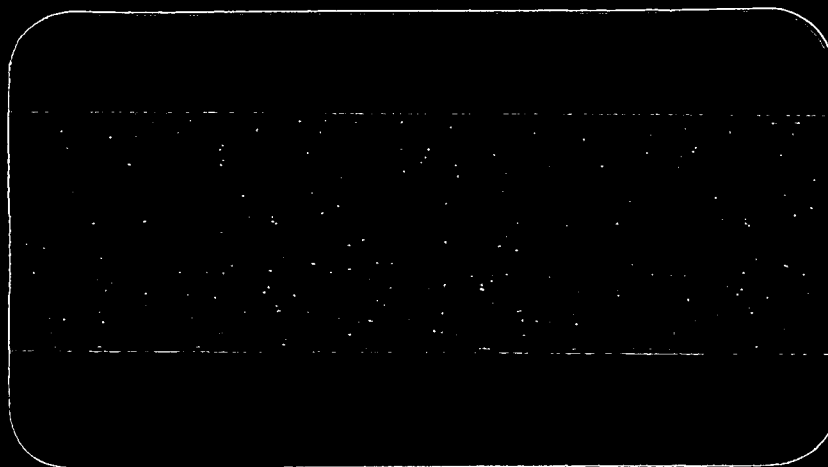


WEC PROPRIETARY CLASS 3



Westinghouse Energy Systems



9206090247 920603
PDR ADDCK 05000261
P PDR

WCAP 13186

**AN EVALUATION OF THE REVISED TRANSFER
TO COLD LEG RECIRCULATION PROCEDURE
H. B. ROBINSON UNIT 2**

January 1992

Westinghouse Electric Corporation
Nuclear and Advanced Technology Division
P. O. Box 355
Pittsburgh, Pennsylvania 15230-0355

©1992 Westinghouse Electric Corporation
All Rights Reserved

WCAP 13186

**AN EVALUATION OF THE REVISED TRANSFER TO
COLD LEG RECIRCULATION PROCEDURE**

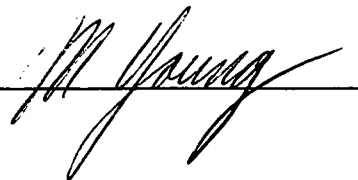
H. B. ROBINSON UNIT 2

January 1992

M. P. Kachmar

Prepared for
Carolina Power and Light Company
by
Westinghouse Electric Corporation

Approved: _____



Westinghouse Electric Corporation
Nuclear and Advanced Technology Division
P. O. Box 355
Pittsburgh, Pennsylvania 15230-0355
©1992 Westinghouse Electric Corporation
All Rights Reserved

Introduction

Formerly the transfer to cold leg recirculation procedure for the H. B. Robinson Unit 2 required that all safety injection (SI) pumps be stopped simultaneously to allow switchover from the injection phase to the cold leg recirculation phase following a loss-of-coolant accident (LOCA). Thus, there was a period of time during which no SI flow would be delivered to the reactor coolant system (RCS). Immediately prior to the brief termination of SI flow from the high head safety injection (HHSI) pump, a residual heat removal (RHR) pump injected to the reactor coolant system for a minimum of one minute. The previous Emergency Operating Procedures (EOP) permitted an interruption in SI flow for as long as 3 minutes following a large break loss-of-coolant accident or as much as 10 minutes following a small break LOCA. Following the interruption in flow during the switchover procedure, a single HHSI pump was available for the delivery of flow into the RCS for any size break. During the recirculation phase of a small break LOCA, the RHR pump does not inject directly into the RCS but takes suction from the containment sump and provides flow to the single HHSI pump and the containment spray (CS) pumps.

Subsequent to the determination of the effects of a 10 minute termination of all of the SI pumps simultaneously during the switchover to recirculation in reference 1, an additional investigation into the effects of only a 3 minute interruption in SI was performed for the SBLOCA. This investigation, performed with only a single HHSI pump available subsequent to the termination period, is the subject of this report. It is noted that the revised cold leg recirculation procedures implemented at H. B. Robinson Unit 2 ensure that no interruption of ECCS flow to the vessel occurs following a large break LOCA, and that only a 3 minute period of interruption, discussed within, occurs for the small break LOCA.

Small Break Analysis

The results of the H. B. Robinson Unit 2 ECCS performance analysis in response to a small break LOCA are documented in reference 2. A spectrum of small break LOCA events ranging from a 1.0" break to a 3.0" break were postulated as part of these analyses. Each case was performed using the Westinghouse NOTRUMP Evaluation Model (references 3 and 4) and calculated the PCT results based upon the performance of only a single HHSI pump. Previously, long term analyses of both a 1.5" break case and a 3.5" SBLOCA break case were performed in reference 1. These analyses modeled a termination of SI for a period of 10 minutes at a time in the transient before the actual calculated switchover time. For the 1.5" break case, the SI termination was modeled at 10,000 seconds following break initiation. As given in reference 1, the actual calculated switchover time was on the order of 10,800 seconds for the 1.5" break case.

Results

The analysis of the 1.5" small break LOCA with a termination of SI for 3 minutes was performed using the same methodology and assumptions as that of the 10 minute case documented in reference 1. As seen in table 1 below, while a secondary clad heat-up period ensued following the termination of safety injection flow for the 3 minute case, this clad temperature excursion was much less limiting than the initial peak-clad-temperature reported in reference 5, and significantly less than that calculated following the 10 minute period of interruption. A comparison of the results from each of the 1.5" SBLOCA cases postulated is given in the following table. It is noted that in the case of the 3 minute interruption of SI, the secondary peak clad temperature occurred at an elevation other than that at which the initial peak clad temperature was calculated.

Table 1

<u>Break Case</u>	<u>PCT</u>	<u>NOSI Period</u>	<u>NO SI PCT</u>
1.5"	1991 °F*	10 minutes	1936 °F
1.5"	1991 °F* @12'	3 minutes	1009 °F @12'
1.5"	1991 °F* @12'	3 minutes	1090 °F @11.5'

* See Note on Page 5

In order to facilitate a comparison of the two cases, the results are depicted graphically in Figures 1 through 24. A description of each of these figures follows:

<u>Figure</u>		<u>Title</u>
<u>1.5" Case</u> <u>3 Minute NOSI</u>	<u>1.5" Case</u> <u>10 Minute NOSI</u>	
1	14	<i>RCS Pressure</i>
2	15	<i>Core Mixture Level</i>
3	16	<i>Downcomer Mixture Level</i>
4	17	<i>Total Mixture Mass of RCS</i>
5	18	<i>Core Outlet Vapor Flow</i>
6	19	<i>Break Vapor Flow</i>
7	20	<i>Pumped Safety Injection Flow</i>
8	21	<i>Core Top Node Void Fraction</i>
9	22	<i>Top Core Vapor Temperature</i>
10	23	<i>Upper Plenum Vapor Temperature</i>
11	24	<i>Clad Temperature at 12.0' ⁽¹⁾</i>
12		<i>Clad/Fluid Temperature at 11.5'</i>
13		<i>Clad/Fluid Temperature at 11.0'</i>

(1) Clad Temperature at Primary PCT Elevation

* This PCT differs from that of reference 2 as a result of modifications made to the clad heat-up Small Break LOCTA computer code. These modifications were reported in reference 5. The use of this code version ensures consistency with the calculations performed in support of the SI termination analyses.

Conclusion - SBLOCA Analysis

As seen from these figures and the discussion provided above, the clad temperature transient following the 3 minute interruption in safety injection is much less than the PCT calculated before the initiation of the switchover procedure. Specifically, in the case of the 1.5" break, approximately 900°F of margin was calculated between the first clad temperature peak and that which occurred following the three minute interruption period. As such, the termination of the single HHSI pump for no more than 3 minutes at the time of initial switchover is acceptable from the perspective of the small break LOCA analysis.

References

- 1) Kachmar, M. P., "An Evaluation of the Revised Transfer to Cold Leg recirculation Procedure - H. B. Robinson Unit 2", WCAP 13071 (Proprietary), WCAP 13072 (Non-Proprietary), September, 1991.
- 2) Osterrieder, R. A., "Small Break LOCA Analyses with One High Head Safety Injection Pump Available for the H. B. Robinson Plant", WCAP-12034, October, 1988.
- 3) Meyer, P. E., "NOTRUMP - A Nodal Transient Small Break and General Network Code", WCAP-10079-P-A, August, 1985.
- 4) Lee, N., et. al., "Westinghouse Small Break ECCS Evaluation Model Using the NOTRUMP Code", WCAP-10054-P-A, August, 1985.
- 5) CPL-91-039, "Carolina Power and Light Company, H.B. Robinson Unit 2 - ECCS Evaluation Model Changes", June 20, 1991.

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

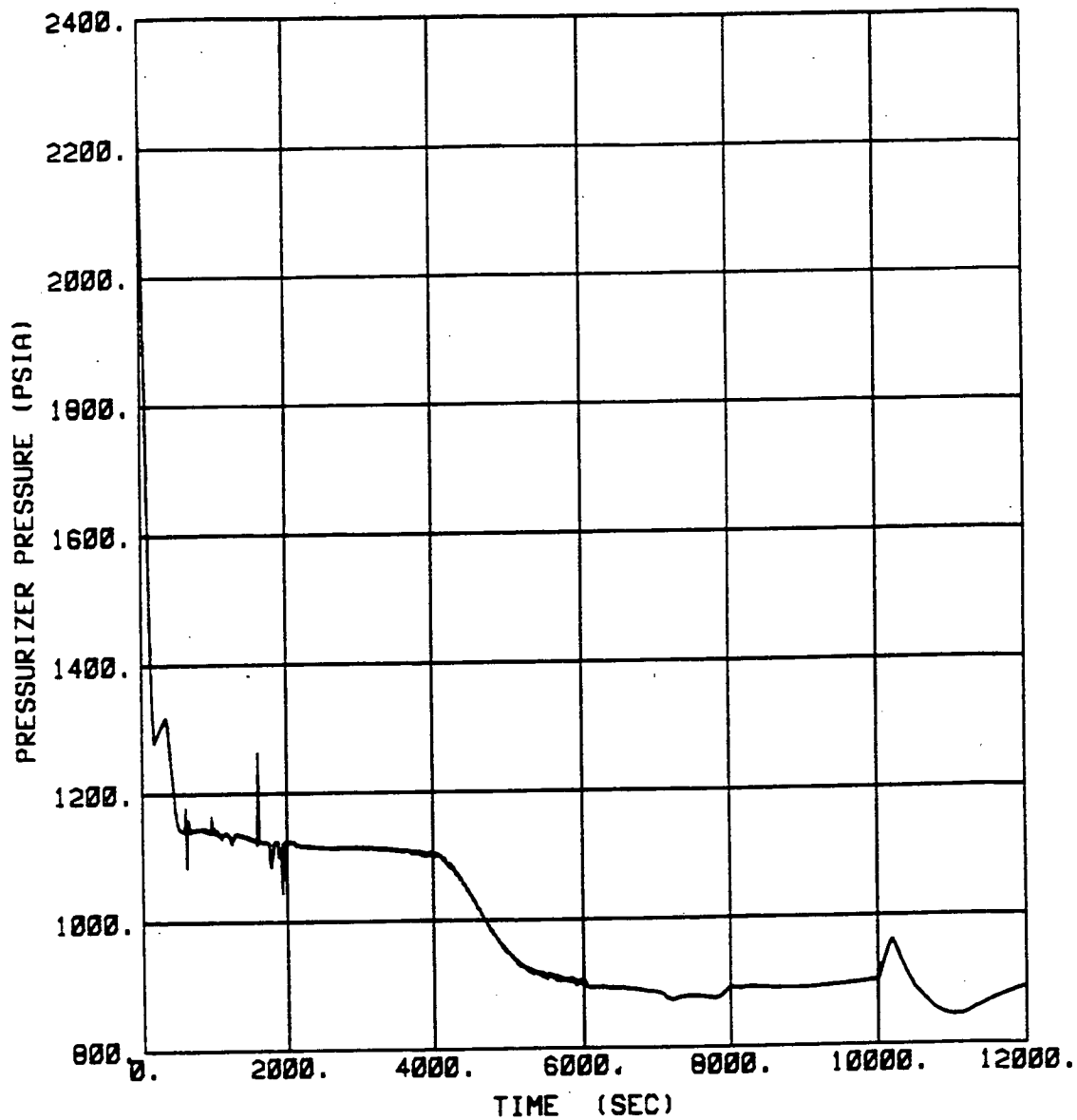
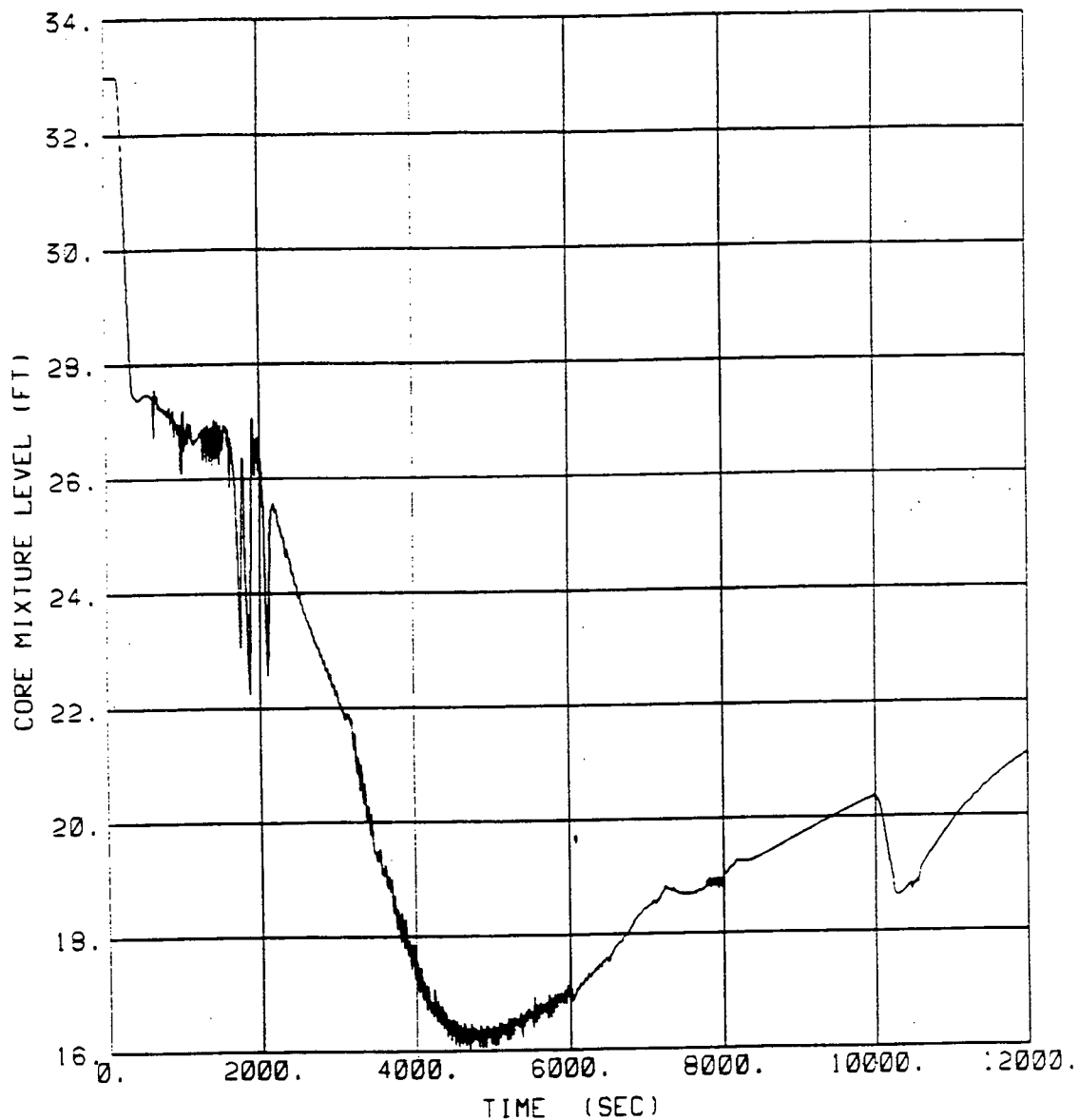


FIGURE 1-PRESSURIZER PRESSURE (PSIA)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION**



**FIGURE 2-CORE MIXTURE LEVEL (FT)
1.5" BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

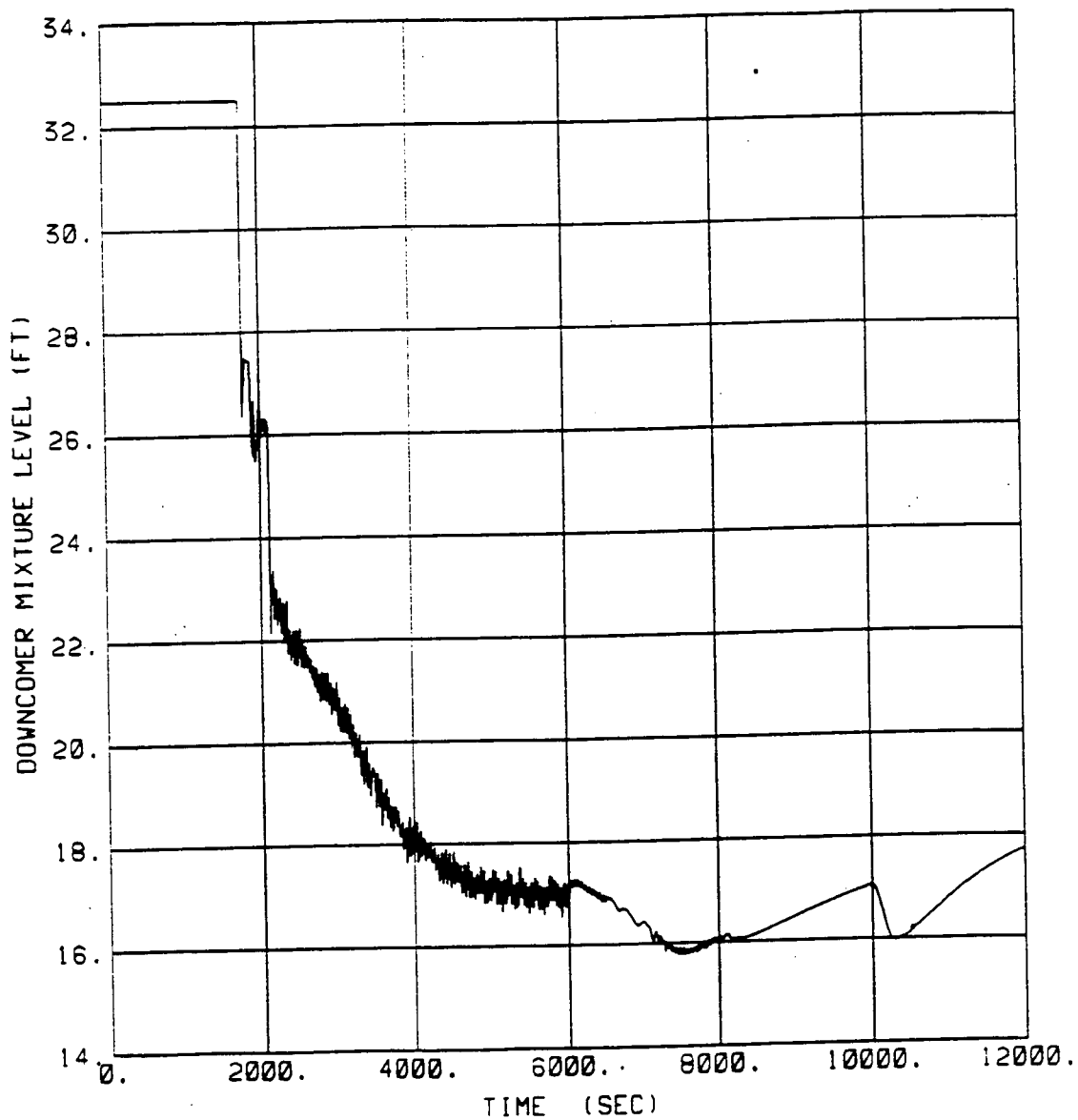


FIGURE 3-DOWNCOMER MIXTURE LEVEL (FT)
1.5" BREAK

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

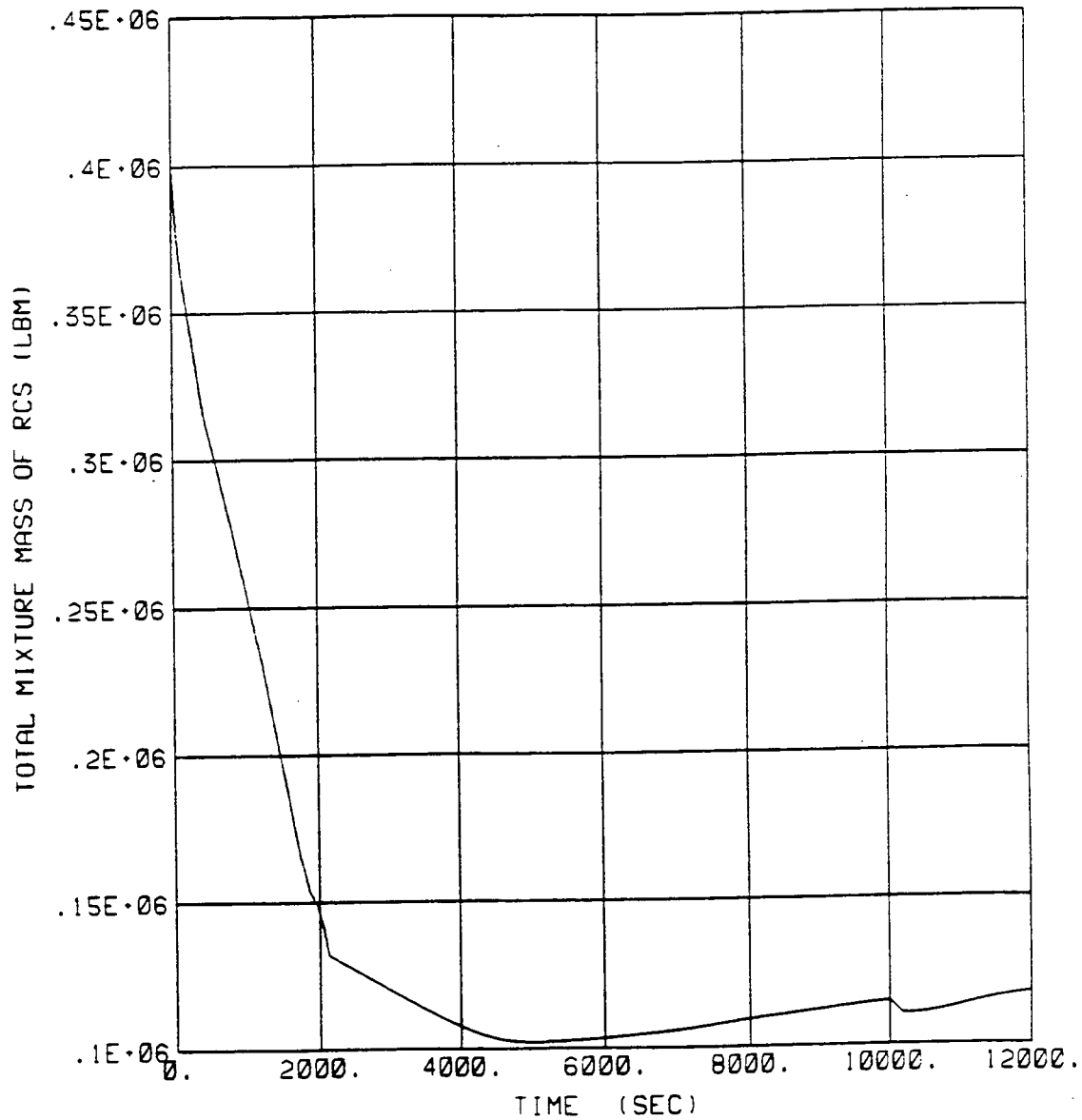


FIGURE 4-TOTAL MIXTURE MASS OF RCS (LBM)
1.5" BREAK

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

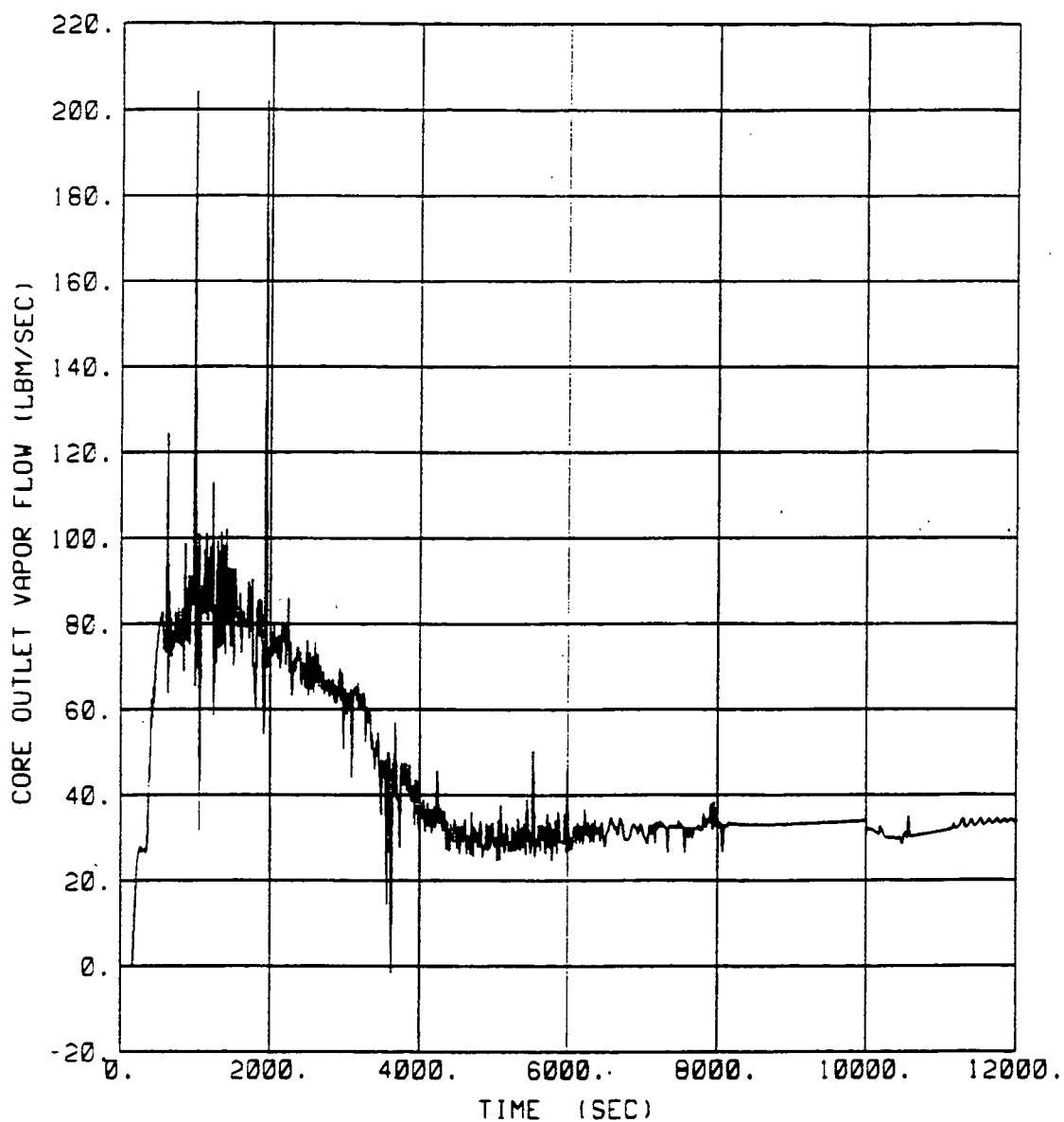


FIGURE 5-CORE OUTLET VAPOR FLOW (LBM/SEC)
1.5" BREAK

H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION

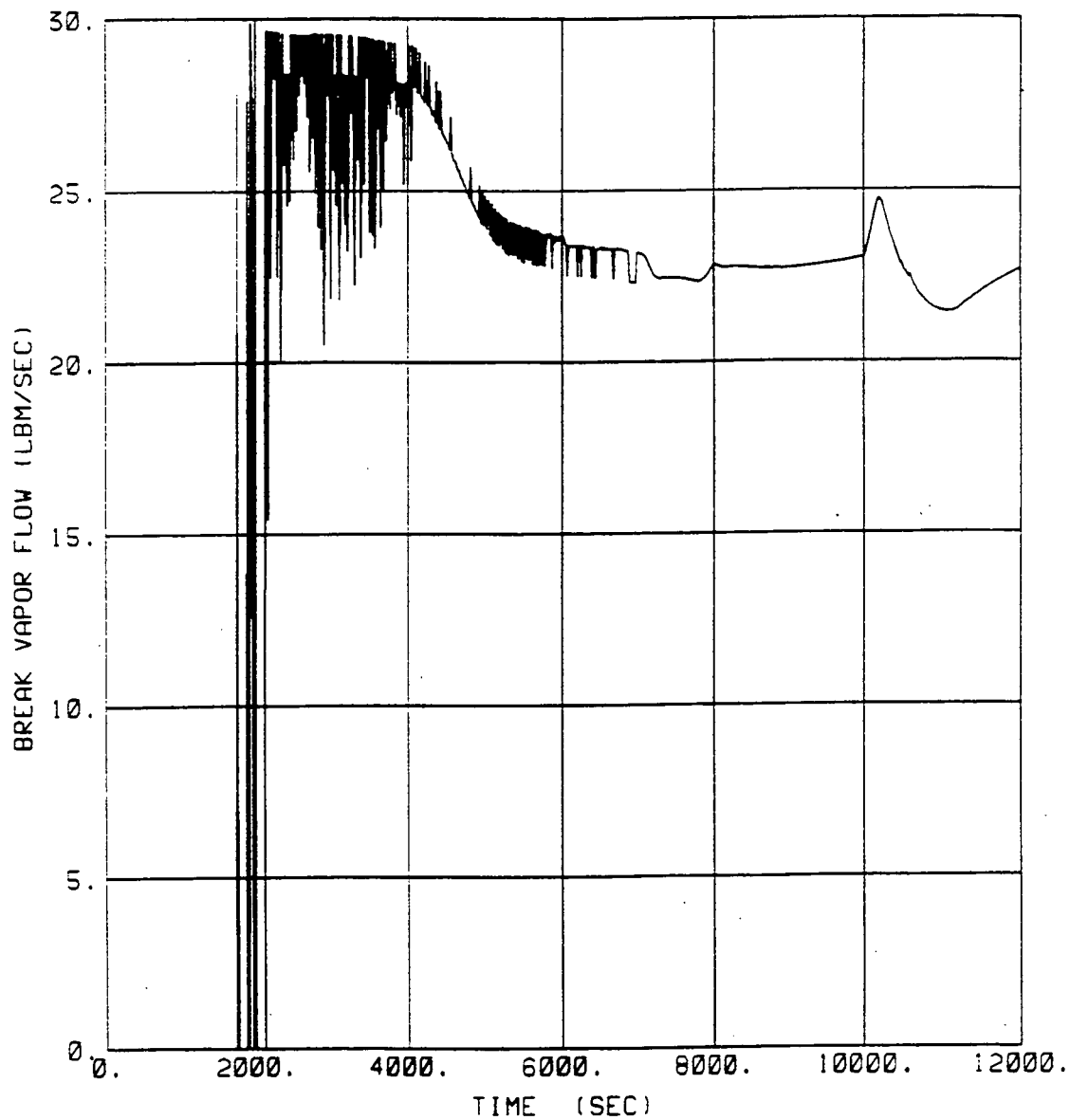


FIGURE 6-BREAK VAPOR FLOW (LBM/SEC)
1.5" BREAK

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

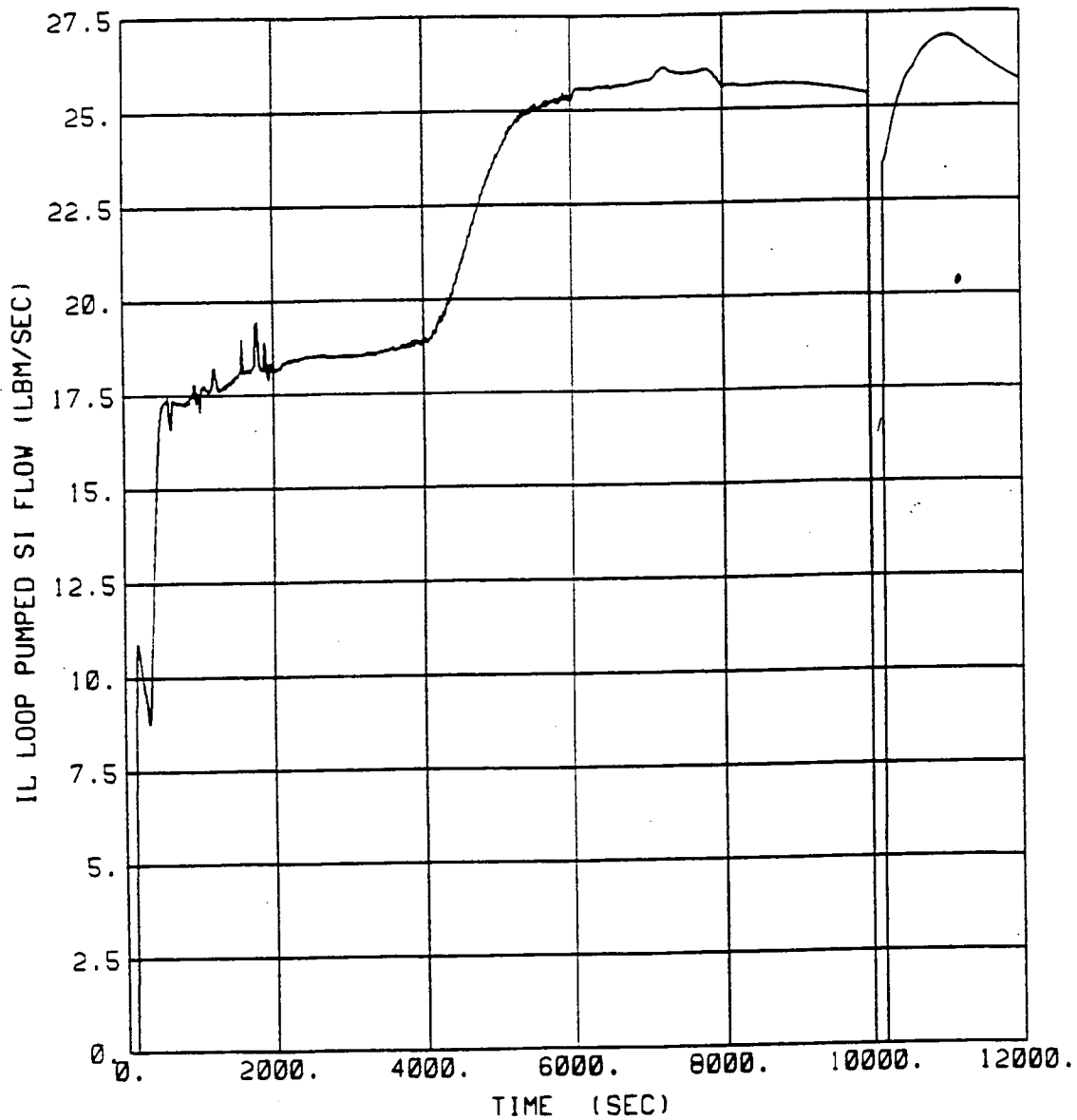


FIGURE 7-IL LOOP PUMPED SI FLOW (LBM/SEC)
1.5" BREAK

H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION

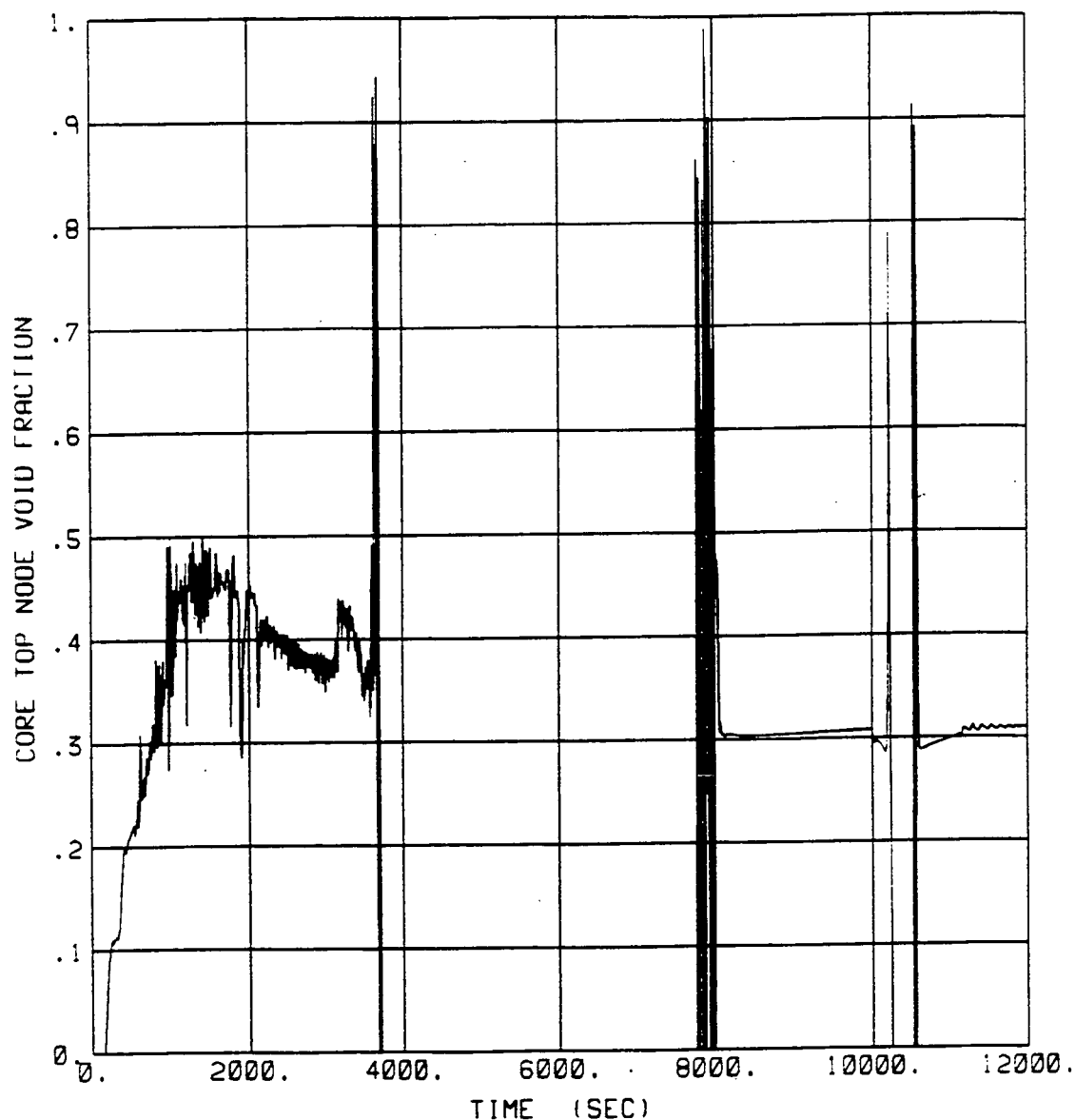
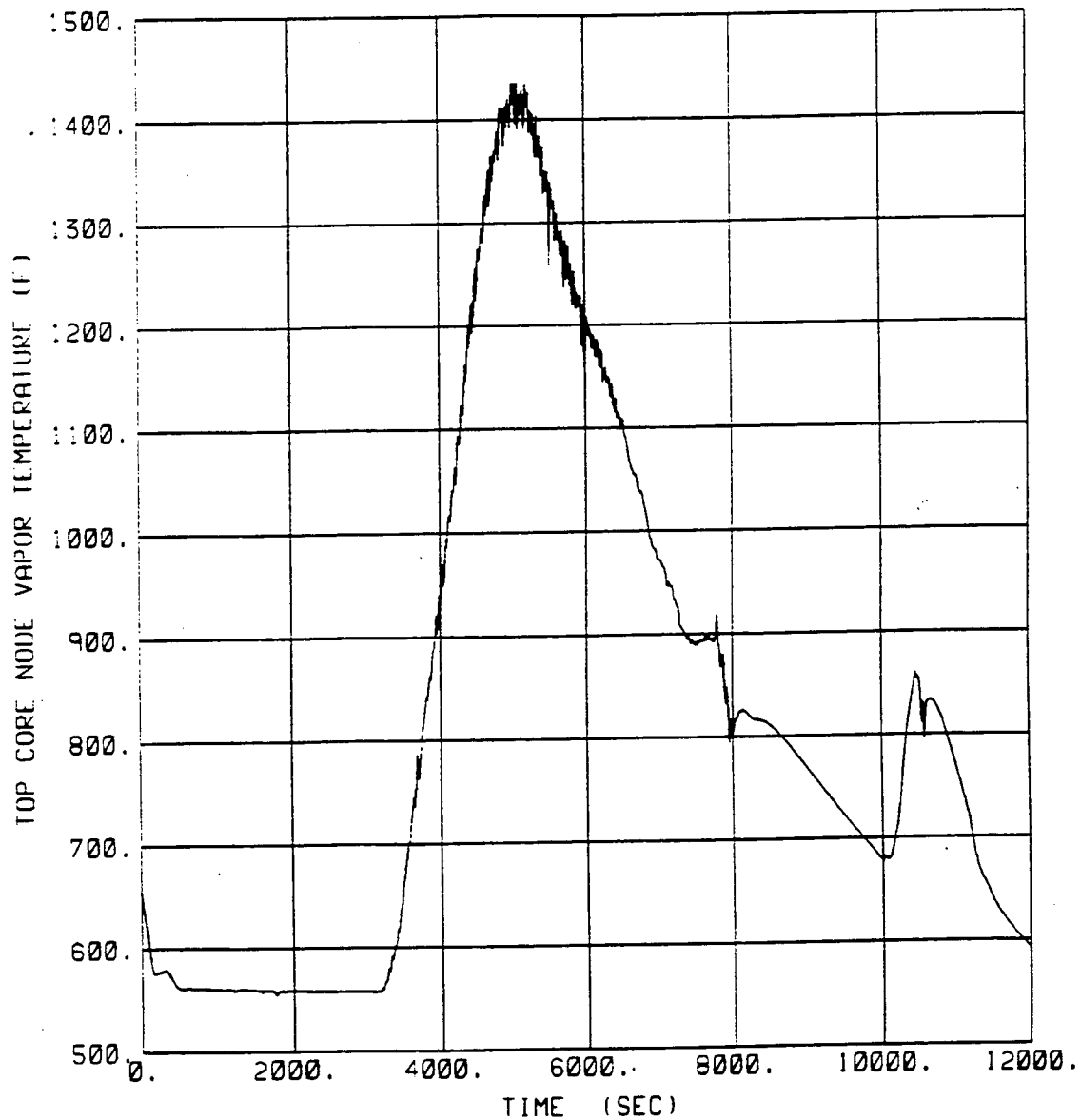


FIGURE 8-CORE TOP NODE VOID FRACTION
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION**



**FIGURE 9-TOP CORE NODE VAPOR TEMPERATURE (F)
1.5" BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

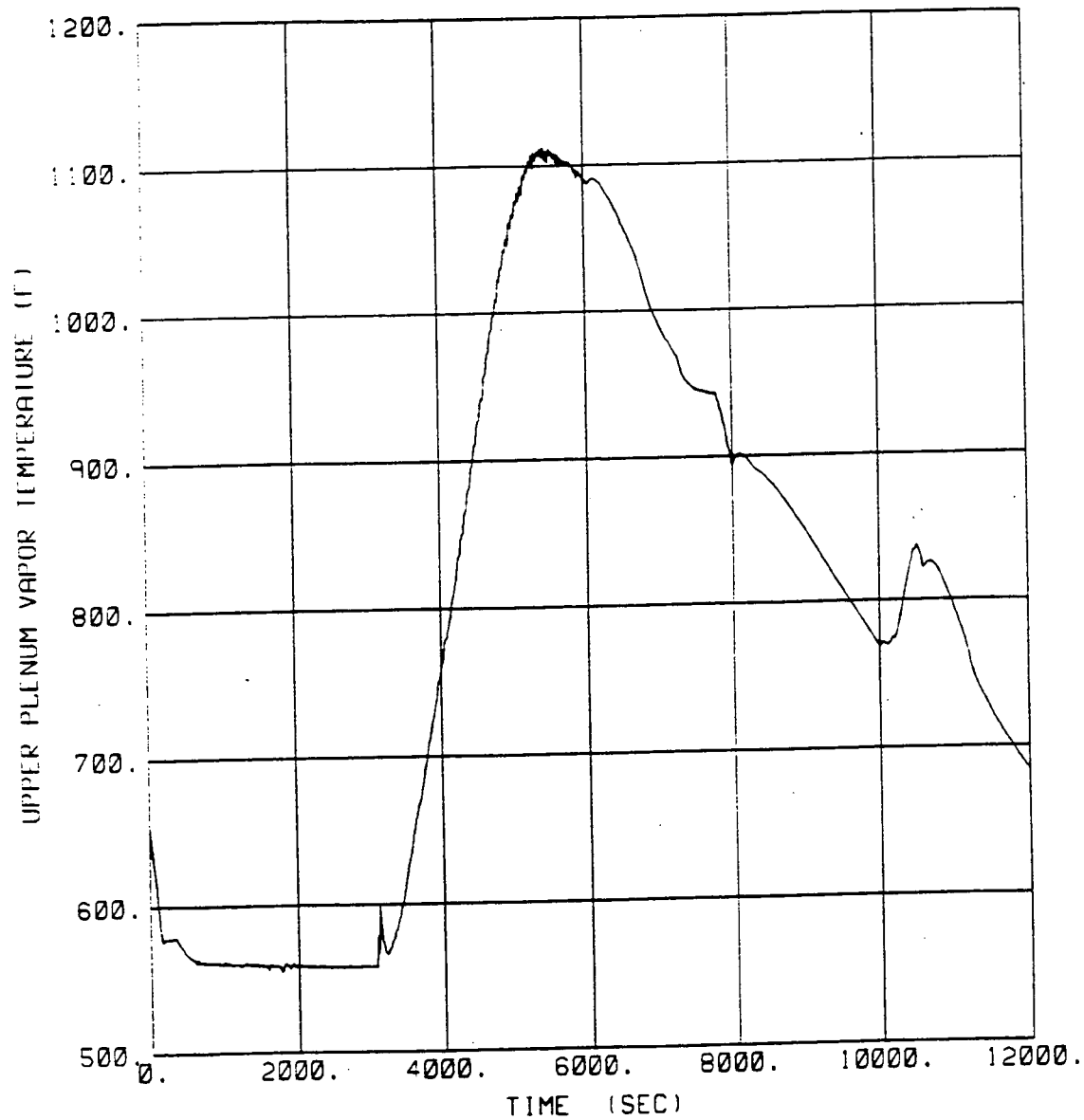
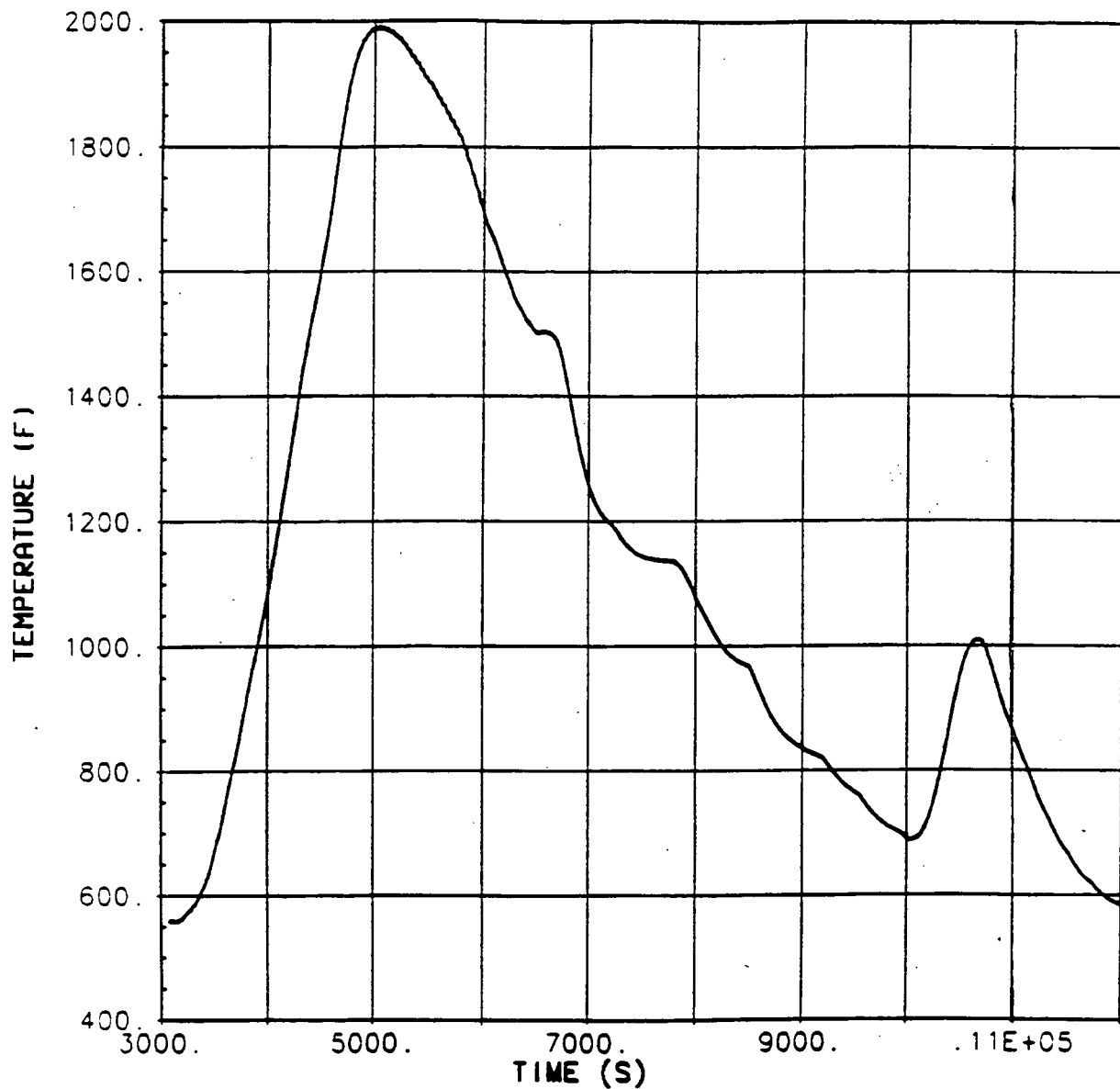


FIGURE 10-UPPER PLENUM VAPOR TEMPERATURE (F)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION**



**FIGURE 11-CLAD TEMPERATURE AT 12.0'
1.5" BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

3 MINUTES SI INTERRUPTION

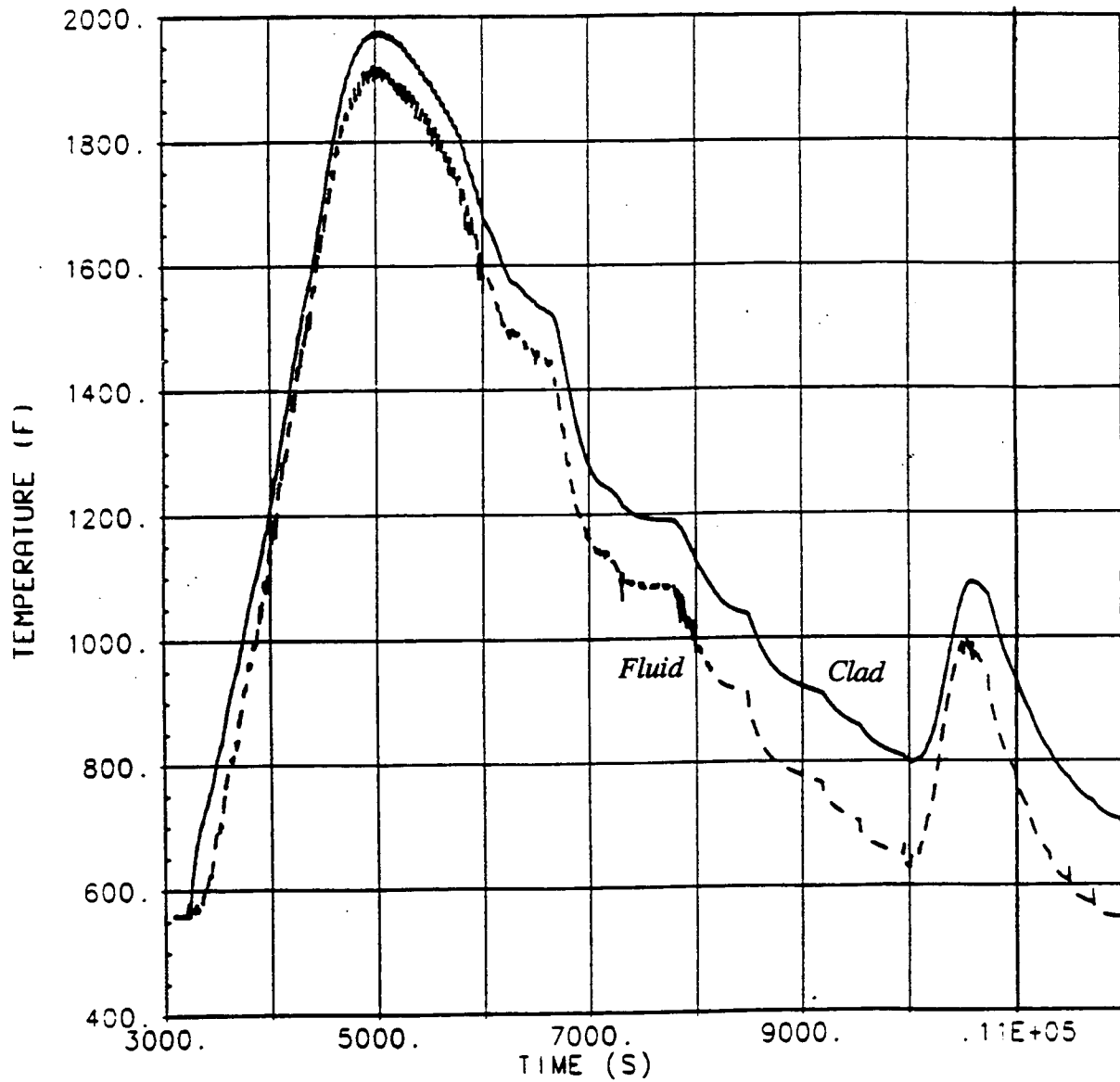
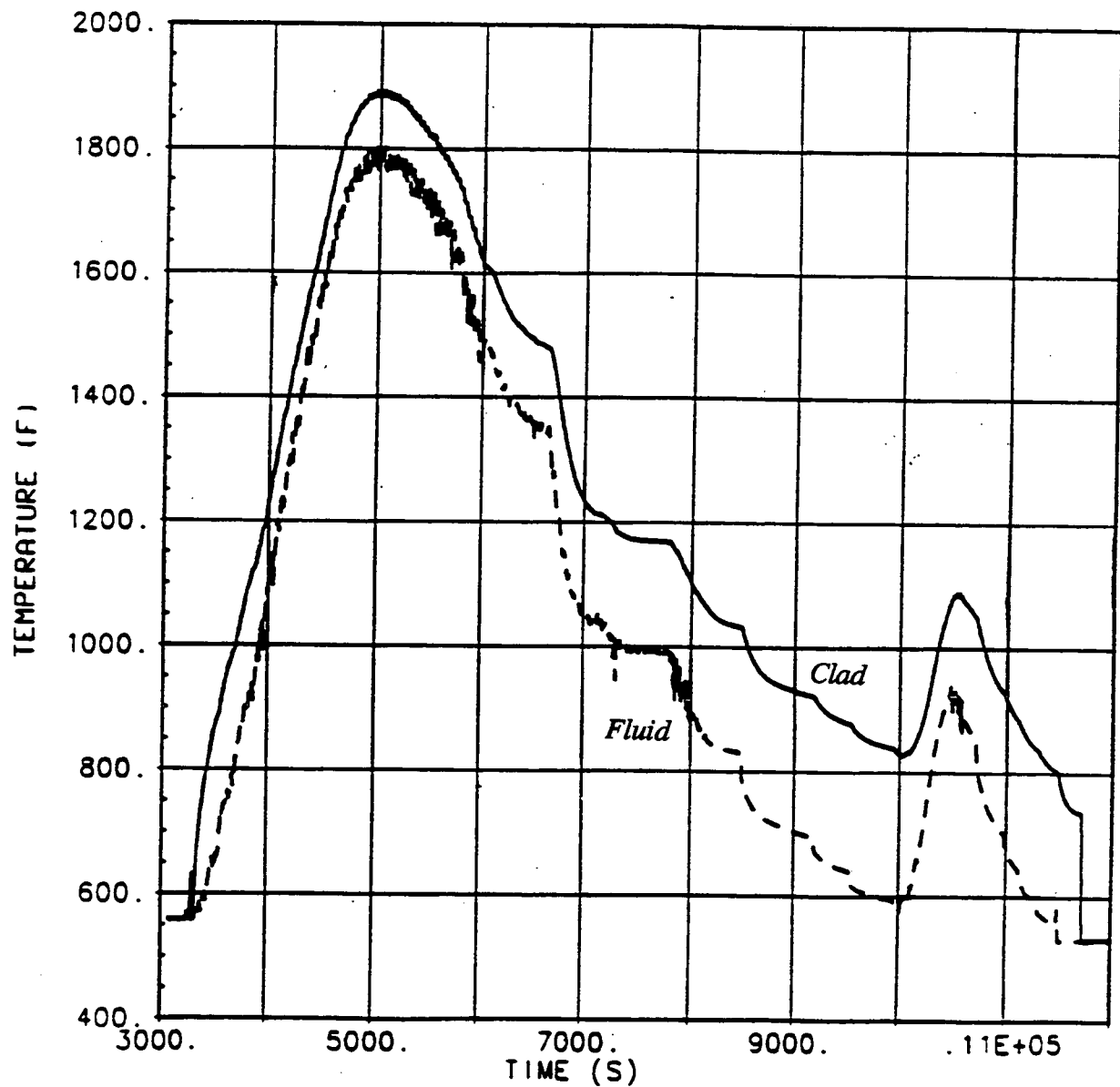


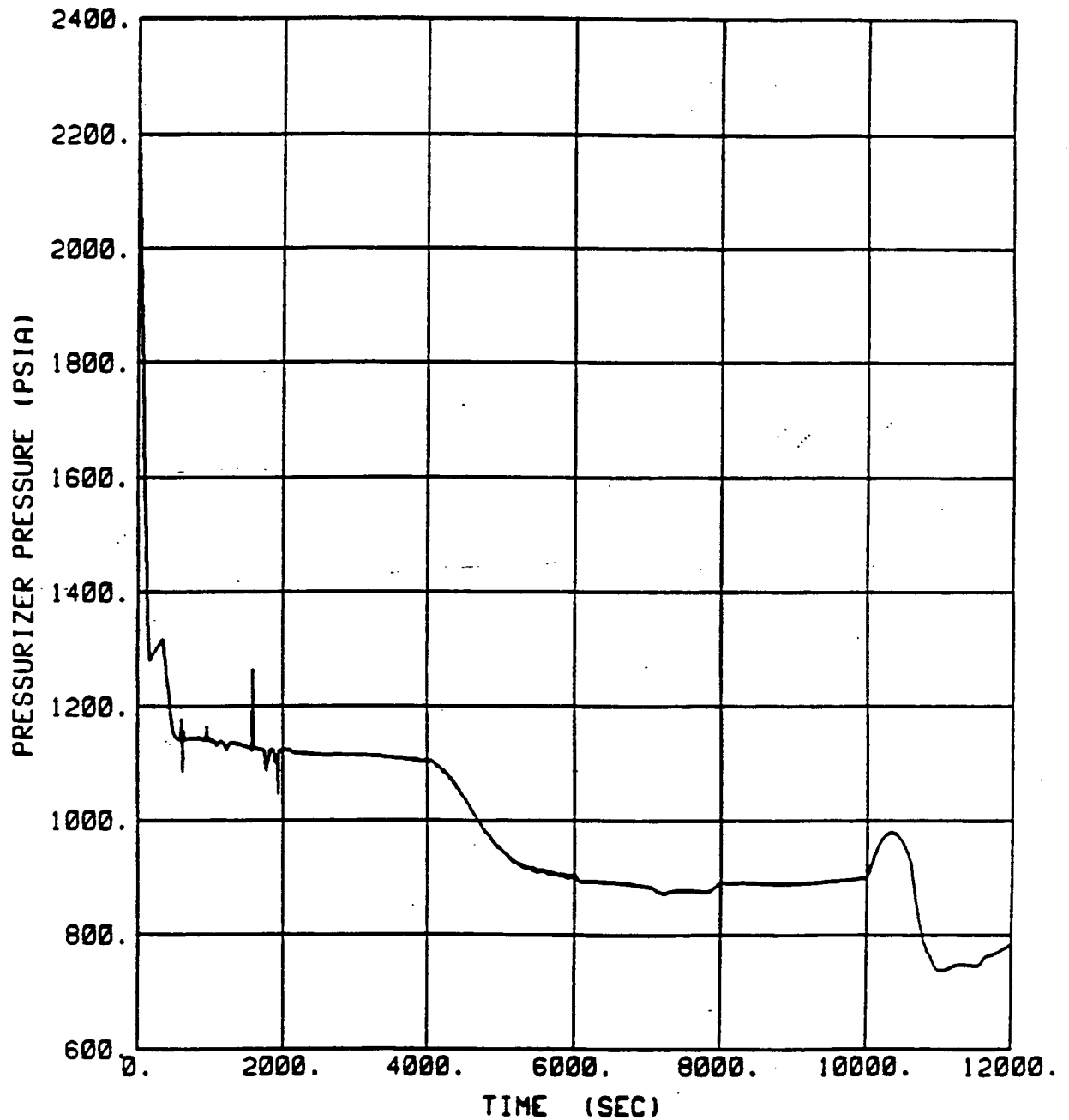
FIGURE 12-CLAD TEMPERATURE AT 11.5'
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
3 MINUTES SI INTERRUPTION**



**FIGURE 13-CLAD TEMPERATURE AT 11.0'
1.5" BREAK**

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
10 MINUTES SI INTERRUPTION**



**FIGURE 14-PRESSURIZER PRESSURE (PSIA)
1.5" BREAK**

H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
10 MINUTES SI INTERRUPTION

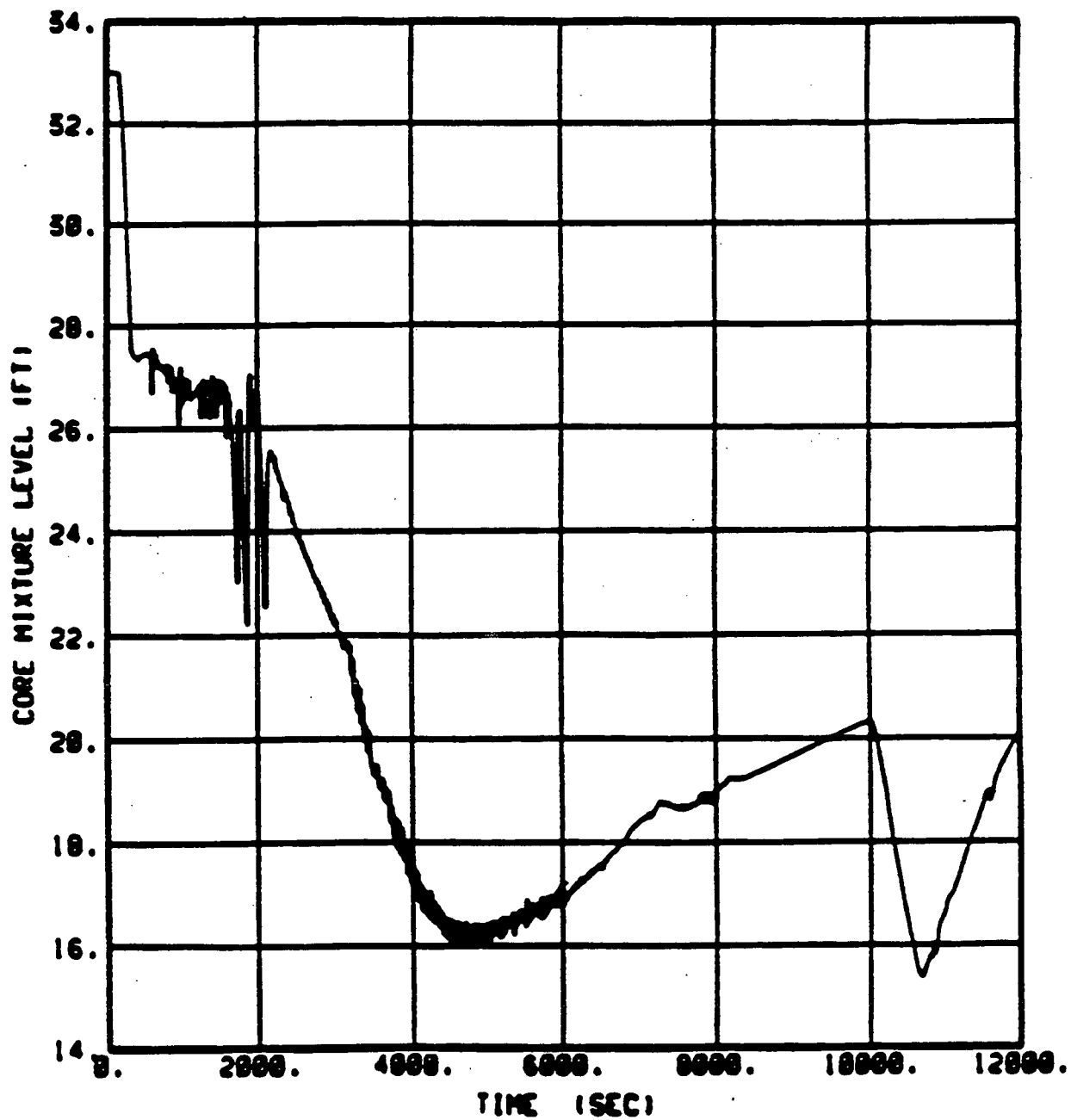
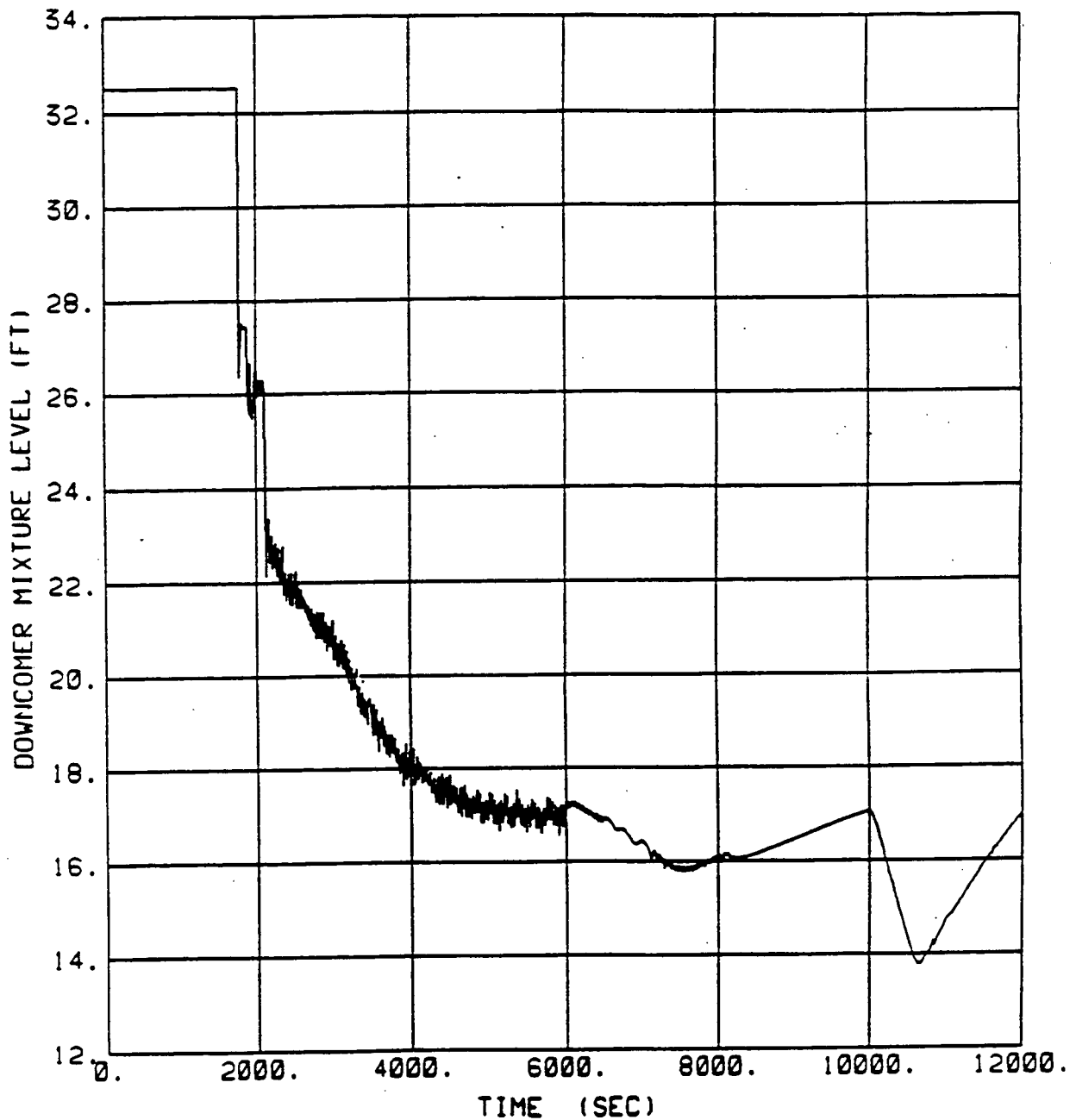


FIGURE 15-CORE MIXTURE LEVEL (FT)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
10 MINUTES SI INTERRUPTION**



**FIGURE 16-DOWNCOMER MIXTURE LEVEL (FT)
1.5' BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

10 MINUTES SI INTERRUPTION

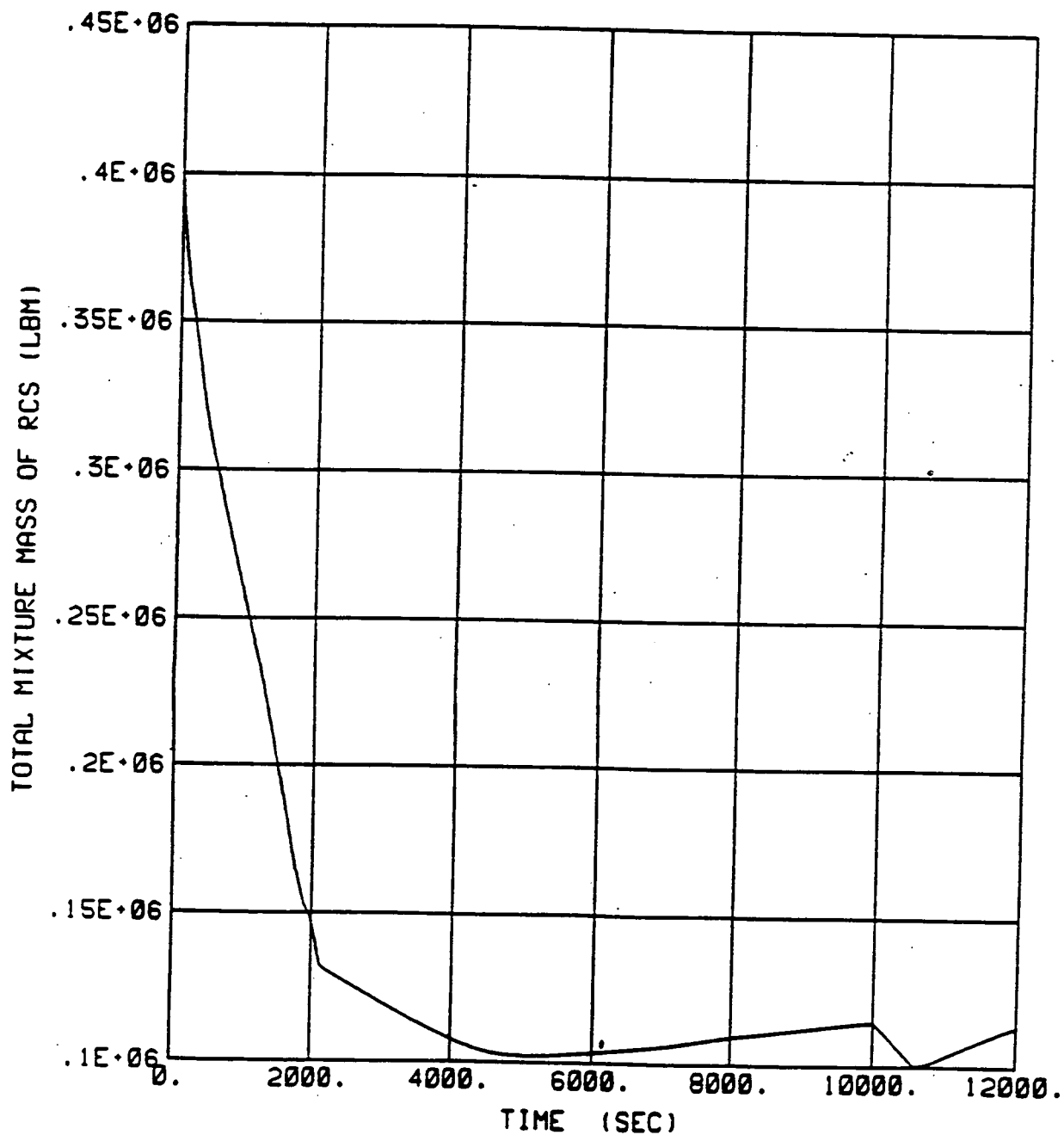
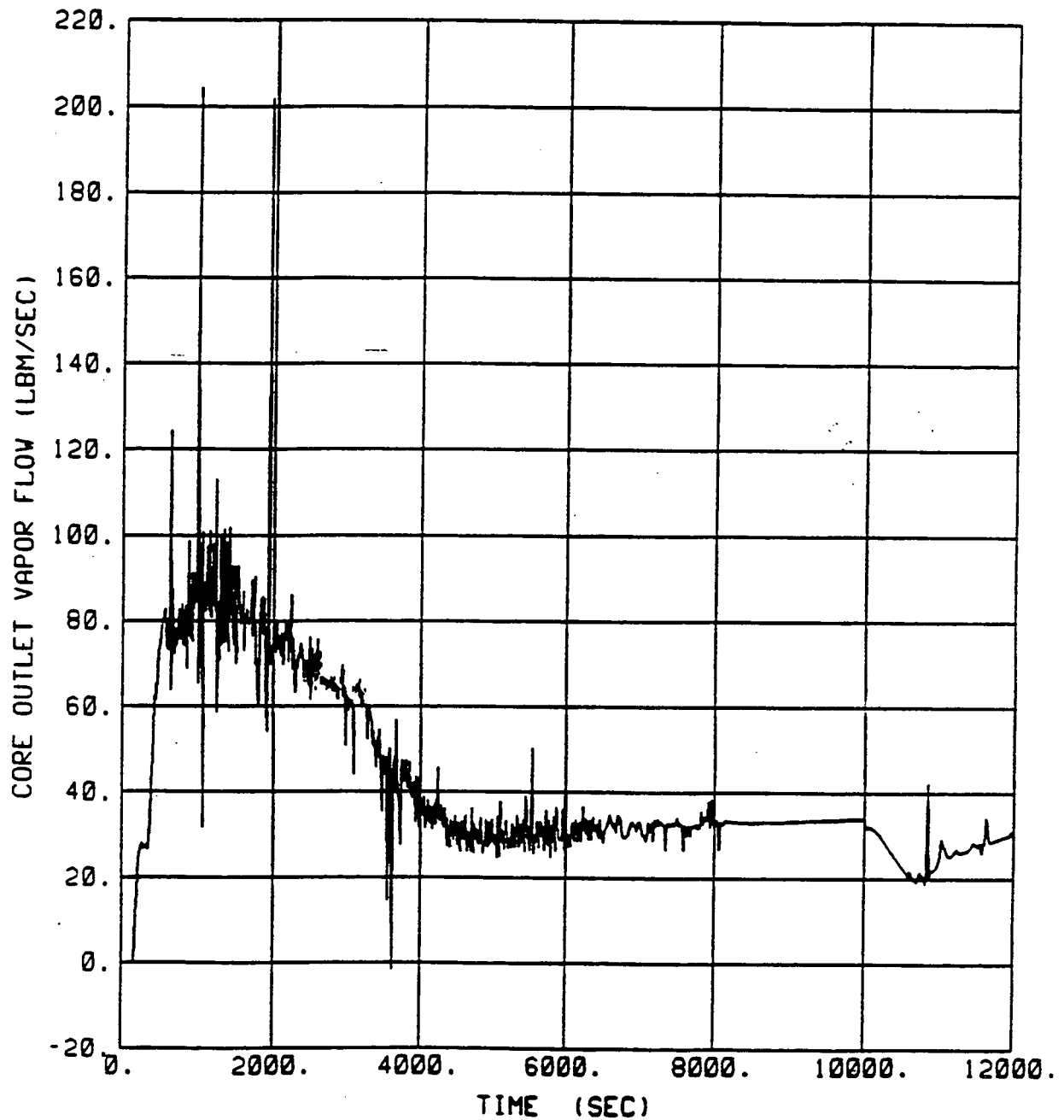


FIGURE 17-TOTAL MIXTURE MASS OF RCS (LBM)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS**

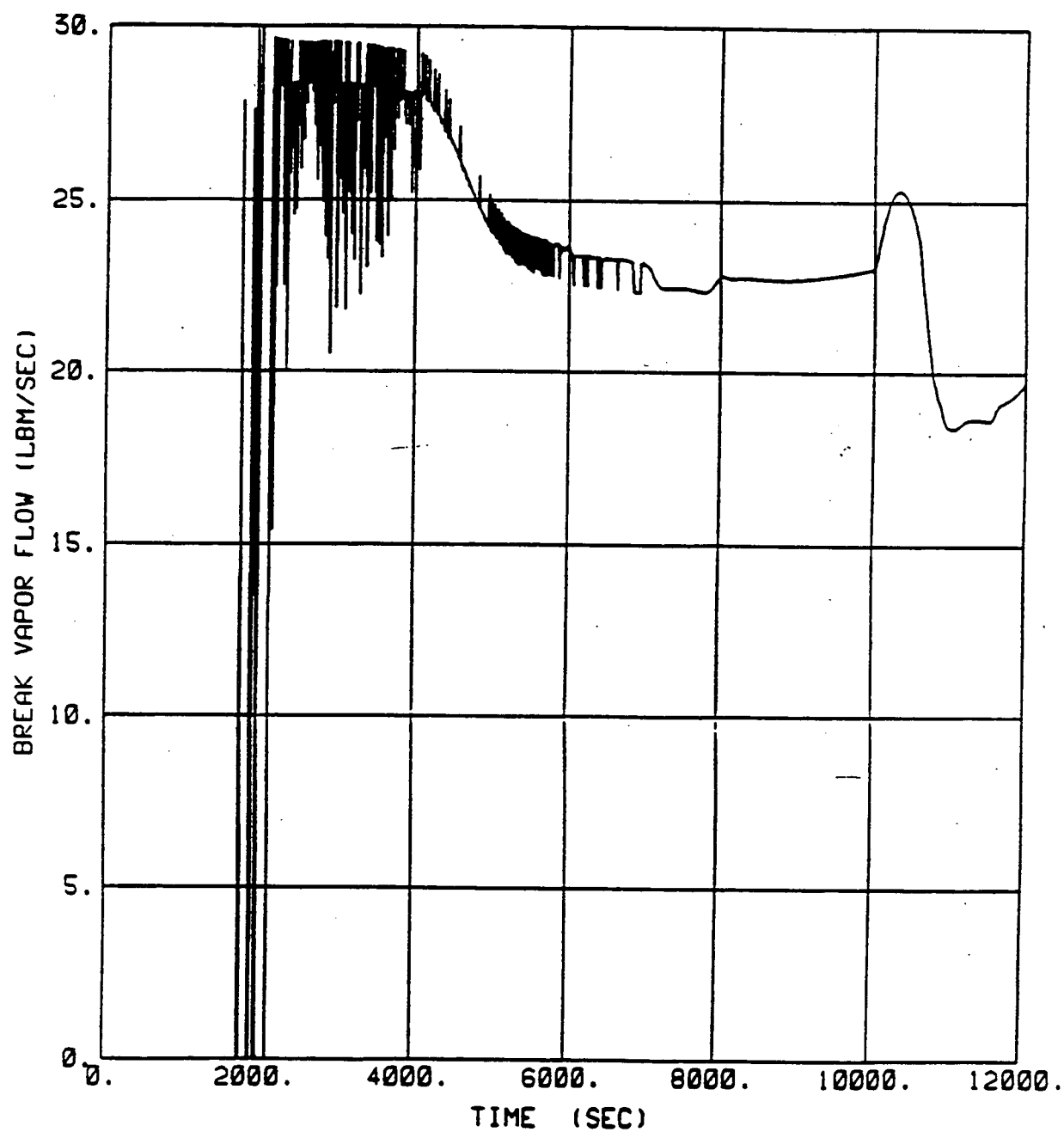
10 MINUTES SI INTERRUPTION



**FIGURE 18-CORE OUTLET VAPOR FLOW (LBM/SEC)
1.5" BREAK**

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS**

10 MINUTES SI INTERRUPTION



**FIGURE 19-BREAK VAPOR FLOW (LBM/SEC)
1.5" BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

10 MINUTES SI INTERRUPTION

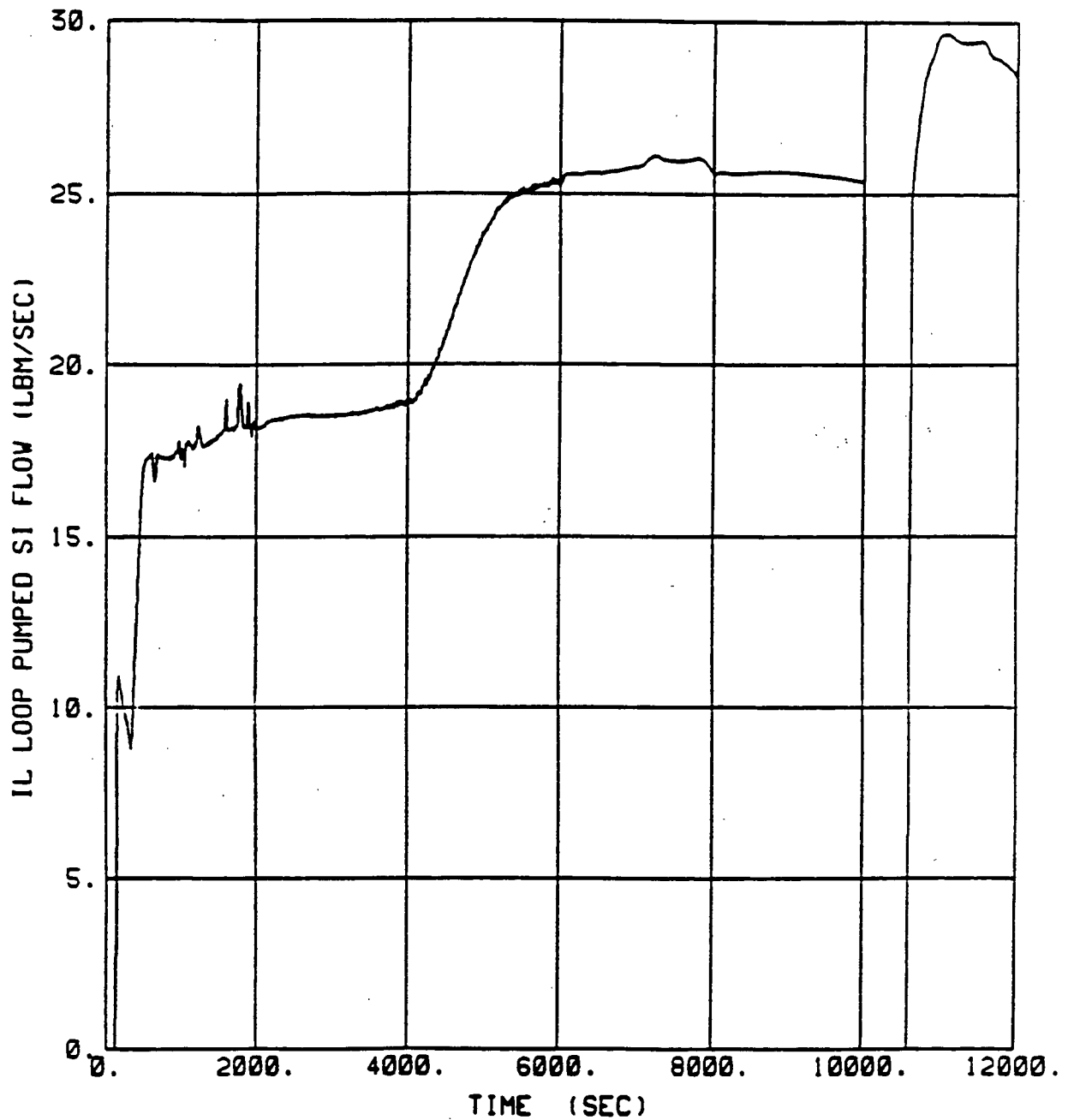
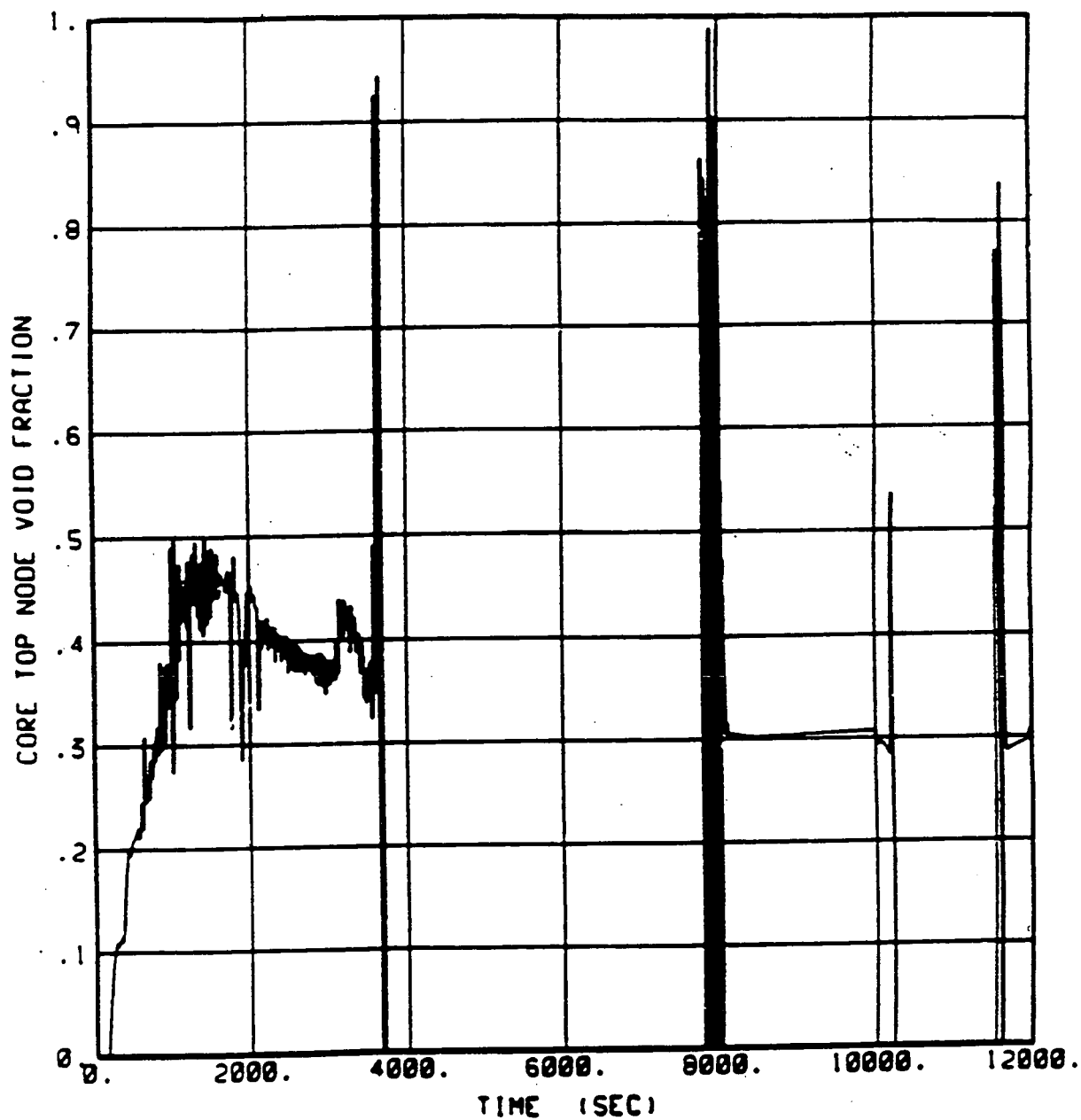


FIGURE 20-IL LOOP PUMPED SI FLOW (LBM/SEC)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS**

10 MINUTES SI INTERRUPTION



**FIGURE 21-CORE TOP NODE VOID FRACTION
1.5" BREAK**

H.B. ROBINSON UNIT 2 1 HHSI SWITCHOVER ANALYSIS

10 MINUTES SI INTERRUPTION

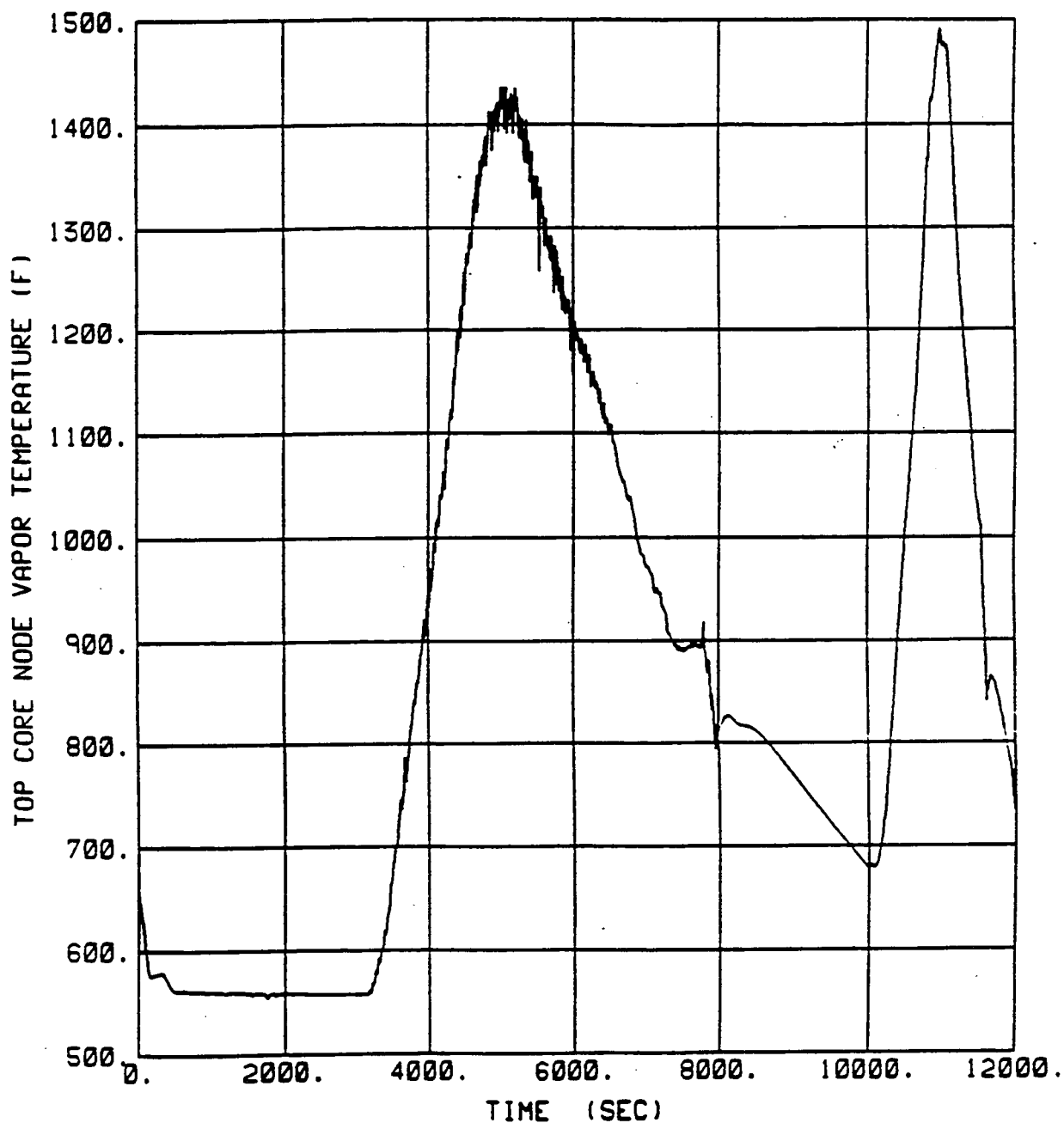
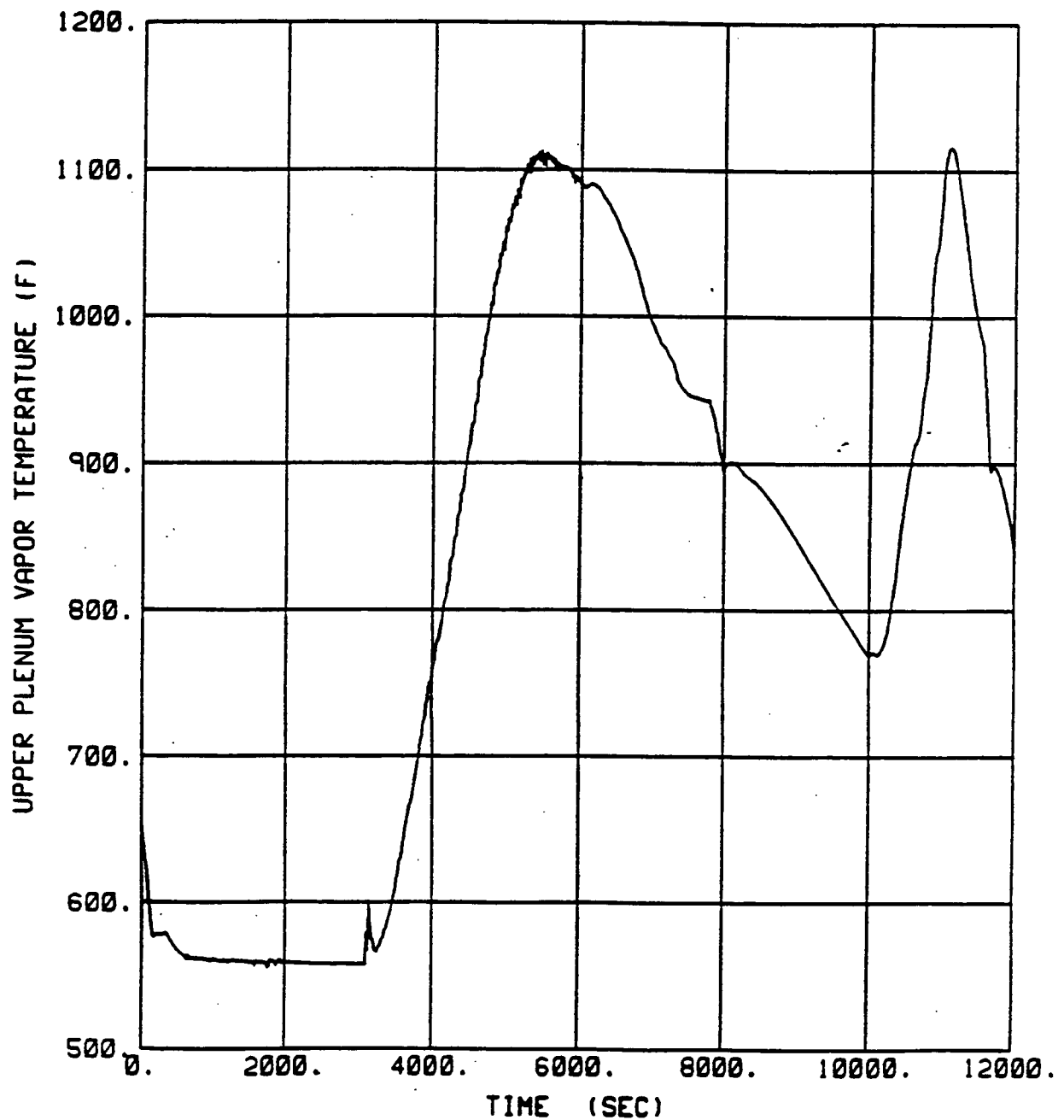


FIGURE 22-TOP CORE NODE VAPOR TEMPERATURE (F)
1.5" BREAK

**H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS**

10 MINUTES SI INTERRUPTION



**FIGURE 23-UPPER PLENUM VAPOR TEMPERATURE (F)
1.5" BREAK**

H.B. ROBINSON UNIT 2
1 HHSI SWITCHOVER ANALYSIS
10 MINUTES SI INTERRUPTION

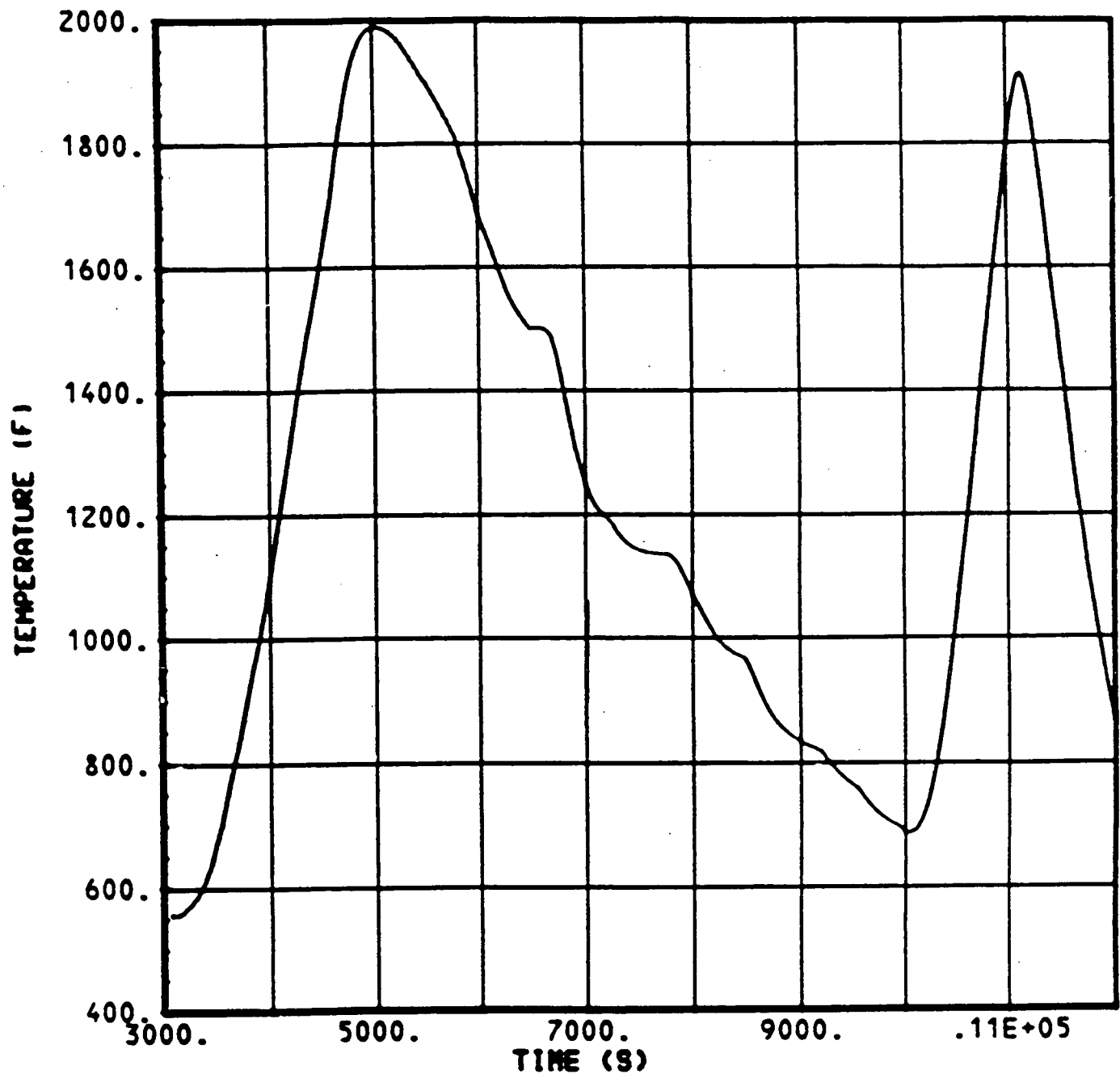


FIGURE 24-CLAD TEMPERATURE AT 12.0'
1.5" BREAK