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EQUIPMENT OUT-OF-SERVICE IN THE INCREASED CORE FLOW DOMAIN FOR LASALLE COUNTY STATION UNITS 1 AND 2

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SUMMARY

This report documents the analyses performed for LaSalle County Station (LSCS) Units 1 and 2 to support continuous operation with either the turbine bypass system or the recirculation pump trip feature out-of-service in the increased core flow (ICF) domain (bounded by 105% of rated core flow).

The analyses documented herein assume a combination of one safety/relief valve out-of-service and one other piece of equipment (turbine bypass system or recirculation pump trip feature) inoperable. Plant operation in the ICF domain is assumed with normal feedwater temperature. Specific cycle-independent operating limit minimum critical power ratio (OLMCPR) are established for each equipment assumed out-of-service. Generic CPR criteria for subsequent reload licensing analyses transients verification are specified to assure the cycle-independent characteristics of these equipment out-of-service OLMCPRs. In addition, verification criteria are also provided for the applicability of these equipment out-of-service OLMCPRs in the event of ICF operation coupled with final feedwater temperature reduction (FFWTR) condition.

The analyses of the above-mentioned equipment out-of-service also showed that there is no potential impact on other accident evaluations such as loss-of-coolant accident (LOCA), containment dynamic loadings and thermal-hydraulic stability results.

1. INTRODUCTION

Equipment out-of-service analyses, including the turbine bypass system and the recirculation pump trip feature, have been previously performed for LSCS units 1 and 2 operating in the standard operating domain as well as in the Extended Load Line Limit region (Reference 1). The purpose of the present report is to extend the applicability of some equipment out-of-service options, namely turbine bypass (TBP) system and recirculation pump trip (RPT) feature, into the ICF domain. Analyses were performed to establish the licensing bases for continued plant operation in the ICF domain with either the TBP or the RPT feature assumed out-of-service. For consistency with Reference 1, the above single equipment failure (RPT and TBP) is also assumed in conjunction with the failure of one safety/relief valve.

Bounding core-wide transient performance is performed to establish the plant operating limits associated with each of the systems assumed out-of-service. The transient analyses assume normal feedwater temperature in the ICF domain. However, criteria are also specified to verify the applicability of the equipment out-of-service OLMCPR in the event of ICF operation with FFWTR. Other areas of concern, such as LOCA, containment dynamic loads and thermal-hydraulic stability are not impacted and are included herein for completeness.

2. SAFETY EVALUATIONS

The potential effect of the turbine bypass system out-of-service (TBP-OOS) is to change the vessel pressurization response of the reactor during anticipated operational occurrences (AOOs) which could conceivably impact the margins or safety limits for plant operation. The function of the recirculation pump trip (RPT) feature is to reduce the severity of the thermal transients on the fuel due to turbine-generator trip and load rejection events by tripping the recirculation pump early in the event. Without the RPT mitigating function, the fuel thermal responses during postulated AOOs would be adversely impacted.

2.1 ANTICIPATED OPERATIONAL OCCURRENCES EVALUATION

2.1.1 Turbine Bypass System Out-of-Service

To establish cycle-independent operating limits for reactor operation with this equipment out-of-service in the ICF domain, a bounding end-of-cycle (EOC) exposure condition, based on the current LSCS 1 Cycle 5 core configuration, is used to develop nuclear input to the transient analysis model. The severity of the transient results is strongly dependent on the effectiveness of the control rod scram action. For this reason, the EOC bounding exposure condition assumes a more top-peaked axial power distribution than the nominal power shape, thus yielding a bounding scram response. This conservative analysis approach is consistent with the previous equipment out-of-service analyses (Reference 1).

For both LSCS units, the AOOs currently analyzed for MCPR consideration as part of the cycle-specific reload licensing scope are the load rejection with no bypass (LRNBP) and the feedwater controller failure (FWCF) maximum demand events (References 2 and 3). Since the LRNBP event does not normally account for the turbine bypass system, the resulting OLMCPR is therefore applicable to both turbine bypass system in-service and out-of-service. However, the FWCF maximum demand event usually takes credit for the

turbine bypass system; as such, this event is re-analyzed with the bypass system assumed inoperable.

Based on the bounding power shape, the LRNBP and FWCF events are re-analyzed at 100% power/105% core flow with the equipment in-service to serve as base cases. Normal feedwater temperature is assumed for the analyses. The FWCF event is then analyzed with the TBP-OOS condition to determine the operating limits associated with this equipment inoperable. LSCS Unit 1 Cycle 5 plant operating parameters are assumed for the transient analyses. For consistency with Reference 1, the equipment out-of-service analyses also assumed one safety/relief valve (with the lowest opening setpoint) to be inoperable.

The analyses results are presented in Table 2-1 and time histories of the key parameters are shown in Figures 2-1 to 2-3. Table 2-2 presents the resulting OLMCPR for the analyzed events.

Based on the FWCF event with no bypass, the operating limits associated with TBP-OOS are:

1.34 (Option A) and 1.32 (Option B).

The OLMCPR result for the FWCF event with TBP-OOS is identical to the similar event analyzed at rated core flow condition (Reference 1). The slight increase in delta CPR normally observed at ICF condition is not apparent in this case. The main reason for this observation is due to the cancelling effect from the lower void coefficient used in the current ICF analyses. The bounding power shape used in Reference 1 analyses were based on LSCS 2 Cycle 4 core which has one reload of GE9 fuel while the ICF bounding power shape is based on the more recent LSCS 1 Cycle 5 core which has two reloads of GE9, and therefore shows a lower void coefficient.

For the FWCF with TBP in-service, the 0.01 increase observed between the rated core flow (Reference 1) and the ICF condition is mostly due to the numerical round-off process.

2.1.2 Recirculation Pump Trip Out-of-Service

The same bounding power shape approach is used for developing a cycle-independent OLMCPR associated with RPT-OOS. The LRNBP event is analyzed with the RPT feature out-of-service. This scenario does not violate the criterion of single equipment failure since the LRNBP is normally analyzed with the TBP inoperable, as previously stated.

Based on the LRNBP without RPT event, the operating limits associated with RPT-OOS are:

1.37 (Option A) and 1.33 (Option B)

For the LRNBP events with and without EOC-RPT as shown in Table 2-2, the delta CPR values are identical to the same events previously analyzed for rated core flow conditions (Reference 1). Similar to the FWCF with TBP-OOS result, the slight increase in delta CPR normally observed at ICF condition is not apparent in both LRNBP cases, and again, the main reason is due to the cancelling effect from the lower void coefficient used in the ICF analyses bases.

For completeness, the FWCF event is also analyzed with TBP system operable and RPT-OOS. The results show that the transient responses are similar to the FWCF with TBP-OOS event previously analyzed. Therefore, the LRNBP event remains the limiting event for RPT-OOS consideration.

2.1.3 Criteria for Cycle-Independent Limits

The above operating limits developed for both the TBP-OOS and the RPT-OOS options in the ICF domain are valid for all future cycles at LSCS Units 1 and 2 loading GE fuel through GE10 design provided that for the standard reload licensing bases at ICF condition,

(1) the LRNBF and turbine trip with no bypass (TTNBP) events result in OLMCPR values less than 1.33 for Option A and 1.29 for Option B.

(2) the FWCF event results in an OLMCPR value of less than 1.29 for Option A and 1.27 for Option B.

2.1.4 Criteria for ICF with FFWTR Condition

The above equipment out-of-service OLMCPRs were developed based on ICF operation with normal feedwater temperature. This section addresses the condition when ICF operation is coupled with reduced feedwater temperature (equivalent up to 100°F feedwater temperature decrease at rated conditions).

Operation with ICF and FFWTR (ICF/FFWTR) would further increase the core inlet subcooling and reduce the void fraction, thus yielding a higher delta CPR requirement for the FWCF event than for the same event analyzed with ICF and normal feedwater temperature. Since FWCF is the limiting event for the TBP-OOS, adjustment may be needed to the cycle-independent OLMCPR limit, as shown in Section 2.1.1 above, if the plant is operating at the ICF/FFWTR condition. Transient analyses at ICF with normal feedwater temperature and ICF/FFWTR are normally performed as part of the LSCS cycle-specific reload licensing analyses. If the cycle-specific analysis for the FWCF event with ICF/FFWTR results in an OLMCPR value less than the values specified in Section 2.1.3 (i.e., 1.29 for Option A and 1.27 for Option B), no further penalty is necessary. If the cycle-specific event yields OLMCPR values greater than those specified in Section 2.1.3, then the delta CPR between the two events must be added to the TBP-OOS limits specified in Section 2.1.1.

Beside the above subcooling increase effect, operation with ICF/FFWTR also decreases the vessel steam flow generation rate and consequently, reduces the vessel pressurization rate during AOOs such as TTNBP and LRNBP. Therefore, the delta CPR requirement for these events would be less severe than for those analyzed with normal feedwater temperature. As such, the OLMCPR for the RPT-OOS option based on the

LRNBP event, as shown in Section 2.1.2 above, are bounding for application in the ICF/FFWTR condition. However, there is a possibility that the limiting event for RPT-OOS will change from the LRNBP to the FWCF event. This condition might occur if the delta CPR referred to in the above paragraph is 0.02 or greater. This increase would bring the Option B OLMCPR for FWCF event with RPT-OOS (presently set at 1.32 similar to the FWCF with TBP-OOS) to 1.34 or greater, and thus exceeding the LRNBP with RPT-OOS OLMCPR value of 1.33.

2.2 ACCIDENTS EVALUATIONS

2.2.1 Loss-of-Coolant Accident Analysis

The TBP system and the RPT feature are not assumed in the LSCS LOCA analyses. Therefore, these equipment failures do not have any impact on the calculated peak clad temperature and linear heat generation rates for LSCS Unit 1 and 2.

2.2.2 Containment LOCA Loads

Likewise, since the calculated break flow rate during a postulated LOCA is not affected by either the TBP-OOS or RPT-OOS, the containment dynamic loadings are also not impacted by these equipment assumed out-of-service in the ICF domain.

2.3 THERMAL-HYDRAULIC STABILITY EVALUATION

The failure of either the TBP system or the RPT feature has no impact on the thermal hydraulic stability evaluation as previously documented in Reference 1.

Table 2-1

TRANSIENT ANALYSIS RESULTS FOR LSCS AT 100P/105F TURBINE BYPASS AND RECIRCULATION PUMP TRIP OUT-OF-SERVICE

Transient Description	Figure Number	Power/ Flow (%NBR)[a]	Peak Neutron Flux (% NBR)	Peak Surface Heat Flux (% Initial)	Peak Steam Line Press. (psig)	Peak Vessel Press. (psig)	ΔCPR[f]
LRNBP[b]	2-1	100/105	577.7	121.8	1150	1180	0.21
FWCF[c]	2-2	100/105	456.5	121.8	1132	1162	0.18
LRNBP w/o RPT	2-3	100/105	704.2	126.6	1150	1188	0.24
FWCF w/o TBP	2-4	100/105	610.1	127.2	1148	1179	0.23

a. % NBR = % nuclear boiler rated
b. LRNBP = Load rejection with bypass failure.
c. FWCF = Feedwater controller failure to maximum demand.
d. RPT = Recirculation Pump Trip
e. TBP = Turbine Bypass
f. Delta critical power ratio, uncorrected for ODYN Option A and Option B

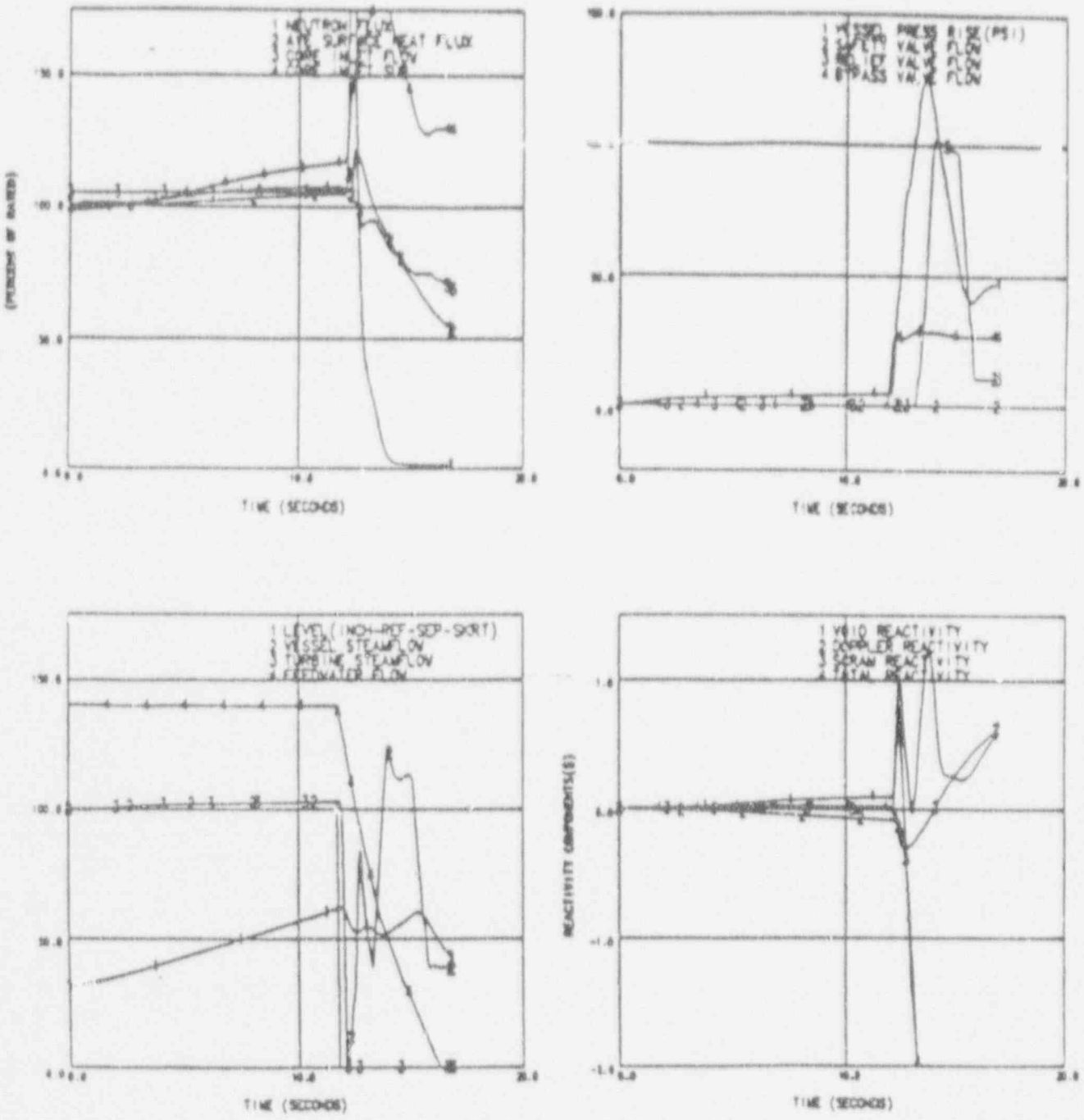

Figure 2-2 Plant Response to Feedwater Controller Failure
Turbine Bypass In-Service, 100P/105F

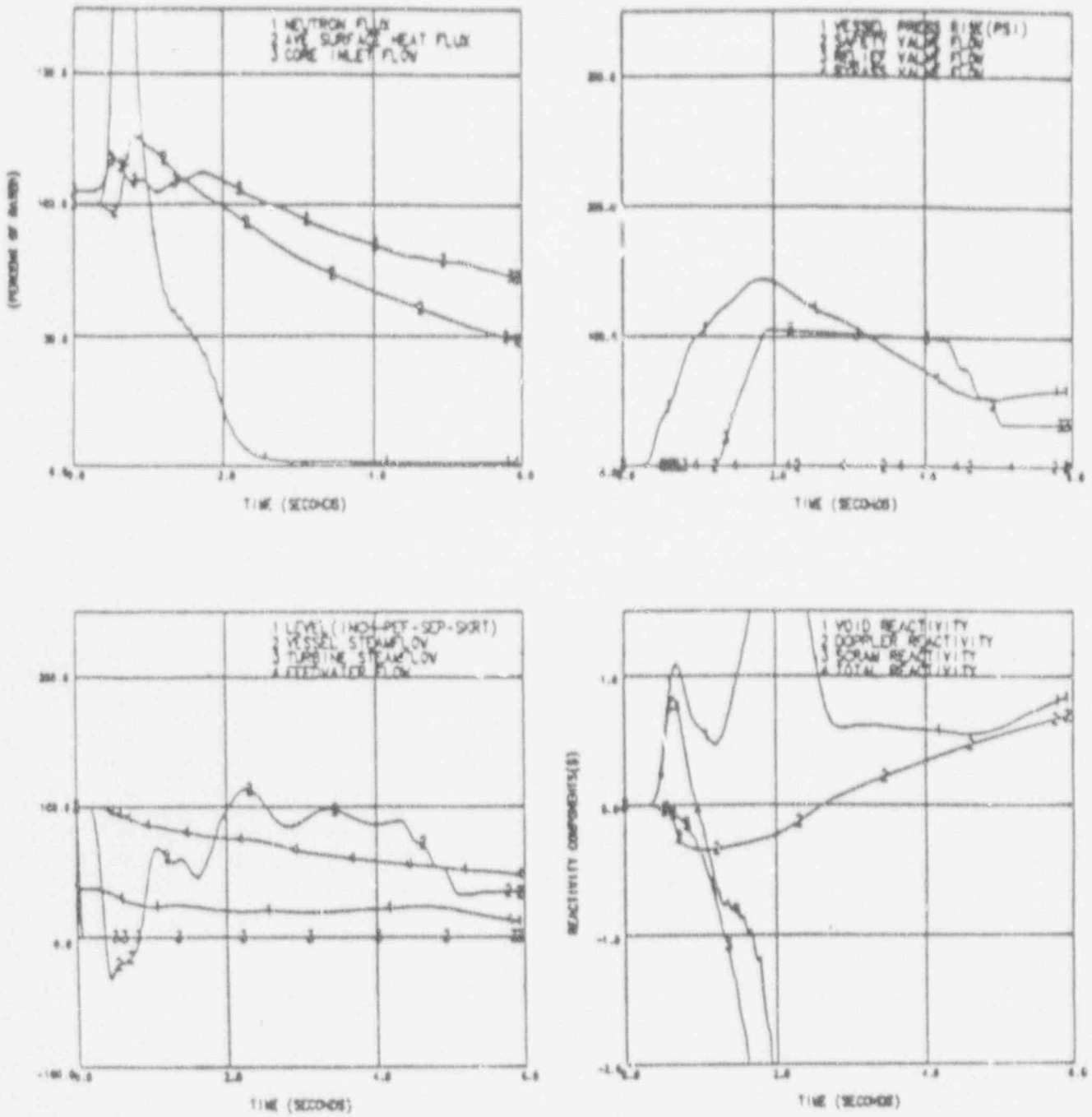

Figure 2-3 Plant Response to Load Rejection with No Bypass Recirculation Pump Trip Out-of-Service, 100P/105F

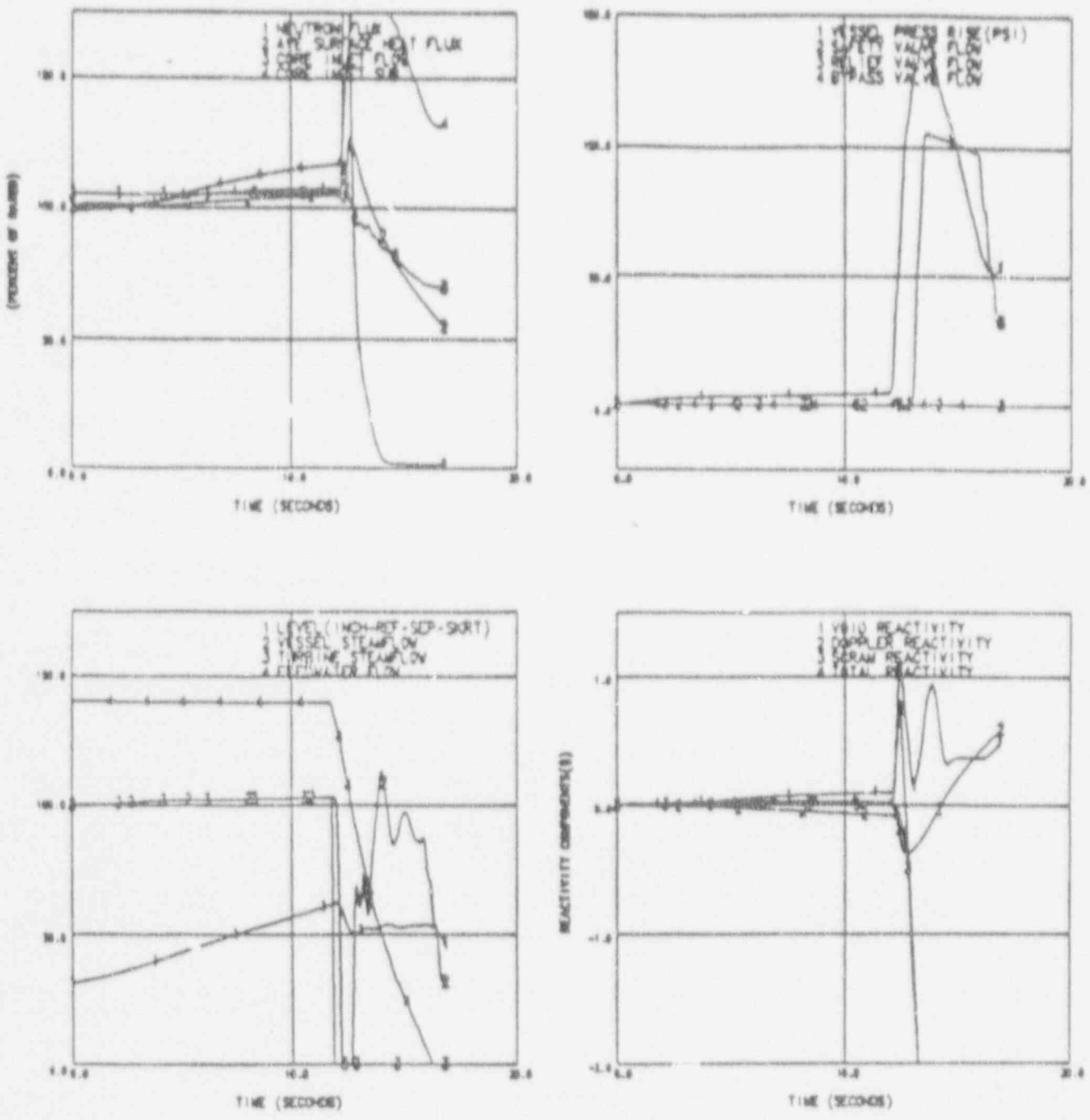

Figure 2-4 Plant Response to Feedwater Controller Failure
Turbine Bypass Out-of-Service, 100P/105F

3. CONCLUSION

The safety evaluations performed for the LSCS Units 1 and 2 have demonstrated that safe plant operation is justified with either the TBP system or the RPT feature assumed out-of-service. Bounding cycle-independent operating limits associated with each equipment out-of-service were developed, along with criteria for subsequent fuel cycles verifications. The safety evaluations also reviewed and confirmed that there is no impact on other accident conditions (such as LOCA or containment dynamic loadings) as well as no impact on the thermal-hydraulic stability consideration.

4. REFERENCES

1. "Extended Operating Domain and Equipment Out-of-Service for LaSalle County Nuclear Station Units 1 and 2", General Electric Company (NEDC-31455, Revision 2), March 1990

2. "Supplemental Reload Licensing Submittal for LaSalle County Station Unit 1, Reload 4 Cycle 5", General Electric Company (23A6525), September 1990.

3. "Supplemental Reload Licensing Submittal for LaSalle County Station Unit 2, Reload 3 Cycle 4", General Electric Company (23A5973), December 1989.