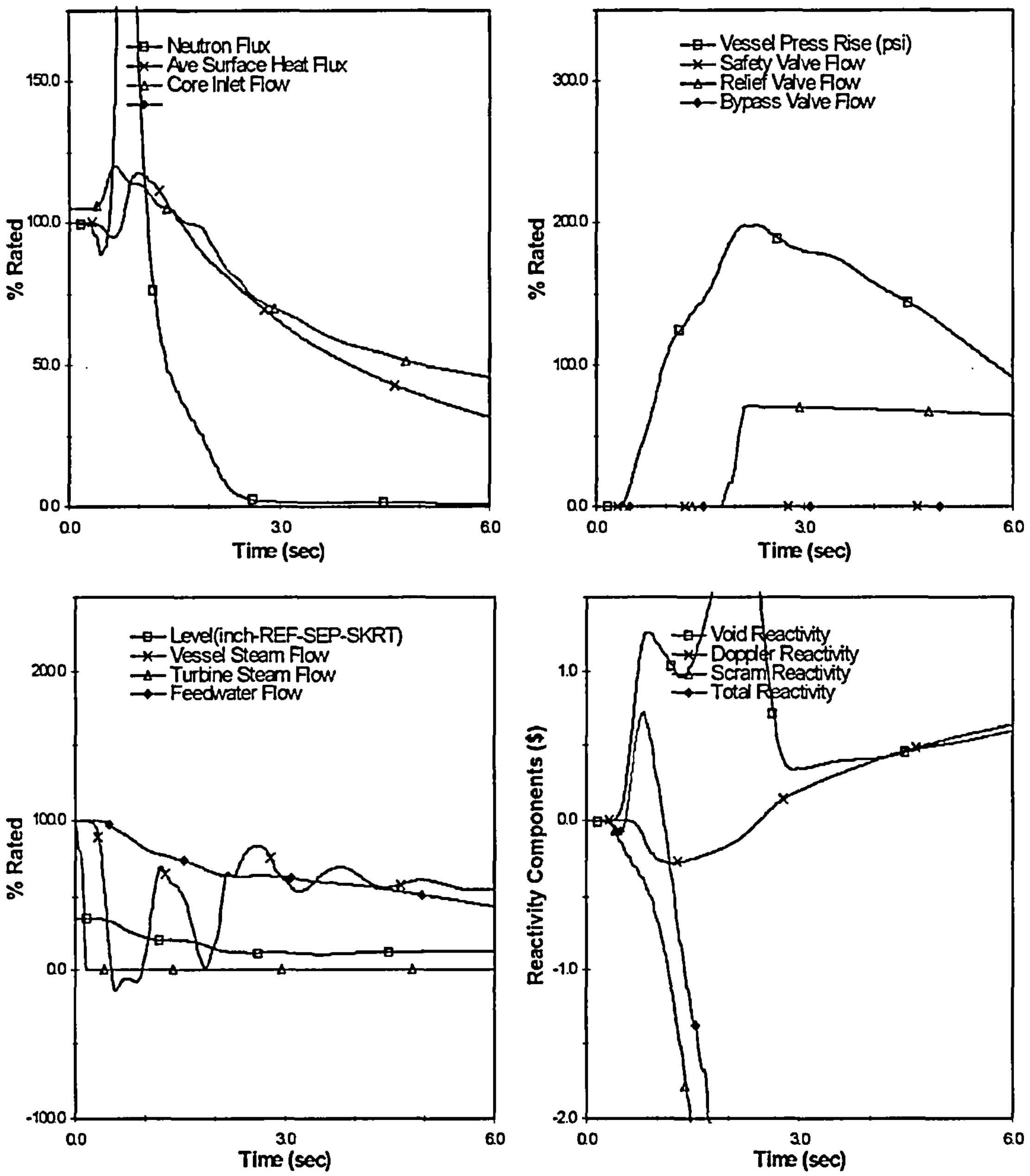


Figure 40 Plant Response to Load Reject w/o Bypass
(BOC14 to EOC14 ICF with RPTOOS (UB))

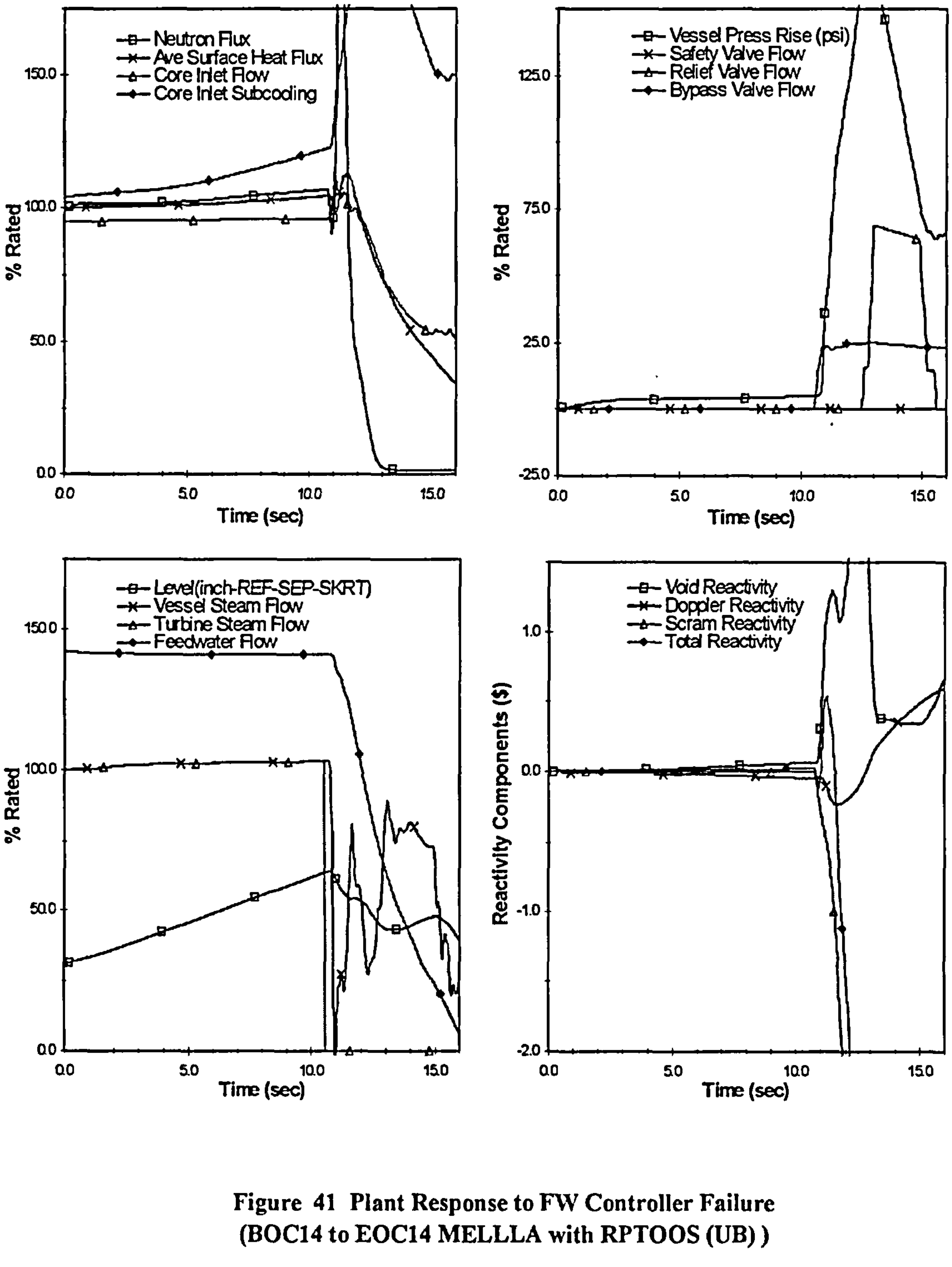


Figure 41 Plant Response to FW Controller Failure (BOC14 to EOC14 MELLLA with RPTOOS (UB))

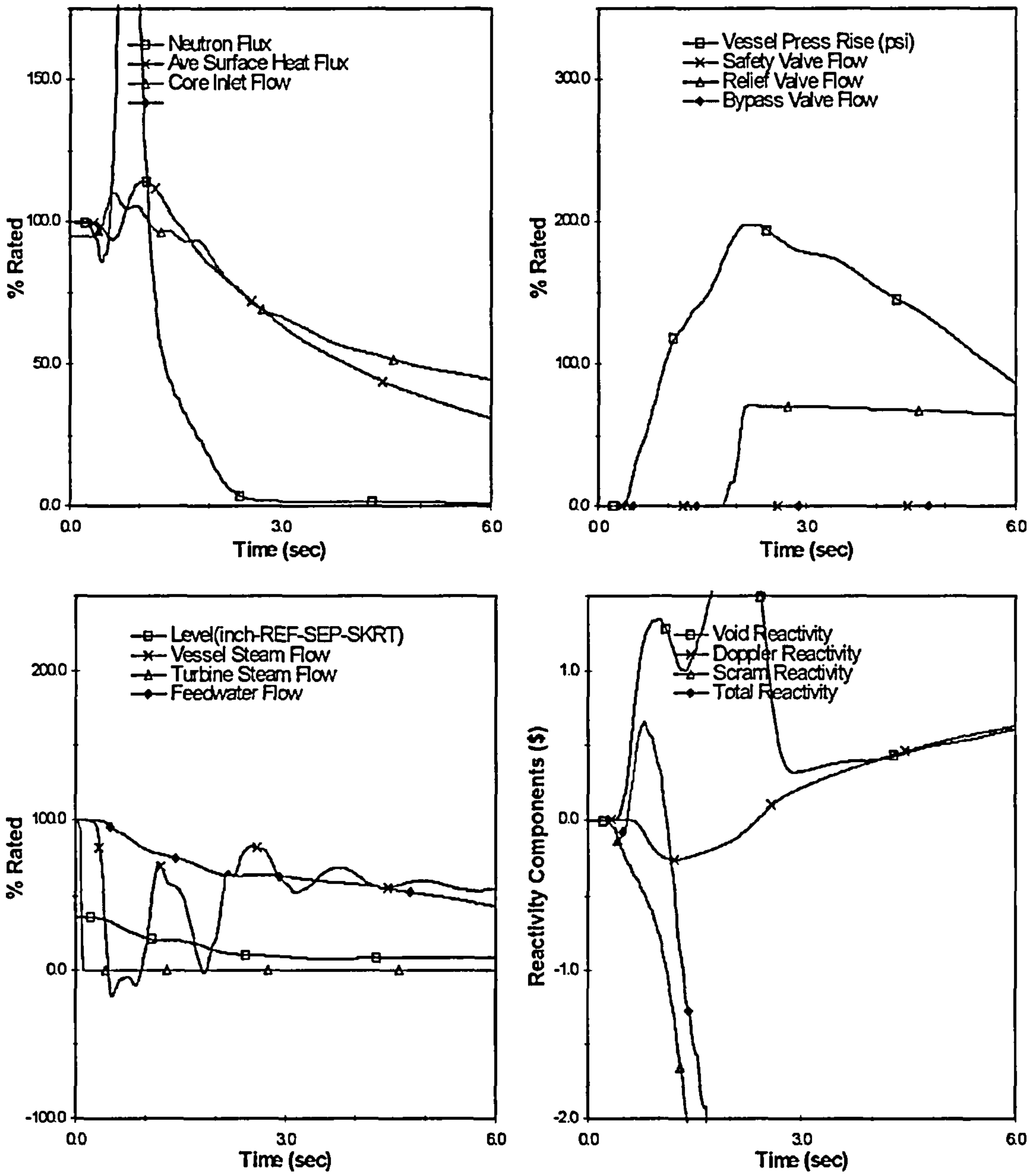


Figure 42 Plant Response to Turbine Trip w/o Bypass (BOC14 to EOC14 MELLLA with RPTOOS (UB))

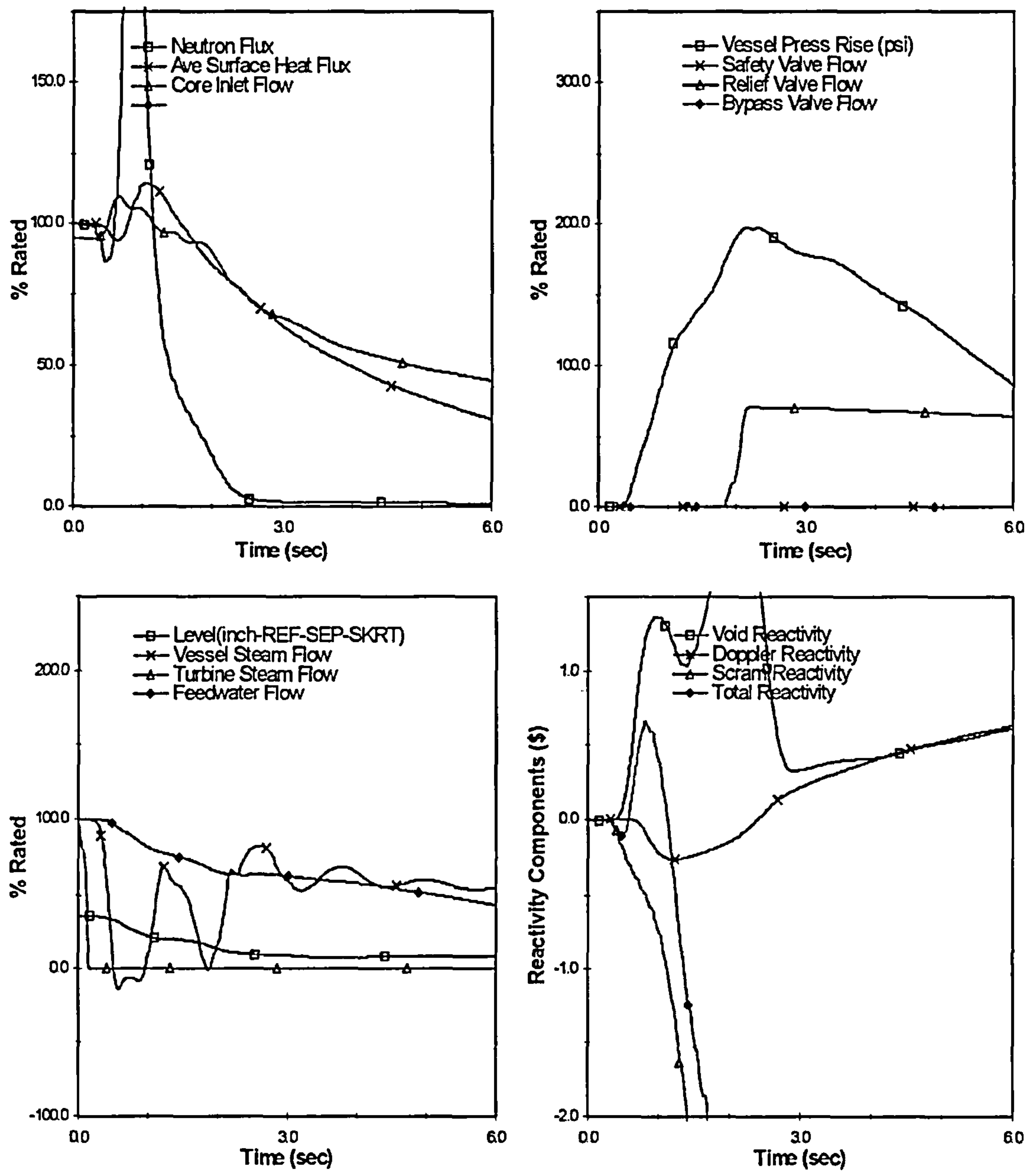


Figure 43 Plant Response to Load Reject w/o Bypass (BOC14 to EOC14 MELLLA with RPTOOS (UB))

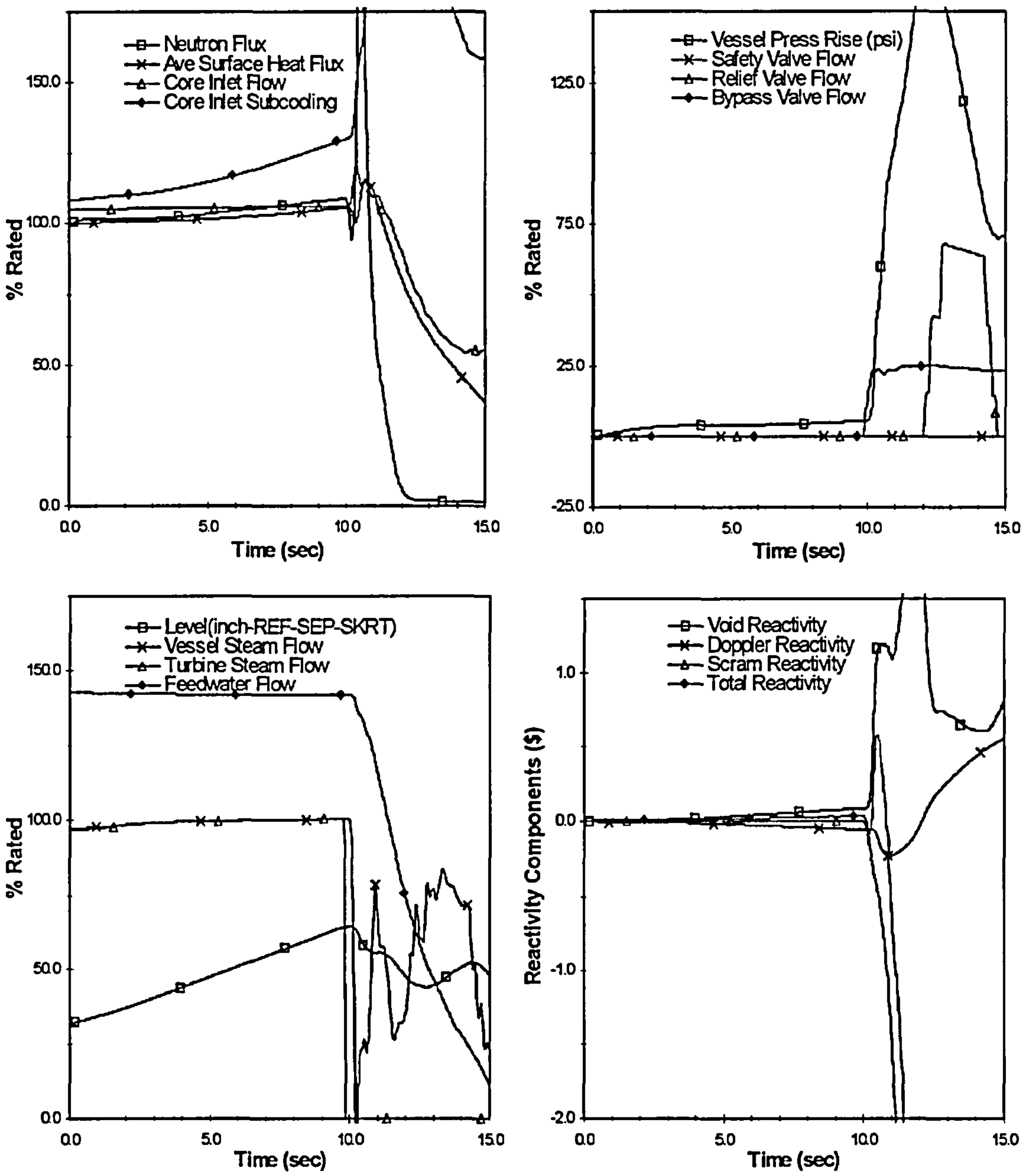


**Figure 44 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) ICF & MFWT with RPTOOS (HBB))**

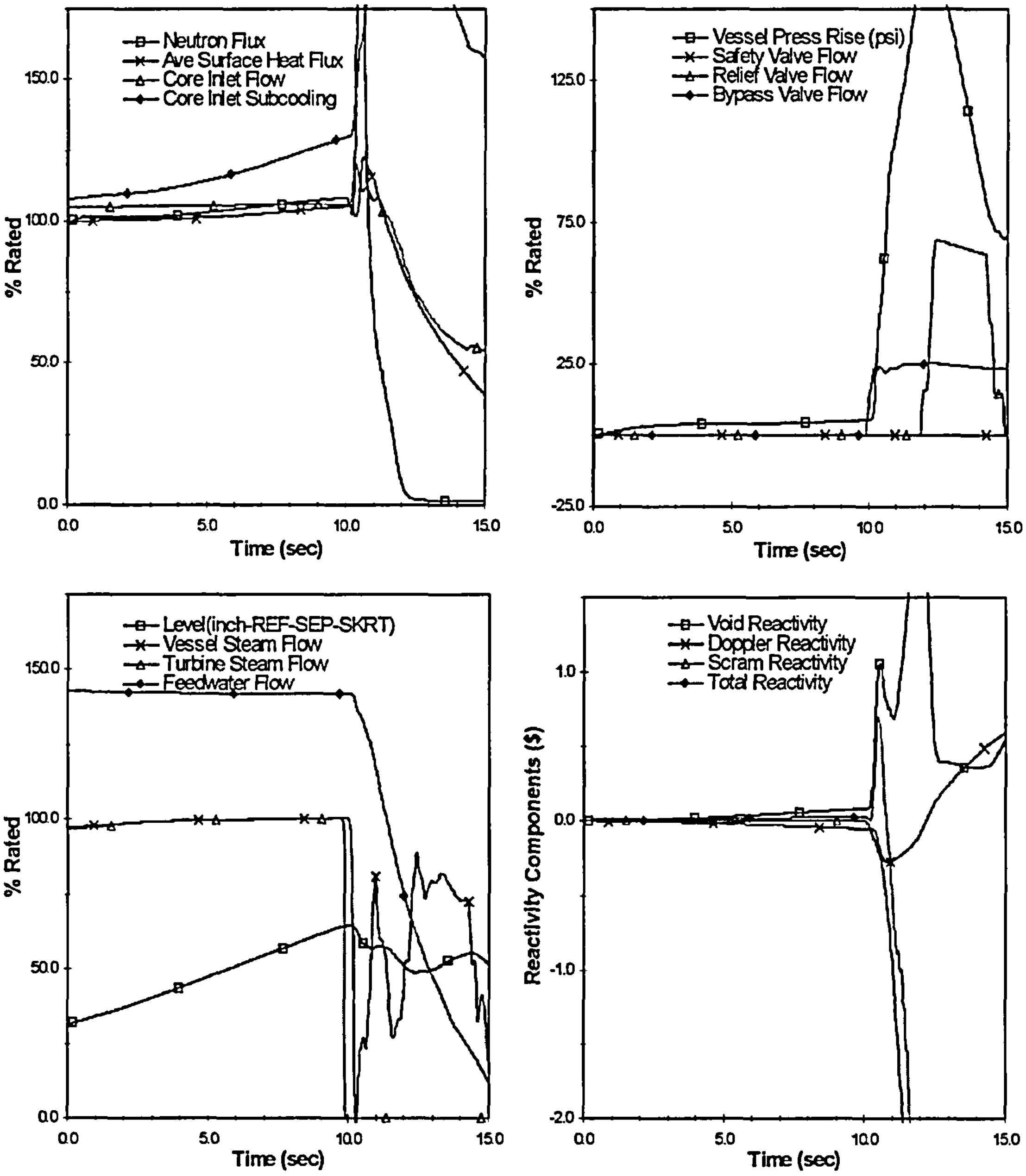


Figure 45 Plant Response to FW Controller Failure
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 ICF & MFWT with RPTOOS (HBB))

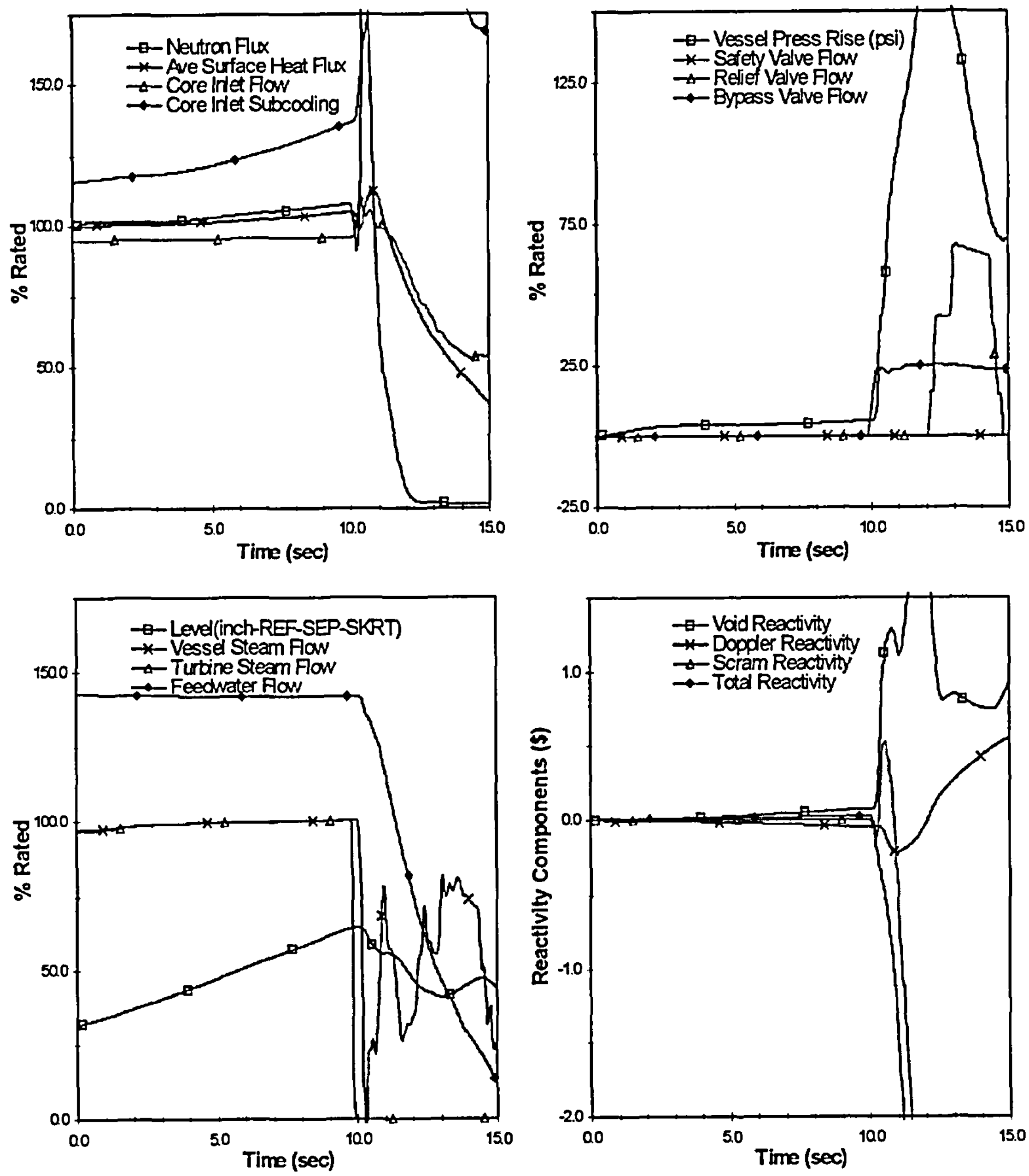


Figure 46 Plant Response to FW Controller Failure
(BOC14 to EOR14-2646 MWd/MT (2400 MWd/ST) MELLLA & MFWT with RPTOOS (HBB))

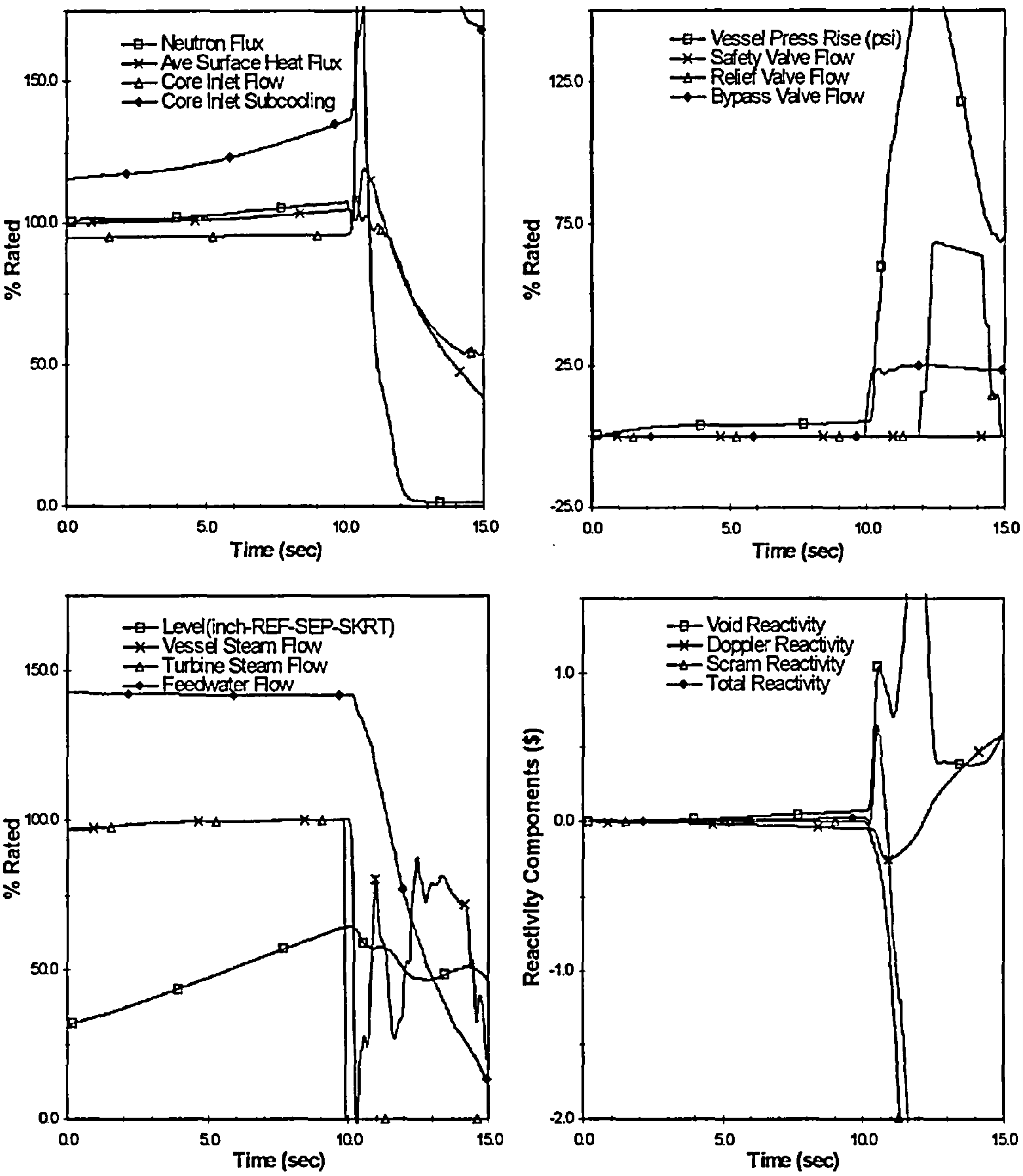


Figure 47 Plant Response to FW Controller Failure
(EOR14-2646 MWd/MT (2400 MWd/ST) to EOC14 MELLLA & MFWT with RPTOOS (HBB))

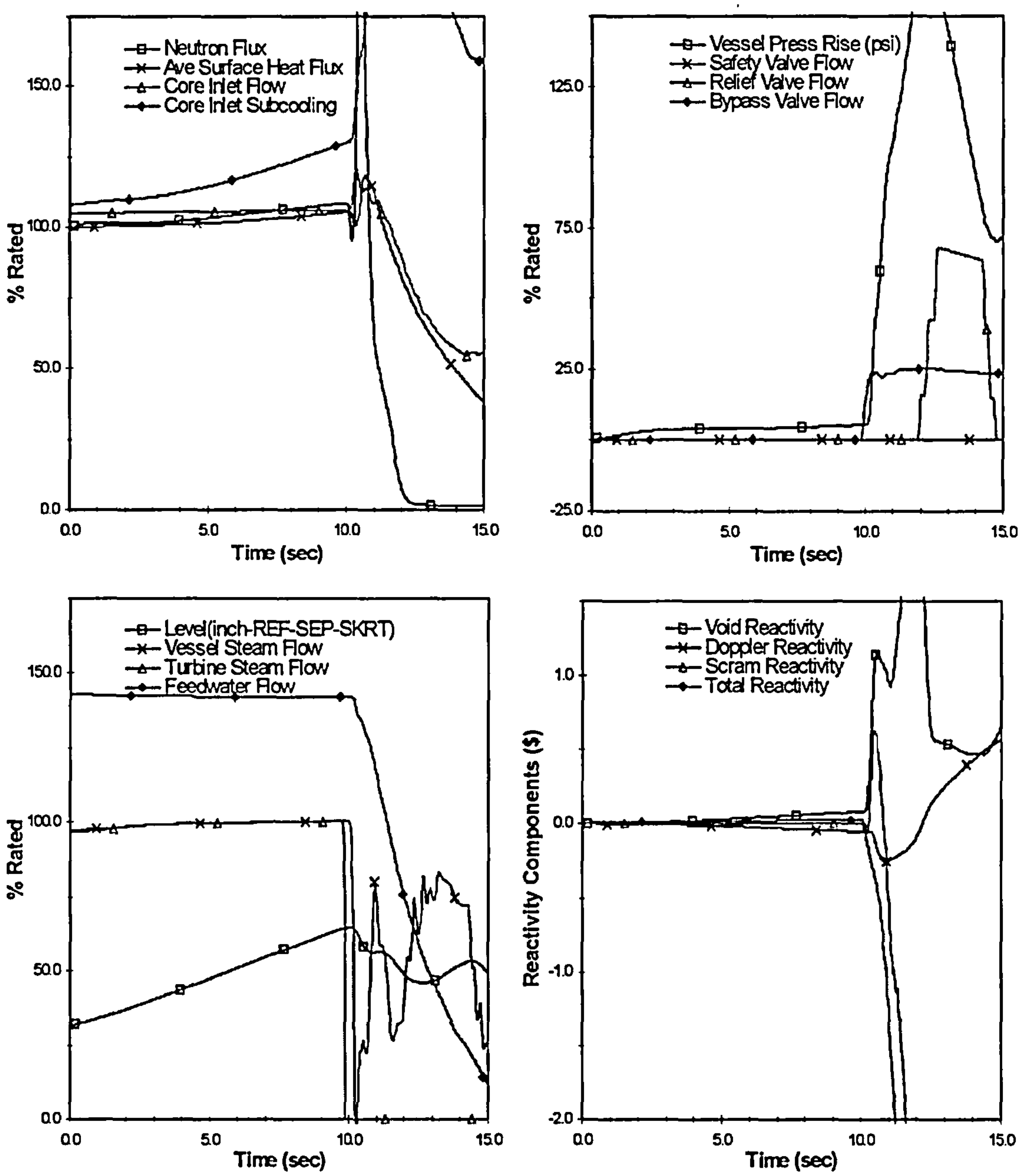


Figure 48 Plant Response to FW Controller Failure
(BOC14 to EOC14 ICF & MFWT with RPTOOS (UB))

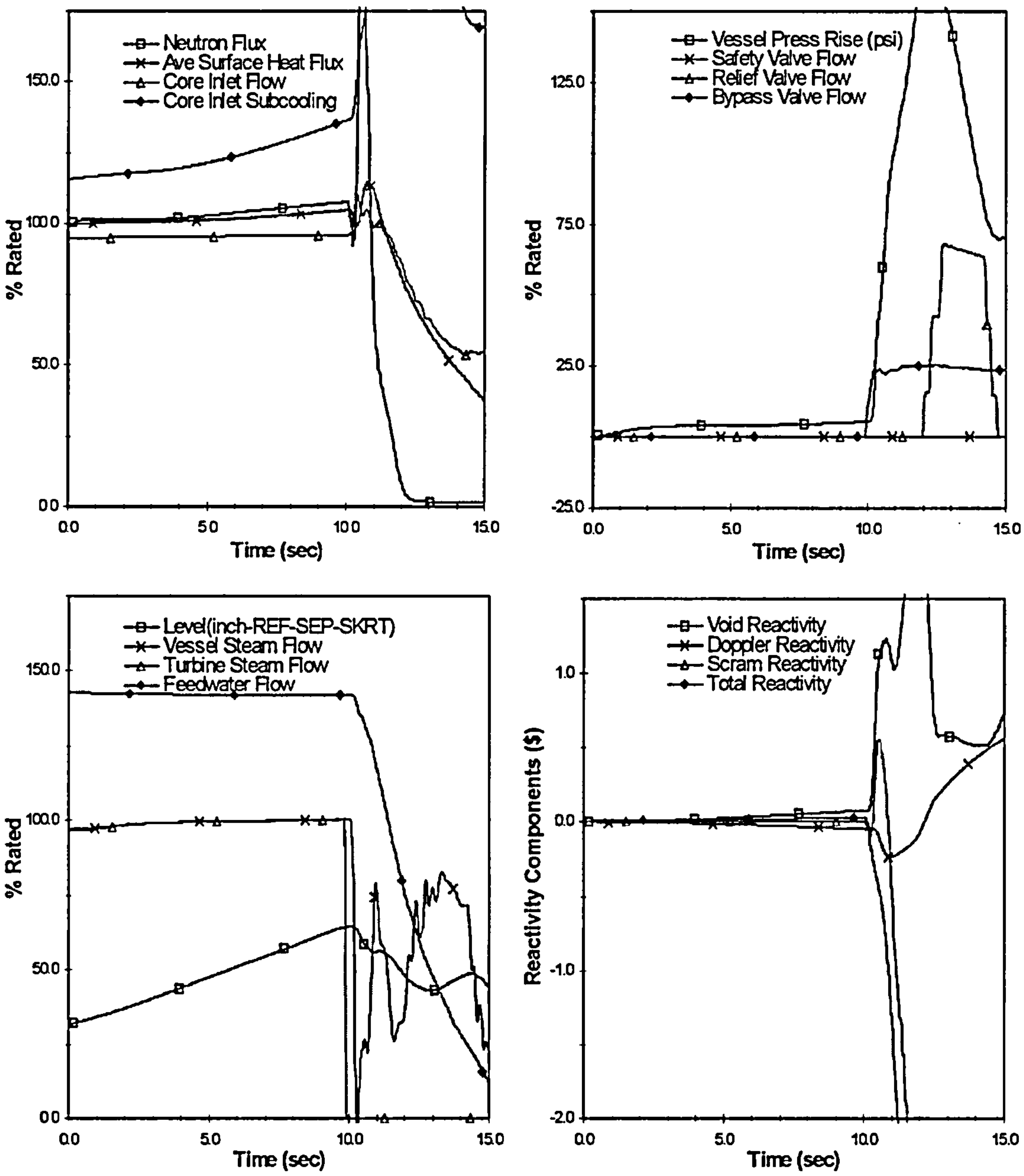


Figure 49 Plant Response to FW Controller Failure
(BOC14 to EOC14 MELLLA & MFWT with RPTOOS (UB))

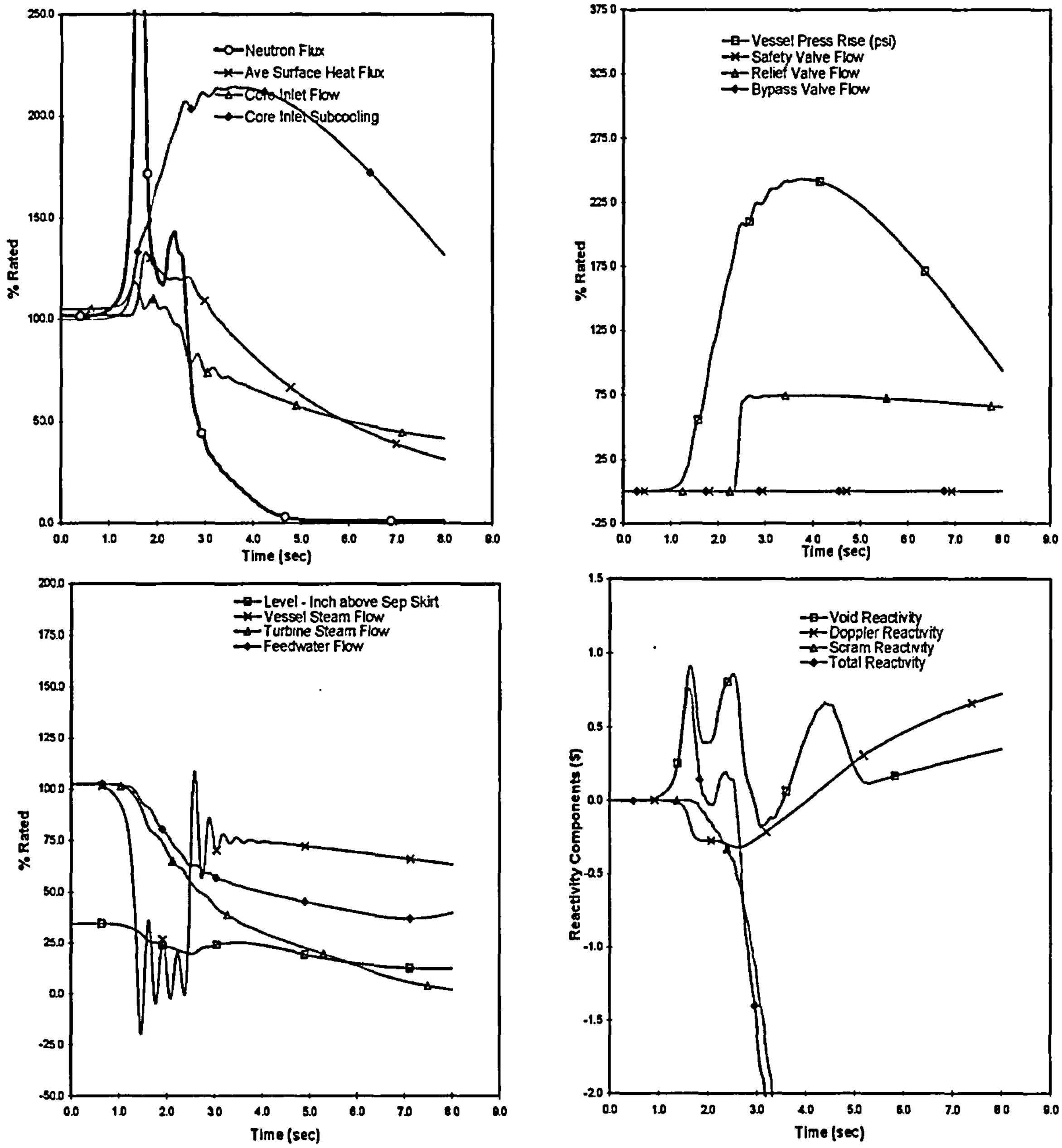


Figure 50 Plant Response to MSIV Closure (Flux Scram) – ICF

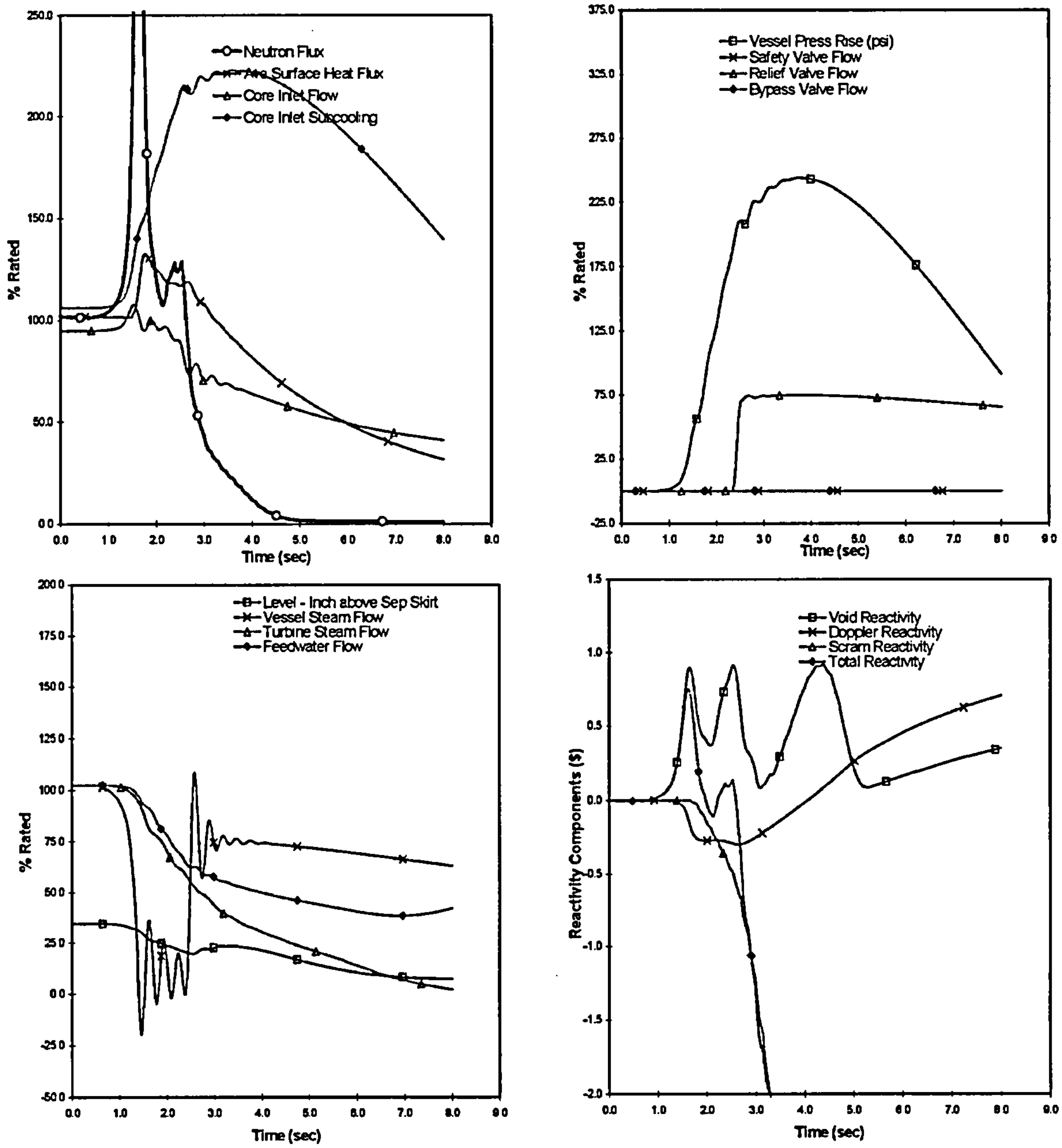


Figure 51 Plant Response to MSIV Closure (Flux Scram) - MELLLA

Appendix A
Analysis Conditions

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

Table A-1

	Analysis Value[14]			
Parameter	ICF	ICF & MFWT	MELLLA	MELLLA & MFWT
Thermal power, MWt	3840.0	3840.0	3840.0	3840.0
Core flow, Mlb/hr	105.0	105.0	94.8	94.8
Reactor pressure (core mid-plane), psia	1036.0	1030.1	1034.0	1028.1
Inlet enthalpy, Btu/lb	526.3	522.4	523.8	519.6
Non-fuel power fraction	0.036	0.036	0.036	0.036
Steam flow, Mlb/hr	16.80	16.28	16.78	16.27
Dome pressure, psig	1005.0	999.4	1005.0	999.4
Turbine pressure, psig	945.8	943.6	946.0	943.7
No. of Safety/Relief Valves[15]	14	14	14	14
Relief mode lowest setpoint, psig	1141.2	1141.2	1141.2	1141.2
Safety mode lowest setpoint, psig	-	-	-	-

---

[14] These analysis values were also applied for RPTOOS condition for ICF and MELLLA.

[15] One SRV is allowed to be out of service.

Appendix B
List of Acronyms

Acronym	Description
ΔCPR	Delta Critical Power Ratio
Δk	Delta k-effective
%NBR	Percent Nuclear Boiler Rated
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
BWROG	Boiling Water Reactor Owners Group
COLR	Core Operating Limits Report
CPPU	Constant Pressure Power Up-rate
CPR	Critical Power Ratio
DIVOM	Delta CPR over Initial MCPR vs. Oscillation Magnitude
DR	Decay Ratio
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
HCGS	Hope Creek Generating Station
HCOM	Hot Channel Oscillation Magnitude
HFCL	High Flow Control Line

Acronym	Description
HPCI	High Pressure Coolant Injection
ICA	Interim Corrective Action
ICF	Increased Core Flow
IMCPR	Initial MCPR
IVM	Initial Validation Matrix
LHGR	Linear Heat Generation Rate
LHGRFAC	Linear Heat Generation Rate Multiplier
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
MFWT	Minimum Feedwater Temperature
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

Acronym	Description
RC	Reference Cycle
RFWT	Reduced Feedwater Temperature
RPS	Reactor Protection System
RPT	Recirculation Pump Trip
RPTOOS	Recirculation Pump Trip Out of Service
RTP	Rated Thermal Power
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
SRV	Safety/Relief Valve
SRVOOS	Safety/Relief Valve(s) Out of Service
SS	Steady State
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
TTHBP	Turbine Trip with Half Bypass
TTNBP	Turbine Trip without Bypass
UB	Under Burn

Appendix C
Decrease In Core Coolant Temperature Events

The Loss-of-Feedwater event was analyzed at 100% rated power 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.

In addition, the Inadvertent HPCI start-up event without a Level 8 turbine trip was shown to be bounded by the LFWH event in accordance with Determination of Limiting Cold Water Event, NEDC-32538P-A.

The Cycle 13 SRLR Rev. 1 (Reference C-1) indicated the Inadvertent HPCI with a Level 8 turbine trip is non-limiting. The Inadvertent HPCI with a Level 8 turbine trip was confirmed as non-limiting for Cycle 14.

References:

C-1. 0000-0031-0596-SRLR, *Supplemental Reload Licensing Report for Hope Creek Unit 1 Reload 12/Cycle 13, Revision 1*, December 2004.

Appendix D
Reactor Recirculation Pump Seizure Event

The reactor recirculation pump seizure event was analyzed for Single Loop Operation (SLO) at HCGS (Reference D-1). This analysis was performed for the HCGS Cycle 13 transition cycle with GE14 and SVEA96+ fuel in the core and transient analysis inputs consistent with the Reload 12/Cycle 13 analyses.

The SLO operating limit minimum critical power ratio (OLMCPR) of 1.51 is required so that the reference SLO safety limit minimum critical power ratio (SLMCPR) of 1.12 is protected in the event of a seizure of the recirculation pump in the active loop. If the cycle-specific SLMCPR changes then the SLO OLMCPR may be adjusted by the following factor:

(Cycle Specific SLMCPR / 1.12)

Thus, for HCGS Cycle 14 with a SLO SLMCPR of 1.09 the SLO OLMCPR required is:

1.51 * (1.09/1.12) = 1.47

In order to protect the required SLO OLMCPR of 1.47 (based on a SLO SLMCPR of 1.09) the following two loop operation (TLO) limit must be maintained consistent with the post ARTS implementation applied in Cycle 13.

As long as the TLO full power OLMCPR is 1.28 or greater, the proposed Hope Creek K(p) curve bounds operation in SLO. If the full power OLMCPR is lower than 1.28 and is not bounded by the cycle specific off-rated limits, then the condition specific SLO OLMCPR of 1.47 should be applied for GE14 fuel and SVEA96+ fuel.

References:

D-1. NEDC-33158P, *Fuel Transition Report for Hope Creek Generating Station*, Revision 4, March 2005.

Appendix E
Power and Flow Dependent Limits

The potentially limiting anticipated operational occurrences (AOOs) and accident analyses were evaluated to support HCGS operation with ARTS off-rated limits as well as operation at CPPU RTP. Analyses were performed to determine the limiting MCPR requirement based on the HCGS fuel and core configuration at CPPU and the off-rated power and flow dependent MCPR and LHGRFAC limit curves (Reference E-1).

A disconnect between the performance of the turbine protection systems and the transient analysis assumptions for a generator load rejection event was identified for the operating domain between Pbypass and the point at which the Power Load Unbalance (PLU) system is enabled. For HCGS, a generator load rejection below the PLU power level would generate a delayed turbine trip. Analyses were performed to show that the generic K(P) and LHGRFAC(P) limits bound this event in the range between Pbypass and the PLU enabling power level (Reference E-1).

References:

E-1. NEDC-33158P, *Fuel Transition Report for Hope Creek Generating Station*, Supplement 1, March 2005.