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175 Curtner Avenue
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NEDO-32165
Class I
DRF A00-05443
June 1994

END-OF-CYCLE RECIRCULATION PUMP TRIP ANALYSIS FOR PEACH BOTTOM ATOMIC POWER STATION UNITS 2 AND 3

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1.0 INTRODUCTION

The purpose of the End-of-Cycle Recirculation Pump Trip (EOC-RPT) system is to reduce the severity of the fuel thermal-mechanical transient excursion resulting from the reactor pressurization following a turbine generator trip or a generator load rejection event. The EOC-RPT modification will improve the thermal response to plant scrams during the latter portion of a typical fuel cycle when slower negative scram reactivity insertion rates are encountered. The analysis results documented in this report can be used to determine and quantify the capability of the EOC-RPT feature to relax the minimum critical power ratio (MCPR) requirement necessary to accommodate anticipated operational occurrences (AOOs) postulated at the Peach Bottoms Atomic Power Station (PBAPS) Units 2 and 3.

(Proprietary information that is contained in NEDC-32165P, Rev. 2) The initiating trip signal used for RPT is either the turbine stop valves (TSV) closure as indicated by their position switches, or turbine control valves (TCV) fast closure as indicated by their loss of hydraulic oil pressure.

2.0 SYSTEM DESCRIPTION

The Recirculation Pump Trip System (RPT) is classified as non safety-related system. Its function is to mitigate the consequences of the turbine/generator trip or load rejection event.

(Proprietary information that is contained in NEDC-32165P, Rev. 2) The RPT system will be operable above the power setpoint for turbine stop valve closure and control valve fast closure scram bypass.

(Proprietary information that is contained in NEDC-32165P, Rev. 2)

The RPT system logic will not cause the inadvertent trip of more than one pump given a single component failure in the system. The redundant sensor circuits in each channel are electrically, mechanically and physically independent so that they are unlikely to be disabled by a common cause except for an electrical power failure.

Testability is provided for one channel to enable routine maintenance to be performed. Indicator lights monitor when the system is bypassed. Indicators are provided for input trip signals, the status of the trip coil, the mechanical position of the circuit breaker, and the ASD stop circuit, for each of the recirculation loops. An annunciator is provided for the RPT activation.

The RPT system design response time delay from start of Turbine Stop Valve Closure or Turbine Control Valve Fast Closure to complete suppression of the electric arc between the fully open contacts of the circuit breaker (Proprietary information that is contained in NEDC-32165P, Rev. 2) or the complete suppression of the ASD output current is shown in Table 1.

The RPT interface with the RPS and the recirculation system is shown in Figure 1.

3.0 ANALYSIS AND RESULTS

The EOC-RPT system is designed to protect the integrity of the fuel barrier in conjunction with the reactor scram function following a postulated AOO. This function is accomplished by tripping both recirculation pumps early in the pressurization phase of the events and introduce negative void reactivity to the core, thus reducing the neutron flux and fuel surface heat flux excursions. Upon detection of a fast closure of the TCVs or the closure of the TSVs at core power level above 30% of rated thermal power the reactor protection system will initiate a reactor scram signal and concurrently a RPT signal to keep the fuel within the design safety limit. (Proprietary information that is contained in NEDC-32165P, Rev. 2) The time required to interrupt the power supply after the initiation of the EOC-RPT signal is as shown in Table 1.

To quantify the margin of improvement to the fuel performance which can be realized with the implementation of the EOC-RPT system, transient analyses are performed for the following AOOs directly affected by the EOC-RPT feature: load rejection with no bypass (LRNBP), turbine trip with no bypass (TTNBP) and feedwater controller failure (FWCF) maximum demand. Core nuclear dynamic parameters and inputs assumptions used in this analysis are consistent with the Cycle 10 reload licensing bases (Reference 1). The events are postulated to initiate at 100% power and 100% flow at EOC exposure condition. Since the FWCF failure event is sensitive to core inlet subcooling effect, this event was analyzed at 100% power/105% core flow with 48°F reduction in feedwater temperature. In addition, the FWCF event is analyzed with the turbine bypass system available as well as out-of-service to provide a sensitivity study of the EOC-RPT function combined with the turbine bypass system. Selected initial conditions are summarized in Table 2.

The core-wide transients analyses results are shown in Table 3 and the corresponding operating MCPR limits are summarized in Table 4. Key parameters responses during the transients are shown in Figures 2 through 5. As can be seen, the EOC-RPT feature reduced the severity of the thermal-mechanical excursions during these transient pressurization events by a significant amount.

Approximately 0.03 to 0.04 delta CPR reduction for the TTNBP, LRNBP and FWCF events can be realized with the implementation of the EOC-RPT system. This margin is applicable to fuel designs from GE7 to GE10 currently in the Peach Bottoms core. To provide a typical margin trend for GE11 fuel, the Cycle 10 limiting event, LRNBP, was analyzed with bounding core nuclear characteristics specific to GE11 consistent with Reference 1 methodology. The results showed that for GE11, the EOC-RPT system also yield an improvement in the operating limit MCPR requirement, about 0.05 lower than without credit for EOC-RPT. Note that the analysis results shown here are cycle-specific and may require verification for future fuel reloads or for new fuel designs.

(Proprietary information that is contained in NEDC-32165P, Rev. 2)

4.0 CONCLUSIONS

The EOC-RPT function reduced the coolant flow delivery to the reactor core during a pressurization event. This flow reduction subsequently introduced negative void reactivity which would limit the transient severity of the fuel thermal-mechanical response. The analyses results documented in this report conducted for PBAPS Unit 2 Cycle 10 confirmed that the implementation of the EOC-RPT system units would yield improvement in the range from 0.03 to 0.05 reduction in the operating limit MCPR requirements for the pressurization transient events. The same improvement trend would be expected for PBAPS Unit 3 base on the similarity in the EOC-RPT system design and the plant configuration between PBAPS Unit 2 and 3.

5.0 REFERENCES

1. Reload Licensing Submittal for Peach Bottoms Atomic Power Station Unit 2 Reload 9 Cycle 10, 23A7188, Revision 0, September 1992

Table 1

RPT SYSTEM RESPONSE TIME

(Proprietary information that is contained in NEDC-32165P, Rev. 2)

Table 2

EOC-RPT ANALYSIS INITIAL CONDITIONS

	TTNBP/LRNBP (100P/100F)	FWCF (100P/105F)
Thermal Power (MWt/% rated)	3293/100	3293/100
Core Flow (Mlb/hr/% rated)	102.5/100	107.62/105
Steam Flow (Mlb/hr)	13.37	12.62
Feedwater Temperature, °F	376	326
Core Coolant Inlet Enthalpy (Btu/lb)	522	517
Dome Pressure (psig)	1005	1005
Core Average Void Fraction (%)	35	32

Table 3

EOC-RPT TRANSIENTS PEAK VALUES

Transients	Power/Flow	Peak Neutron Flux, %	Peak Heat Flux, %	Peak Steamline Press., psig	Peak Vessel Press., psig
LRNBP w/o RPT	100/100	509.4	125.5	1173	1210
LRNBP w/ RPT	100/100	423.8	120.7	1173	1204
TTNBP w/o RPT	100/100	486.9	124.5	1172	1209
TTNBP w/ RPT	100/100	397.3	119.1	1172	1202
FWCF w/o RPT (w/ TBP-OOS)	100/105, FWTR	507.5	132.7	1170	1208
FWCF w/ RPT (w/ TBP-OOS)	100/105, FWTR	405.7	126.7	1170	1202

Note: FWTR = Feedwater temperature reduction
TBP-OOS = Turbine bypass out-of-service

Table 4

EOC-RPT DELTA CPR RESULTS

Transient	Power/Flow	Uncorr.	Delta CPR Opt. A	Delta CPR Opt. B
LRNBP w/o RPT	100/100	.198	.25	.21
LRNBP w/ RPT	100/100	.170	.22	.18
LRNBP w/o RPT (GE11 Fuel)	100/100	.293	.39	.31
LRNBP w/ RPT (GE11 Fuel)	100/100	.241	.34	.26
TTNBP w/o RPT	100/100	.188	.24	.20
TTNBP w/ RPT	100/100	.159	.21	.17
FWCF w/o RPT, (w/ TBP-OOS)	100/105, FWTR	.227	.27	.24
FWCF w/ RPT (w/ TBP-OOS)	100/105, FWTR	.195	.23	.21

(Proprietary information that is contained in NEDC-32165P, Rev. 2)

Figure 1. **RPT Interface with RPS and Recirculation System Diagram**

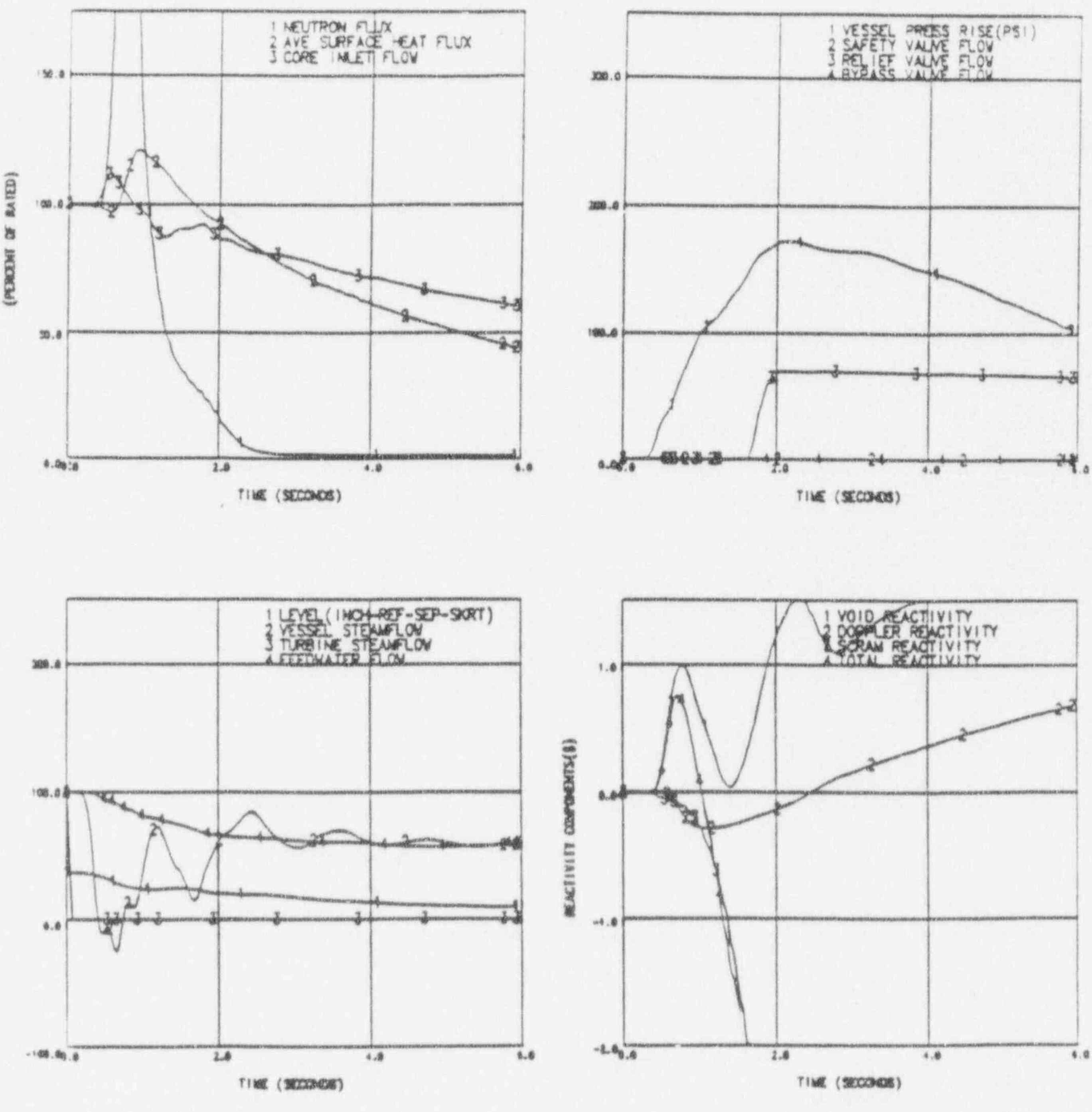

Figure 2. **Plant Responses to Load Rejection with No Bypass, 100P/100F, EOC-RPT**

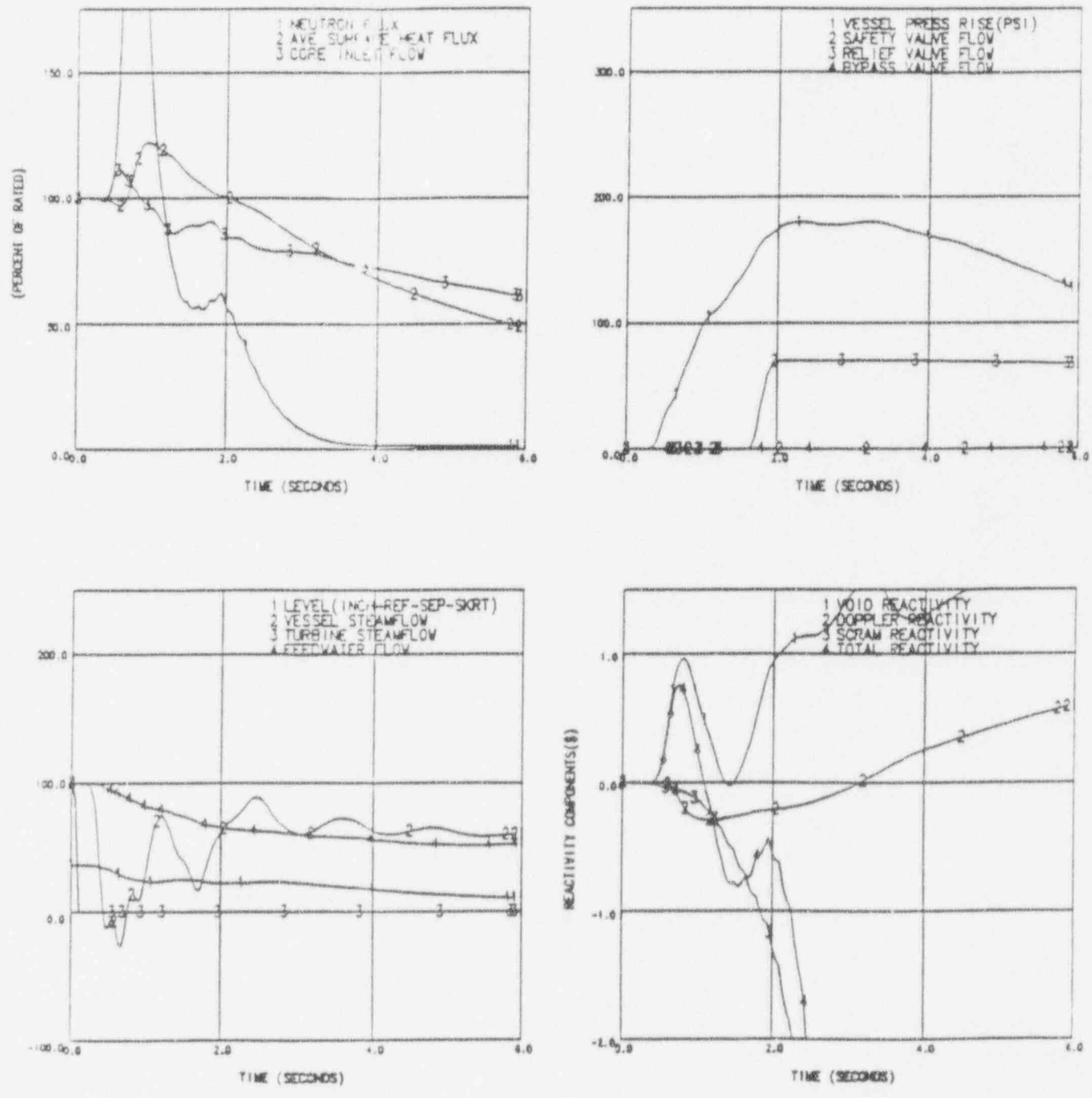

Figure 3. **Plant Responses to Turbine Trip with No Bypass, 100P/100F, EOC-RPT**

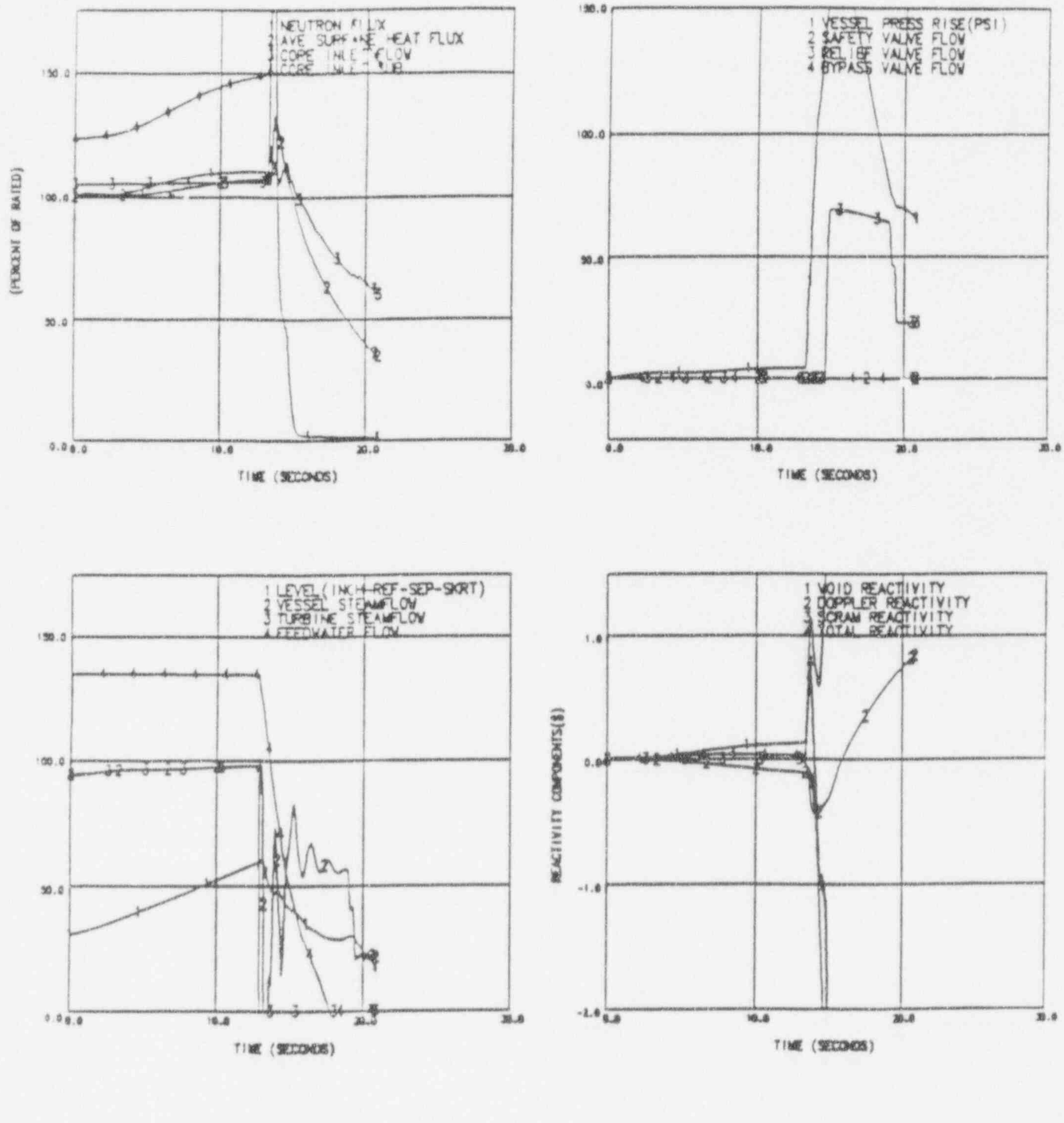

Figure 4. **Plant Responses to Feedwater Controller Failure, Maximum Demand, 100P/105F, FWTR, TBP-OOS**

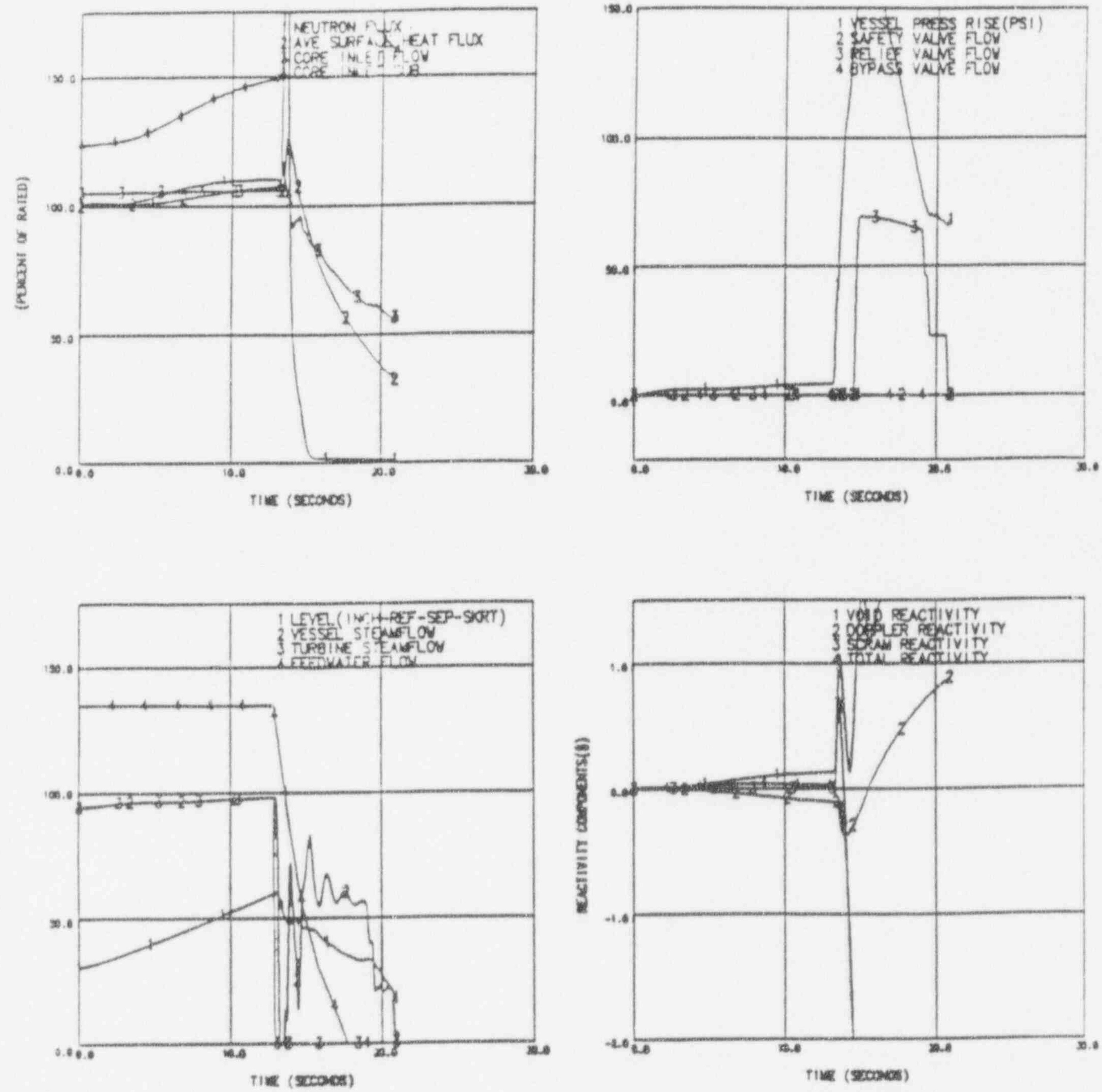

Figure 5. **Plant Responses to Feedwater Controller Failure, Maximum Demand, 100P/105F, FWTR, TBP-OOS, EOC-RPT**

APPENDIX: TECHNICAL SPECIFICATIONS CHANGES

The following changes to the current PBAPS technical specifications are recommended for the implementation of the EOC-RPT feature:

1) Modify the description of instrumentation that initiates recirculation pump trip to include EOC-RPT function, to be provided by signals from Turbine Stop Valves or Turbine Control Valves Closure.

2) Modify the trip level setting for recirculation pump trip to include Turbine Stop Valve position and Turbine Control Valve hydraulic oil pressure.

3) Modify the test and calibration for recirculation pump trip to include verification of the time delay from turbine-generator trip signal to the interruption of the power supply to the recirculation pump motor, i.e. the complete suppression of the electric arc between the circuit breaker contacts, or the complete suppression of the ASD output current.

4) Modify affected bases.