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ADVANCED NUCLEAR FUELS CORPORATION

MILLSTONE UNIT 2
SMALL BREAK LOCA ANALYSIS

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1.0 INTRODUCTION

This document presents the results of a small break loss-of-coolant accident (SBLOCA) analysis for the Millstone Unit 2 reactor. Break spectrum calculations were performed to determine the limiting break size. The break spectrum included break sizes of 1%, 1.9%, 3%, and 4% of the cross-sectional area of a cold leg pipe. Sensitivity calculations were performed to support an asymmetric steam generator tube plugging level of 23.5 ± 5.9%. Justification is also performed to justify a 300 second primary coolant pump trip delay time following the Safety Injection Actuation Signal (SIAS). Justification is provided to support a reduction in primary coolant temperature of up to 12°F at full power operation.

2.0 SUMMARY OF RESULTS

The results of the analysis indicated the limiting break size with symmetric steam generator tube plugging was the 1.9% break. The peak cladding temperature (PCT) for this case was calculated to be 1811°F with a maximum local cladding oxidation of 4.17%. The results for asymmetric steam generator tube plugging at the limiting break size are similar to the results for symmetric tube plugging, with the PCT being slightly higher for the symmetric tube plugging case. The calculations support a 300 second primary coolant pump trip delay time following the SIAS. The analysis also supports a reduction in the primary coolant temperature of up to 12°F.

The analysis supports full power operation at 2754 MWt (2700 MWt plus 2% uncertainty) with an average steam generator tube plugging level of 23.5% and a maximum asymmetry of 5.9%. The analysis supports a maximum Linear Heat Rate (LHR) of 15.1 kW/ft and a radial peaking factor of 1.61. The analysis demonstrates that the 10 CFR 50.46(b) criteria are satisfied for the Millstone Unit 2 reactor. The peak cladding temperatures calculated for this analysis are bounded by the peak cladding temperatures calculated for the large break LOCA analysis for Millstone Unit 2 (Ref. 1).

3.0 ANALYSIS

The purpose of the SBLOCA analysis is to demonstrate that the criteria stated in 10 CFR 50.46(b) are met. The criteria are:

1. The calculated peak fuel element cladding temperature does not exceed the 2200°F limit.

2. The amount of fuel element cladding which reacts chemically with water or steam does not exceed 1% of the total amount of zircaloy in the core.

3. The cladding temperature transient is terminated at a time when the core geometry is still amenable to cooling. The hot fuel rod cladding oxidation limit of 17% is not exceeded during or after quenching.

4. The core temperature is reduced and decay heat is removed for an extended period of time, as required by the long-lived radioactivity remaining in the core.

Section 3.1 of this report provides a description of the postulated small break loss-of-coolant transient. Section 3.2 describes the analytical models used in the analysis. Section 3.3 provides a description of the Millstone Unit 2 plant and a summary of the system parameters used in the SBLOCA analysis. Section 3.4 provides a summary of the results of the break spectrum calculations. Section 3.5 summarizes the results of the delayed pump trip sensitivity analysis. Section 3.6 summarizes the results of the asymmetric steam generator tube plugging level sensitivity analysis. Section 3.7 provides arguments to support a reduction in primary coolant temperature at full power operation.

3.1 Description of SBLOCA Transient

The small break LOCA is generally defined as a break in the PWR pressure boundary which has an area of 0.5 ft^2 or less (~10% of cold leg pipe area). This range of break areas encompasses small lines which penetrate the primary pressure boundary. Small breaks could involve pressurizer relief and safety valves, charging and letdown lines, drain lines, and instrumentation lines. The limiting break size is generally in the neighborhood of 2% of the cold leg pipe area. The most limiting break location is in the cold leg pipe at the discharge side of the pumps, particularly with primary pumps tripped on the SIAS. This break location results in the largest amount of inventory loss and the largest fraction of Emergency Core Cooling System (ECCS) fluid ejected out the break. This produces the greatest degree of core uncovery and the longest fuel rod heatup time.

The SBLOCA transient is characterized by a slow depressurization of the primary system with a reactor trip occurring at a low primary pressure of 1750 psia in the Millstone Unit 2 plant. The SIAS occurs when the system has depressurized to 1600 psia. The capacity and shutoff head of the High Pressure Safety Injection (HPSI) pumps are important parameters in the SBLOCA transient. The single failure criteria is satisfied by the loss of one diesel generator. In the Millstone Unit 2 SBLOCA analysis, one additional HPSI pump is assumed to be out of service for maintenance, so that only one HPSI pump is available.

HPSI injection is delayed for 30 seconds after reactor scram to model a possible loss-of-offsite power at reactor scram. This 30 second delay in starting the diesel generator and HPSI pump does not affect the limiting 1.9% break or smaller break size cases because the delay time is satisfied before the primary system pressure has decayed to the shutoff head of the HPSI pumps. For break sizes larger than 1.9%, HPSI flow is delayed only a few seconds due to the startup delay time. Also, the HPSI flow rate becomes less significant as the break size increases above the limiting break size. Therefore, the assumption of loss-of-offsite power has a very small effect on the small break LOCA analysis.

The SBLOCA transient can be categorized into three break sizes (1) "small" small breaks, (2) "medium size" small breaks, and (3) "large" small breaks. The scenario is different for each category of break sizes. The "small" small breaks are characterized by inventory losses that are less than the makeup capacity of the HPSI and charging pumps such that core uncovery is limited. The core level is eventually recovered and hot rod heatup is limited. The "large" small breaks are characterized by a larger primary system depressurization rate such that the Safety Injection Tank (SIT) pressure is reached in sufficient time to limit the core uncovery and hot rod heatup. The HPSI pumps have limited influence in the "large" small break transient. The "medium size" small break transient is generally the most limiting. In this transient the rate of inventory loss from the primary system is large enough that the HPSI and charging pumps cannot preclude significant core uncovery. The primary system depressurization rate is very slow, extending the time required to reach the SIT pressure. This tends to maximize the heatup time of the hot rod and produces the maximum peak cladding temperature. It also results in the longest time-at-temperature, which maximizes the local cladding oxidation. The limiting break is characterized by a short injection of emergency core coolant from the Safety Injection Tanks. The additional fluid injected into the core increases the steaming rate and raises the primary system pressure above the SIT pressure, thus stopping flow from the Safety Injection Tanks. By the time the primary system pressure drops to the SIT pressure, the flow out the break has dropped to less than the HPSI and charging pump flow, so the level in the core is slowly recovered by the HPSI and charging pumps.

The time allowed for operators to manually trip the primary coolant pumps following the SIAS is an important parameter. If the primary pumps operate after break uncovery (transition to mostly steam flow), additional inventory loss from the system, more core uncovery, and higher peak cladding temperatures will occur. Therefore, the base calculations for this analysis tripped the primary coolant pumps at the SIAS, and a sensitivity study was performed to justify a 300 second primary pump coolant trip delay time following the SIAS.

3.2 Analytical Models

The approved ANF SBLOCA evaluation model (Ref. 2) consists of three computer codes. The appropriate conservatisms prescribed by Appendix K of 10 CFR 50 are incorporated.

(1) The RODEX2 code (Ref. 3) was used to determine the initial fuel stored energy which is used to initialize the system code.

(2) The ANF version of RELAP5/MOD2 (ANF-RELAP) was used to model the primary system and secondary side of the steam generators during the blowdown. The governing conservation equations for mass, energy, and momentum transfer are used along with appropriate correlations consistent with Appendix K of 10 CFR 50. The reactor core in ANF-RELAP was modeled with heat generation rates determined from reactor kinetics equations with actinide and decay heating as required by Appendix K. The reactor core was modeled with two connected parallel channels. One channel simulates a higher power region which represents 30% of the core. The other channel simulates an average of the remaining 70% of the core. The peaking factor for the higher power region used in the analysis represents the average peaking factor for that region. The analysis is not sensitive to the value of the peaking factor for the higher power region over the range of peaking factors predicted for Cycle 10 and future cycles. Nodalization in the upper downcomer was sufficiently detailed to simulate circumferential flow around the downcomer from the intact loops to the broken loop and the resistance to flow around the hot leg nozzles where they penetrate the downcomer.

(3) The TOODEE2 code was used to simulate the behavior of the hot rod during the entire transient. The code uses fluid flow rate, temperature, and mixture level boundary conditions from the ANF-RELAP system calculation.

3.3 Plant Description and Summary of Analysis Parameters

The Millstone Unit 2 nuclear power plant is a Combustion Engineering (CE) designed pressurized water reactor which has two hot leg pipes, two U-tube steam generators, and four cold leg pipes with one reactor coolant pump in each cold leg. The plant utilizes a large dry containment. The reactor coolant system is nodalized in the ANF-RELAP model into control volumes representing reasonably homogeneous regions, interconnected by flow paths or "junctions". The two cold legs connected to the intact loop steam generator were assumed to be symmetrical and were modeled as one intact cold leg with appropriately scaled input. The model considers four Safety Injection Tanks, a pressurizer, and two steam generators with both primary and secondary sides of the steam generators modeled. Main feedwater flow and safety relief valves were modeled on the secondary side of the steam generator. The HPSI and Low Pressure Safety Injection (LPSI) pumps were modeled as fill junctions at the SIT lines, with conservative flows given as a function of system back-pressure. However, the system pressure does not decay to the shutoff head of the LPSI pumps in the SBLOCA analysis. One charging pump was included in the model with half of the flow directed to one intact loop and the other half directed to the broken loop. The primary coolant pump performance curves are characteristic of the Millstone Unit 2 pumps. A steam generator tube plugging level of 23.5% was assumed with a maximum asymmetry of 5.9%.

A conservative top skewed axial power shape with an ASI of 0.11 and peaked at a relative core height of 0.9 was used in the analysis. This shape was renormalized to represent a peak LHR of 15.1 kW/ft at a relative core height of 0.9.

Values for system parameters used in the analysis are given in Table 3.1.

3.4 Break Spectrum Base Case Results

Calculations were performed for break sizes corresponding to 1.0%, 1.9%, 3.0%, and 4.0% of the flow area of one cold leg. The cases reported in this section assume an even number of tubes were plugged in each steam generator.

and that the reactor coolant pumps were tripped at the time of the SIAS. All calculations were performed with a peak LHR of 15.1 kW/ft. The results of the break spectrum study are given in Table 3.2. Calculated event times for the various break sizes are given in Tables 3.3 through 3.6.

The results show the 1.9% break size to be the limiting break, with a peak cladding temperature of 1811°F. The 1.9% break size is the limiting case because it results in the slowest rate of depressurization to the SIT pressure. The core is uncovered for the longest period of time, resulting in the most severe fuel heatup. The 3.0% and 4.0% break sizes experienced a more rapid depressurization to the SIT pressure, which limited the length of time the core was uncovered, and the depth of the core uncovery. Thus, the PCTs predicted for the 3.0% and 4.0% break sizes were less than the PCT predicted for the 1.9% break size. Calculations indicated that core uncovery would be less severe for break sizes less than 1.9% and the HPSI and charging pumps would recover the liquid level in the core without flow from the Safety Injection Tanks.

The blowdown calculation for the 1.0% break indicated that the mixture level did not drop below the top of the core, thus precluding fuel rod heatup. The High Pressure Safety Injection system was sufficient to keep the core covered without flow from the SIT. A TOODEE2 hot rod heatup calculation was not performed for this case.

Results for the 1.9%, 3%, and 4% break sizes are shown in Figures 3.1 through 3.14.

3.5 Pump Trip Delay Results

Calculations were performed to justify a 300 second primary coolant pump trip delay following the SIAS. A delayed pump trip will postpone the time of break uncovery if the pump trip delay results in pump shut down after the time at which the break would have uncovered with pumps shut off at the SIAS. If the break uncovery time is postponed, the break flow rate will be increased until the pumps are shut off and more mass will be lost from the primary system. The break uncovers 310 seconds after the SIAS for the 1.9% break size with pumps off at SIAS. For this break size, a 300 second pump trip delay would not result in a significantly different integrated mass loss from the primary system. Since the time of break uncovery, with pumps off at the SIAS, increases for break sizes smaller than 1.9%, the same conclusion is reached for smaller break sizes. However, for break sizes greater than 1.9% with pumps off at the SIAS, the time to break uncovery following the SIAS becomes less than the 300 second trip delay time. In this case, more mass would be lost out the break with up to a 300 second pump trip delay which would result in a deeper core uncovery.

A calculation was performed for the 4% break size with a 300 second pump trip delay. This calculation bounds smaller break sizes and shorter pump trip delay times because it maximizes the additional mass loss from the primary system. The break uncovers 183 seconds after the SIAS for the 4% break size with pumps off at the SIAS. With a 300 second pump trip delay a significant amount of additional mass is lost from the primary system so that when the pumps are shut off, a more severe core uncovery occurs. A comparison of the mixture levels is shown in Figure 3.16 for the case with pumps tripped at the SIAS versus the case with the delayed pump trip. The total heatup time is less for the case with the pump trip delay because (1) continued pump operation keeps the mixture level above the core and precludes core heatup until the pumps are shut off, and (2) once the pumps are shut off, system depressurization occurs more rapidly to the SIT pressure. However, the heatup rate is much higher once the pumps are shut off because very little steam is generated in the core due to the deep core uncovery. The overall effect is a higher PCT for the case with the delayed pump trip. The PCT for the case with pumps tripped at the SIAS was predicted to be 1521°F while the PCT for the case with the delayed pump trip was predicted to be 1650°F.

The results of the pump trip delay case are given in Table 3.7. The event times for this case are given in Table 3.8. Comparisons of system pressure, core mixture level, and total system mass for the cases with and without delayed pump trip are shown on Figures 3.15 to 3.17, respectively. A plot of cladding temperature for the case with delayed pump trip is shown in Figure 3.18.

3.6 Asymmetric Steam Generator Tube Plugging Results

The break spectrum calculations reported in Section 3.4 considered a steam generator tube plugging level of 23.5% in each steam generator. A calculation was performed to determine the sensitivity of the base case limiting break (1.9%) results to asymmetric steam generator tube plugging. An asymmmetry of 5.9% was analyzed. The calculation assumed 2500 tubes were plugged in the broken loop steam generator and 1500 tubes plugged in the intact loop steam generator. The event times for this calculation are given in Table 3.9. It can be seen that the event times are similar to the base case calculation. SIT flow begins 18 seconds earlier for the asymmetric case and the core heatup time is 19 seconds less for the asymmetric case. The PCT for the asymmetric case is 1765°F compared to 1811°F for the base case.

The system response was observed to be similar between the two cases analyzed. Because the blowdown response for the asymmetric case showed no significant difference from the base case, a case with the greater number of tubes plugged in the intact loop steam generator would also have a nearly identical system response. It is concluded that asymmetric steam generator tube plugging does not significantly change the system behavior and does not alter the conclusion that 10 CFR 50.46(b) criteria are met.

3.7 Reduced Primary Temperature Operation

This section presents justification to support a reduction in primary coolant temperature of up to 12°F at full power operation. The effect of a reduced primary coolant temperature on the SBLOCA analysis is projected to be very small. The primary pressure will initially drop to the saturation pressure at the hot leg temperature which will be about 140 psi lower than for the base case. The primary pressure will follow a saturated condition below the base case and level out at about the same pressure as for the base case since the secondary safety valve setpoint is tne same for both cases.

During the early part of the transient when subcooled fluid exists at the break, the break flow rate could be slightly higher, but the initial mass in the primary system will be about 1.5% larger due to the higher initial density. Overall, the inventory in the primary system will not change significantly. Break uncovery and system depressurization to the SIT pressure will occur at about the same times, resulting in a similar core heatup time. With little change in the mass inventory and a similar core heatup time, the PCT will not change significantly. Therefore, a reduction in the initial primary system temperature of up to 12°F will not change the conclusion that the 10 CFR 50.46(b) criteria are met for the Millstone Unit 2 plant.

Table 3.1 Millstone Unit 2 SBLOCA System Analysis Parameters

Primary Heat Output, MWt	2700*
Primary Coolant Flow Rate, lbm/hr	1.28×10^8 (340,000 gpm)
Primary Coolant System Volume, ft^3	10,506**
Operating Pressure, psia	2250
Inlet Coolant Temperature, °F	549
Reactor Vessel Volume, ft^3	4534
Pressurizer Total Volume, ft^3	1500
Pressurizer Liquid Total, ft^3	922
SIT Total Volume, ft^3 (one of four)	2019
SIT Liquid Volume, ft^3	1150.5
SIT Pressure, psia	215.0
SIT Fluid Temperature, °F	106.8
Total Number of Tubes per Steam Generator	8519
Number of Tubes Plugged per Steam Generator	2000 (23.5%)
Steam Generator Secondary Flow Rate, lbm/hr	6.02×10^6
Steam Generator Secondary Pressure, psia	817.6
Steam Generator Feedwater Temperature, °F	435
Reactor Coolant Pump Rated Head, ft	271.8
Reactor Coolant Pump Rated Torque, ft-lbf	31,560
Reactor Coolant Pump Rated Speed, rpm	892
Initial Reactor Coolant Pump Speed, rpm	863.5***

* Primary heat output used in ANF-RELAP model - 1.02 x 2700 = 2754 MWt.

** Includes pressurizer total volume and 23.5% average SGTP.

***Value used in ANF-RELAP for initialization.

Table 3.1 Millstone Unit 2 SBLOCA System Analysis Parameters (Cont.)

Reactor Coolant Pump Moment of Inertia, $lbm\text{-}ft^2$	100,000
SIS Fluid Temperature, °F	100.0
Reactor Scram Low Pressure Setpoint, psia	1750
SIAS Activation Setpoint Pressure, psia	1600
Secondary Safety Valve Setpoint, psia (nominal) (up to 3% uncertainty in lift pressure was considered in the analysis)	1000
HPSI and Charging Pump Delay Time, sec	30.0
Charging Pump Flow Rate, gpm	40
HPSI Flow Rate versus RCS Backpressure	

RCS Pressure (psia)	HPSI Flow (One Pump) (gpm)
1225	0
1200	79
1100	198
800	371
500	475
209	564
200	567
160	579
120	592
80	605
40	619
14.7	628
0	633

Table 3.2 Millstone Unit 2 SBLOCA Break Spectrum Base Case Analysis Results*

	1.9% Break	3.0% Break	4.0% Break
Peak LHR (kW/ft)	15.1	15.1	15.1
Hot Rod Burst			
- Time (sec)	1274.6	No rupture occurs	No rupture occurs
- Elevation (ft)	10.72		
- Channel Blockage Fraction	0.43		
Peak Cladding Temperature			
- Temperature (°F)	1811.3	1577.6	1521.0
- Time (sec)	1529.1	757.1	516.1
- Elevation (ft)	10.47	10.72	10.47
Metal-Water Reaction			
- Local Maximum	4.17	0.82	0.61
- Elevation of Local Max. (ft)	10.72	10.47	10.47
- Hot Pin Total (%)	0.78	0.54	0.51
- Core Maximum (%)	<1.0	<1.0	<1.0

* 1.0% break not included because no core heatup was predicted.

Table 3.3 Calculated Event Times for 1.0% Break

TIME, sec	EVENT
0.0	Break opened
25.45	Reactor scrams on low primary pressure.
37.15	SIAS reached. RCP tripped.
111.	HPSI injection begins.
548.	Broken loop broken leg pump suction clears of liquid.
584.	Intact loop pump suction clears of liquid.
626.	Break uncovers, passes nearly pure steam.
2232.	Minimum primary system mass reached
4000.	Calculation terminated.

Table 3.4 Calculated Event Times for 1.9% Break

TIME, sec	EVENT
0.0	Break opened
13.80	Reactor scrams on low primary pressure.
20.15	SIAS reached. RCP tripped.
63.0	HPSI injection begins.
262.	Broken loop intact leg pump suction clears of liquid.
298.	Intact loop pump suction clears of liquid.
330.	Break uncovers, passes nearly pure steam.
766.	Top of core begins to heatup.
1246.	Minimum primary system mass reached.
1522.	SIT flow initiated.
1529.	Peak cladding temperature reached.
1540.	SIT flow terminated.
2000.	Calculation terminated.

Table 3.5 Calculated Event Times for 3.0% Break

TIME, sec	EVENT
0.0	Break opened
9.80	Reactor scrams on low primary pressure.
14.95	SIAS reached. RCP tripped.
46.	HPSI injection begins.
190.	Broken loop intact leg pump suction clears of liquid.
198.	Intact loop pump suction clears of liquid.
270.	Break uncovers, passes nearly pure steam.
356.	Top of core begins to heatup.
754.	Minimum primary system mass reached, SIT flow initiated.
757.	Peak cladding temperature reached.
784.	SIT flow terminated.
900.	Calculation terminated.

Table 3.6 Calculated Event Times for 4.0% Break

TIME, sec	EVENT
0.0	Break opened
8.40	Reactor scrams on low primary pressure.
12.75	SIAS reached. RCP tripped.
39.	HPSI injection begins.
142.	Broken loop intact leg pump suction clears of liquid.
156.	Intact loop pump suction clears of liquid.
196.	Break uncovers, passes nearly pure steam.
287.	Top of core begins to heatup.
514.	Minimum primary system mass reached, SIT flow initiated.
516.	Peak cladding temperature reached.
800.	Calculation terminated.

Table 3.7 Millstone Unit 2 SBLOCA Analysis Results for 4% Break, with Delayed RCP Trip
(RCP Trip Delayed 300 seconds after SIAS)

Peak LHR (kW/ft)	15.1
Hot Rod Burst	
- Time (sec)	516.6
- Elevation (ft)	10.47
- Channel Blockage Fraction	0.50
Peak Cladding Temperature	
- Temperature (°F)	1649.9
- Time (sec)	523.1
- Elevation (ft)	10.22
Metal-Water Reaction	
- Local Maximum (%)	0.95
- Elevation of Local Max. (ft)	10.47
- Hot Pin Total (%)	0.527
- Core Maximum (%)	<1.0

Table 3.8 Calculated Event Times for 4.0% Break, with Delayed RCP Trip

TIME, sec	EVENT
0.0	Break opened
8.40	Reactor scrams on low primary pressure.
12.75	SIAS reached.
39.	HPSI injection begins.
313.	RCP Tripped.
335.	Top of core begins to heatup.
452.	Minimum primary system mass reached, SIT flow initiated.
523.	Peak cladding temperature reached.
556.	Calculation terminated.

Table 3.9 Calculated Event Times for 1.9% Break with Asymmetric Steam Generator Tube Plugging

TIME, sec	EVENT
0.0	Break opened
13.85	Reactor scrams on low primary pressure.
20.30	SIAS reached. RCP tripped.
63.	HPSI injection begins.
288.	Intact loop pump suction clears of liquid.
308.	Broken loop intact cold leg pump suction clears of liquid.
338.	Break uncovers, passes nearly pure steam.
764.	Top of core begins to heatup.
1262.	Minimum primary system mass reached
1504.	SIT flow initiated.
1508.	Peak cladding temperature reached.
1526.	SIT flow terminated.
2000.	Calculation terminated.

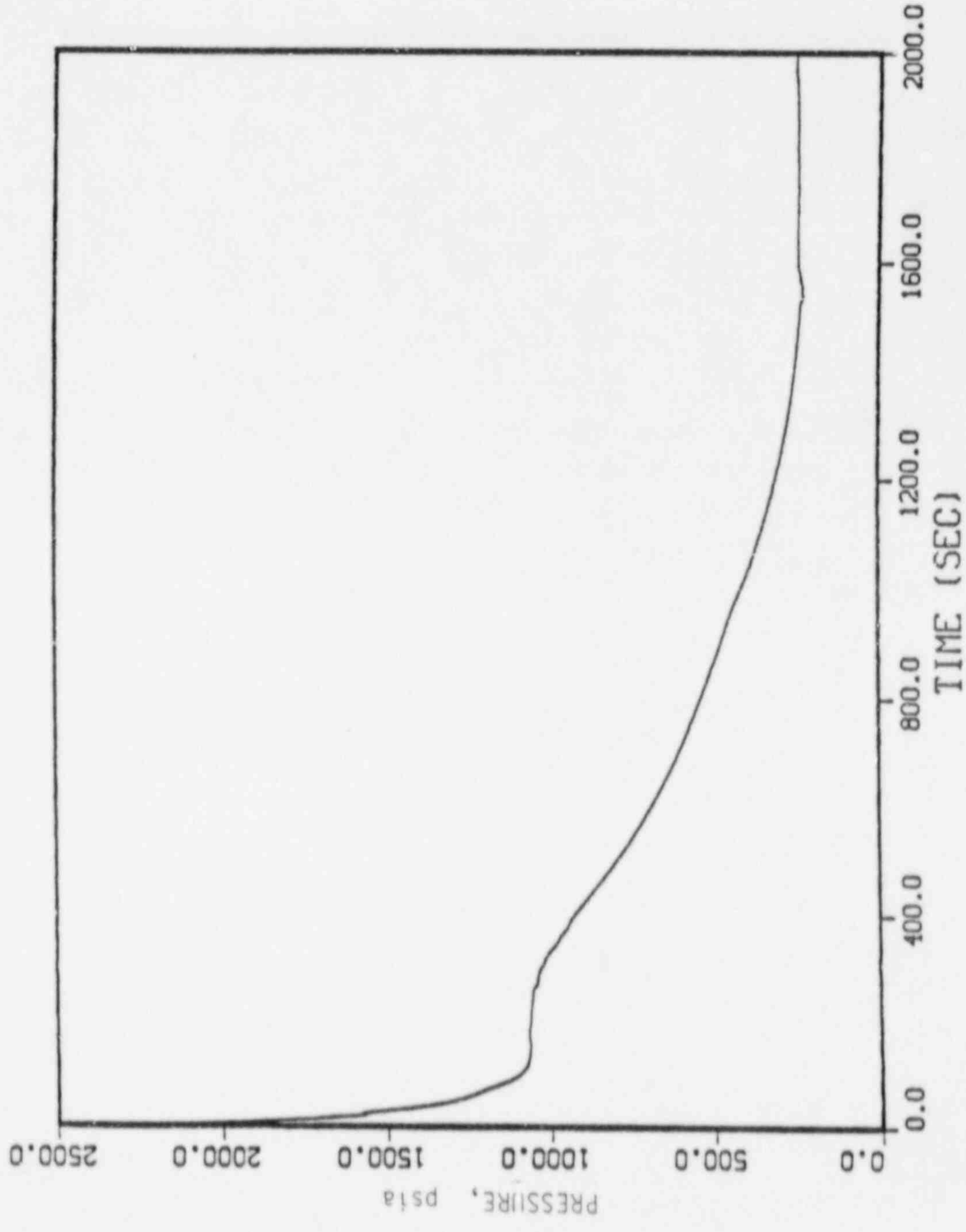

FIGURE 3.1 PRIMARY SYSTEM PRESSURE FOR 1.9% BREAK

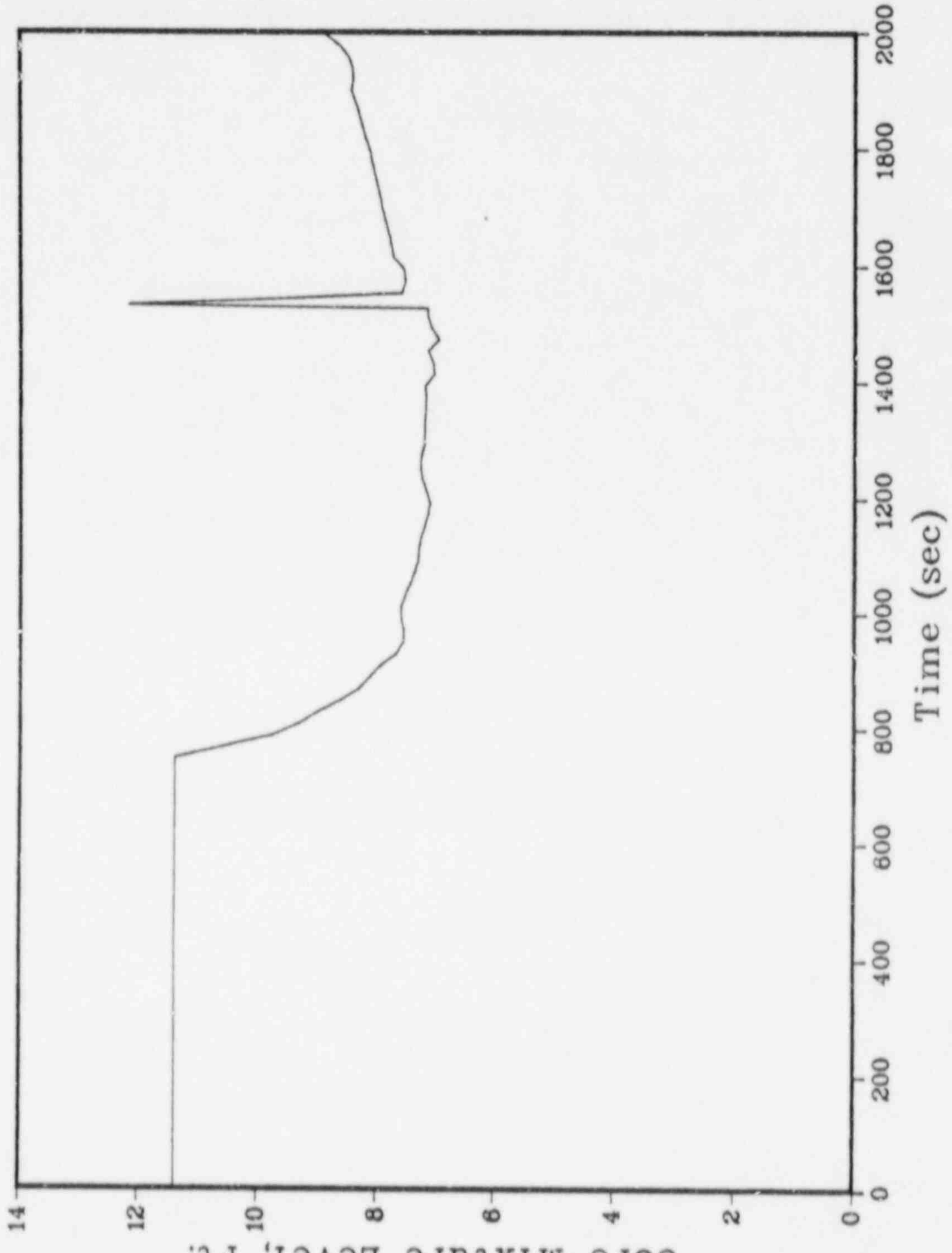

FIGURE 3.2 CORE MIXTURE LEVEL FOR 1.9% BREAK

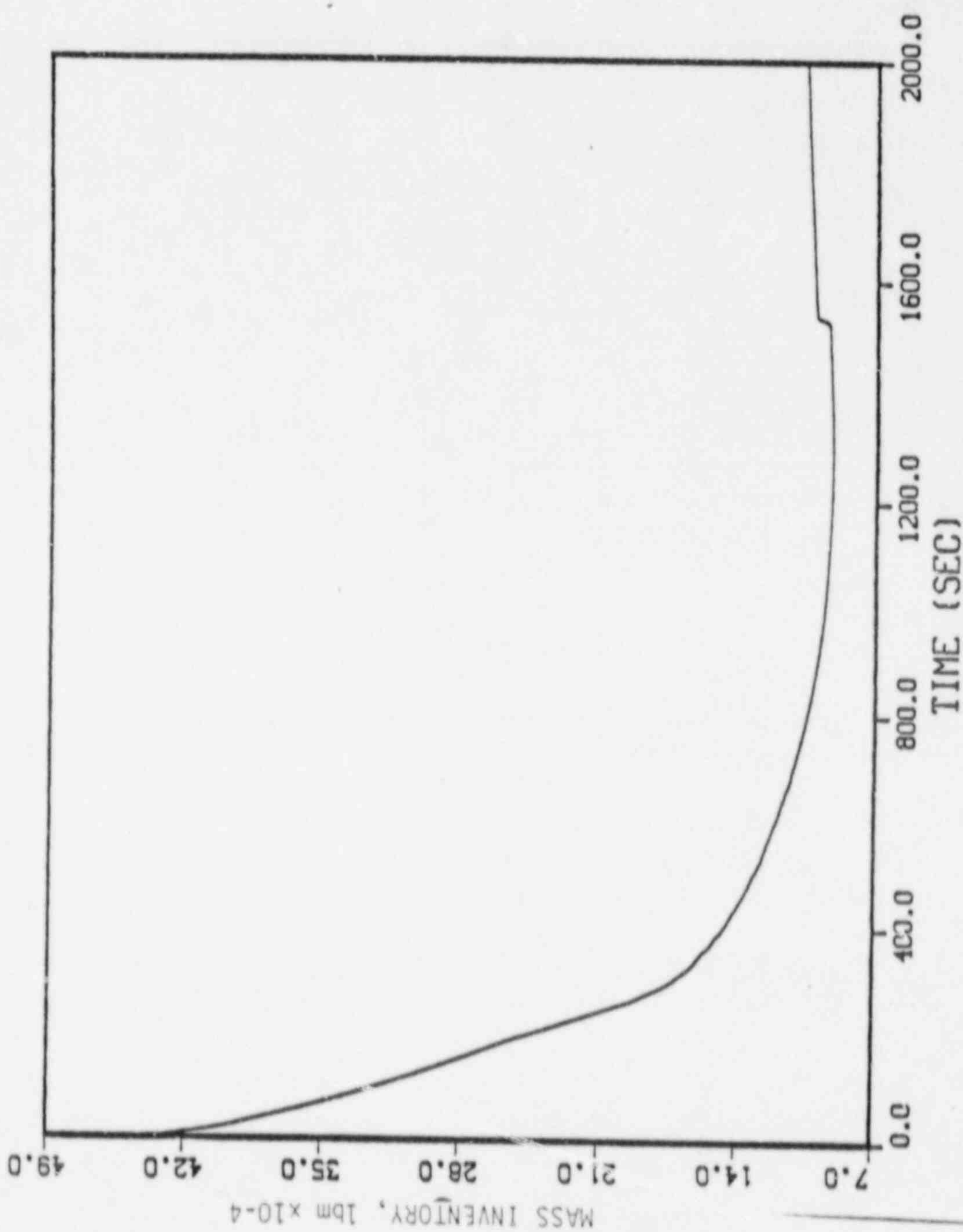

FIGURE 3.3 TOTAL SYSTEM MASS FOR 1.9% BREAK

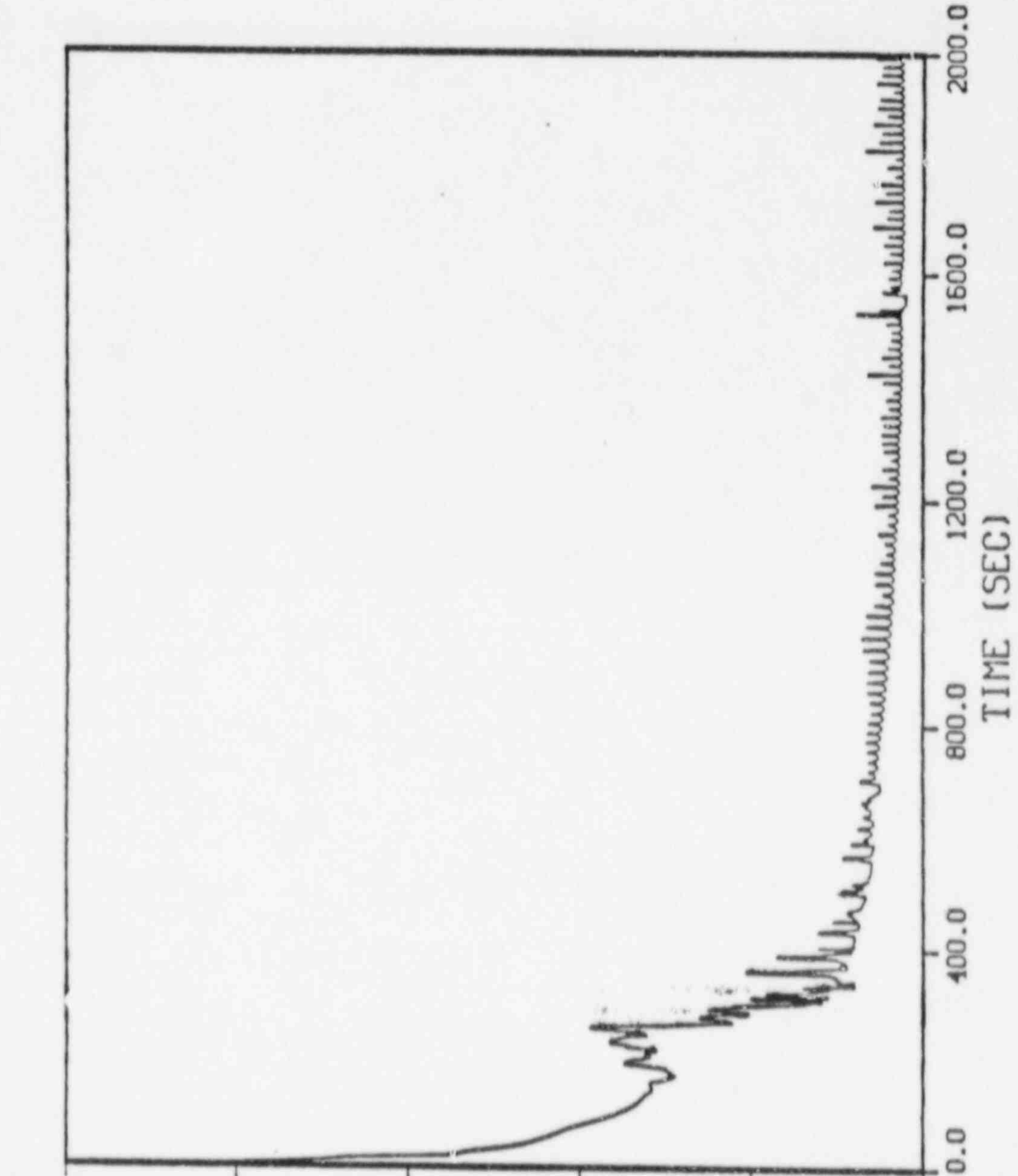

FIGURE 3.4 BREAK FLOW RATE FOR 1.9% BREAK

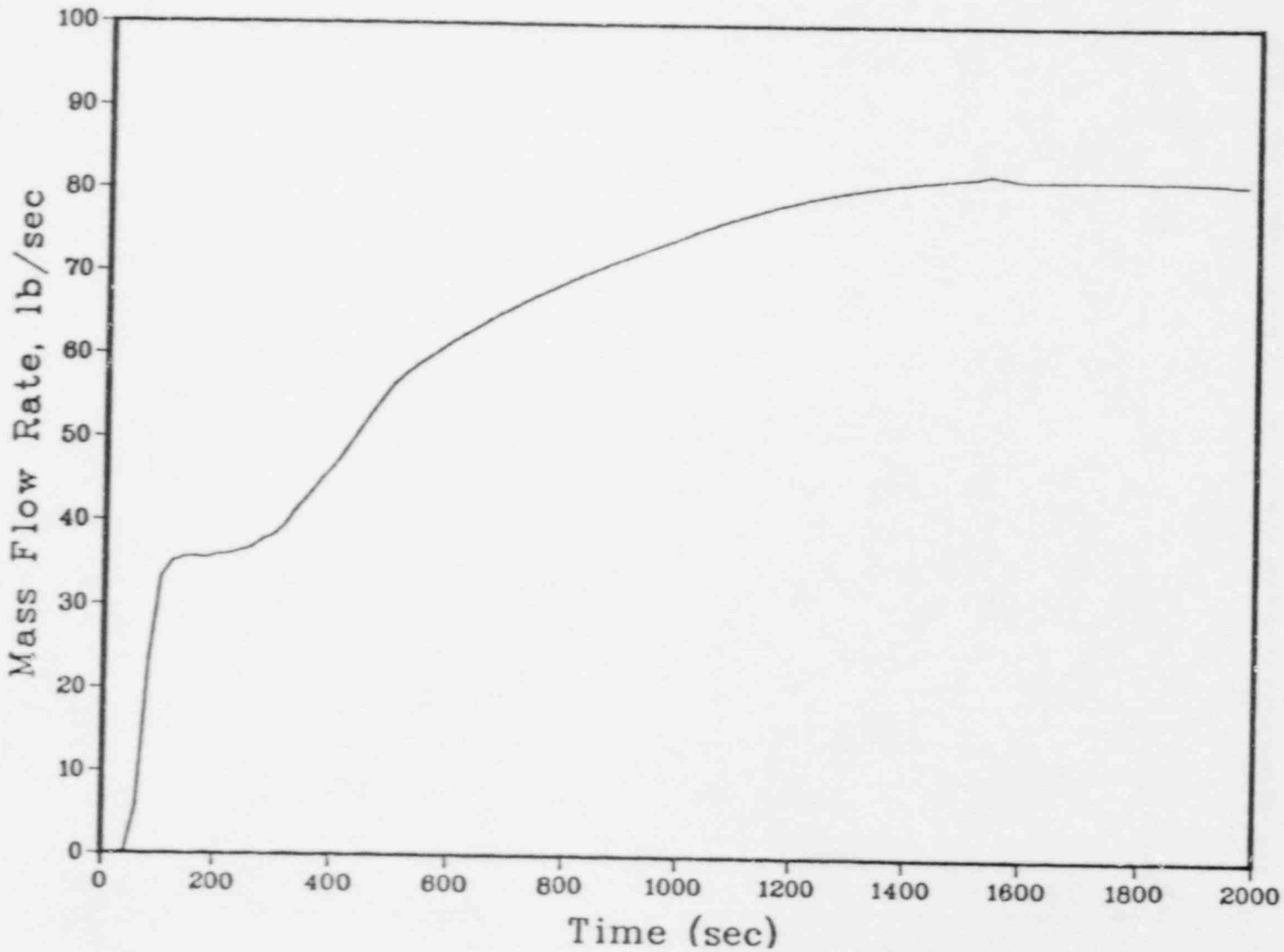

FIGURE 3.5 TOTAL HPSI AND CHARGING PUMP FLOW RATE FOR 1.9% BREAK

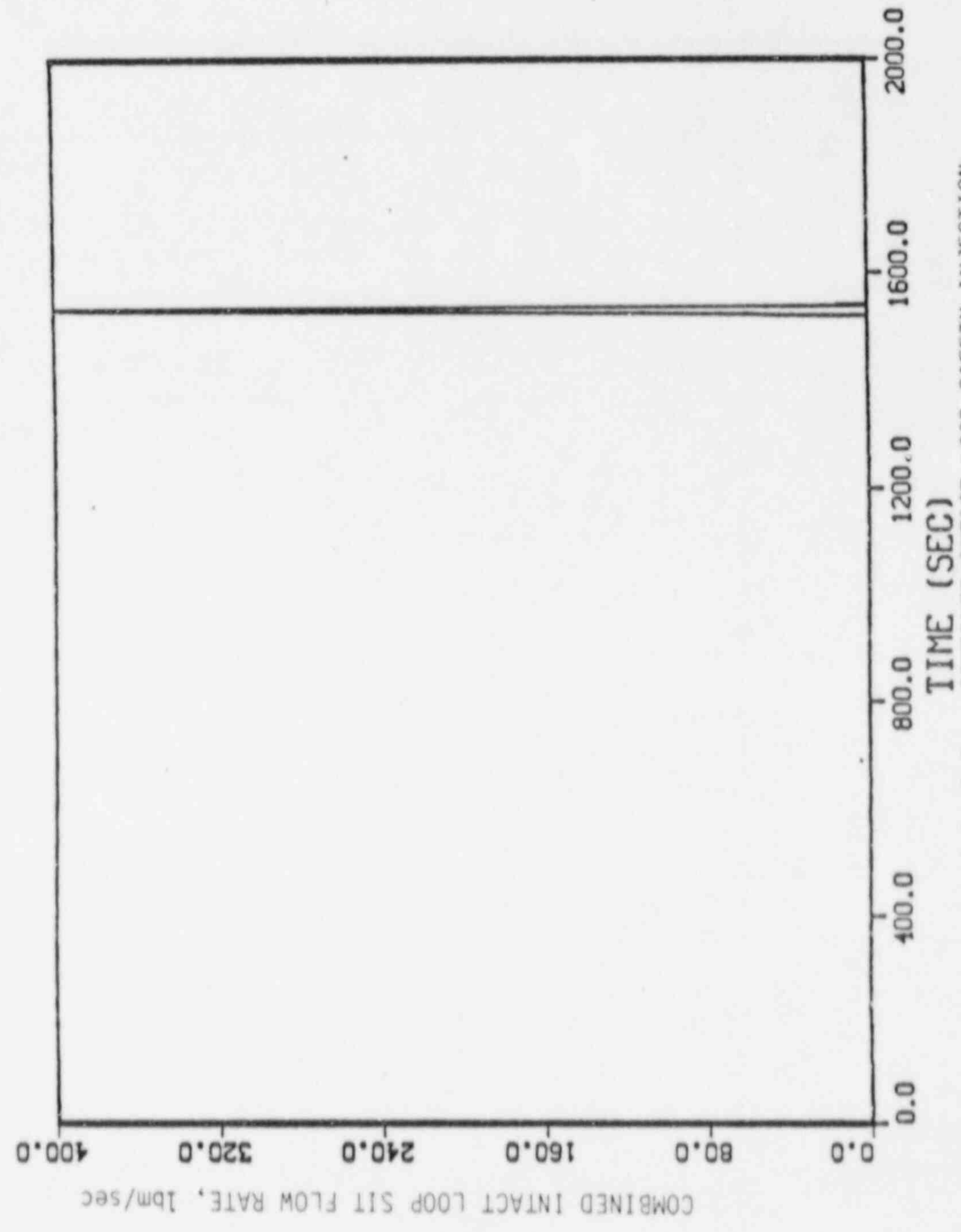

FIGURE 3.6 COMBINED INTACT LOOP SAFETY INJECTION TANK FLOW RATE FOR 1.9% BREAK

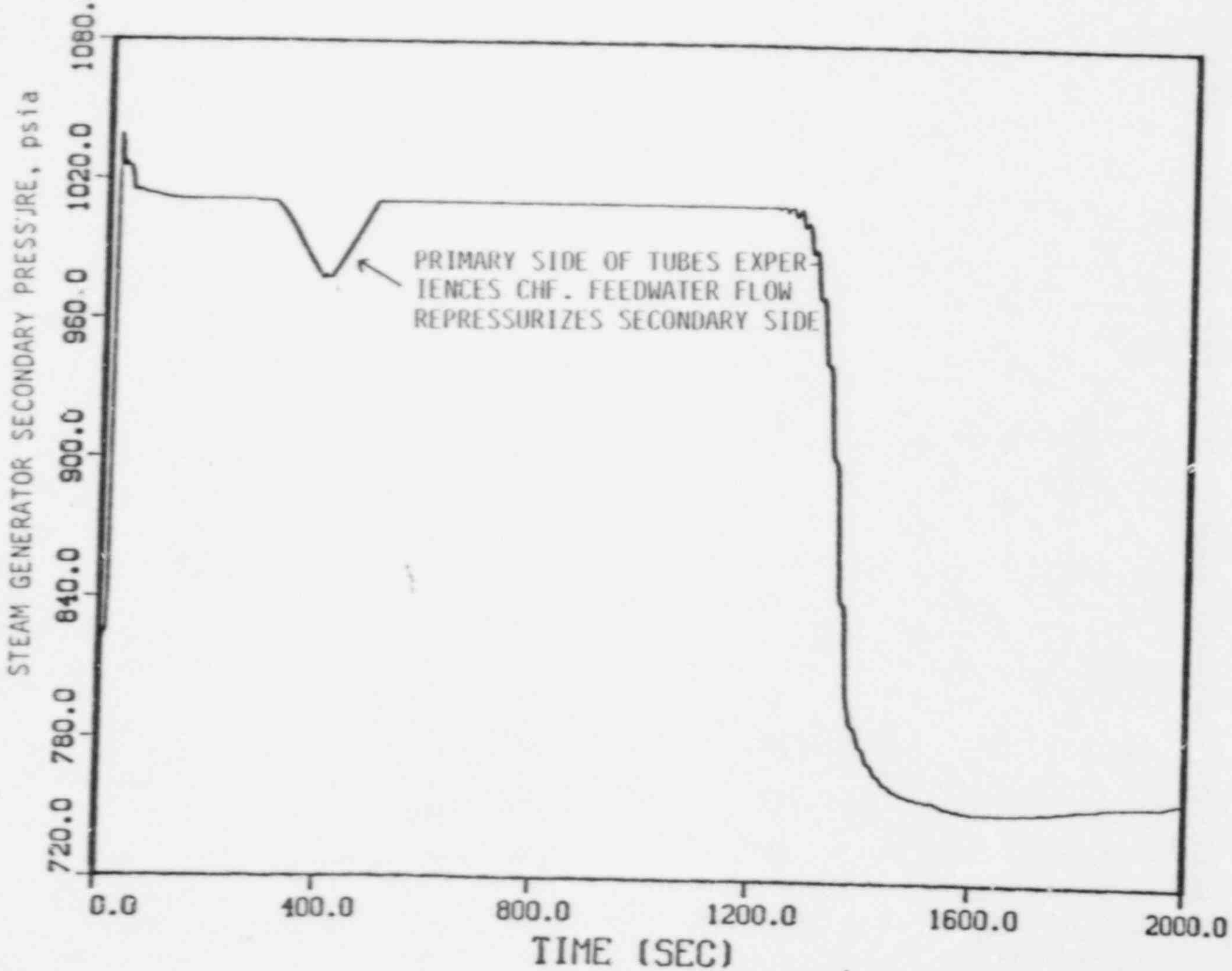

FIGURE 3.7 STEAM GENERATOR SECONDARY PRESSURE FOR 1.9% BREAK

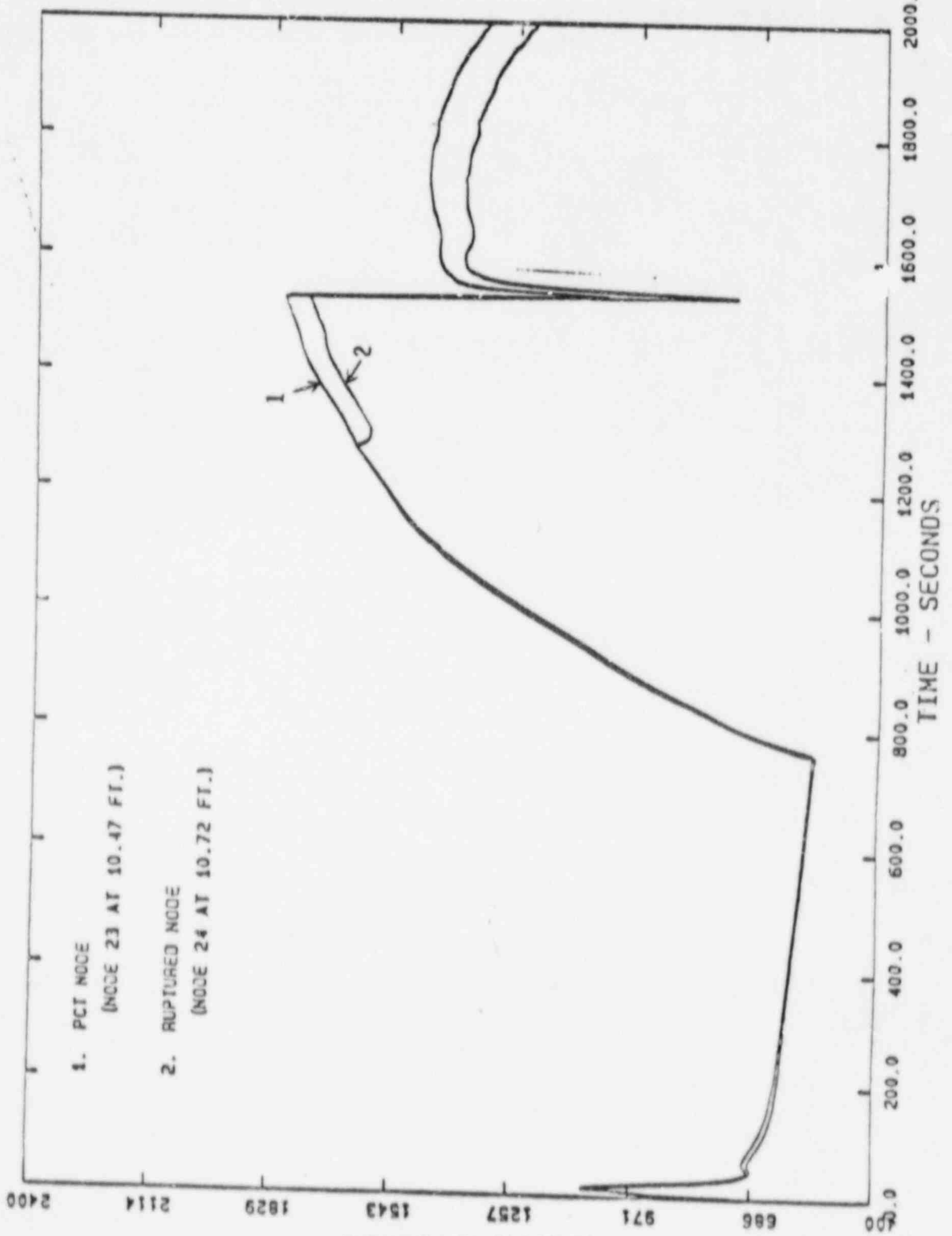

FIGURE 3.8 PEAK CLADDING TEMPERATURE FOR 1.9% BREAK

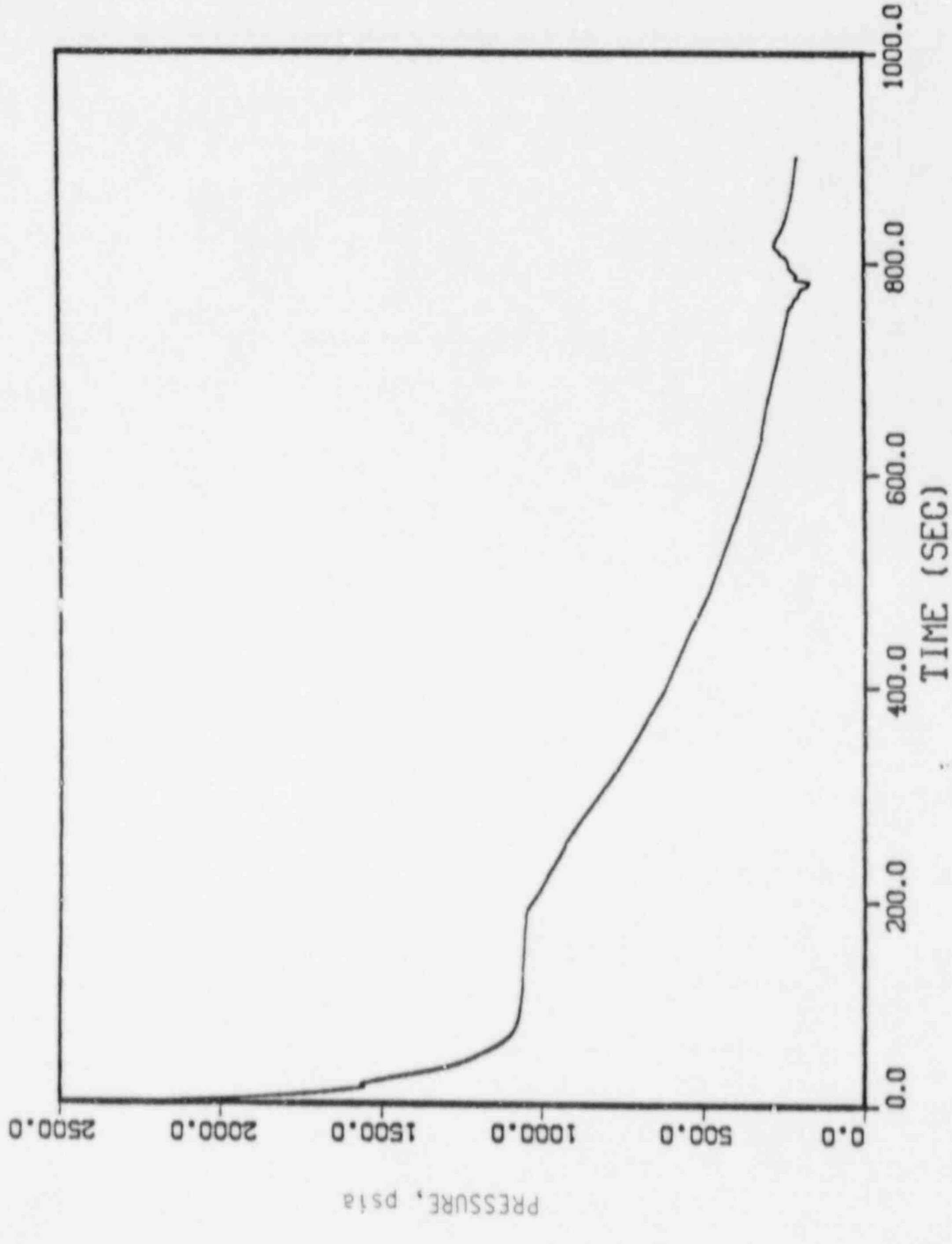

FIGURE 3.9 PRIMARY SYSTEM PRESSURE FOR 3% BREAK

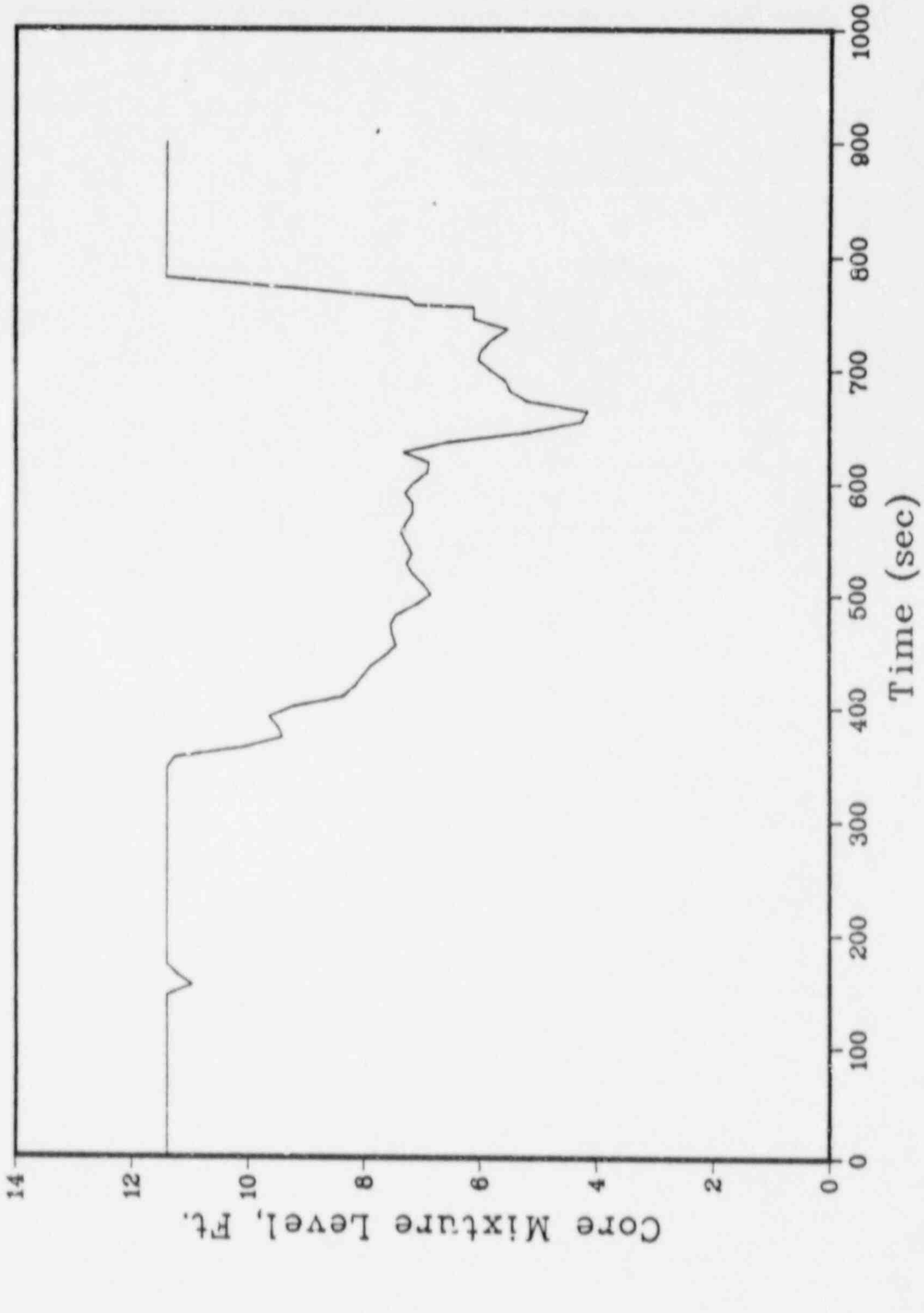

FIGURE 3.10 CORE MIXTURE LEVEL FOR 3% BREAK

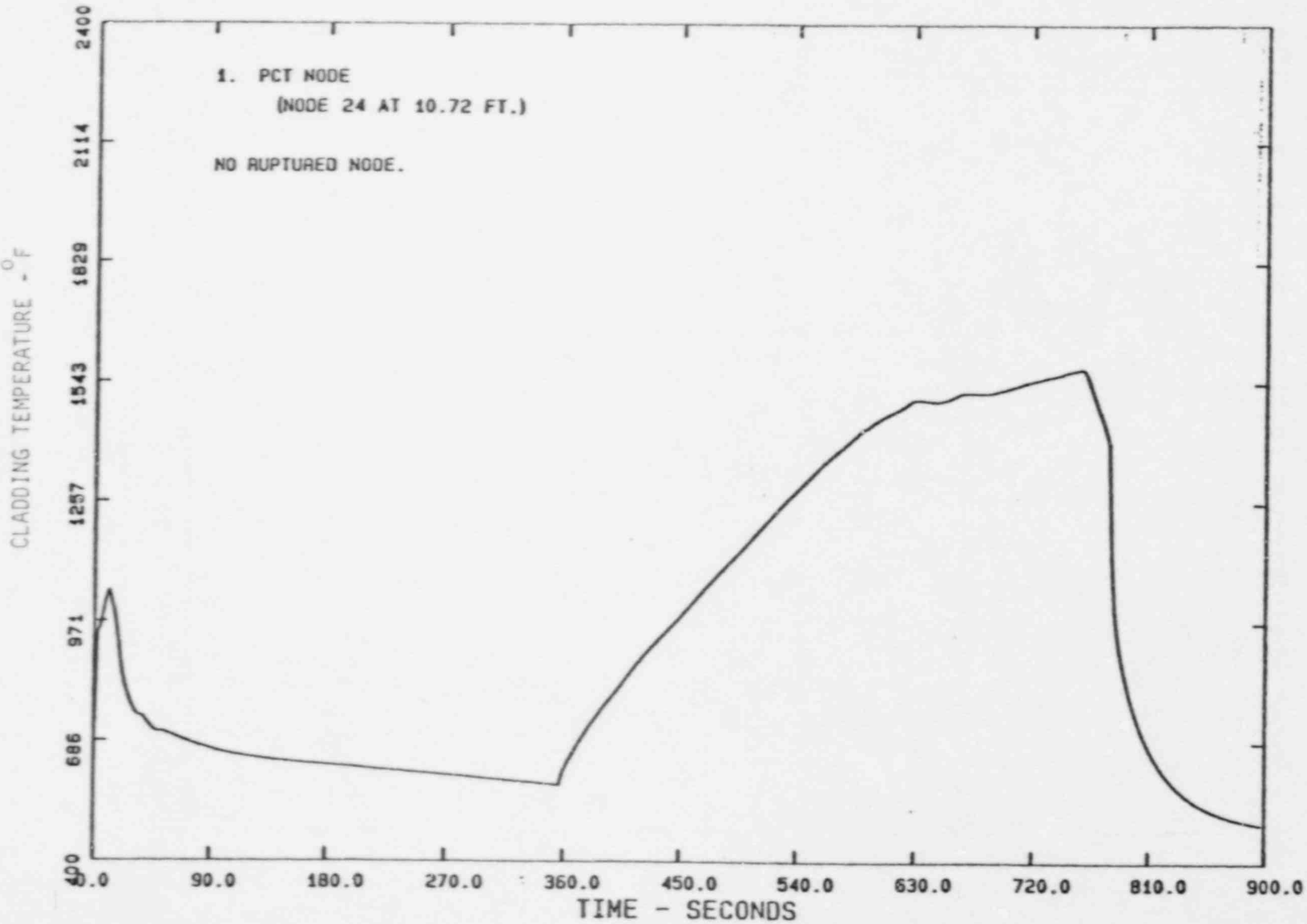

FIGURE 3.11 PEAK CLADDING TEMPERATURE FOR 3% BREAK

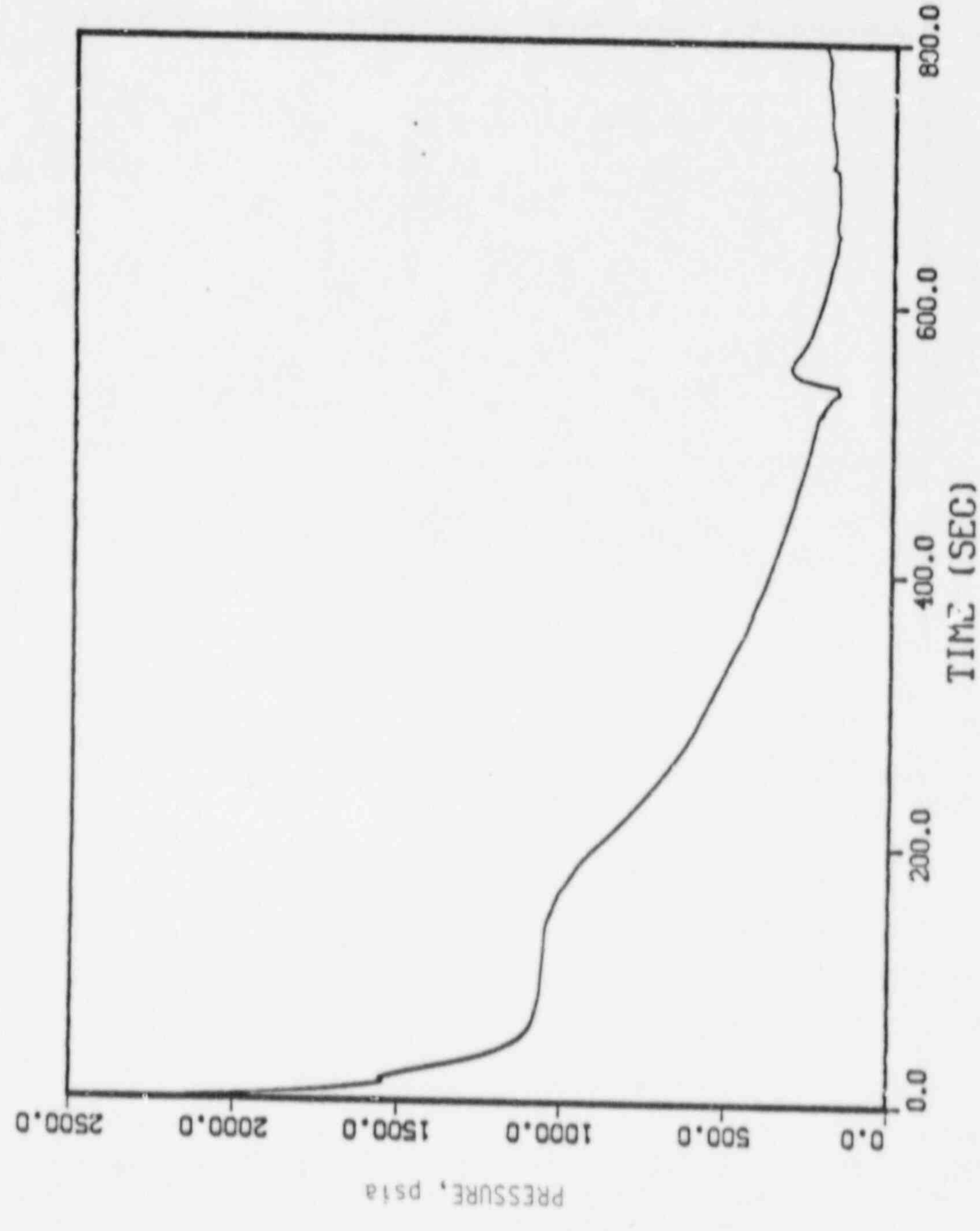

FIGURE 3.12 PRIMARY SYSTEM PRESSURE FOR 4% BREAK

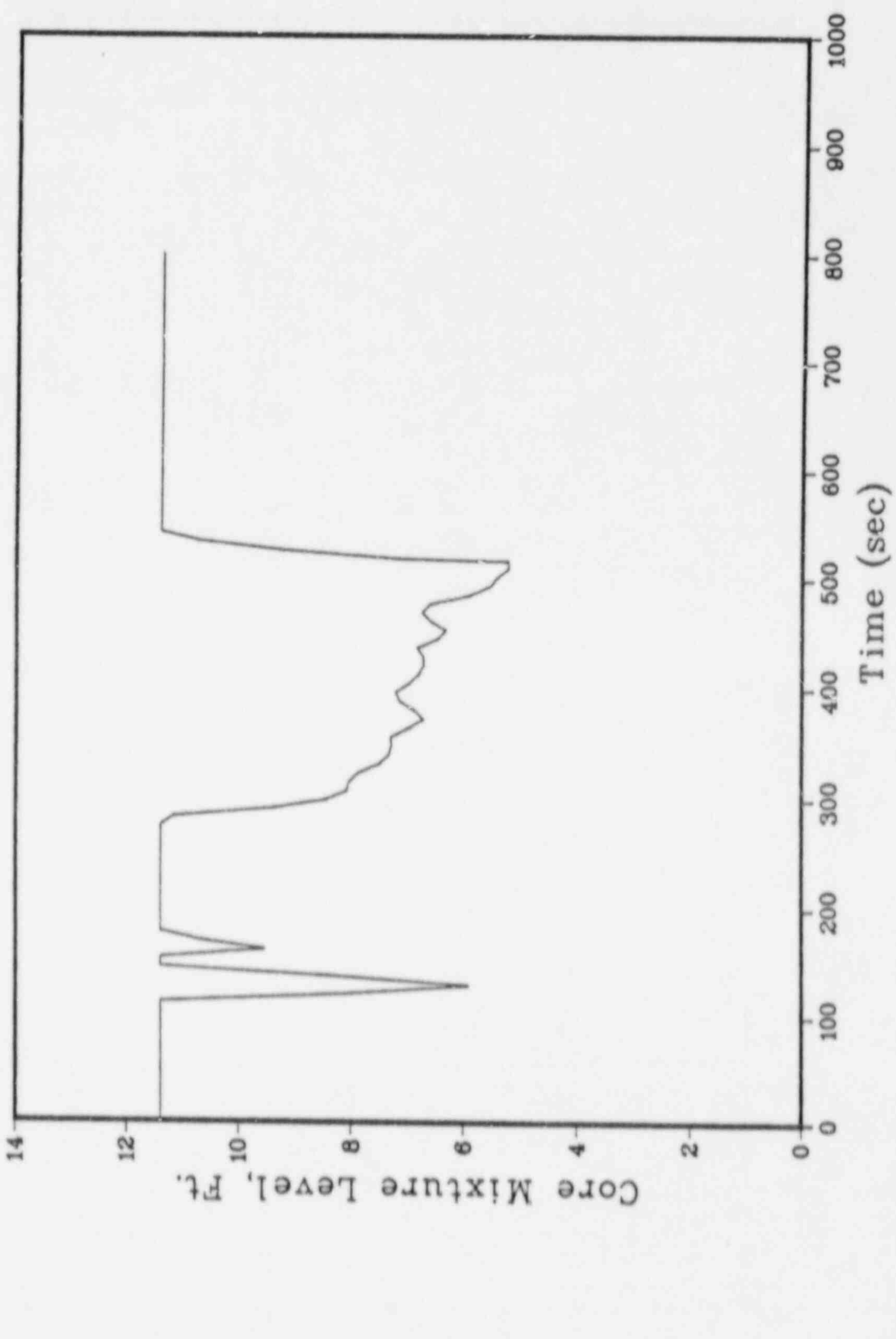

FIGURE 3.13 CORE MIXTURE LEVEL FOR 4% BREAK

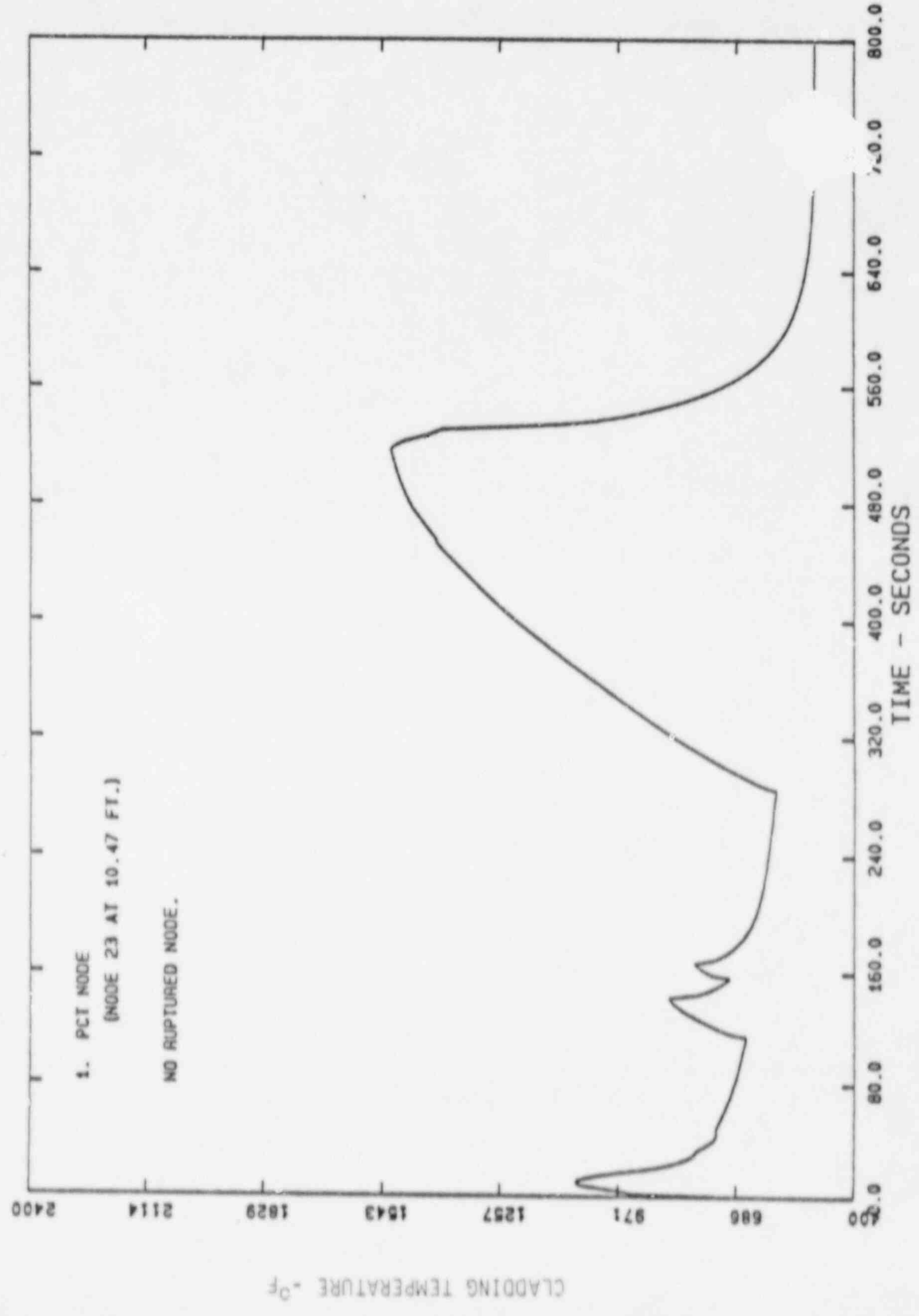

FIGURE 3.14 PEAK CLADDING TEMPERATURE FOR 4% BREAK

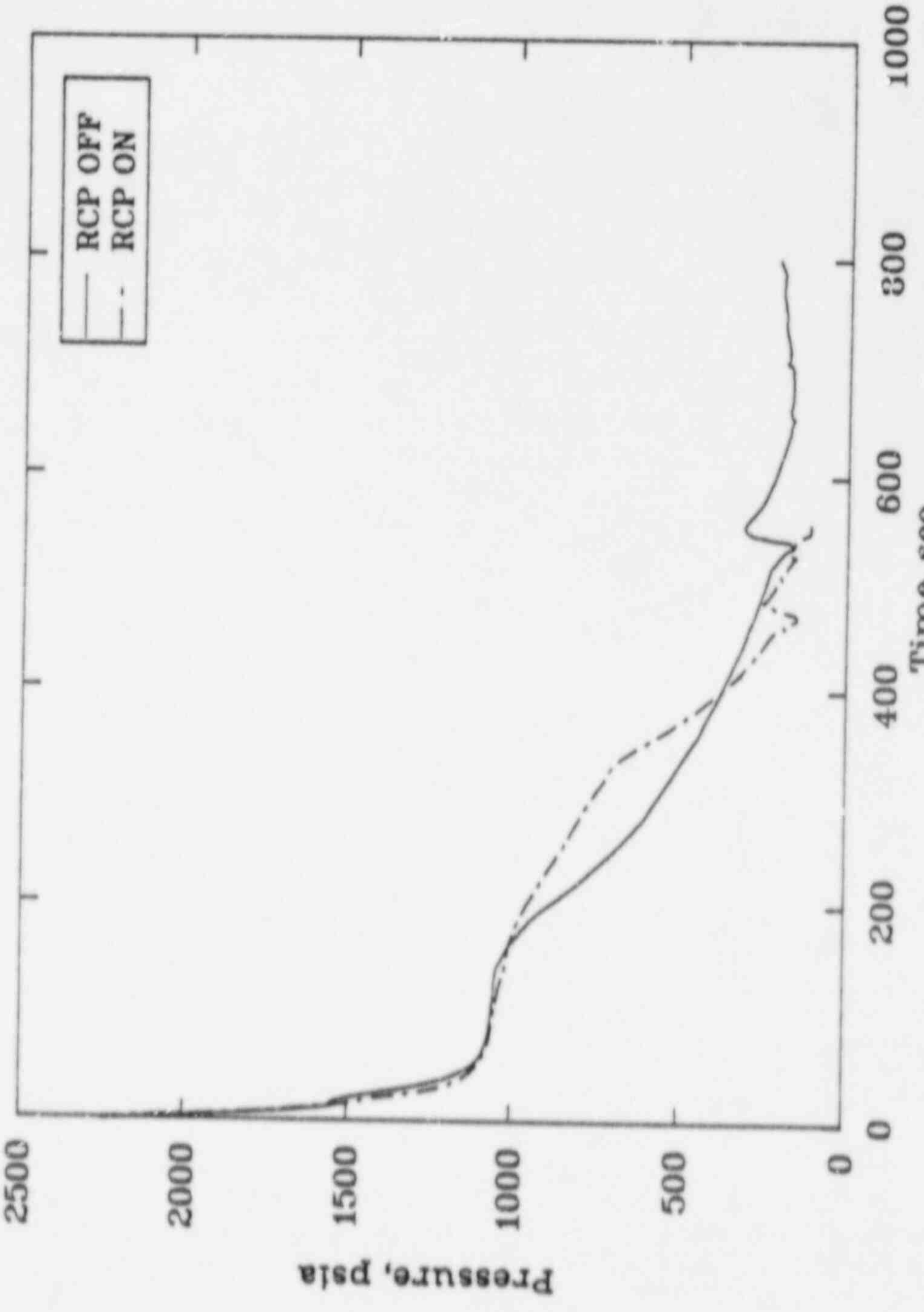

FIGURE 3.15 PRIMARY SYSTEM PRESSURE FOR 4% BREAK, PUMPS OFF AT SIAS VERSUS DELAYED PUMP TRIP

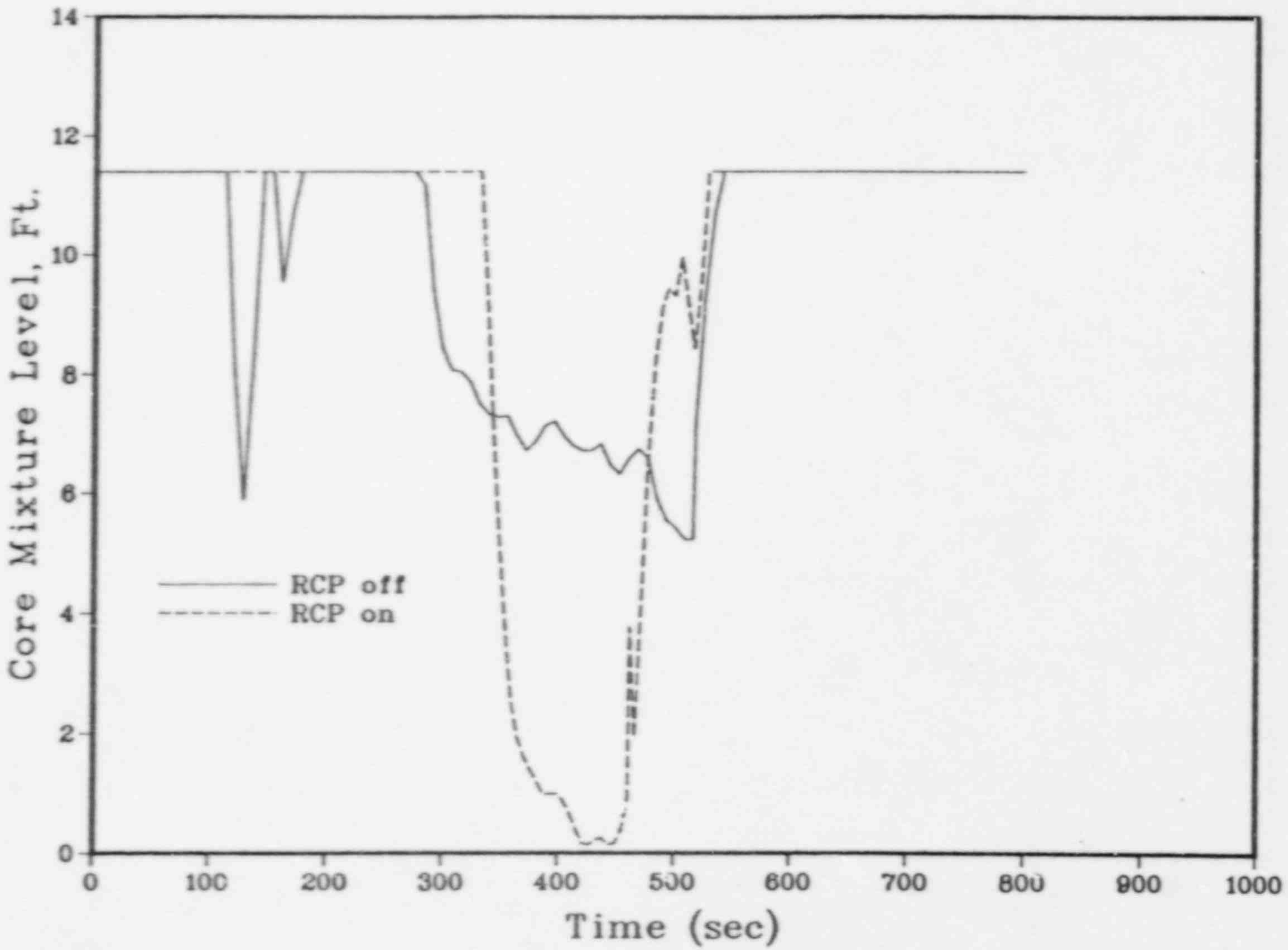

FIGURE 3.16 CORE MIXTURE LEVEL FOR 4% BREAK, PUMPS OFF AT SIAS VERSUS DELAYED PUMP TRIP

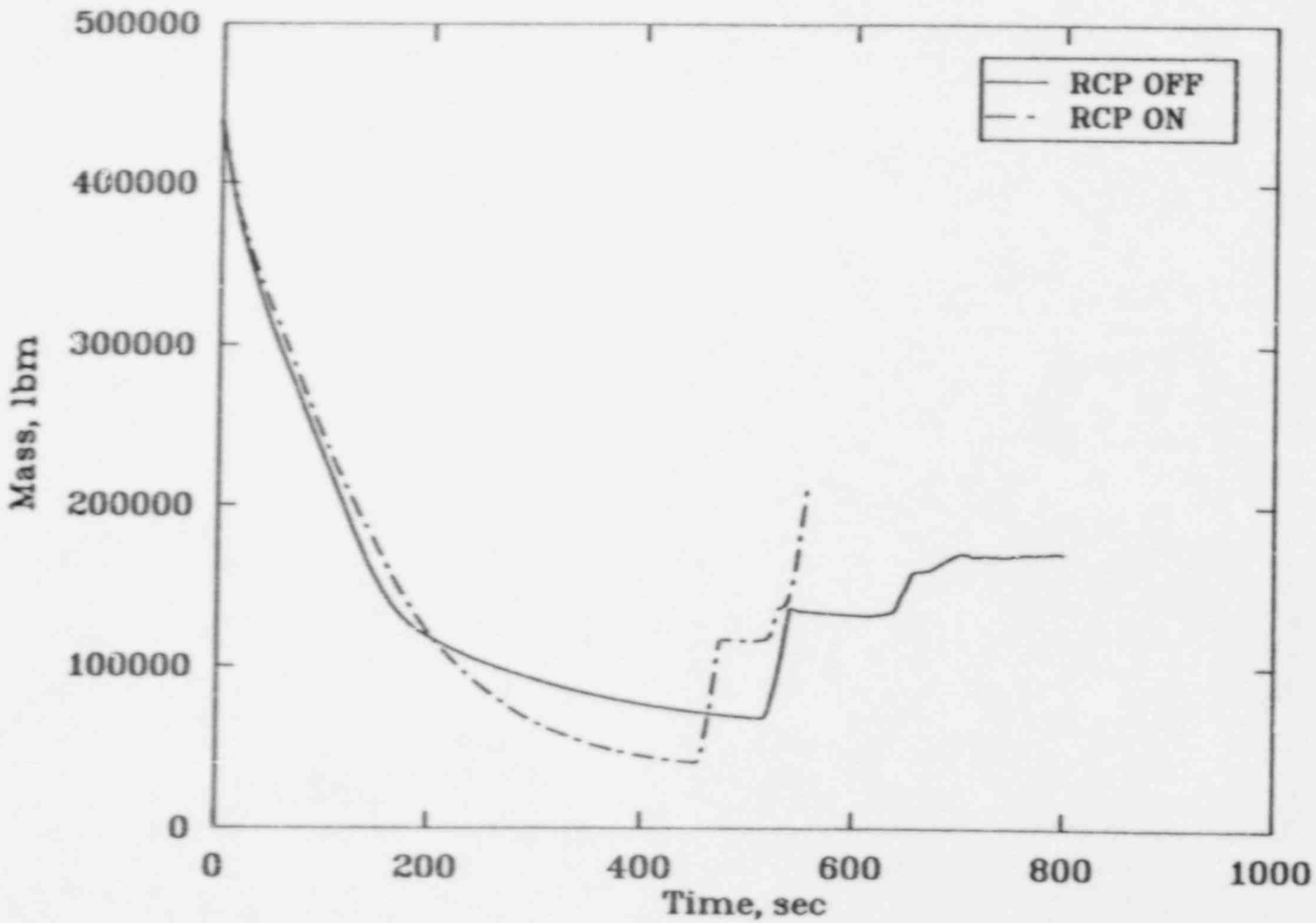

FIGURE 3.17 TOTAL SYSTEM MASS FOR 4% BREAK, PUMPS OFF AT SIAS VERSUS DELAYED PUMP TRIP

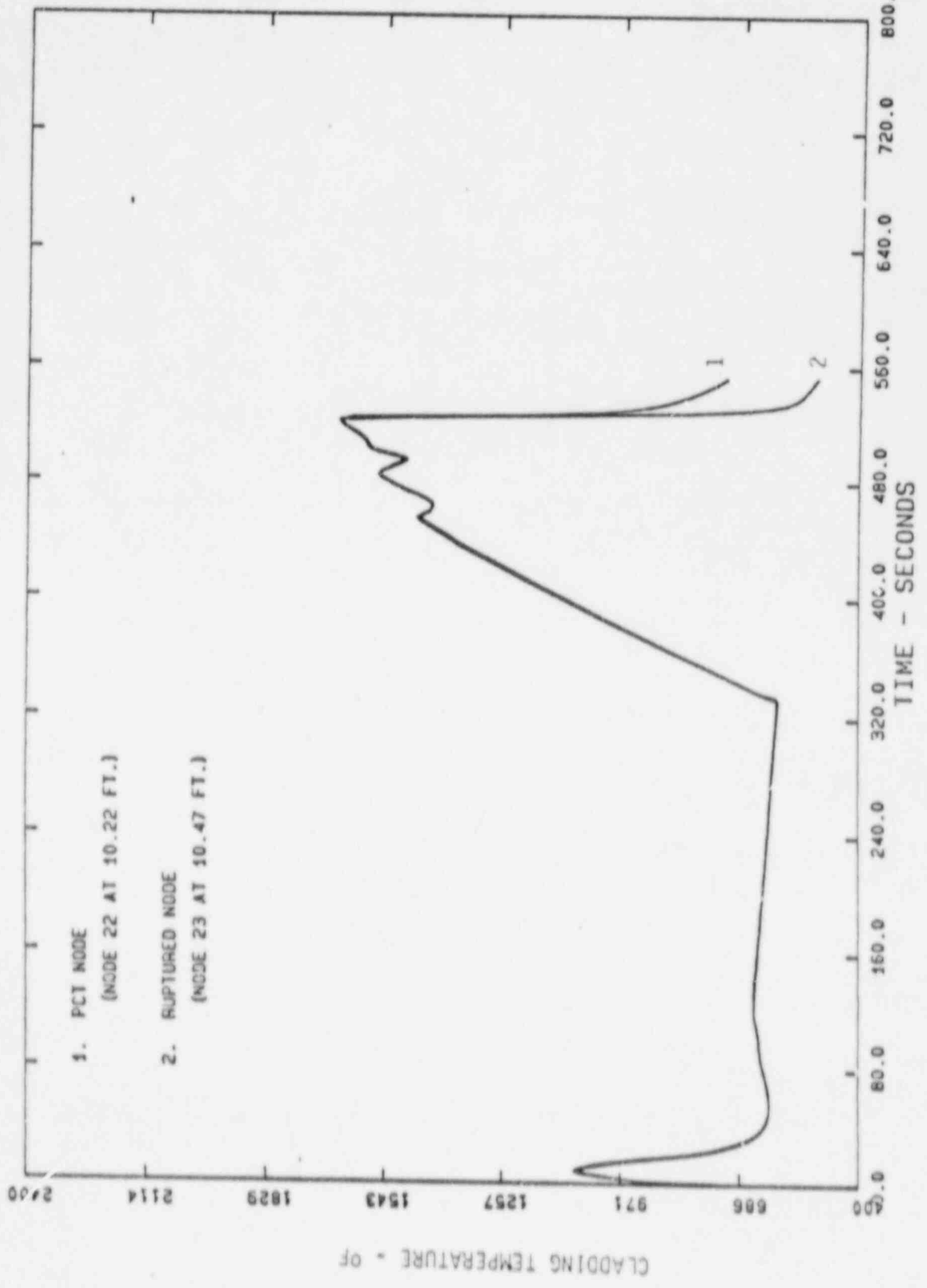

FIGURE 3.18 PEAK CLADDING TEMPERATURE FOR 4% BREAK, WITH DELAYED PUMP TRIP

4.0 CONCLUSIONS

The results of the SBLOCA analysis for the Millstone Unit 2 reactor determined the 1.9% break size to be the limiting break with the approved SBLOCA evaluation model. The analysis supports full power operation at a power level of 2754 MWt (2700 + 2% uncertainty), with an average steam generator tube plugging level of 23.5% and a maximum asymmetry of 5.9%. The analysis supports a peak LHR of 15.1 kW/ft and a radial peaking factor of 1.61. The analysis supports a 300 second primary coolant pump trip delay following the SIAS and a reduction in primary coolant temperature of up to 12°F at full power operation.

The analysis supports Cycle 10 and is intended to support operation for future cycles. Operation of Millstone Unit 2 with ANF 14x14 fuel within the above stated criteria assures that the NRC acceptance criteria for small break Loss-of-Coolant Accidents (10 CFR 50.46(b)) will be met with the emergency core cooling system for Millstone Unit 2.

5.0 REFERENCES

(1) ANF-88-118, "Millstone Unit 2 Large Break LOCA/ECCS Analysis," Advanced Nuclear Fuels Corp., August 1988.

(2) Letter, Ashok C. Thadani (Assistant Director for Systems, Division of Engineering & Systems Technology Office of NRR) to Gary M. Ward (ANF Manager, Reload Licensing), "Acceptance for Referencing Topical Report XN-NF-82-49(P), Revision 1, Exxon Nuclear Company Evaluation Model-EXEM PWR Small Break Model", dated July 12, 1988.

(3) XN-NF-81-58(P)(A), Revision 2, and Supplements 1 & 2, "RODEX2: Fuel Rod Thermal-Mechanical Response Evaluation Model", Exxon Nuclear Company, March 1984.