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H. B. ROBINSON STEAM ELECTRIC PLANT UNIT 2
SMALL BREAK LOCA ANALYSIS

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H. B. ROBINSON STEAM ELECTRIC PLANT UNIT 2

SMALL BREAK LOCA ANALYSIS

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1.0 INTRODUCTION

This document presents the results of the small-break loss-of-coolant accident (SBLOCA) analysis for the H. B. Robinson Steam Electric Plant Unit 2. This SBLOCA analysis supports a nuclear enthalpy rise factor ($F_{\Delta H}$) of 1.75 and a total peaking factor (F_Q^T) of 2.5. Break spectrum calculations were performed for break sizes of 1.5, 2.0, 2.5 and 3.0 inches in diameter, at the pump discharge section of a cold leg pipe. A steam generator tube plugging level of 6% was assumed in the analysis. Calculations were also performed to evaluate the impact of a three-minute Safety Injection (SI) interruption, during a transfer to cold leg recirculation procedure, following a small-break LOCA for the plant.

2.0 SUMMARY OF RESULTS

The SBLOCA break spectrum calculations identified the 2-inch break size to be the limiting break. The peak cladding temperature (PCT) for the 2-inch break size was calculated to be 1994 °F with a maximum local cladding oxidation of 9.8%. The analysis also supports the termination of the SI for three minutes, during a transfer to cold leg recirculation procedure, following a small-break LOCA. A second cladding heatup was predicted during the switchover procedure. The highest second heatup was observed for the 3-inch break case, and was predicted to be 1081 °F. The magnitude of this heatup, however, was small compared with the initial heatup.

The analysis supports full power operation of the plant at 2346 MWt (2300 MWt plus 2% uncertainty) with a steam generator tube plugging level of up to 6%. The analysis also supports an $F_{\Delta H}$ of 1.75, and an F_Q^T of 2.5 with the axially dependent power peaking limit curve [k(z)] shown in Figure 3.1.

The analysis demonstrates that the 10 CFR 50.46(b) criteria are satisfied for the H. B. Robinson Steam Electric Plant Unit 2.

3.0 ANALYSIS

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

1. The calculated maximum fuel element cladding temperature shall not exceed 2200°F.
2. The amount of fuel element cladding which reacts chemically with water or steam does not exceed 1% of the Zircaloy within the heated length of the core.
3. The cladding temperature transient is terminated at a time when the core geometry is still amenable to cooling. The local fuel rod cladding oxidation shall not exceed 17%.
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 brief description of the H. B. Robinson Steam Electric Plant Unit 2 and presents a summary of the system parameters considered in the SBLOCA analysis. Section 3.4 provides a summary of the results of the SBLOCA break spectrum analysis. Evaluation of the transfer to cold leg recirculation procedure is discussed in Section 3.5.

3.1 Description of SBLOCA Transient

The postulated 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 relief and safety valves, charging and letdown lines, drain lines, and instrumentation lines. The most limiting break location is in the cold leg pipe at the discharge side of the pumps. This break location results in the largest amount of inventory loss and

the largest fraction of Emergency Core Cooling System (ECCS) fluid being ejected out through 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 (1850 psia for H. B. Robinson Unit 2). The Safety Injection Actuation Signal (SIAS) occurs when the system has further depressurized (1715 psia for H. B. Robinson Unit 2). The capacity and shutoff head of the High Head Safety Injection (HHSI) pumps are important parameters in the SBLOCA transient.

The SBLOCA transient can be categorized into three ranges of break sizes. The scenario is different for each range of break sizes. The "small" small breaks are characterized by inventory losses that are less than the makeup capacity of the HHSI pumps such that core uncovery is limited or precluded. The core level is eventually recovered and hot rod heatup is limited. "Large" small breaks are characterized by a larger primary system depressurization rate such that the accumulator pressure is reached in sufficient time to limit the core uncovery and hot rod heatup. The HHSI pumps have limited influence in the "large" small break transient. The break sizes between the "small" and "large" small breaks are generally the most limiting. For "medium" small breaks, the rate of inventory loss from the primary system is large enough that the HHSI pumps cannot preclude significant core uncovery. The primary system depressurization rate is very slow, extending the time required to reach the accumulator pressure. This tends to maximize the heatup time of the hot rod and produces the maximum peak cladding temperature (PCT). It also results in the longest time with the core being at elevated temperatures, which maximizes the local cladding oxidation. Core recovery for the limiting break begins when intact loop SI flow and accumulator flow exceed primary system inventory lost out the break.

3.2 Analytical Models

The SNP SBLOCA evaluation model (Ref. 1) consists of three computer codes. The appropriate conservatisms, prescribed by Appendix K of 10 CFR 50, are incorporated.

1. The RODEX2 code (Ref. 2) was utilized to determine the initial fuel stored energy and gap conditions for the initialization of the system blowdown and hot rod response calculations.
2. The SNP version of RELAP5/MOD2 (ANF-RELAP) (Ref. 3) 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.
3. The TOODEE2 code (Ref. 4) was employed to simulate the behavior of the hot rod during the entire transient. The code uses nodal fluid flow rate, steam temperatures above the mixture level, and mixture level boundary conditions from the ANF-RELAP system calculation.

3.3 Plant Description and Summary of Analysis Parameters

The H. B. Robinson Steam Electric Plant Unit 2 is a Westinghouse (W) designed 3-loop Pressurized Water Reactor (PWR), having three hot leg pipes, three inverted U-tube steam generators, and three cold leg pipes with one reactor coolant pump in each cold leg.

The reactor coolant system of the plant is nodalized in the ANF-RELAP model into control volumes representing reasonably homogeneous regions, interconnected by flow paths or "junctions." The model includes three identical accumulators, a pressurizer, and three steam generators with both primary and secondary sides modeled. All three loops of the plant were simulated separately in order to provide an accurate representation of the plant. A steam generator tube plugging level of 6% was assumed. The HHSI and Low Head Safety Injection (LHSI) pumps were modeled as fill junctions at the accumulator lines, with conservative flows

given as a function of system back-pressure. However, the system pressure does not decrease to the shutoff head of the LHSI pumps in the SBLOCA analysis. The primary coolant pump performance curves were characteristic of Westinghouse pumps.

The reactor core was modeled as a single radial region with 15 unevenly spaced axial nodes. A finer nodalization in the core upper region was utilized to provide adequate detail of the boundary conditions that are transferred to the TOODEE2 code. The heat generation rate, in the ANF-RELAP reactor core model, was determined from reactor kinetics equations with actinide and decay heating as prescribed by Appendix K.

Loss-of-offsite power was assumed to occur at reactor trip in the analysis which results in tripping of the Reactor Coolant Pumps (RCPs). Single failure criteria was satisfied by assuming the loss of one diesel generator, which results in the disabling of one HHSI pump and one of the two motor-driven auxiliary feedwater pumps. In the analysis, one additional HHSI pump was assumed to be out of service for maintenance, so that only one HHSI pump was available. Initiation of the HHSI system was conservatively assumed to be delayed 28.5 seconds beyond the time at which the SIAS occurs to model the delay time required for diesel generator startup and switching following loss-of-offsite power. The HHSI pump shutoff head, however, was not reached until after the 28.5 second delay time was satisfied for all break sizes analyzed. The disabling of a motor-driven auxiliary feedwater pump would leave one motor driven and the turbine pump available. However, no credit for the turbine-driven auxiliary feedwater pump was taken because minimum auxiliary feed flow will cause the steam generators to remove conservatively less primary energy; consequently, delaying the accumulator activation time. Delayed accumulator activation would allow the core to stay uncovered, at elevated temperatures, for a longer time.

In the analysis, the RCPs were tripped at reactor scram. Tripping the RCPs at scram is conservative as this assumption impedes the loop seal clearing

process and hence allows additional mass to escape from the system prior to the clearing of the loop seals. The reduced system water inventory, subsequently, contributes to the severity of the transient.

A conservative top skewed axial power shape, with an Axial Offset (AO) of 5%, an $F_{\Delta H}$ of 1.75, and peaked at a relative core height of 0.81, was used in the ANF-RELAP calculations. The Technical Specifications require operation within an AO of 5%. The nominal power shape target AO value, at the end-of-cycle (EOC), is -0.221%. Therefore, the use of an AO of 5% bounds any possible axial power shape. The hot rod response analysis, using the TOODEE2 code, is based on an F_Q^T of 2.5 with the k(z) curve shown in Figure 3.1.

Important system parameters, used in the analysis, are given in Table 3.1.

3.4 Results of the Break Spectrum Calculations

SBLOCA break spectrum calculations were performed for break diameters of 1.5, 2.0, 2.5, and 3.0 inches in one of the cold legs of the reactor coolant system. Predicted event times, for the different break sizes, are summarized in Table 3.2. Results from TOODEE2 hot rod response calculations are presented in Table 3.3.

The results show the 2-inch break to be the limiting break because it resulted in the slowest rate of depressurization to the accumulator pressure, exposing the core for the longest period of time, and causing the most severe fuel heatup. The 2.5- and 3.0-inch break sizes experienced a more rapid depressurization to the accumulator pressure, which limited the length of time the core was uncovered, and the depth of the core uncovery. Thus, the PCTs predicted for the 2.5- and 3.0-inch cases were less than the PCT predicted for the 2.0-inch break size. The blowdown calculation for the 1.5-inch break indicated that the mixture level did not drop below the top of the core, thus precluding fuel rod heatup. The 2.5- and 3.0-inch break calculations represent the "large" small breaks, and are characterized by a larger primary system

depressurization rate, such that, the accumulator activation pressure is reached in sufficient time to limit the core uncovery and hot rod heatup. The 1.5-inch break, on the other hand, represents the "small" small breaks and is characterized by inventory losses that are less than the makeup capacity of the HHSI pump such that core uncovery is limited or precluded.

The PCT, for the limiting break SBLOCA analysis (2-inch break), was calculated to be 1994 °F with a maximum local cladding oxidation of 9.8%.

System ANF-RELAP results for the break spectrum calculations are illustrated in Figures 3.2 through 3.41. Figures 3.42 through 3.50 depict the TOODEE2 PCT node cladding temperature, core mixture level, and PCT node clad heat transfer coefficient, for the different break sizes. The core mixture level in the TOODEE2 hot rod response calculations was defined to occur at the core void plane of 80%. A TOODEE2 hot rod response calculation was not performed for the 1.5-inch break since the mixture level remained above the top of the core.

3.5 Evaluation of the Transfer to Cold Leg Recirculation Procedure

The transfer to cold leg recirculation procedure for H. B. Robinson Steam Electric Plant Unit 2 requires that all safety injection (SI) pumps be stopped simultaneously to allow switchover from the injection phase to the cold leg recirculation phase following a small-break loss-of-coolant accident. According to the cold leg recirculation procedures, implemented at H. B. Robinson Steam Electric Plant Unit 2, a 3-minute period of SI interruption occurs for the small-break LOCA (Ref. 5, page 10).

The post-SBLOCA SI switchover from the injection phase to the cold leg recirculation phase was evaluated for H. B. Robinson Steam Electric Plant Unit 2 as required by Reference 6. The study was performed for all break sizes that were analyzed for the break spectrum calculations, and also for a break size of 4 inches. The latter case, which did not predict a secondary heatup, was

included in this analysis to assure that the limiting break size had been considered.

Early switchover times were estimated, for the different break sizes, by using an early containment spray activation time and a maximum containment spray flow rate. The use of an early switchover time is conservative because at an early time the core decay heat is relatively high and the inventory low. The switchover was assumed to occur when the Refueling Water Storage Tank (RWST) emptied to a level of 9%. Assuming a maximum containment spray flow rate compensates for any measurement uncertainty associated with the RWST water level. Table 3.4 presents the calculated SI interruption and reactivation times used in the analysis.

The results of the analysis are depicted in Figures 3.51 through 3.68. As can be observed from these figures, no significant secondary heatup or vessel inventory reduction was predicted during the course of this event. Table 3.5 summarizes the impact of the 3-minute SI interruption, during the switchover from injection to recirculation phase, on the analysis. For the 1.5- and 4.0-inch break events, the core void fractions indicate that the mixture level does not drop below the top of the core during the SI interruption. The reasons being; slow inventory loss rate for the former case, and higher SI flow and an early accumulator activation, resulting from rapid system depressurization, for the latter case. The highest secondary heatup was observed for the 3-inch break case, which was calculated to be 1081 °F. This case shows the highest secondary heatup due to the combination of relatively high decay heat level and low Reactor Coolant System (RCS) inventory that prevails in the core at the relatively early SI termination time (see Table 3.4). The magnitude of this heatup, which bounds the secondary heatup calculated following the termination of SI flow for other break size cases is small compared with the initial heatup. Hence, it can be concluded that the termination of the SI injection for 3 minutes, during the SBLOCA event, is in conformance with 10 CFR 50.46(b) criteria.

Table 3.1 H. B. Robinson Unit 2, SBLOCA System Analysis Parameters

Primary Heat Output, MWt	2300*
Primary Coolant Flow Rate, lbm/hr	107.8×10^6
Primary Coolant System Volume, ft^3	9,122**
Operating Pressure, psia	2250
Inlet Coolant Temperature, °F	548.4
Reactor Vessel Volume, ft^3	3621
Pressurizer Total Volume, ft^3	1300
Pressurizer Liquid Total, ft^3	780
Accumulator Volume, ft^3 (each of three)	1200
Accumulator Liquid Volume, ft^3	825
Accumulator Pressure, psig	600
Accumulator Fluid Temperature, °F	120
Total Number of Tubes per Steam Generator	3214
Number of Tubes Plugged per Steam Generator	192.84 (6%)
Secondary Flow Rate / Steam Generator, lbm/hr	3.37×10^6
Steam Generator Secondary Pressure, psia	800
Steam Generator Feedwater Temperature, °F	441.5
Reactor Coolant Pump Rated Head, ft	266
Reactor Coolant Pump Rated Torque, ft-lbf	22,363
Reactor Coolant Pump Rated Speed, rpm	1190
Initial Reactor Coolant Pump Speed, rpm	1220.1***
Reactor Coolant Pump Moment of Inertia, lbm-ft^2	70,000
SI Fluid Temperature, °F	70
Reactor Scram Low Pressure Setpoint, psia	1850
SIAS Activation Setpoint Pressure, psia	1715
HHSI Pump Delay Time on SIAS, sec	28.5

* Primary heat output used in ANF-RELAP model 1.02 x 2300 = 2346 Mwt.
** Includes pressurizer total volume and 6% SGTP.
*** Value used in ANF-RELAP for initialization.

Table 3.1 H. B. Robinson Unit 2, SBLOCA System Analysis Parameters (Cont.)

HHSI Flow Rate Versus RCS Backpressure

RCS Pressure (psia)	Total HHSI Flow* (One Pump) (lbm/s)	Total LHSI Flow* (One Pump) (lbm/s)
1380.0	0.00	0.0
1304.0	13.80	0.0
1200.0	21.60	0.0
1000.0	32.55	0.0
800.0	41.40	0.0
600.0	48.90	0.0
400.0	56.25	0.0
200.0	63.75	0.0
138.0	65.25	0.0
135.0	65.40	175.0
120.0	65.70	375.0
95.0	66.45	575.0
65.0	67.20	725.0
14.7	68.40	875.0

* This flow is evenly distributed to the 3 loops

Table 3.2 Calculated Event Times During SBLOCA

EVENT	TIME, SEC			
	Break Size			
	1.5-in.	2.0-in.	2.5-in.	3.0-in.
Event initiation	0.0	0.0	0.0	0.0
Reactor Trip (RCP trip, SG Feed & Steam valves begin to close)	64.7	36.8	24.1	17.3
SG Safety Valves Open	75.0	47.0	34.0	27.0
SIAS + 28.5 sec delay	131.6	89.9	70.5	60.4
SI Starts	146.0	92.0	71.0	61.0
Auxiliary Feed On	135.6	107.4	94.6	87.7
2 Phase Flow at Break	~820.0	493.0	317.0	227.0
Loop Seal Clears (IL-1)	-	~1520.0	~780.0	~520.0
Loop Seal Clears (IL-2)	~3500.0	-	-	-
Top of Core Uncovers (Top of core at 80% Void Fraction)	N/A	2032.5	1165.5	769.5
Accumulator Injection	N/A	3103.8	1818.0	1150.0
PCT Occurs (From TOODEE2)	N/A	3161.0	1937.6	1215.0
End of Calculation	15000.0	3500.0	2300.0	2400.0

Table 3.3 H. B. Robinson Unit 2, SBLOCA Analysis Results

	Break Size			
	1.5-in.*	2.0-in.	2.5-in.	3.0-in.
Hot Rod Burst				
- Time (sec)	N/A	**2921.**	1821.	no
- Elevation (ft)	N/A	**10.5**	10.5	burst
- Channel Blockage Fraction	N/A	**0.2039**	0.2768	predicted
Peak Clad Temperature				
- Temperature (°F)	N/A	**1994.**	1768.	1572.
- Time (sec)	N/A	**3161.**	1938.	1215.
- Elevation (ft)	N/A	**10.5**	10.0	10.5
Metal-Water Reaction				
- Local Maximum (%)	N/A	**9.83**	3.05	1.00
- Elevation of Local Max. (ft)	N/A	**10.5**	10.5	10.5
- Hot Pin Total (%)	N/A	**0.85**	0.36	0.15

* No TOODEE2 calculation was performed for the 1.5-inch break case since the mixture level remained above the top of the core.

Table 3.4 Transfer to Cold Leg Recirculation Procedure Analysis Parameters

Break Size (inch)	SI Interruption Time* (s)	SI Reactivation Time (s)	End Problem Time (s)
1.5	7915	8095	8500
2.0	7076	7256	8000
2.5	5997	6177	7000
3.0	4678	4858	6000
4.0	1321	1501	2000

* Estimation of this time was conservatively based on a maximum containment spray flow rate (from both spray trains) of 3400 gpm and early break-size-dependent spray actuation times. Availability of one train of fan coolers (two fan coolers), as a result of the loss of one diesel generator, was assumed in the calculation of containment spray actuation times, which was performed as a part of a containment response analysis. An RWST volume of 300,000 gallons was used.

Table 3.5 Transfer to Cold Leg Recirculation Procedure Analysis Results

	Break Size				
	1.5-in.*	2.0-in.	2.5-in.	3.0-in.	4.0-in.*
Secondary Peak Cladding Temperature					
- Temperature (°F)	N/A	950.	1014.	1081.	N/A
- Time (sec)	N/A	7500.	6380.	5010.	N/A
- Elevation (ft)	N/A	11.0	11.0	10.5	N/A
Metal-Water Reaction					
- Local Maximum (%)	N/A	10.01	3.25	1.02	N/A
- Elev. of Local Max. (ft)	N/A	10.5	10.5	10.5	N/A
- Hot Pin Total (%)	N/A	0.88	0.40	0.15	N/A

* No TOODEE2 calculation was performed for these case since the mixture level remained above the top of the core.

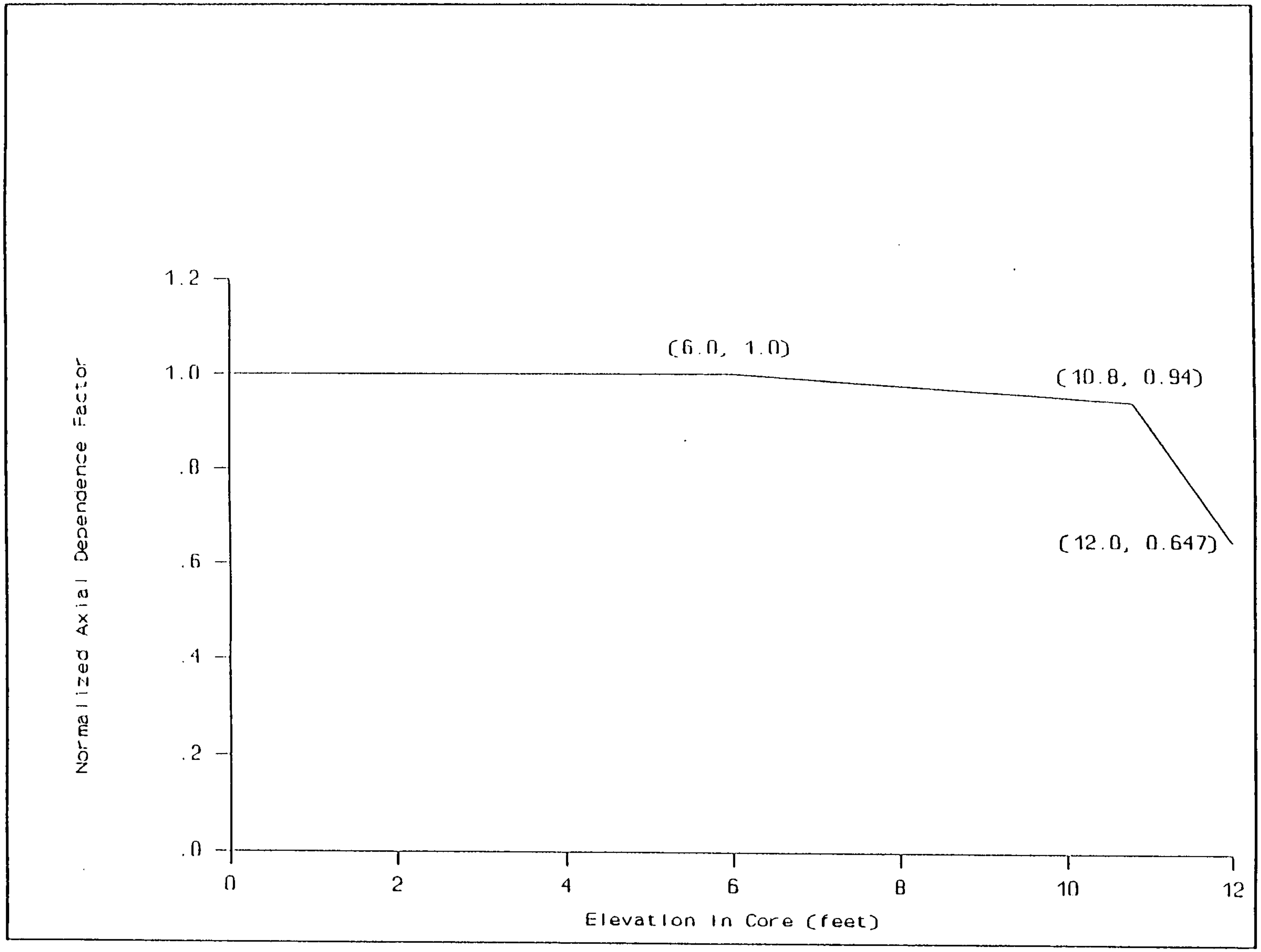

Figure 3.1 H.B. Robinson 2 Normalized Axial Dependence of F_Q^T Versus Elevation

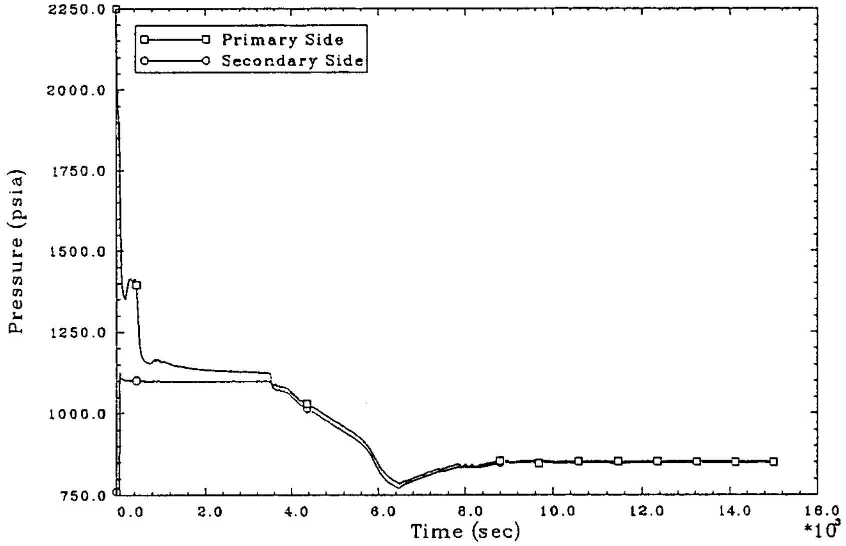

Figure 3.2 System Pressure
H.B. Robinson 2, 1.5-Inch SBLOCA

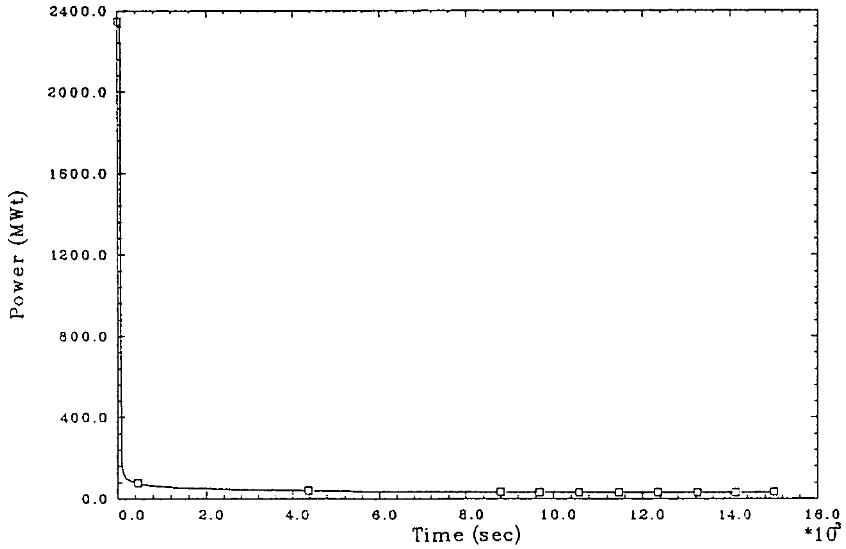

Figure 3.3 Core Power
H.B. Robinson 2, 1.5-Inch SBLOCA

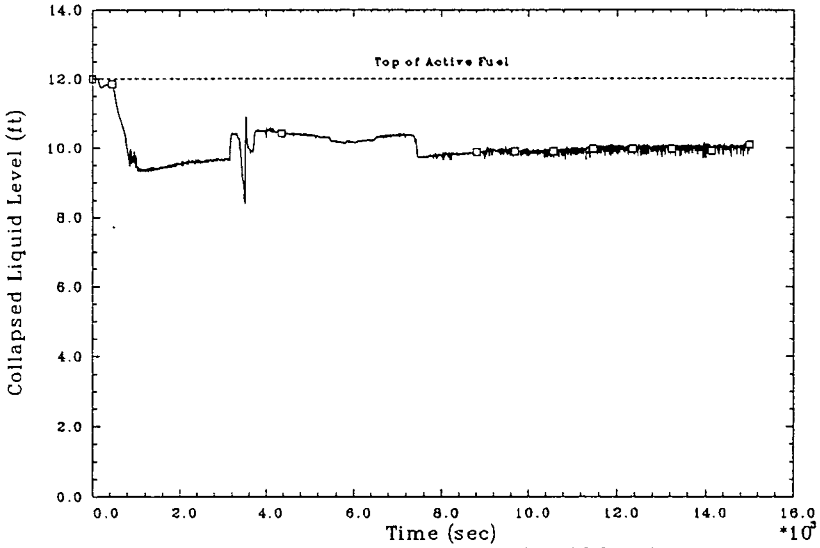

Figure 3.4 Core Collapsed Liquid Level
H.B. Robinson 2, 1.5-Inch SBLOCA

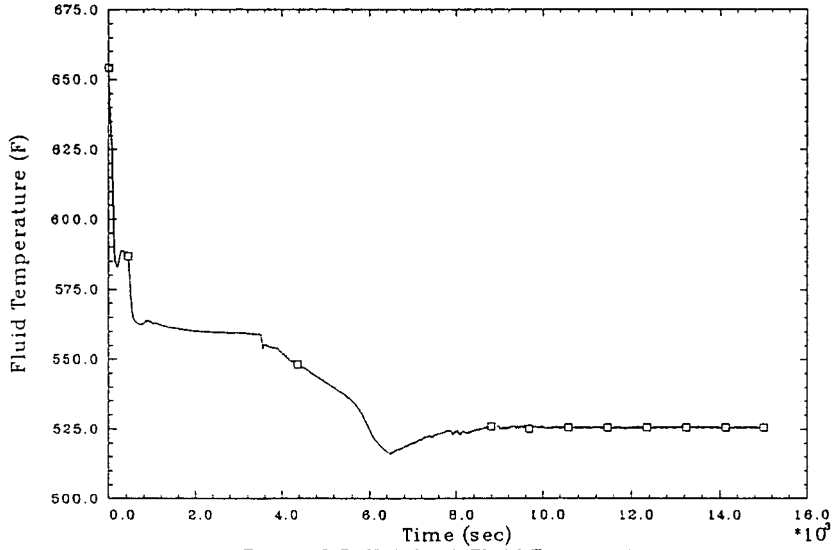

Figure 3.5 Hot Spot Fluid Temperature
H.B. Robinson 2, 1.5-Inch SBLOCA

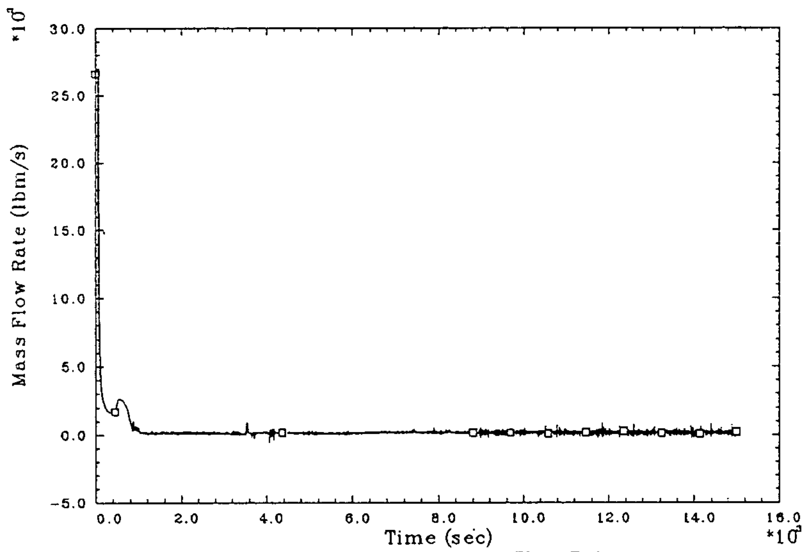

Figure 3.6 Core Outlet Flow Rate
H.B. Robinson 2, 1.5-Inch SBLOCA

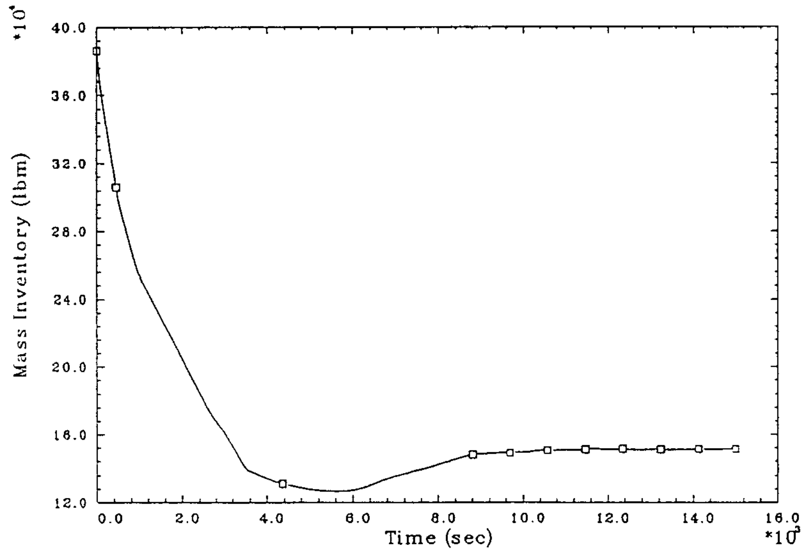

Figure 3.7 Total Primary System Mass
H.B. Robinson 2, 1.5-Inch SBLOCA

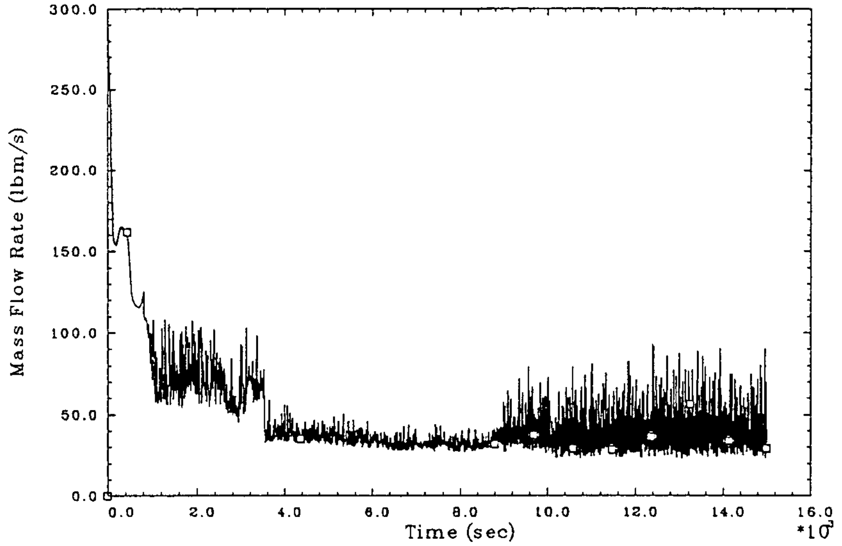

Figure 3.8 Break Flow Rate
H.B. Robinson 2, 1.5-Inch SBLOCA

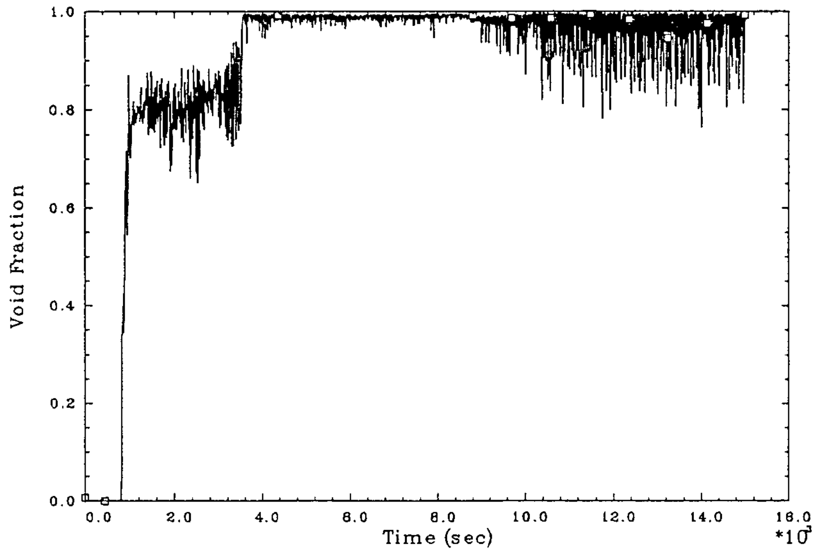

Figure 3.9 Break Void Fraction
H.B. Robinson 2, 1.5-Inch SBLOCA

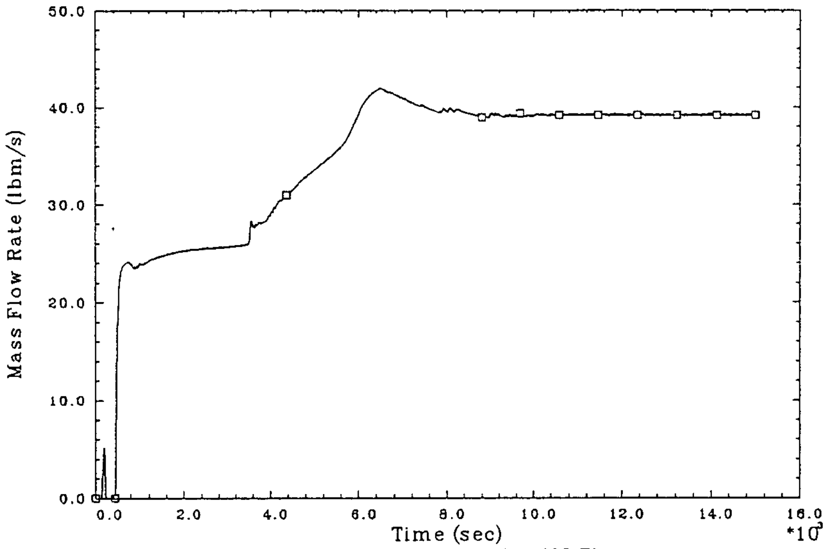

Figure 3.10 Combined HHSI Flow
H.B. Robinson 2, 1.5-Inch SBLOCA

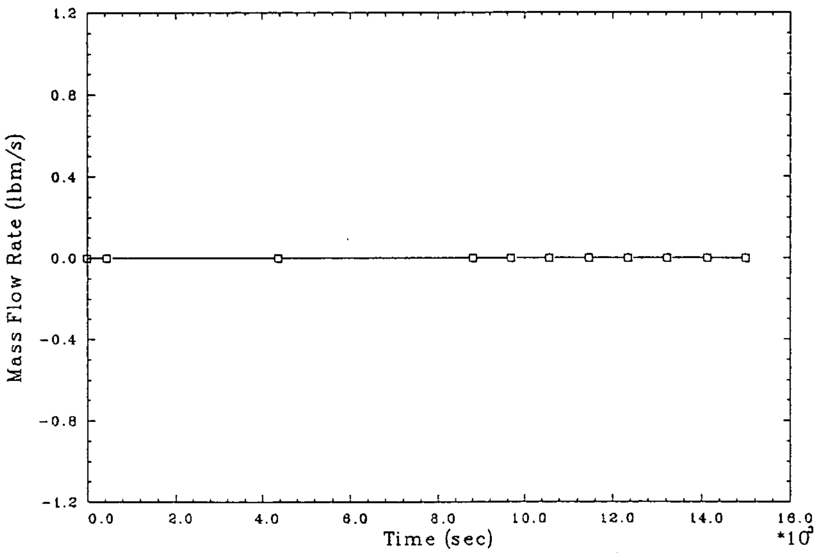

Figure 3.11 Combined Accumulator Flow
H.B. Robinson 2, 1.5-Inch SBLOCA

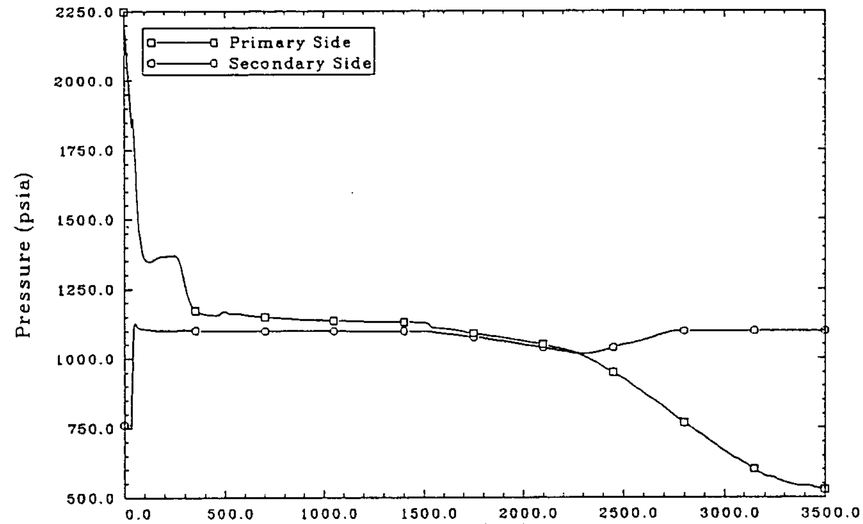

Figure 3.12 System Pressure
H.B. Robinson 2, 2.0-Inch SBLOCA

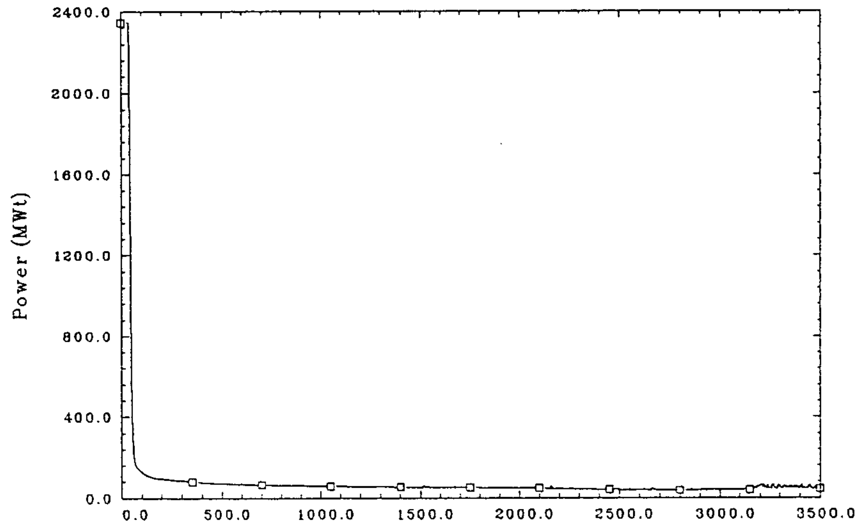

Figure 3.13 Core Power
H.B. Robinson 2, 2.0-Inch SBLOCA

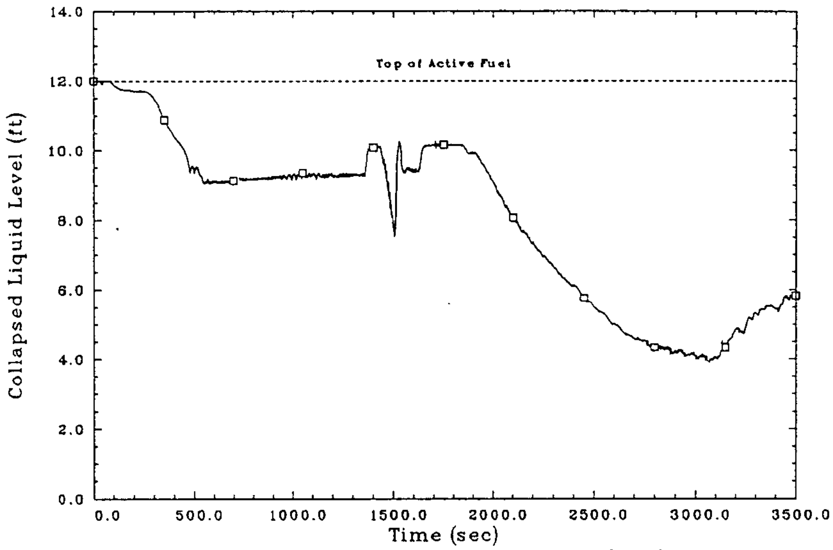

Figure 3.14 Core Collapsed Liquid Level
H.B. Robinson 2, 2.0-Inch SBLOCA

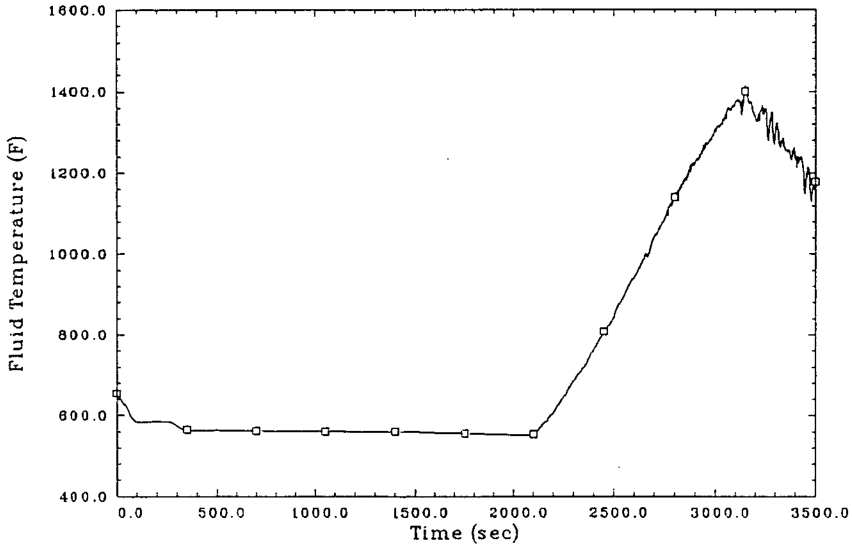

Figure 3.15 Hot Spot Fluid Temperature
H.B. Robinson 2, 2.0-Inch SBLOCA

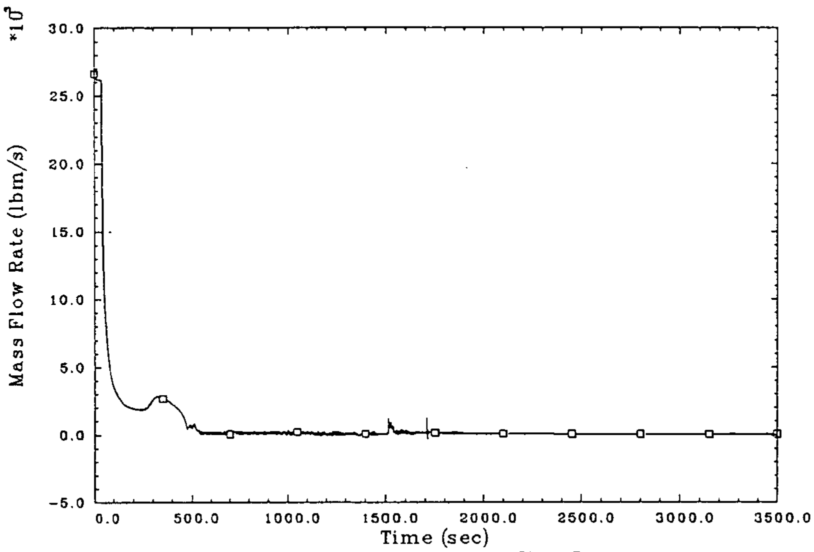

Figure 3.16 Core Outlet Flow Rate
H.B. Robinson 2, 2.0-Inch SBLOCA

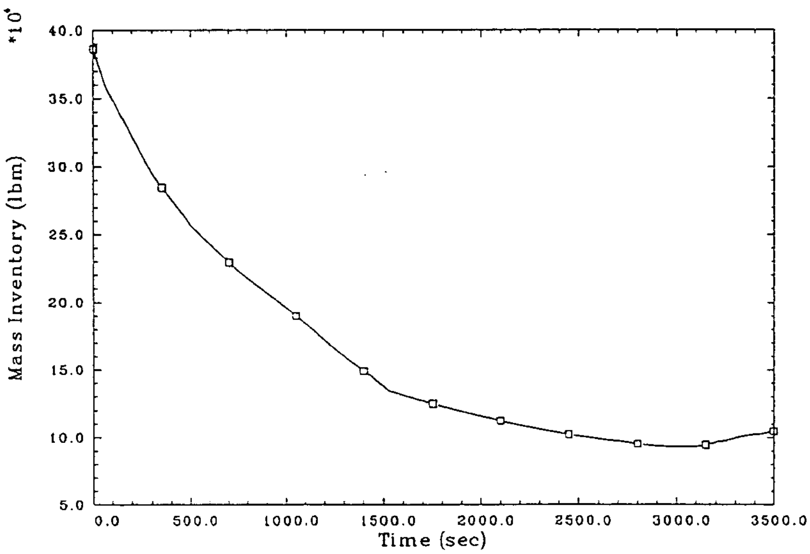

Figure 3.17 Total Primary System Mass
H.B. Robinson 2, 2.0-Inch SBLOCA

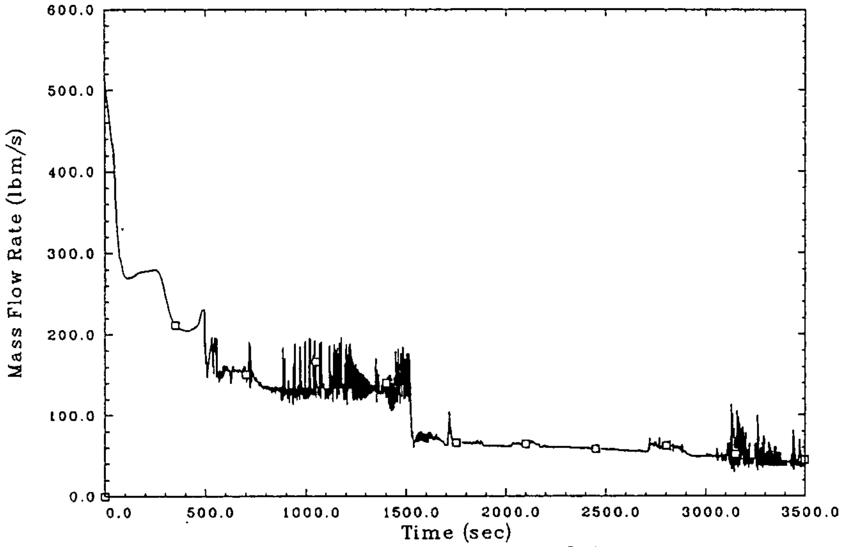

Figure 3.18 Break Flow Rate
H.B. Robinson 2, 2.0-Inch SBLOCA

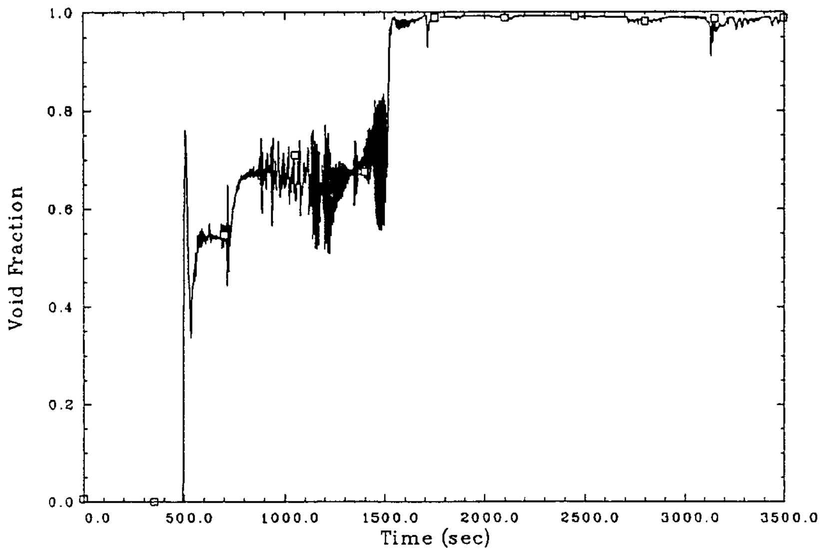

Figure 3.19 Break Void Fraction
H.B. Robinson 2, 2.0-Inch SBLOCA

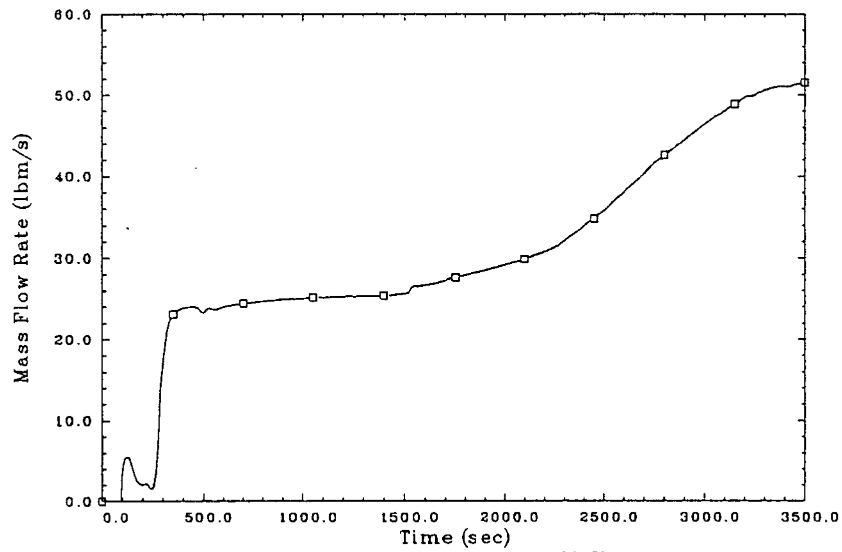

Figure 3.20 Combined HHSI Flow
H.B. Robinson 2, 2.0-Inch SBLOCA

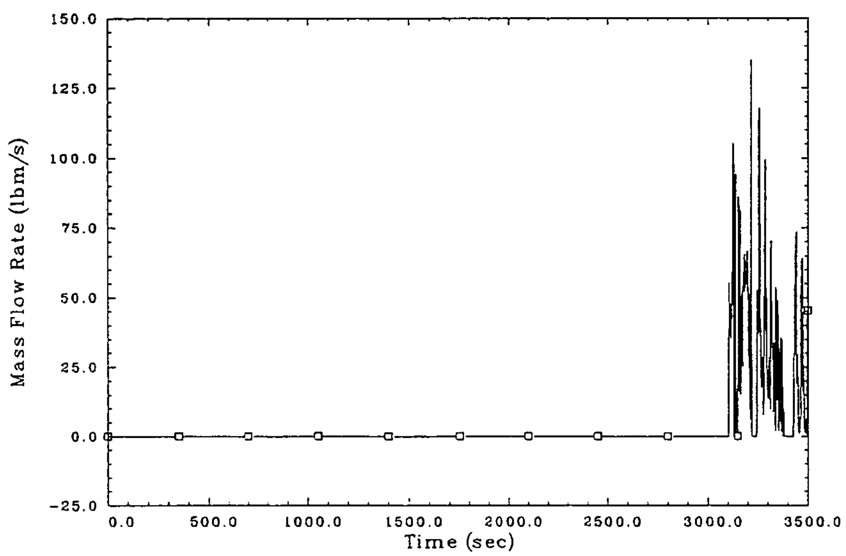

Figure 3.21 Combined Accumulator Flow
H.B. Robinson 2, 2.0-Inch SBLOCA

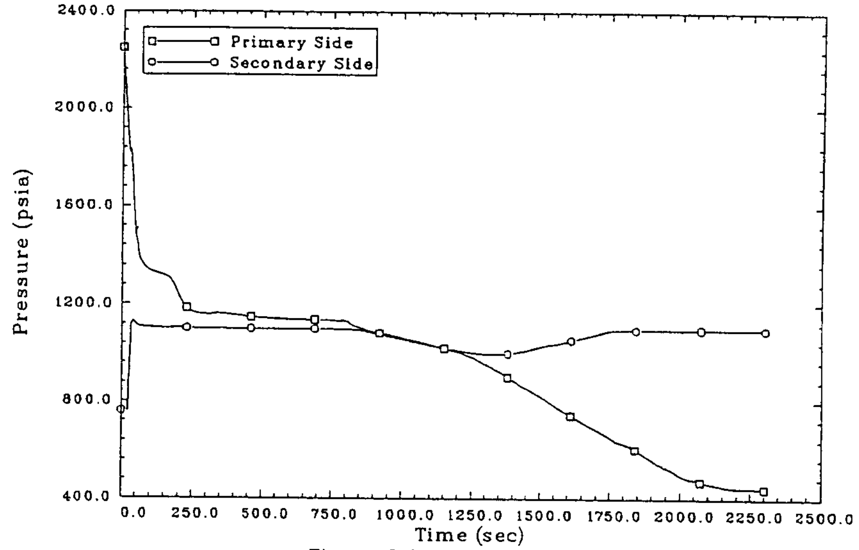

Figure 3.22 System Pressure
H.B. Robinson 2, 2.5-Inch SBLOCA

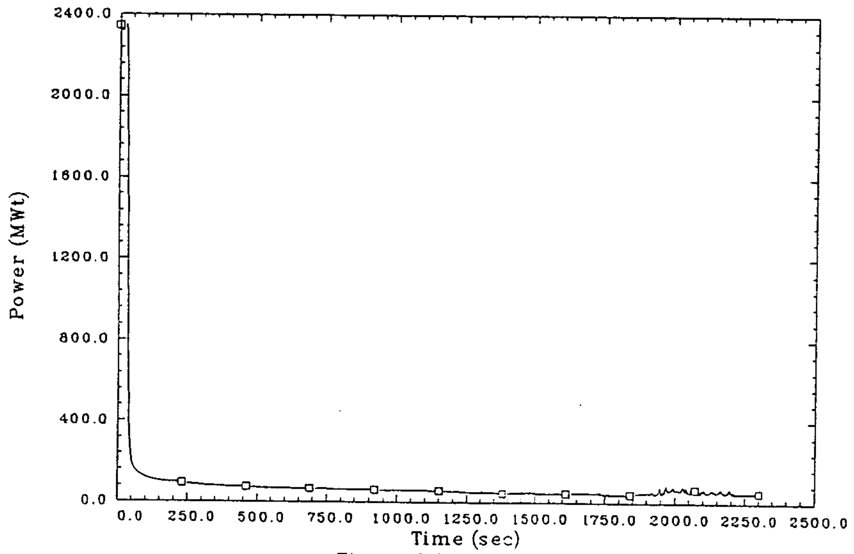

Figure 3.23 Core Power
H.B. Robinson 2, 2.5-Inch SBLOCA

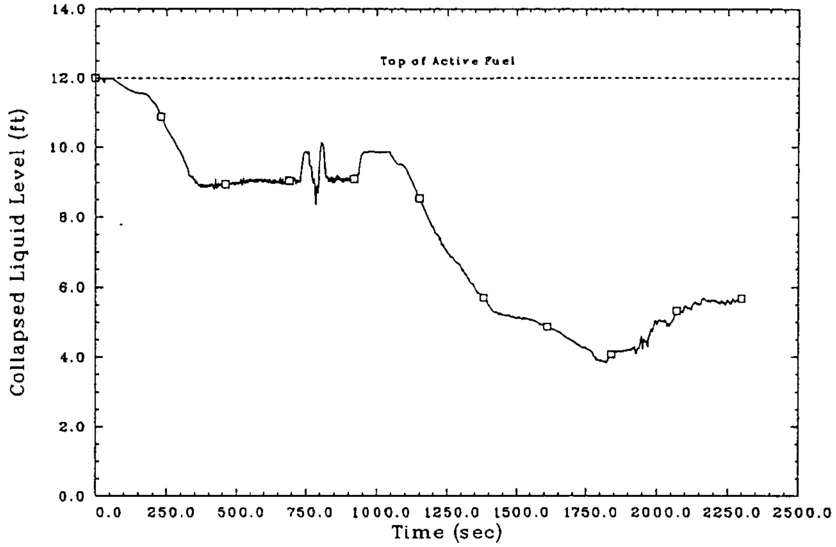

Figure 3.24 Core Collapsed Liquid Level
H.B. Robinson 2, 2.5-Inch SBLOCA

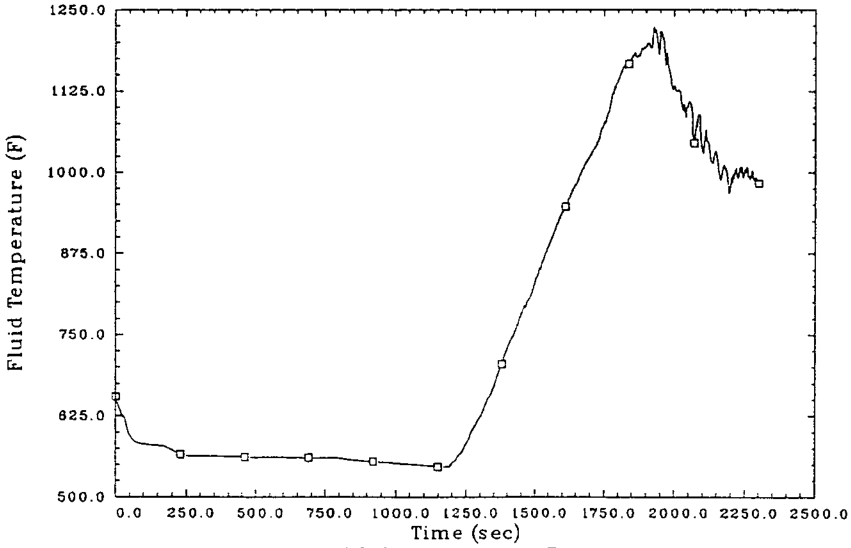

Figure 3.25 Hot Spot Fluid Temperature
H.B. Robinson 2, 2.5-Inch SBLOCA

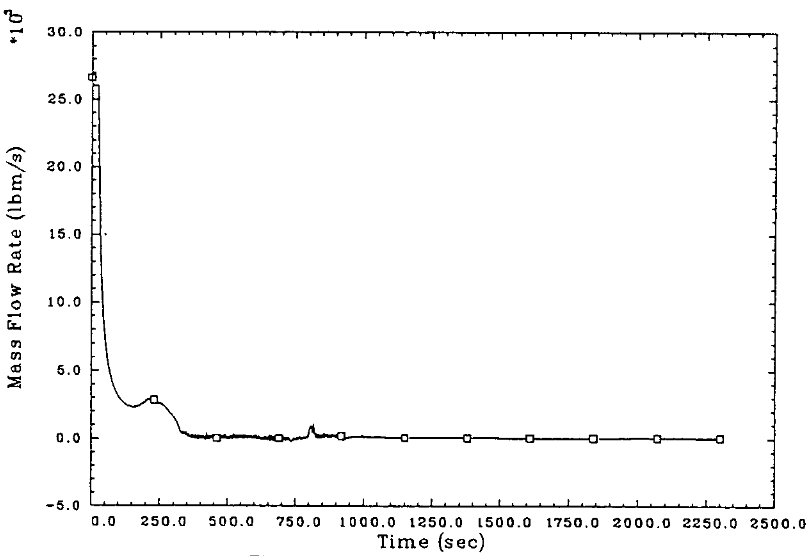

Figure 3.26 Core Outlet Flow Rate
H.B. Robinson 2, 2.5-Inch SBLOCA

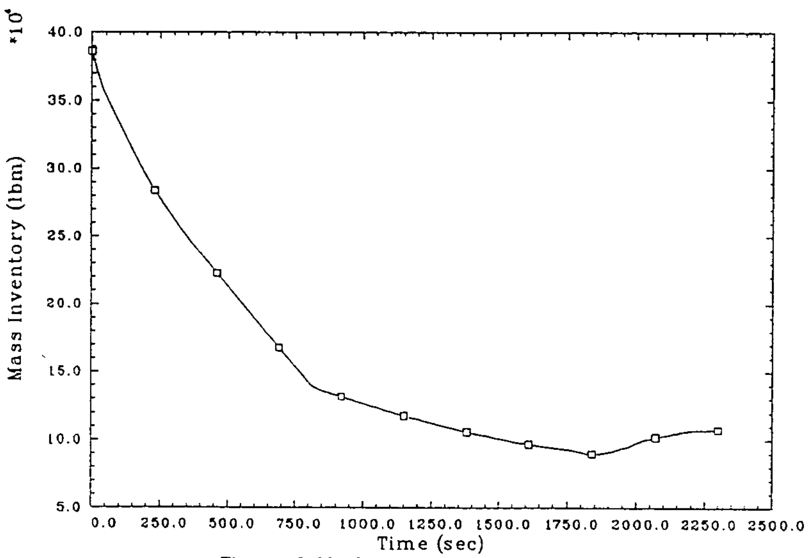

Figure 3.27 Total Primary System Mass
H.B. Robinson 2, 2.5-Inch SBLOCA

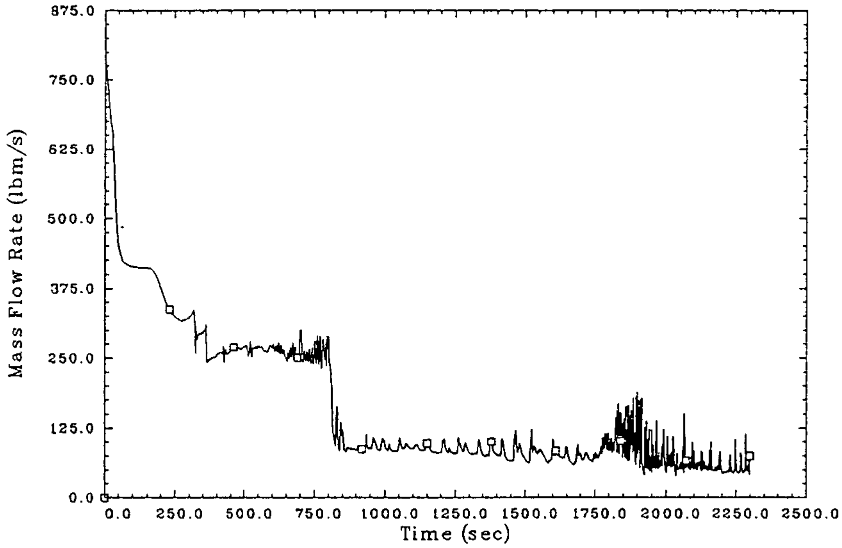

Figure 3.28 Break Flow Rate
H.B. Robinson 2, 2.5-Inch SBLOCA

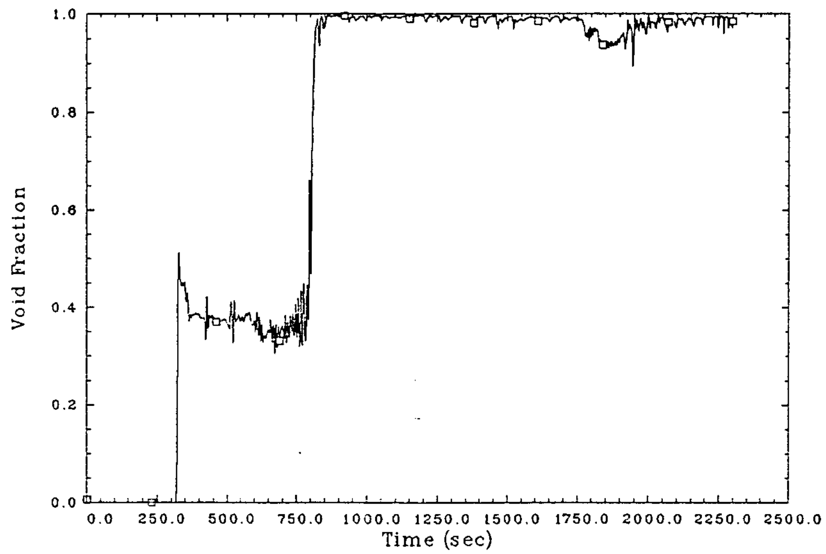

Figure 3.29 Break Void Fraction
H.B. Robinson 2, 2.5-Inch SBLOCA

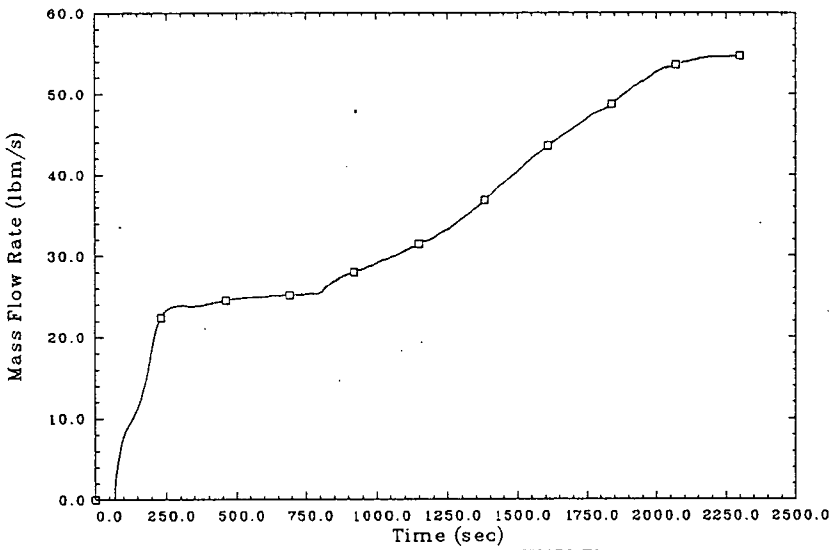

Figure 3.30 Combined HHSI Flow
H.B. Robinson 2, 2.5-Inch SBLOCA

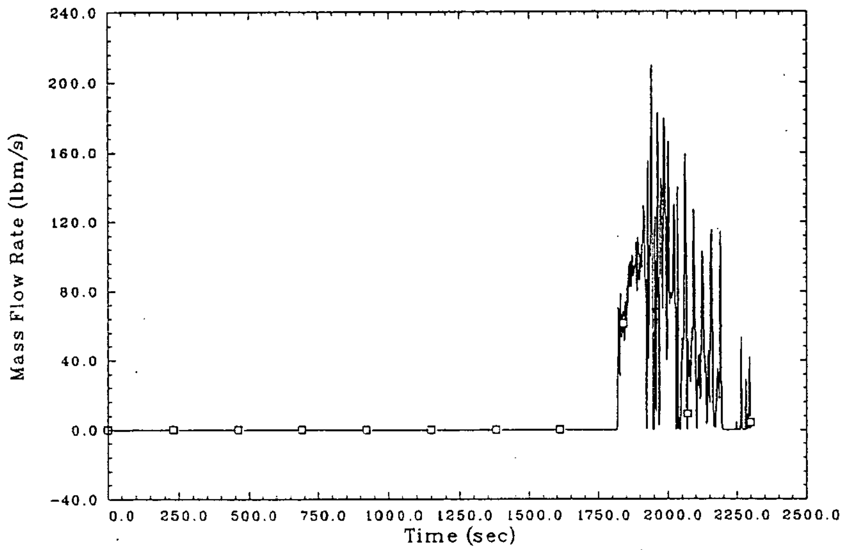

Figure 3.31 Combined Accumulator Flow
H.B. Robinson 2, 2.5-Inch SBLOCA

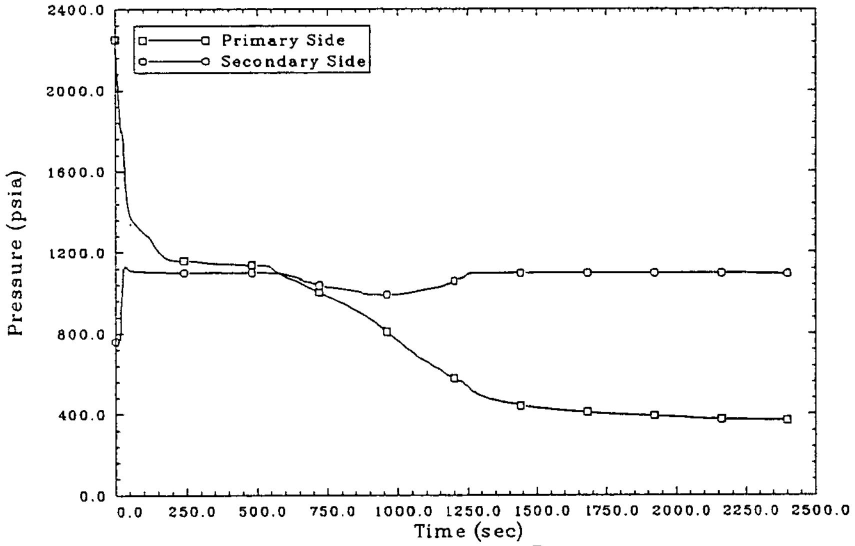

Figure 3.32 System Pressure
H.B. Robinson 2, 3.0-Inch SBLOCA

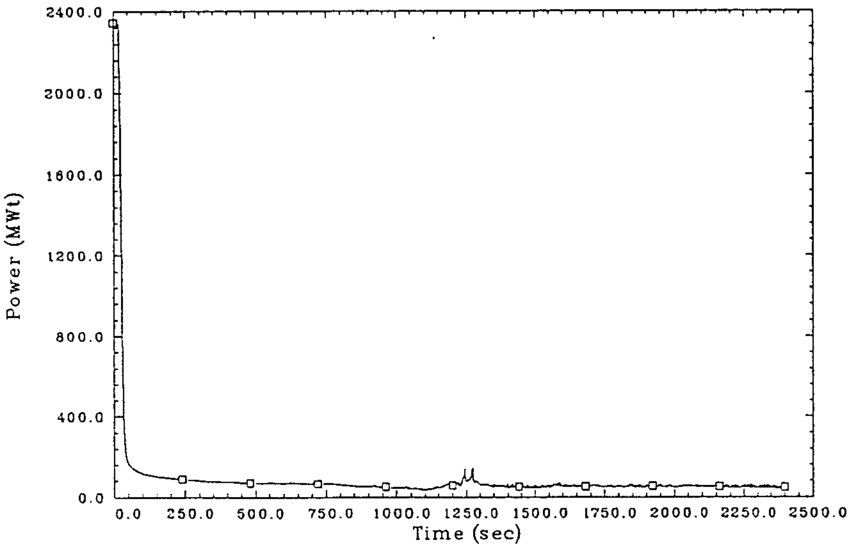

Figure 3.33 Core Power
H.B. Robinson 2, 3.0-Inch SBLOCA

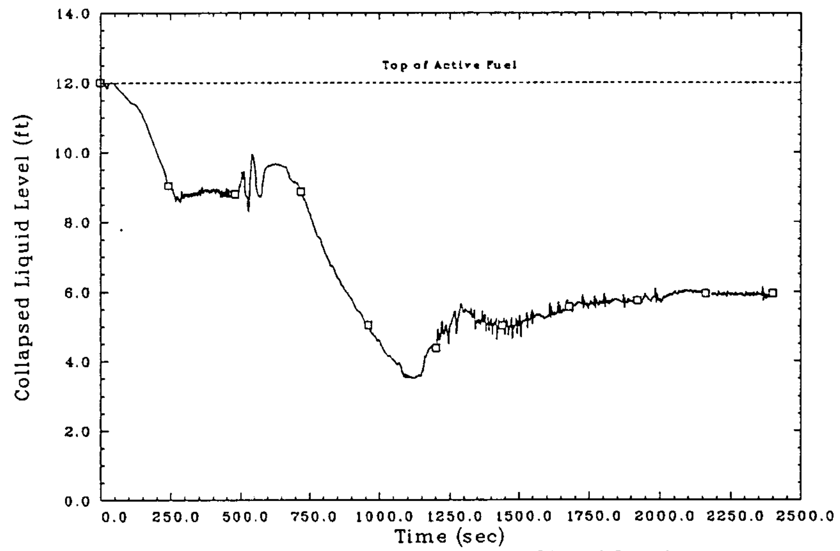

Figure 3.34 Core Collapsed Liquid Level
H.B. Robinson 2, 3.0-Inch SBLOCA

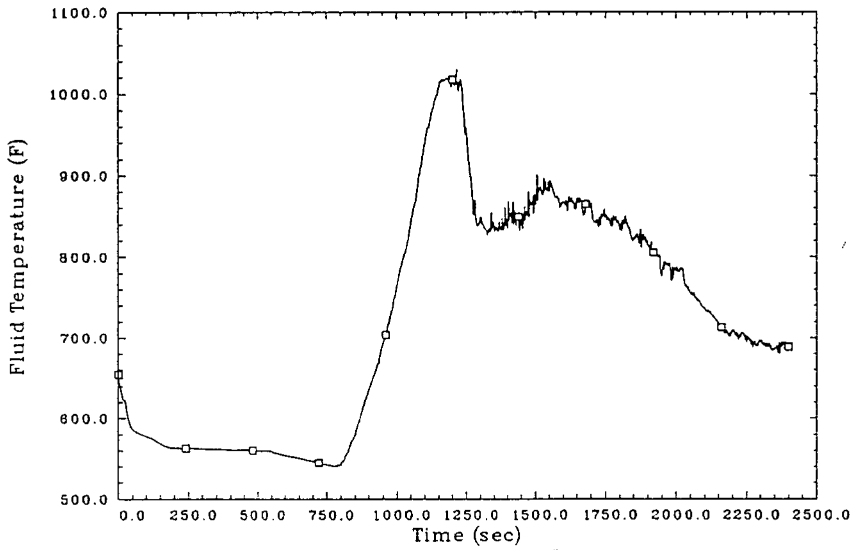

Figure 3.35 Hot Spot Fluid Temperature
H.B. Robinson 2, 3.0-Inch SBLOCA

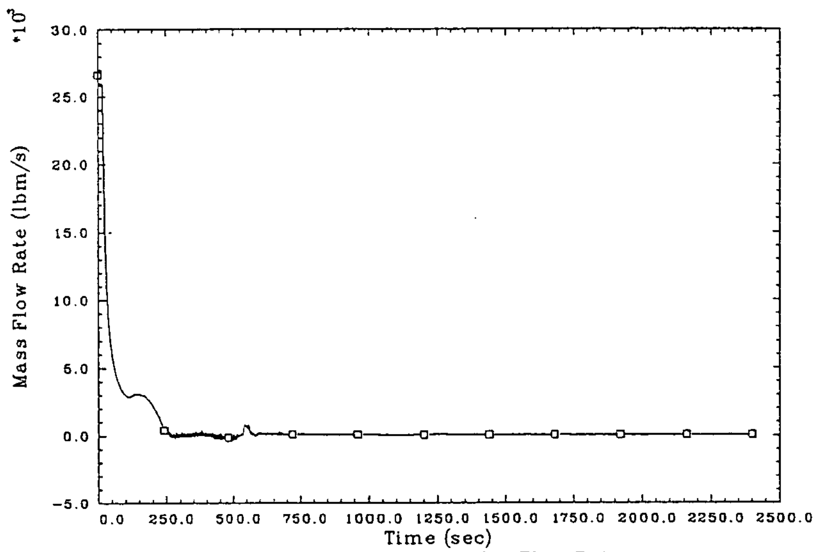

Figure 3.36 Core Outlet Flow Rate
H.B. Robinson 2, 3.0-Inch SBLOCA

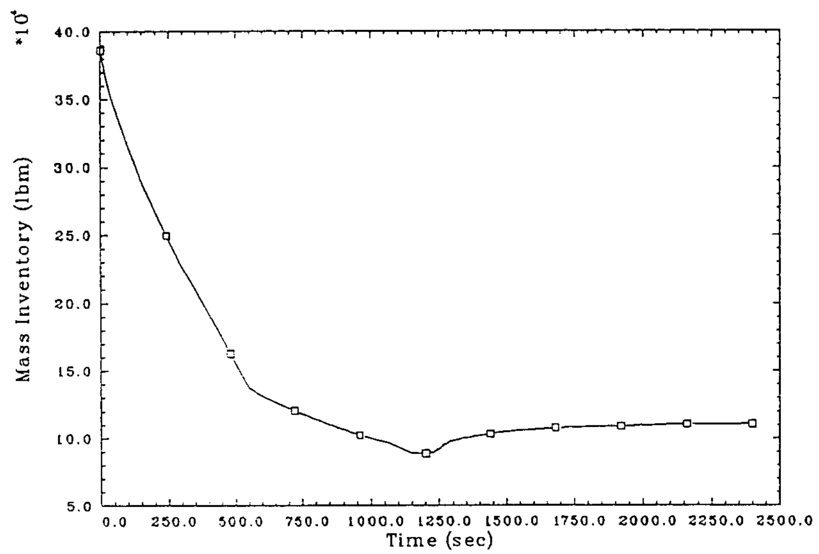

Figure 3.37 Total Primary System Mass
H.B. Robinson 2, 3.0-Inch SBLOCA

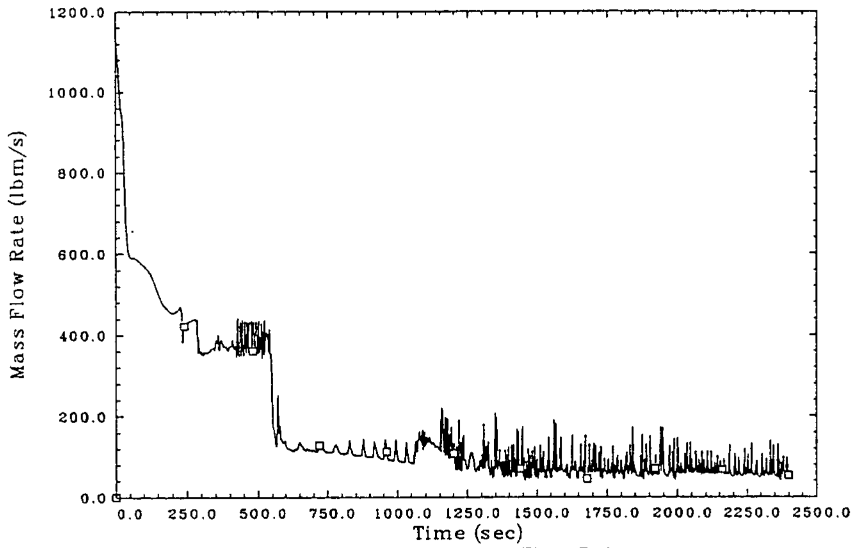

Figure 3.38 Break Flow Rate
H.B. Robinson 2, 3.0–Inch SBLOCA

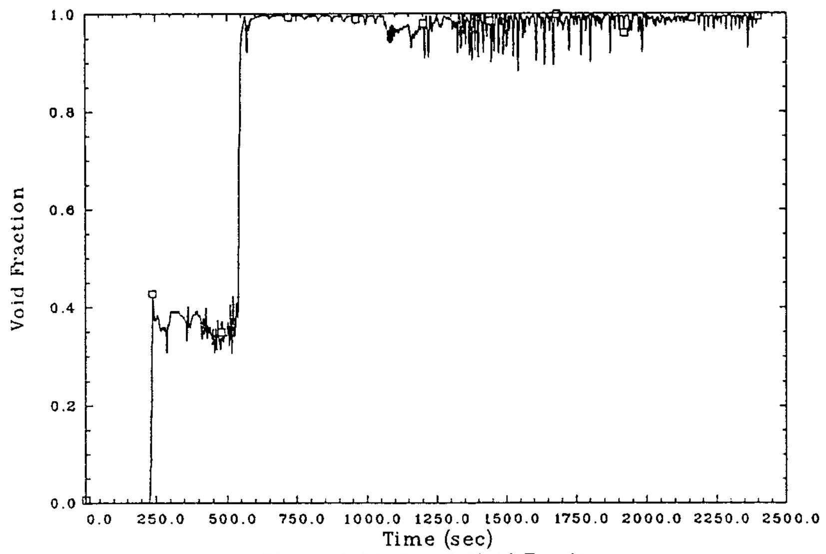

Figure 3.39 Break Void Fraction
H.B. Robinson 2, 3.0–Inch SBLOCA

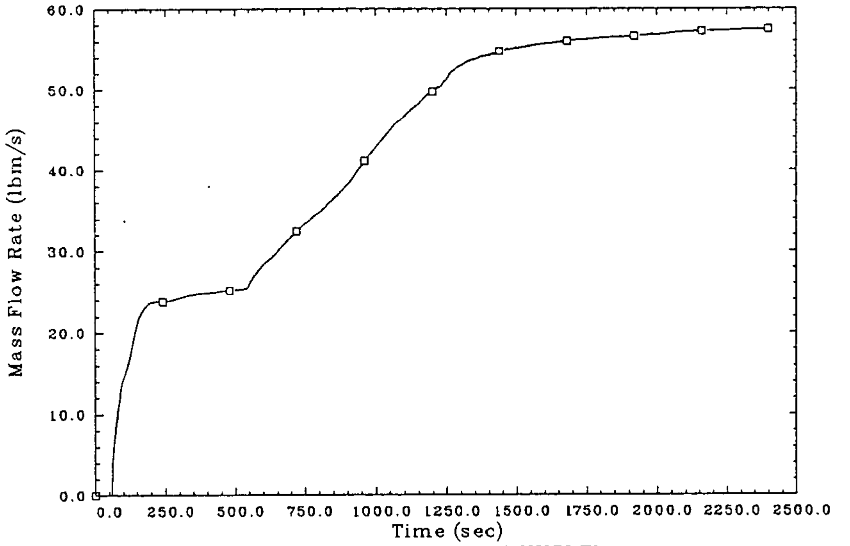

Figure 3.40 Combined HHSI Flow
H.B. Robinson 2, 3.0–Inch SBLOCA

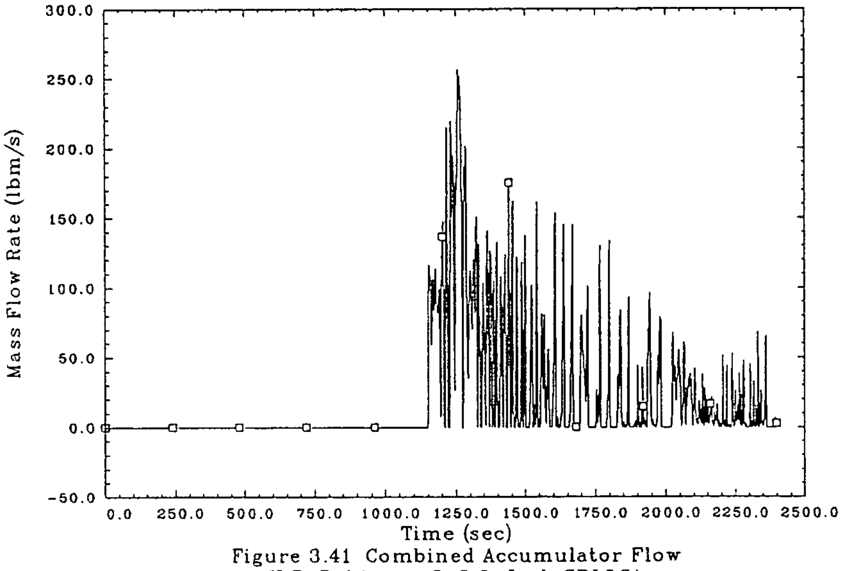

Figure 3.41 Combined Accumulator Flow
H.B. Robinson 2, 3.0–Inch SBLOCA

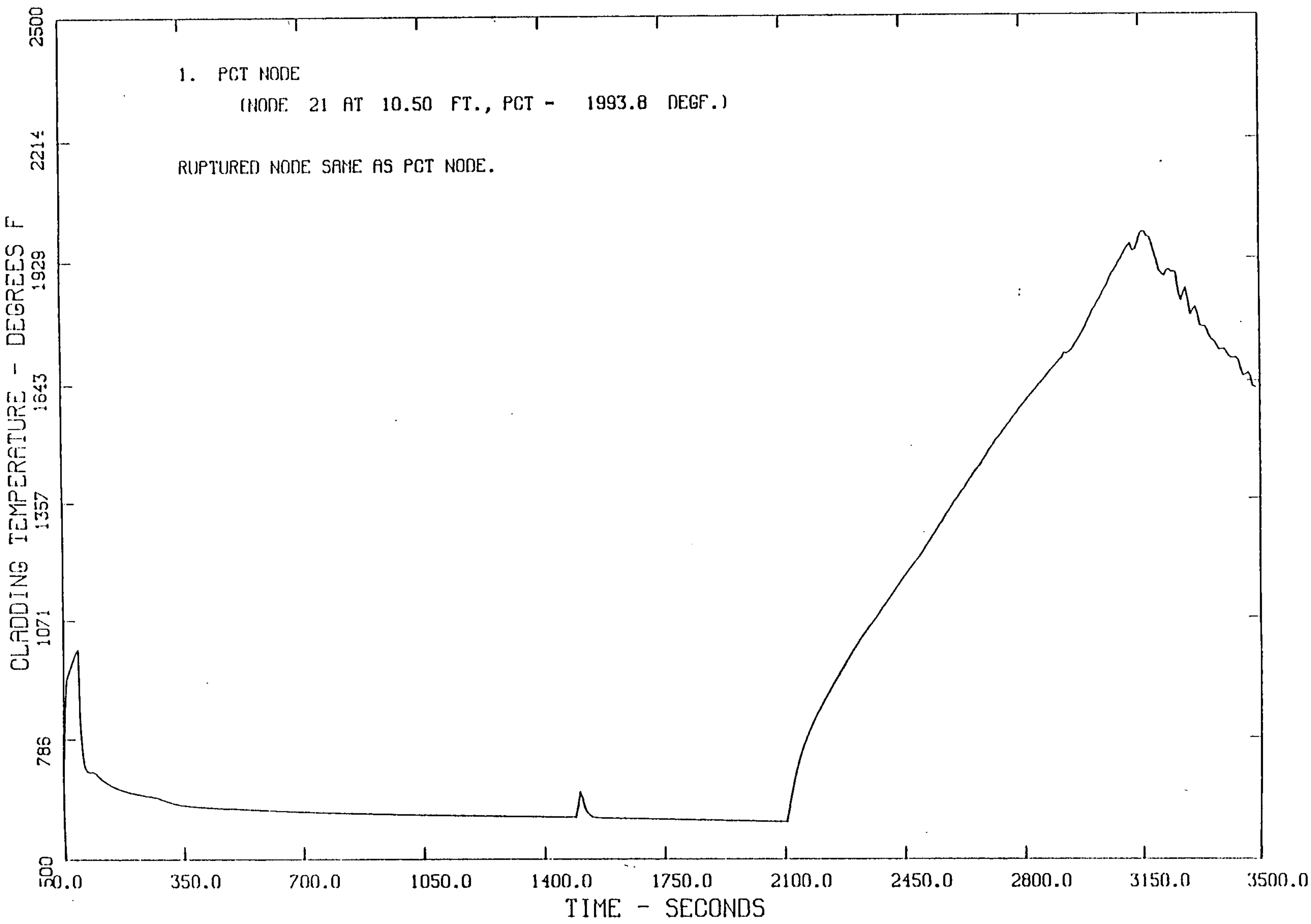

Figure 3.42 Hot Rod Temperature Response During 2.0-Inch SBLOCA

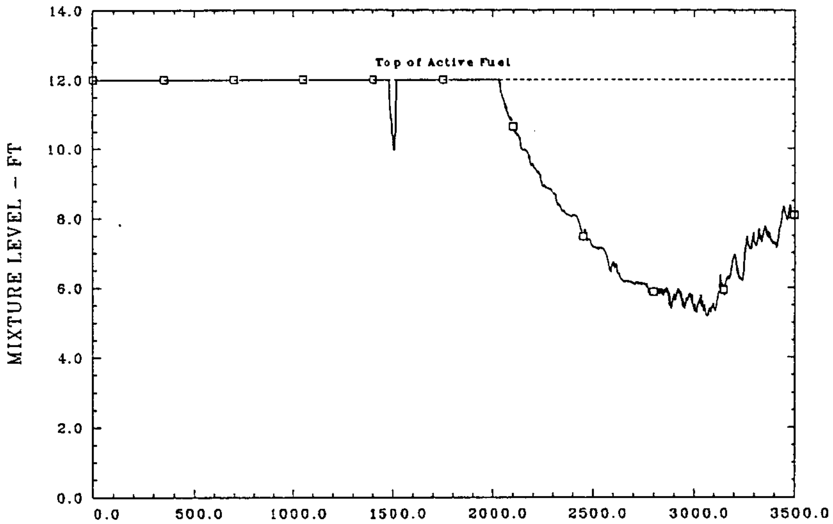

Figure 3.43 Core Mixture Level
H.B. Robinson 2, 2.0-Inch SBLOCA

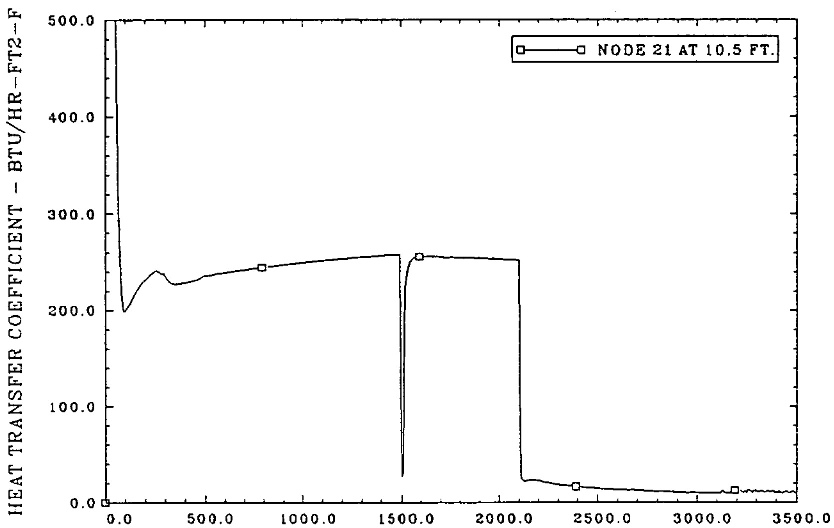

Figure 3.44 Clad Heat Transfer Coefficient
H.B. Robinson 2, 2.0-Inch SBLOCA

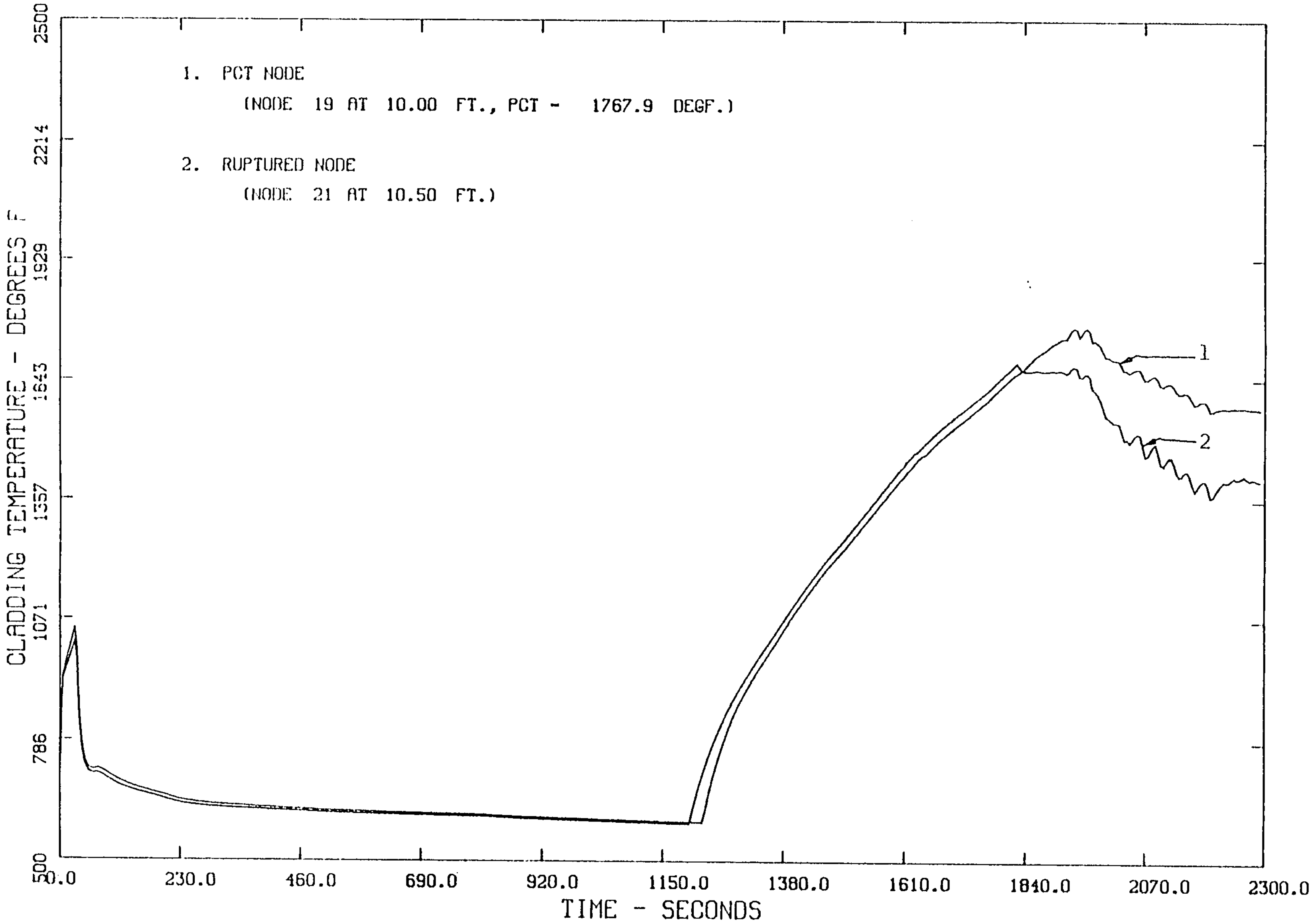

Figure 3.45 Hot Rod Temperature Response During 2.5-Inch SBLOCA

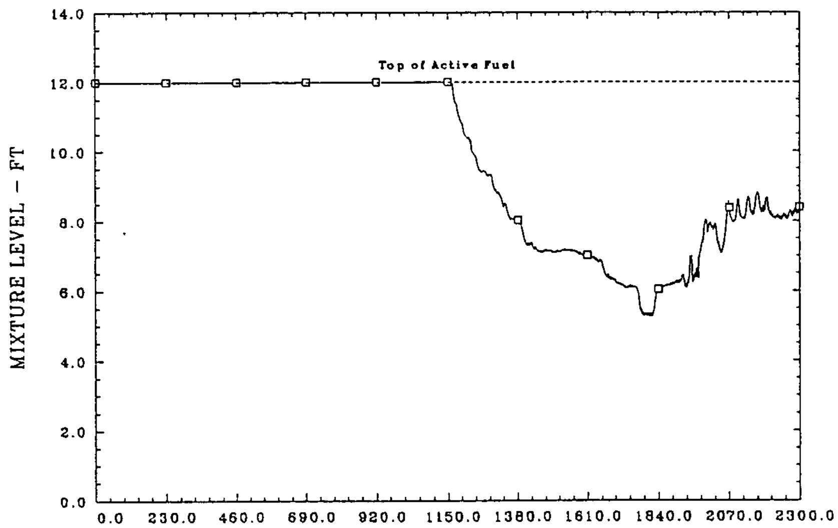

Figure 3.46 Core Mixture Level
H.B. Robinson 2, 2.5-Inch SBLOCA

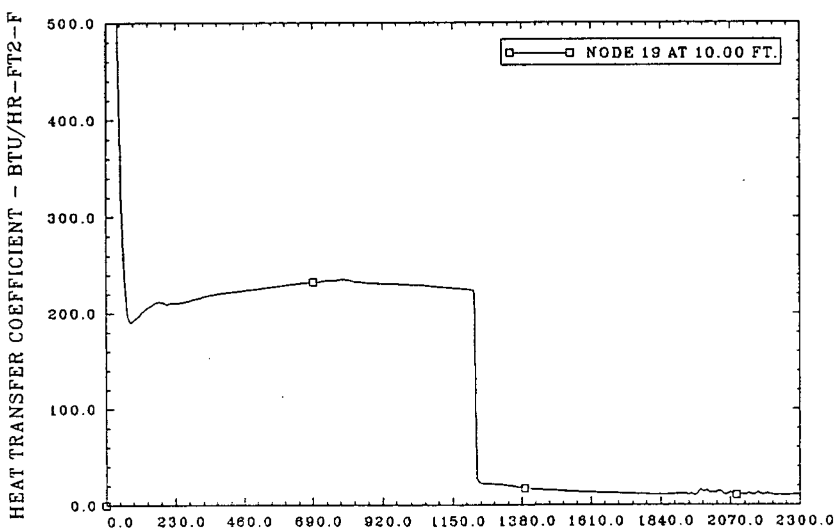

Figure 3.47 Clad Heat Transfer Coefficient
H.B. Robinson 2, 2.5-Inch SBLOCA

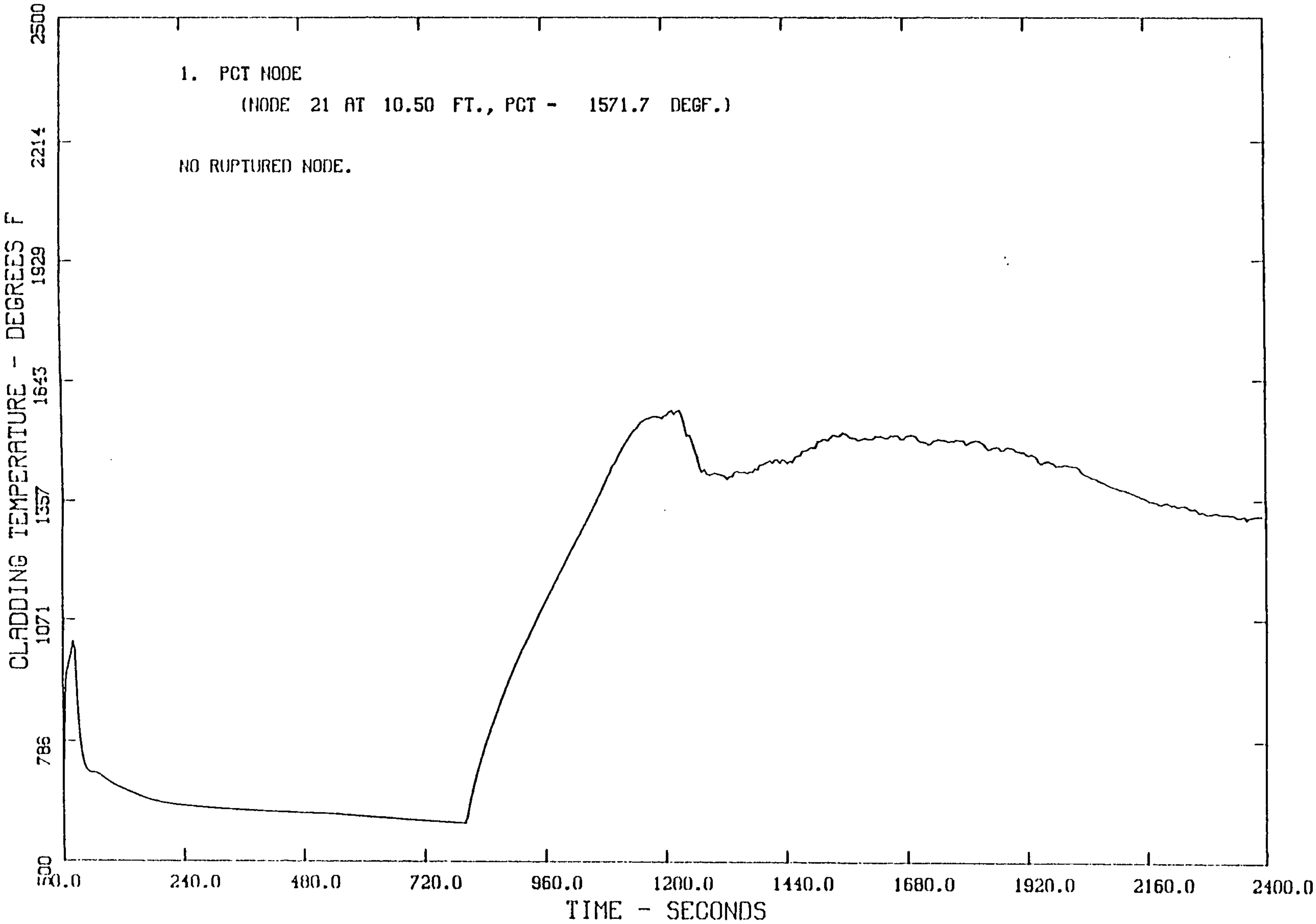

Figure 3.48 Hot Rod Temperature Response During 3.0-Inch SBLOCA

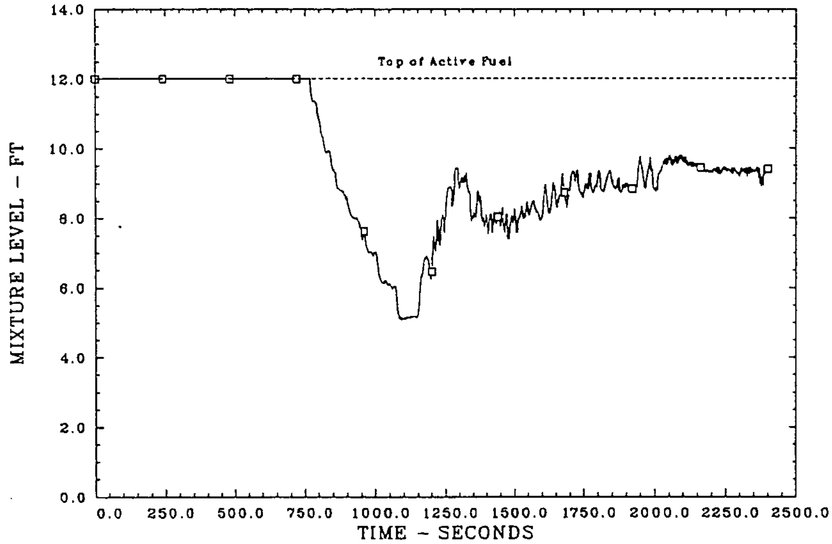

Figure 3.49 Core Mixture Level
H.B. Robinson 2, 3.0-Inch SBLOCA

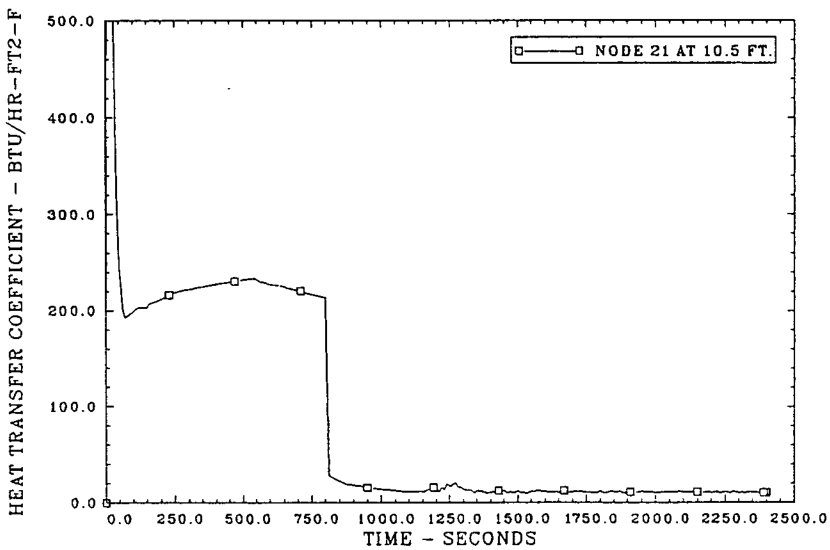

Figure 3.50 Clad Heat Transfer Coefficient
H.B. Robinson 2, 3.0-Inch SBLOCA

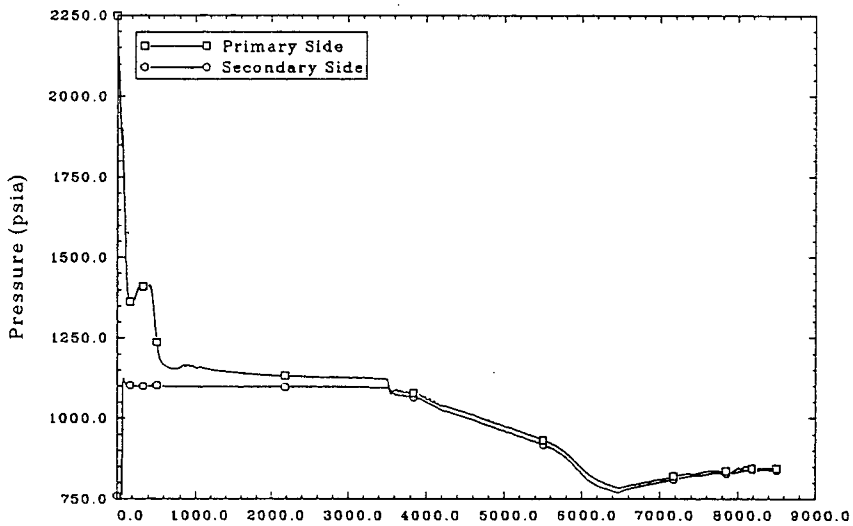

Figure 3.51 System Pressure
1.5-Inch SBLOCA, 3-Min. SI Interruption

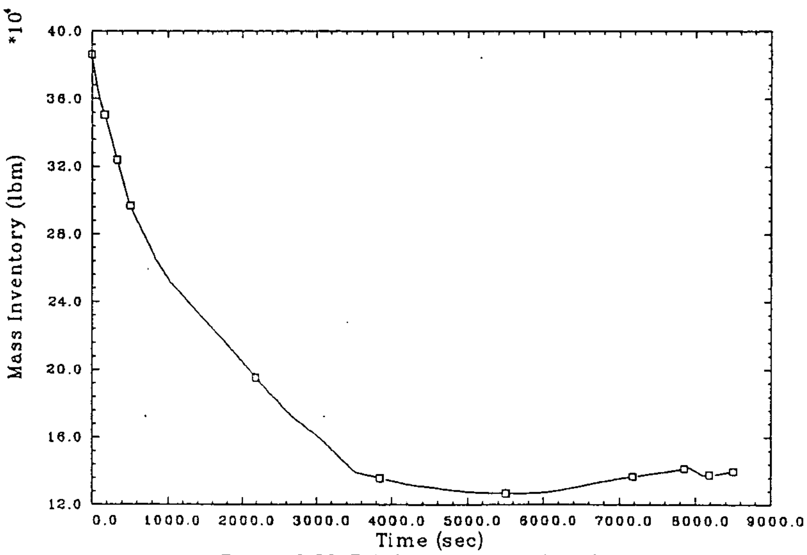

Figure 3.52 Total Primary System Mass
1.5-Inch SBLOCA, 3-Min. SI Interruption

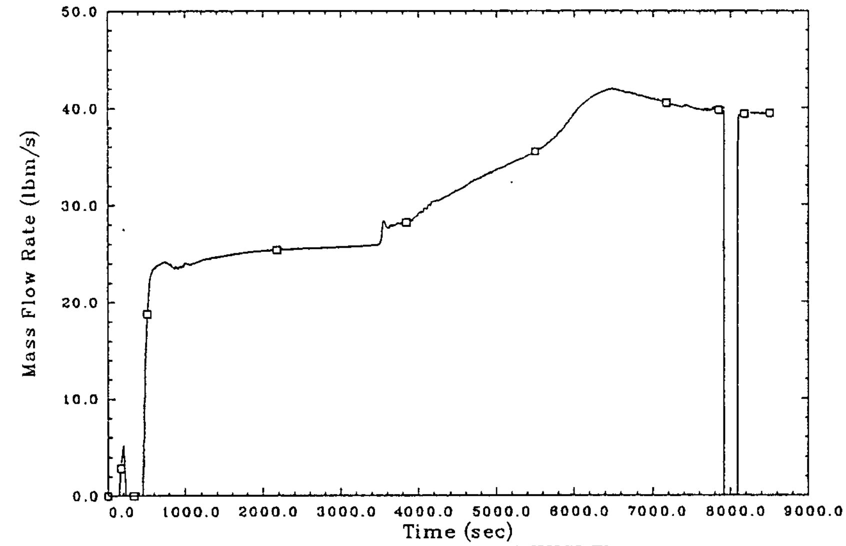

Figure 3.53 Combined HHSI Flow
1.5-Inch SBLOCA, 3-Min. SI Interruption

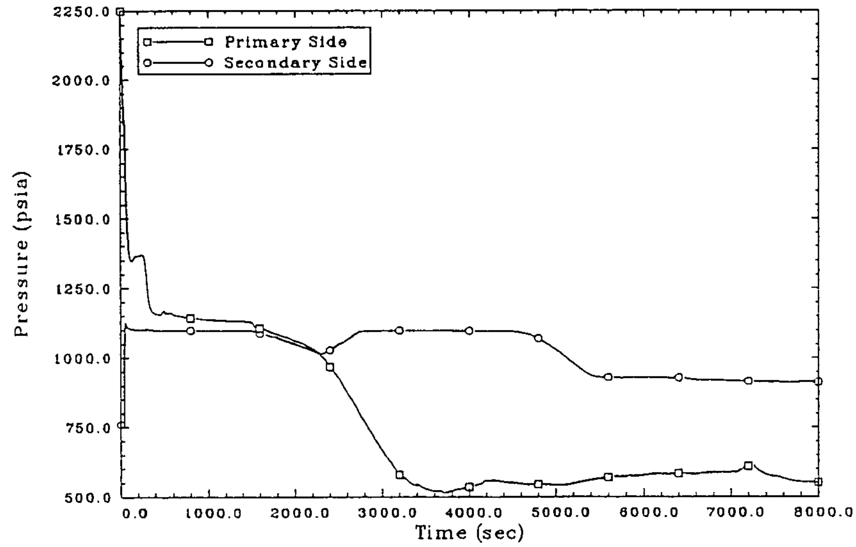

Figure 3.54 System Pressure
2.0-Inch SBLOCA, 3-Min. SI Interruption

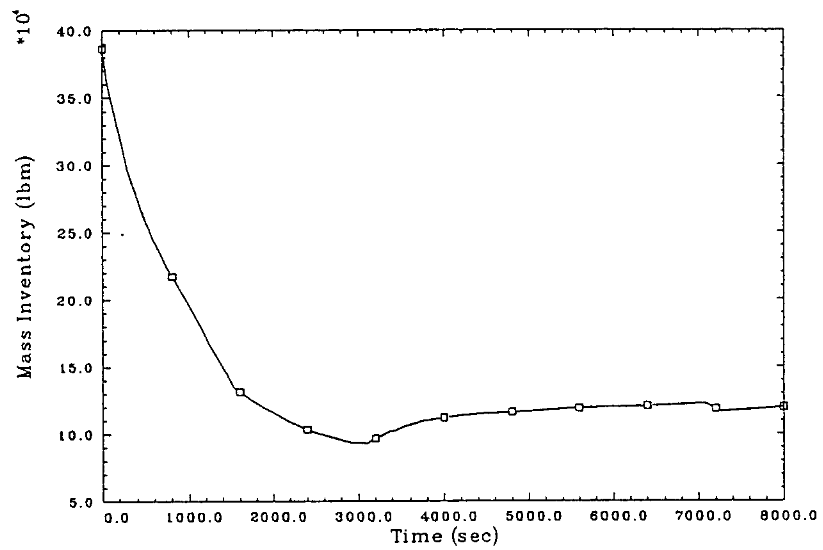

Figure 3.55 Total Primary System Mass
2.0-Inch SBLOCA, 3-Min. SI Interruption

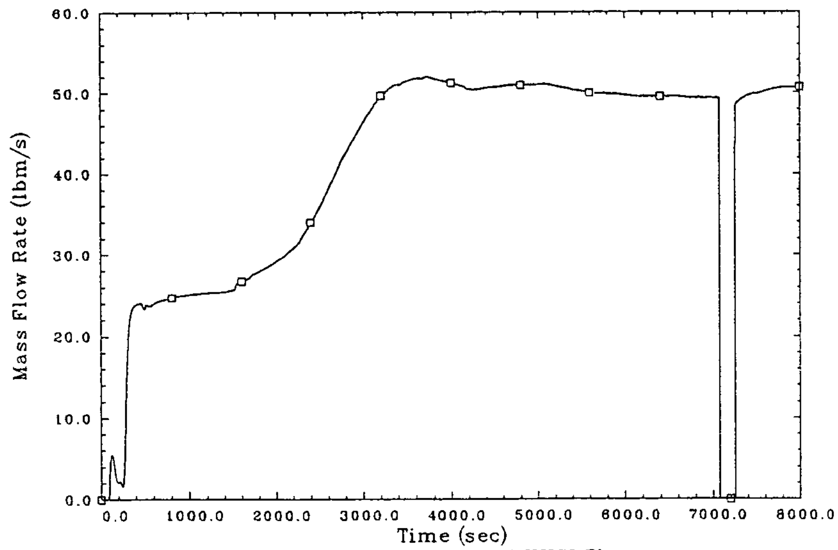

Figure 3.56 Combined HHSI Flow
2.0-Inch SBLOCA, 3-Min. SI Interruption

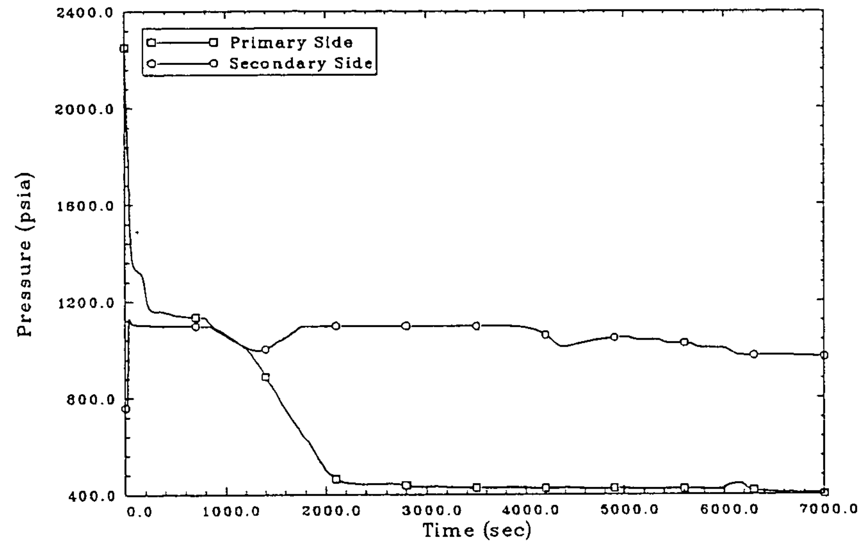

Figure 3.57 System Pressure
2.5-Inch SBLOCA, 3-Min. SI Interruption

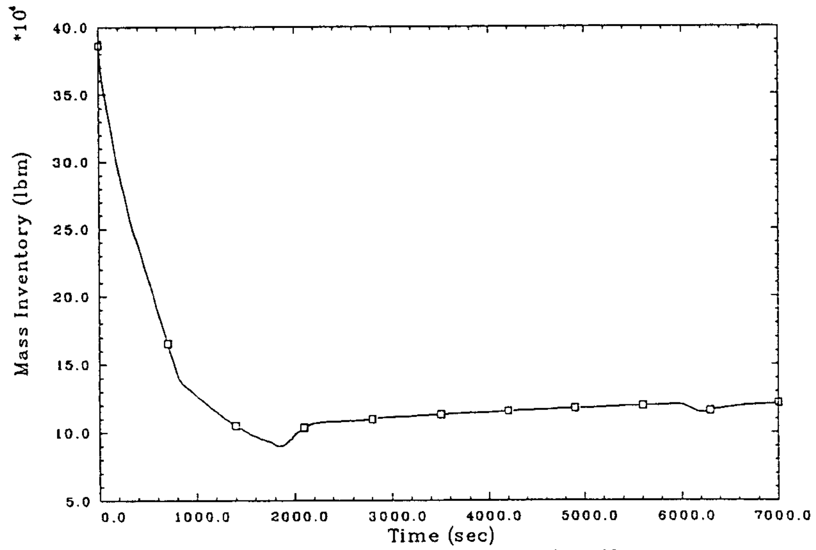

Figure 3.58 Total Primary System Mass
2.5-Inch SBLOCA, 3-Min. SI Interruption

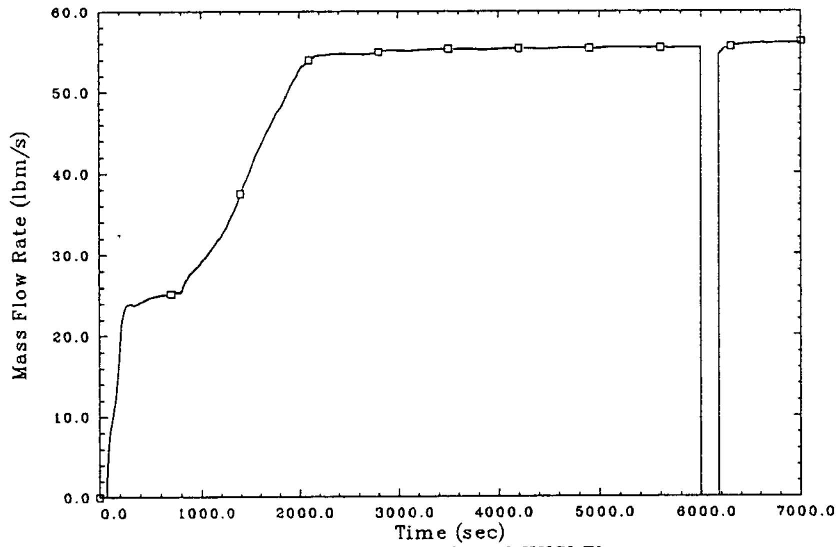

Figure 3.59 Combined HHSI Flow
2.5-Inch SBLOCA, 3-Min. SI Interruption

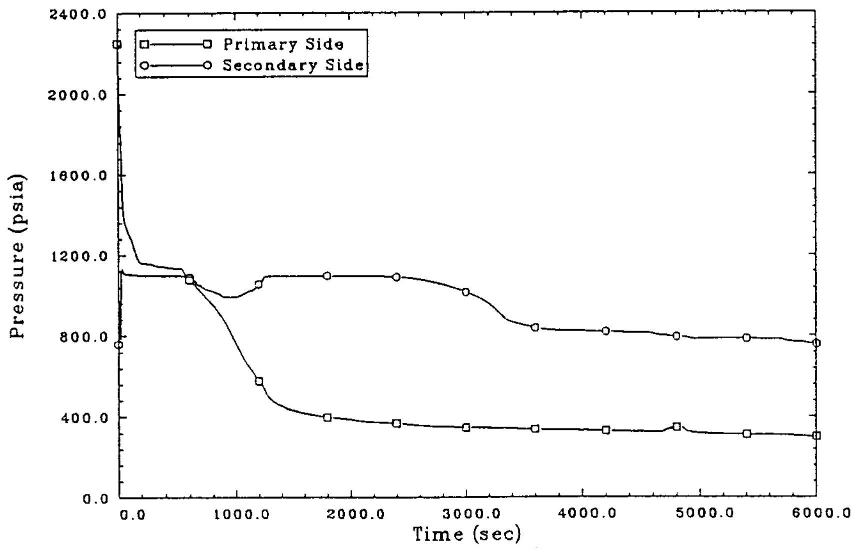

Figure 3.60 System Pressure
3.0-Inch SBLOCA, 3-Min. SI Interruption

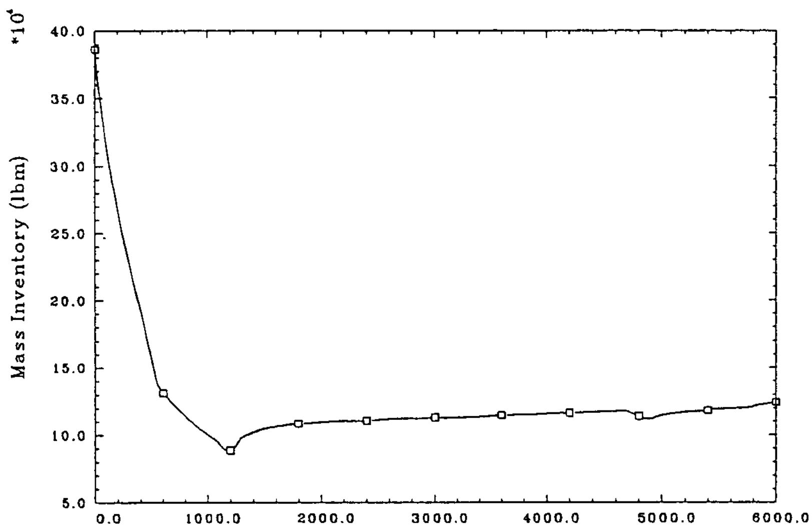

Figure 3.61 Total Primary System Mass
3.0-Inch SBLOCA, 3-Min. SI Interruption

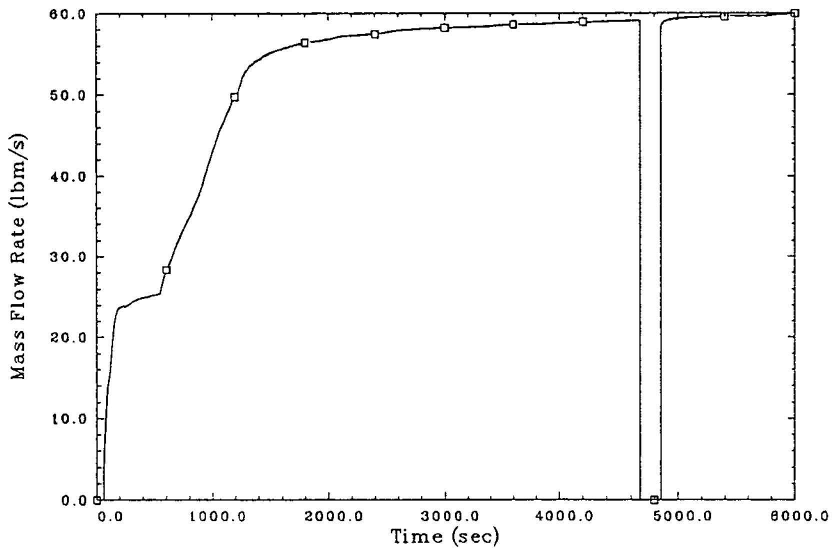

Figure 3.62 Combined HHSI Flow
3.0-Inch SBLOCA, 3-Min. SI Interruption

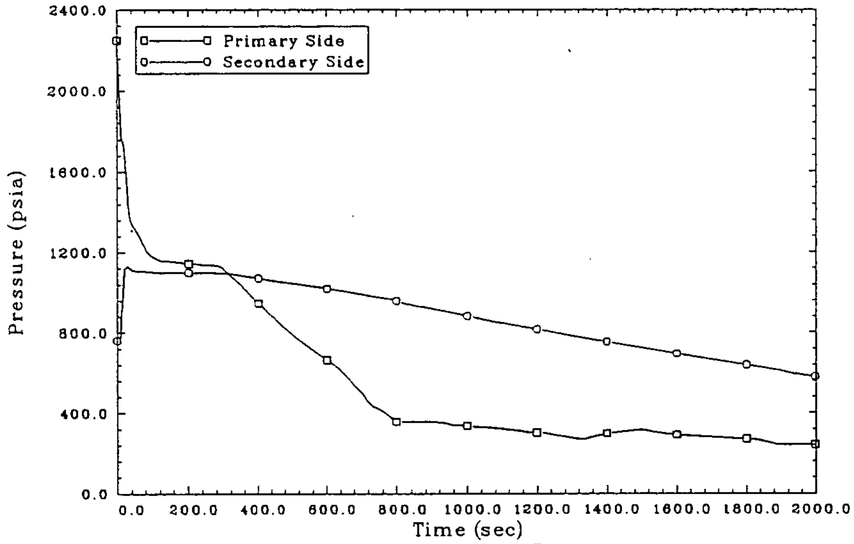

Figure 3.63 System Pressure
4.0-Inch SBLOCA, 3-Min. SI Interruption

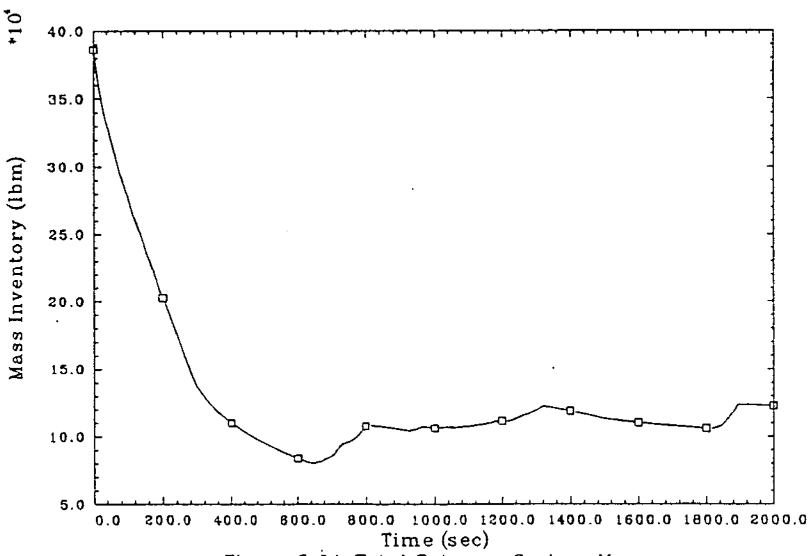

Figure 3.64 Total Primary System Mass
4.0-Inch SBLOCA, 3-Min. SI Interruption

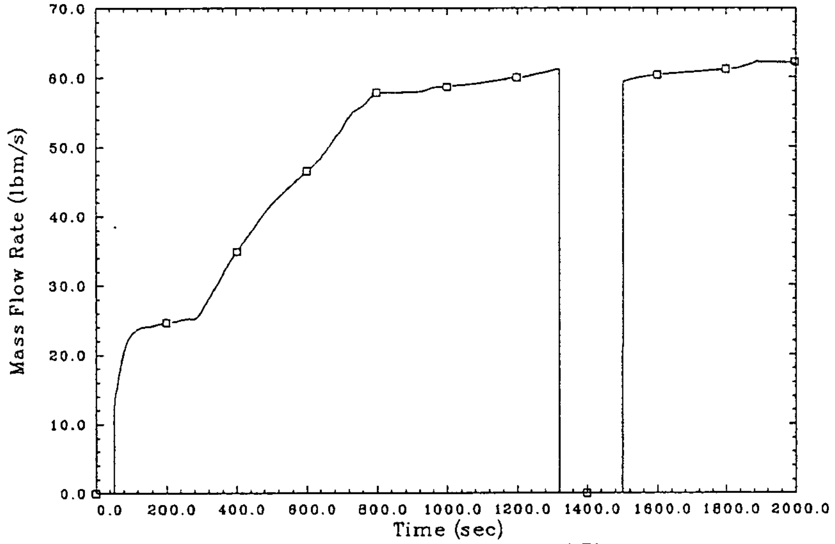

Figure 3.65 Combined HHSI Flow
4.0-Inch SBLOCA, 3-Min. SI Interruption

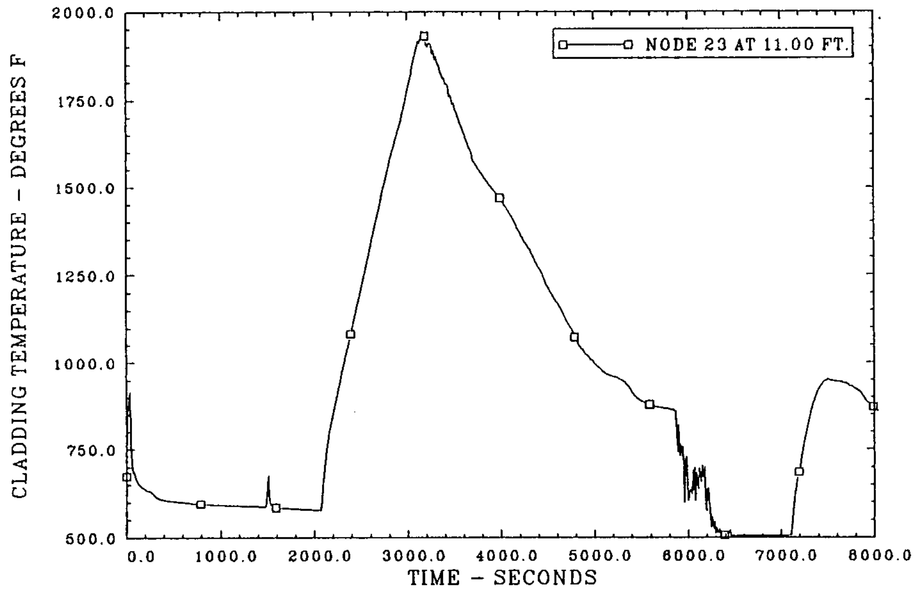

Figure 3.66 Secondary Heatup
2.0-Inch SBLOCA, 3-Min. SI Interruption

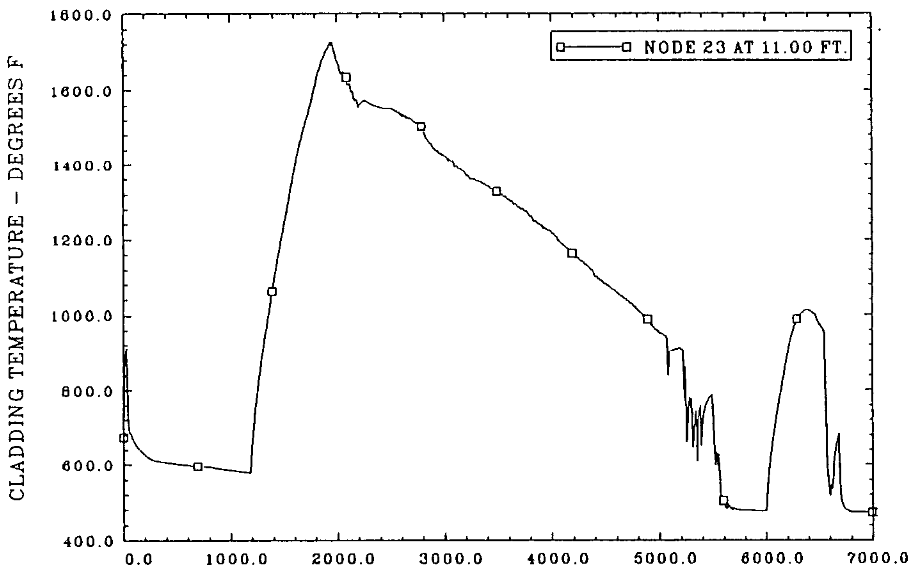

Figure 3.67 Secondary Heatup
2.5–Inch SBLOCA, 3–Min. SI Interruption

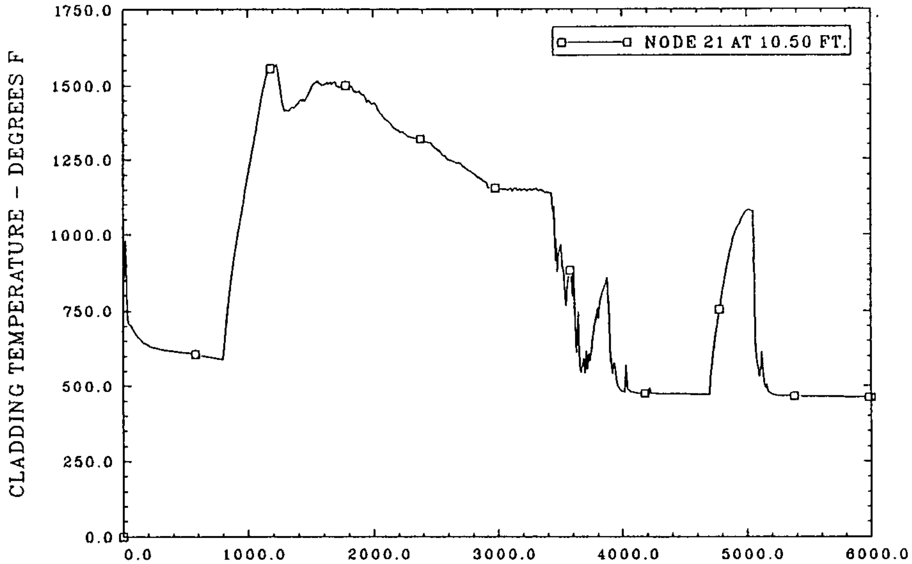

Figure 3.68 Secondary Heatup
3.0-Inch SBLOCA, 3-Min. SI Interruption

4.0 CONCLUSIONS

The small-break LOCA analysis for H. B. Robinson Steam Electric Plant Unit 2 identified the 2-inch diameter break SBLOCA to be the limiting break for the plant. The analysis supports operation of H. B. Robinson Steam Electric Plant Unit 2 at a nominal power level of 2300 Mwt and steam generator tube plugging of up to 6.0%. The analysis also supports a peak LHR of 15.26 Kw/ft and an $F_{\Delta H}$ of 1.75. A three-minute SI interruption, during a transfer to cold leg recirculation procedure, is also supported by the analysis.

Operation of H. B. Robinson Steam Electric Plant Unit 2 with SNP 15x15 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 (ECCS) for H. B. Robinson Steam Electric Plant Unit 2.

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5. "End Path Procedure EPP-9, Transfer to Cold Leg Recirculation," H. B. Robinson SEG Plant, Plant Operating Manual, Volume 3, Part 4, Revision 10, June 1992.

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SMALL BREAK LOCA ANALYSIS

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