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SUPPLEMENT 1

ADVANCED NUCLEAR FUELS CORPORATION

WNP-2 PLANT TRANSIENT ANALYSIS WITH FINAL FEEDWATER TEMPERATURE REDUCTION CYCLE 4 ANALYSIS

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CYCLE 4 ANALYSIS

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1.0 INTRODUCTION

ANF has performed analyses supporting final feedwater temperature reduction (FFTR) for WNP-2 as reported in Reference 1. The change in minimum critical power ratio (MCPR) resulting from the FFTR was determined for the limiting transients. Operating MCPR limits for WNP-2 with FFTR were then proposed based on these analyses. The FFTR analyses in Reference 1 were performed using neutronic input data for WNP-2 Cycle 3 and ANF transient methodology. This supplement presents additional FFTR analysis results using Cycle 4 neutronics data for the most limiting transients.

The analyses of Reference 1 addressed potentially limiting transients as determined for jet pump BWR's in XN-NF-79-71[4]. For the Cycle 4 analysis, only the most limiting rapid pressurization events, the load rejection without bypass (LRNB) and feedwater controller failure (FWCF) transients which may be sensitive to cycle specific changes, were recalculated.

The FFTR analysis was performed consistent with the WNP-2 cycle specific reload analysis (References 2 and 3) employing the same methodology (References 4 and 5). The models were appropriately adjusted to reflect the conditions for FFTR operation. Thus, the differences in the results between the FFTR cases and the normal feedwater cases are due only to the feedwater temperature reduction and cycle specific neutronics.

2.0 SUMMARY

The effects on critical power ratio requirements for the potentially limiting plant system transient events with a FFTR of 65°F or less are shown in Table 2.1 for both Cycle 3 and Cycle 4. Based on the Cycle 3 analysis, the effect of FFTR is to increase the delta CPR for the LRNB event by up to 0.02 and decrease the delta CPR for the FWCF event by as much as 0.01. The Cycle 4 FFTR LRNB results showed no delta CPR change for ANF fuel and a delta CPR increase of 0.01 for GE fuel relative to the Cycle 4 events with normal feedwater temperature. The Cycle 4 FFTR FWCF results showed a delta CPR decrease of 0.01, which is the same as shown for Cycle 3.

Thus, the Cycle 3 FFTR results bound the Cycle 4 results.

TABLE 2.1 THERMAL MARGIN SUMMARY FOR OPERATION WITH FFTR*

Transient	Cycle	% Power/%Flow	Effect of FFTR** On MCPR Limit	
			GE Fuel	ANF Fuel
LRNB	3	104/106	0.02	0.02
LRNB	4	104/106	0.01	0.00
FWCF	3	47/106	-0.01	-0.01
FWCF	4	47/106	-0.01	-0.01

*These transients were evaluated with normal scram speed.

**Maximum difference (FFTR MCPR - Normal MCPR)

3.0 TRANSIENT ANALYSIS FOR THERMAL MARGIN

3.1 Design Basis

The system transient analysis, performed to determine the effects of feedwater temperature reduction on the MCPR operating limits, assumed the following:

1. The plant is operating on a normal 12 month cycle.
2. A feedwater temperature reduction of 65°F is used to extend the operating cycle.
3. Conservatively, the plant is assumed to operate 18 days at full thermal power with the feedwater temperature reduced prior to any coastdown.
4. The plant is operating with the recirculation flow control valves in the wide-open position, producing 106% of rated core flow at 100% core thermal power.
5. Control rod insertion time is based on WNP-2 measured (normal) scram speed.
6. Integral power to the hot channel was increased by 10% for the pressurization transient thermal margin evaluations, consistent with Reference 6.

These assumptions are consistent with the assumptions for the Cycle 3 FFTR analysis.

The load rejection without bypass event was performed at the 104% power/106% flow point with normal (as measured) scram speed. Since feedwater controller failure transients are more severe at reduced power because of the capability for a larger change in feedwater flow (and a corresponding increase in core thermal power prior to a high water level trip), the FWCF transient evaluation was performed at the minimum power (47%) allowed for increased core flow (106%). The initial conditions used in the Cycle 4 analysis at the 104% power/106% flow point are as shown in Table 3.1. The most limiting exposure in the extended cycle is at the end of full core thermal power capability with FFTR when the control rods are fully withdrawn from the core. The thermal margin limits established in this evaluation conservatively apply to feedwater temperature reductions of less than 65°F and to cases where the control rods are partially inserted.

The calculational models and plant operational parameters used to determine the thermal margin are consistent with those used in the WNP-2, Cycle 3 reload and FFTR analysis and the Cycle 4 reload and FFTR analysis. The models include the ANF plant transient and core thermal-hydraulic codes as described in References 5, 6, 7, and 8. The plant operational parameters utilized in this evaluation are summarized in Table 3.2.

3.2 Anticipated Transients

ANF considers eight categories of potential system transient occurrences for Jet Pump BWRs in XN-NF-79-71(4). The two most thermal limiting events determined for Cycle 3(2) and Cycle 4(3) were evaluated for the FFTR operating states.

These transients are:

- Load Rejection Without Bypass (LRNB)
- Feedwater Controller Failure (FWCF)

The WNP-2 reactor was operated in the single loop mode (one active recirculation loop and reduced power) during significant portions of Cycles 1 and 2. This affects the neutronics for Cycle 3 and makes it typical of cycles following single loop operation. Cycle 3 operated with both recirculation pumps active (full power), and as a result the Cycle 4 end of cycle neutronics used herein are more typical of 2 loop WNP-2 operation. Thus, the impacts of FFTR as calculated for Cycle 3 and Cycle 4 represent the effect of FFTR on MCPR limits for considerably different prior plant operations.

A summary of the Cycle 3[2] and Cycle 4[3] transient analyses including FFTR is shown in Table 3.3.

3.2.1 Load Rejection Without Bypass

This event is the most limiting of the class of transients characterized by rapid vessel pressurization. The generator load rejection causes a turbine control valve trip, which initiates a reactor scram and a recirculation pump trip (RPT). Figures 3.1 and 3.2 depict the time variance of critical reactor and plant parameters for the load rejection without bypass (LRNB) event with normal scram speed, and with FFTR as initiated from the 104% power/106% flow state point for Cycle 4.

Table 3.3 shows the delta CPR values for the LRNB transients, with RPT operable, and with normal scram speed (NSS).

The effect of the FFTR is to slightly increase the severity of the 104/106 LRNB event. This result is attributed to a core void distribution that causes an axial power peak higher in the core. Axial power peaks higher in the core for FFTR conditions relative to normal feedwater temperature conditions were observed both in the Cycle 3 and Cycle 4 analyses. The 104/106 LRNB event is limiting for the extended cycle FFTR conditions, and the Cycle 3 FFTR results bound the Cycle 4 FFTR results.

3.2.2 Feedwater Controller Failure

Failure of the feedwater control system is postulated to lead to a maximum increase in feedwater flow into the vessel, resulting in a power increase prior to a high water level reactor trip. The power increase is terminated by reactor scram, RPT, and pressure relief from the opening of the turbine bypass valves.

Because the total change in feedwater flow is the greatest from reduced power conditions, the FWCF is more severe from reduced power states. The FWCF transient event was analyzed from the lowest power (47%) allowed for increased core flow operation. Figures 3.3 and 3.4 present the time variation of key variables in the Cycle 4 analyses. The delta CPR values for the FWCF event, with RPT, normal scram speed, and with and without (Cycle 3 and Cycle 4 reload analysis) FFTR are shown in Table 3.3.

The heat balance at the FFTR state condition shows a slightly lower steam flow than for normal feedwater conditions. When the FWCF event occurs, the maximum feedwater flow is limited only by the feedwater pumps head/flow characteristics. Thus, the water level in the vessel rises faster and the high water level trip occurs at a lower power level in the FFTR modes. This results in a smaller transient delta CPR for FWCF transients with FFTR.

TABLE 3.1 DESIGN REACTOR AND PLANT CONDITIONS FOR CYCLE 4 FFTR OPERATION

Reactor Thermal Power (104%)	3464 MWt
Total Recirculating Flow (106%)	115.0 Mlb/hr
Core Channel Flow	102.1 Mlb/hr
Core Bypass Flow	12.9 Mlb/hr
Core Inlet Enthalpy	520.8 Btu/lbm
Vessel Pressures	
Steam Dome	1023.2 psia
Upper Plenum	1036.1 psia
Core	1042.7 psia
Lower Plenum	1059.0 psia
Turbine Pressure	971.9 psia
Feedwater/Steam Flow	13.8 Mlb/hr
Feedwater Enthalpy	335.2 Btu/lbm
Recirculating Pump Flow (per pump)	17.26 Mlb/hr
Feedwater Temperature Reduction	65.0°F
Cycle Extension	≤18 days*

*At 100% core power.

TABLE 3.2 SIGNIFICANT PARAMETER VALUES USED IN ANALYSIS FOR WNP-2

High Neutron Flux Trip	126.2%
Void Reactivity Feedback	10% above nominal*
Time to De-energize Pilot Scram Solenoid Valves	200 msec
Time to Sense Fast Turbine Control Valve Closure	80 msec
Time from High Neutron Flux Time to Control Rod Motion	290 msec
Scram Insertion Times (normal)**	0.404 sec to Notch 45
	0.660 sec to Notch 39
	1.504 sec to Notch 25
	2.624 sec to Notch 5
Turbine Stop Valve Stroke Time	100 msec
Turbine Stop Valve Position Trip	90% open
Turbine Control Valve Stroke Time (Total)	150 msec
Fuel/Cladding Gap Conductance	581. Btu/hr-ft2-F

*For rapid pressurization transients a 10% multiplier on integral power is used, see Reference 6 for methodology description.

**Slowest measured average Control Rod insertion time to specified notches for each group of 4 control rods arranged in a 2x2 array.

TABLE 3.2 SIGNIFICANT PARAMETER VALUES USED IN ANALYSIS FOR WNP-2 (Continued)

Safety/Relief Valve Performance	
Settings	Technical Specifications
Relief Valve Capacity	228.2 lbm/sec (1091 psig)
Pilot Operated Valve Delay/Stroke	400/100 msec
MSIV Stroke Time	3.0 sec
MSIV Position Trip Setpoint	85% open
Condenser Bypass Valve Performance	
Total Capacity	990 lbm/sec
Delay to Opening (80% open)	300 msec
Fraction of Energy Generated in Fuel	0.965
Vessel Water Level (above Separator Skirt)	
High Level Trip (L8)	73 in
Normal	49.5 in
Low level Trip (L3)	21 in
Maximum Feedwater Runout Flow	
Two Pumps	5799 lbm/sec
Recirculating Pump Trip Setpoint	1170 psig Vessel Pressure

TABLE 3.2 SIGNIFICANT PARAMETER VALUES USED IN ANALYSIS FOR WNP-2 (Continued)

Control Characteristics	
Sensor Time Constants	
Steam Flow	1.0 sec
Pressure	500 msec
Others	250 msec
Feedwater Control Mode	Three-Element
Feedwater 100% Mismatch	
Water Level Error	48 in
Steam Flow Equiv.	100%
Flow Control Mode	Manual
Pressure Regulator Settings	
Lead	3.0 sec
Lag	7.0 sec
Gain	3.3%/psid

TABLE 3.3 RESULTS OF SYSTEM PLANT TRANSIENT ANALYSES

Event	Maximum Neutron Flux (% Rated)	Maximum Core Average Heat Flux (% Rated)	Maximum System Pressure (psig)	Delta CPR GE Fuel	Delta CPR ANF Fuel
LRWB, Cycle 3, RPT Operable, NSS	295	115	1165	0.25	0.23
LRWB, Cycle 3 RPT Operable, NSS, FFTR	308	118	1170	0.27	0.25
LRWB, Cycle 4, RPT Operable, NSS	373	119	1170	0.25	0.24
LRWB, Cycle 4, RPT Operable, NSS, FFTR	334	119	1170	0.26	0.24
FWCF, Cycle 3, (47% Power/106% Flow), NSS, RPT Operable	156	54	1015	0.26	0.24
FWCF, Cycle 3 (47% Power/106% Flow), NSS, RPT Operable, FFTR	156	54	1008	0.25	0.23
FWCF, Cycle 4, (47% Power/106% Flow), NSS, RPT Operable	103	50	1010	0.12	0.11
FWCF, Cycle 4, (47% Power/106% Flow), NSS, RPT Operable, FFTR	98	50	1001	0.11	0.10

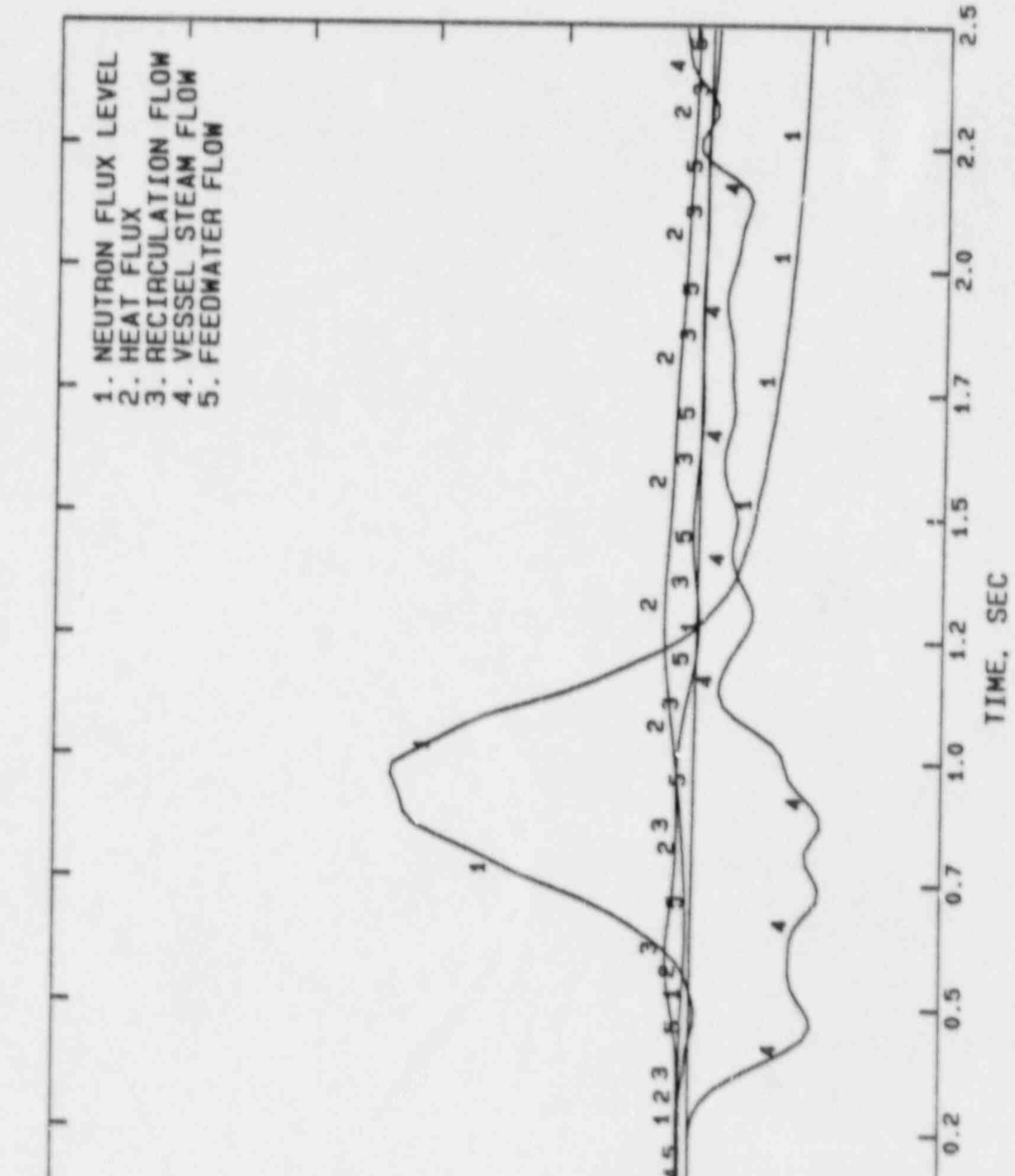

Figure 3.1 Cycle 4 FFTR Load Rejection Without Bypass, RPT Operable, Normal Scram Speed

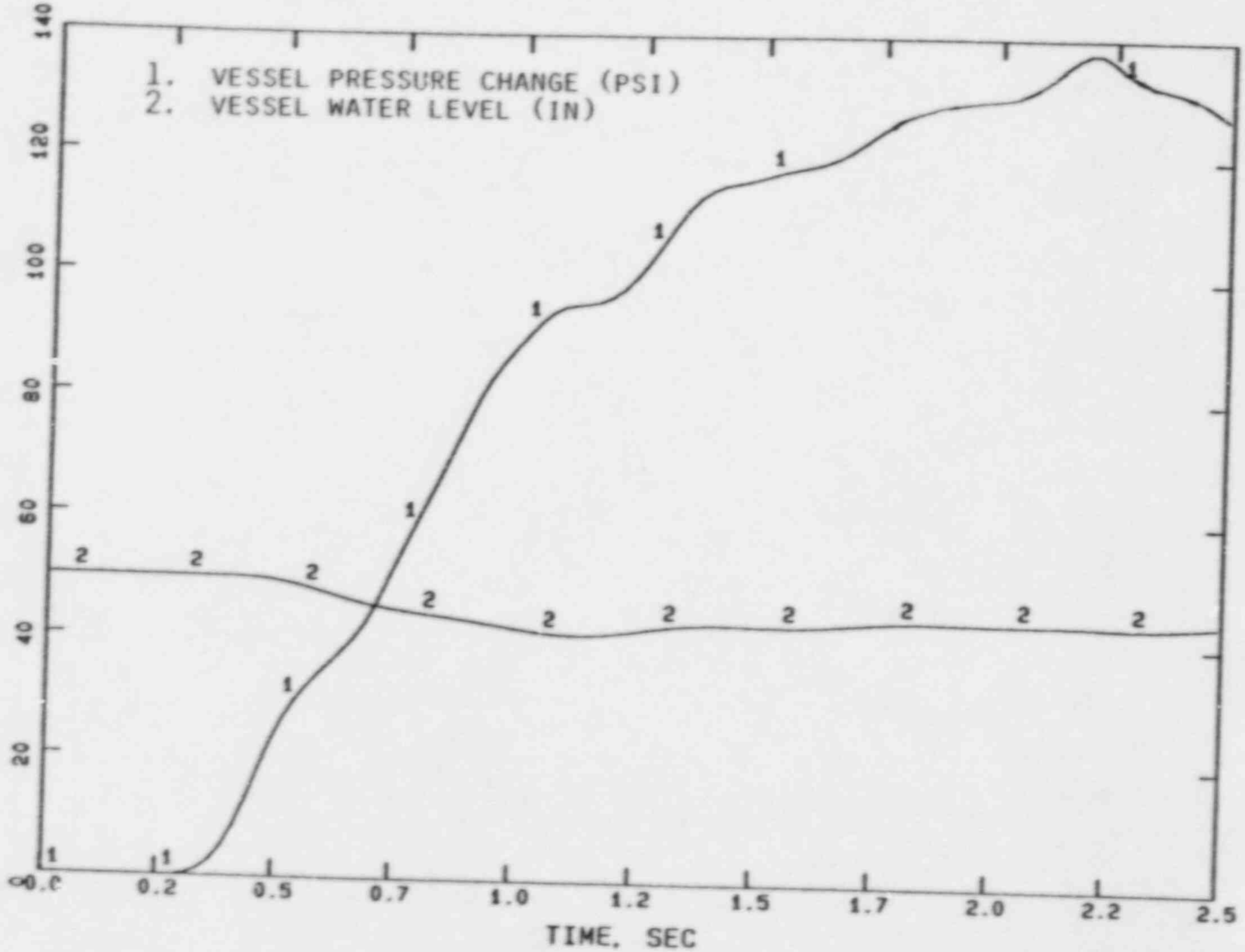

Figure 3.2 Cycle 4 FFTR Load Rejection Without Bypass, RPT Operable, Normal Scram Speed

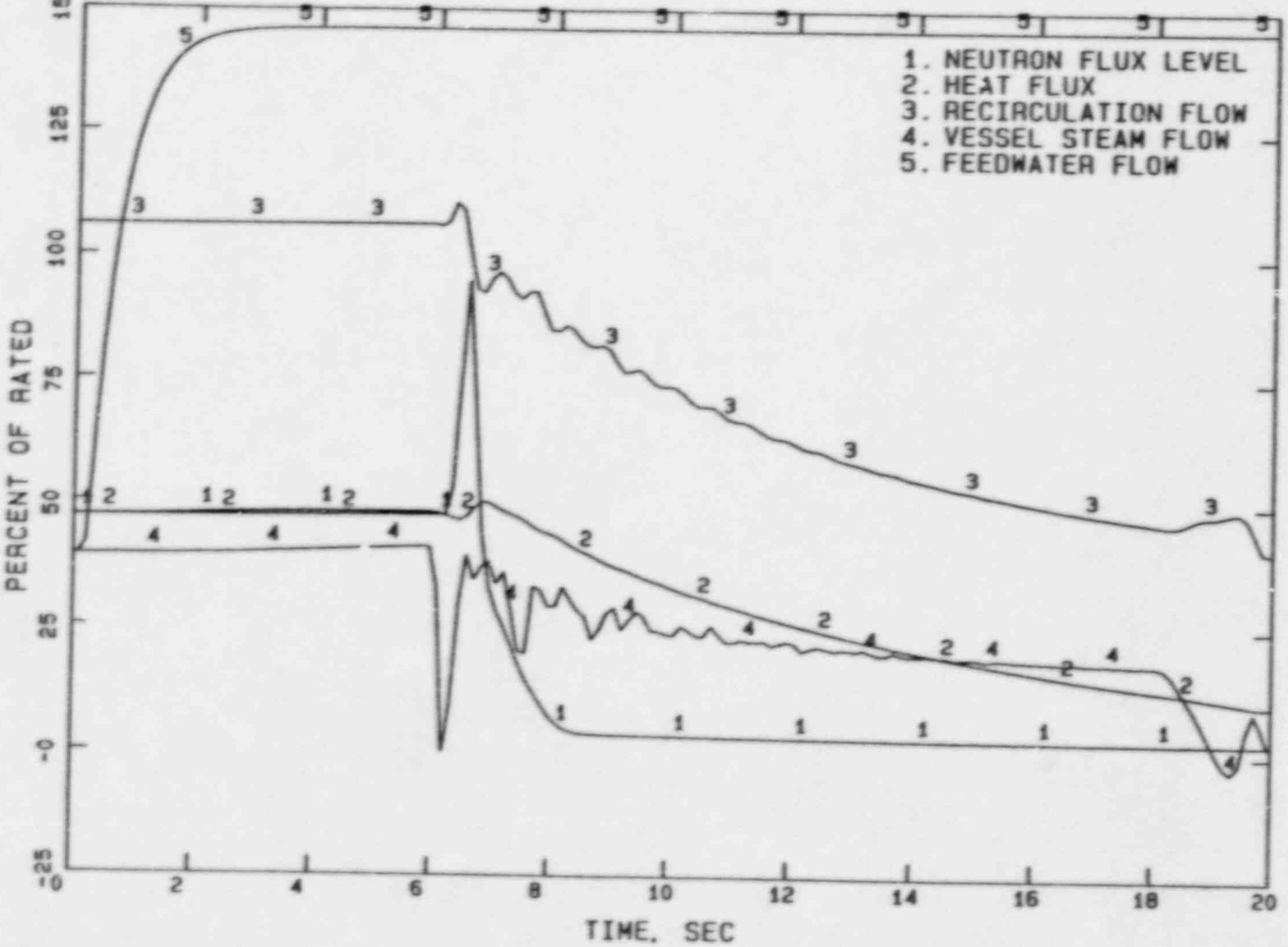

Figure 3.3 Cycle 4 FFTR Feedwater Controller Failure Results For 47% Power And 106% Flow, RPT Operable, Normal Scram Speed

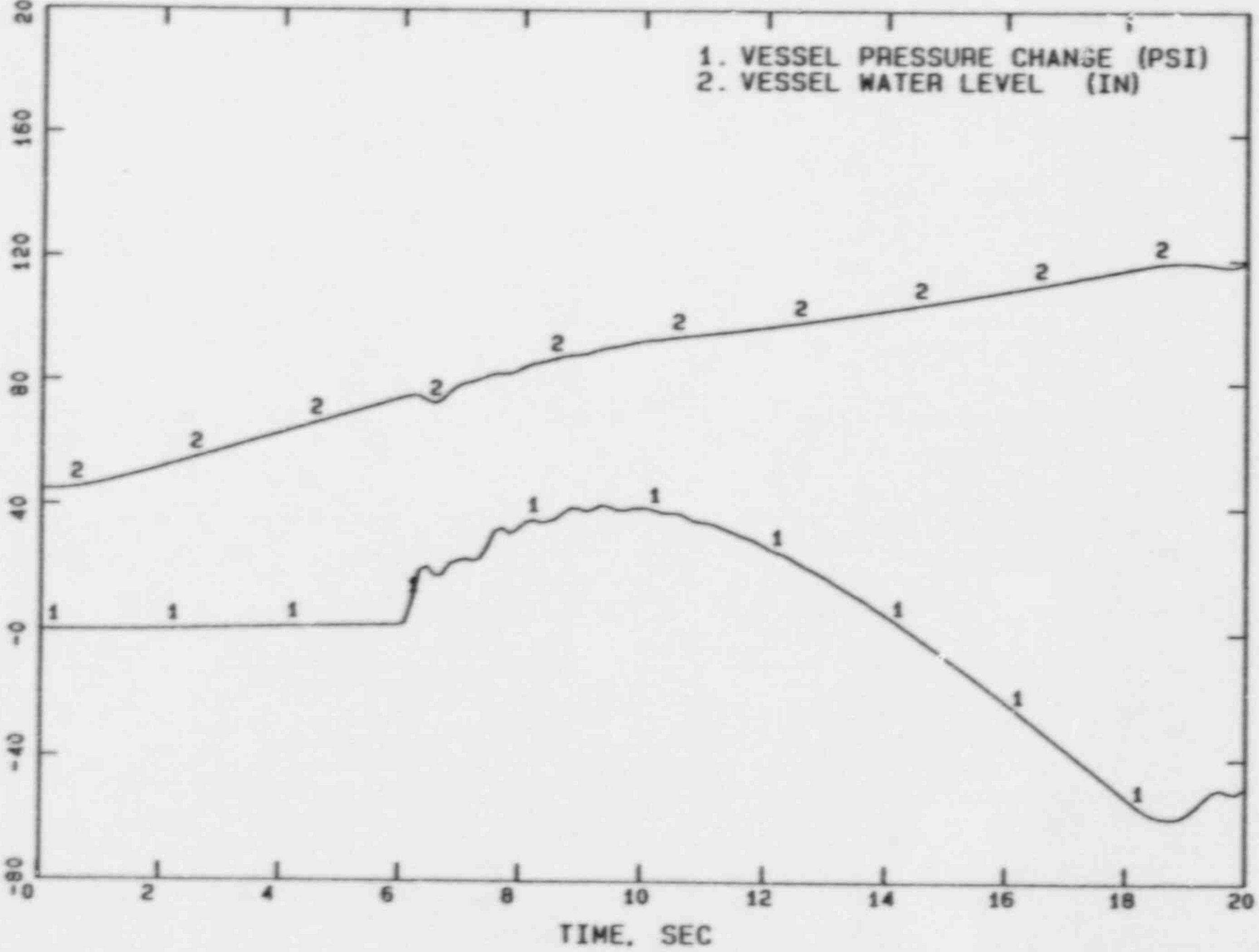

Figure 3.4 Cycle 4 FFTR Feedwater Controller Failure Results For 47% Power And 106% Flow, RPT Operable, Normal Scram Speed

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