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B&W Document 86-1103585-00, "System Response to Total Loss of SG Heat Sink," (August 7, 1979)

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SYSTEM RESPONSE TO TOTAL LOSS OF SG HEAT SINK

1. Introduction

An analysis of a complete loss of feedwater transient accident for the 177-FA lowered-loop plants has been conducted. The analysis was performed utilizing a "realistic" decay heat curve, and assumed that offsite power was lost and that the operator actuated one of the HPI systems at 1200 seconds.

2. Summary and Conclusions

An analysis of a complete loss of feedwater transient for the 177-FA lowered-loop plants has been performed utilizing a "realistic" decay heat curve. Consistent with the operating procedures, it was assumed that the operator would initiate the HPI system by 20 minutes. A single failure in the HPI system was included in the evaluation.

The analysis demonstrated that 1 HPI pump provided sufficient makeup to prevent core uncovery. The ultimate heat sink for this transient is the containment via energy release through the pressurizer safety valves. Since no core uncovery occurs, cladding temperatures would remain within a few degrees of the satuated fluid temperature and no cladding rupture nor metal-water reaction occurs. Thus, the criteria of 10 CFR 50.46 is satisfied for this transient.

3. Results of Analysis

3.1 Method

Since the system response for this transient is relatively quiescient, detailed noding of the primary system is not required, thus, the analysis in this report was performed using a six-node CRAFT model to develop the history of the reactor coolant system hydrodynamics. Figure 1 shows a schematic diagram of the model. Node 1 comprises the cold leg pump discharge piping, the reactor vessel (RV) downcomer, and the lower plenum of the RV. Node 2 represents the steam generator, primary side and the cold legs suction piping, while Node 3 represents the core, RV upper plenum, and the hot leg piping. Nodes 4, 5, and 6 of the model are used to simulate the pressurizer, containment, and the secondary side of the steam generators, respectively.

The assumptions used in the analysis are listed below:

1. The reactor is operating at 102% of the steady-state power level of 2772 MWt.
2. Loss of main feedwater flow to the steam generator occurs at time zero. The auxiliary feedwater systems are assumed not to operate.
3. Offsite power is not available.
4. The reactor trips on high pressure at 2300 psig.
5. No credit is taken for operation of the PORV.
6. The pressurizer safety valves start to open at the set pressure of 2500 psig. They are assumed to be full open at 103% of the set pressure.
7. The discharge rate through the code safety valves is calculated using the Bernoulli equation, for subcooled fluid discharging through the valve, and the Moody correlation, for two-phase or steam flow through the valve. The flow area utilized for the safety valves was chosen such that the Moody calculated discharge rate, for steam flow through the valve at the valve rated pressure, is equivalent to the design capacity of the valve.
8. Actuation of one HPI train, via operator action at 20 minutes, is assumed. A single failure is assumed which renders the other HPI train inoperable. Operator guidelines specify that, upon loss of SG heat sink, he should manually actuate all HPI trains.
9. In order to simulate a realistic decay heat curve, 1.0 times the 1971 ANS standard was utilized.

3.2 Results

Figures 2 through 5 show the transient system response for this accident. The following table presents key results of the analysis:

Sequence of events	Time, s
Loss of main feedwater, turbine trip, loss of offsite power (RC pumps coastdown)	0.
Reactor trips on high pressure	8.
SG side inventory boiled-off	100.0
Pressurizer goes solid	350.
Two pressurizer code safeties open	400.
Long term cooling estab. (based on 1 HPI)	8900.

Figure 2 shows the core pressure transient. Following the simultaneous loss of main feedwater and offsite power, the fluid in the RCS expands due to decreasing heat transfer via the steam generator, and the RCS pressure increases. At 8 seconds, the high pressure trip setpoint (2300 psig) is reached, thus causing the reactor to scram. Pressure then starts to decrease due to contraction of the fluid in the RCS caused by the decrease in core power. At 100 seconds, the steam generator inventory has been boiled-off, which results in a loss of heat sink and a heatup of the RCS fluid, and repressurization of the system. At 350 seconds, the pressurizer becomes "solid," and the system pressure rapidly increases to the code safety valve set pressure of 2500 psig. The system pressure remains at this value for the remainder of the transient with the safety valves acting as a path to the ultimate heat sink of the RCS for this accident, i.e., the containment.

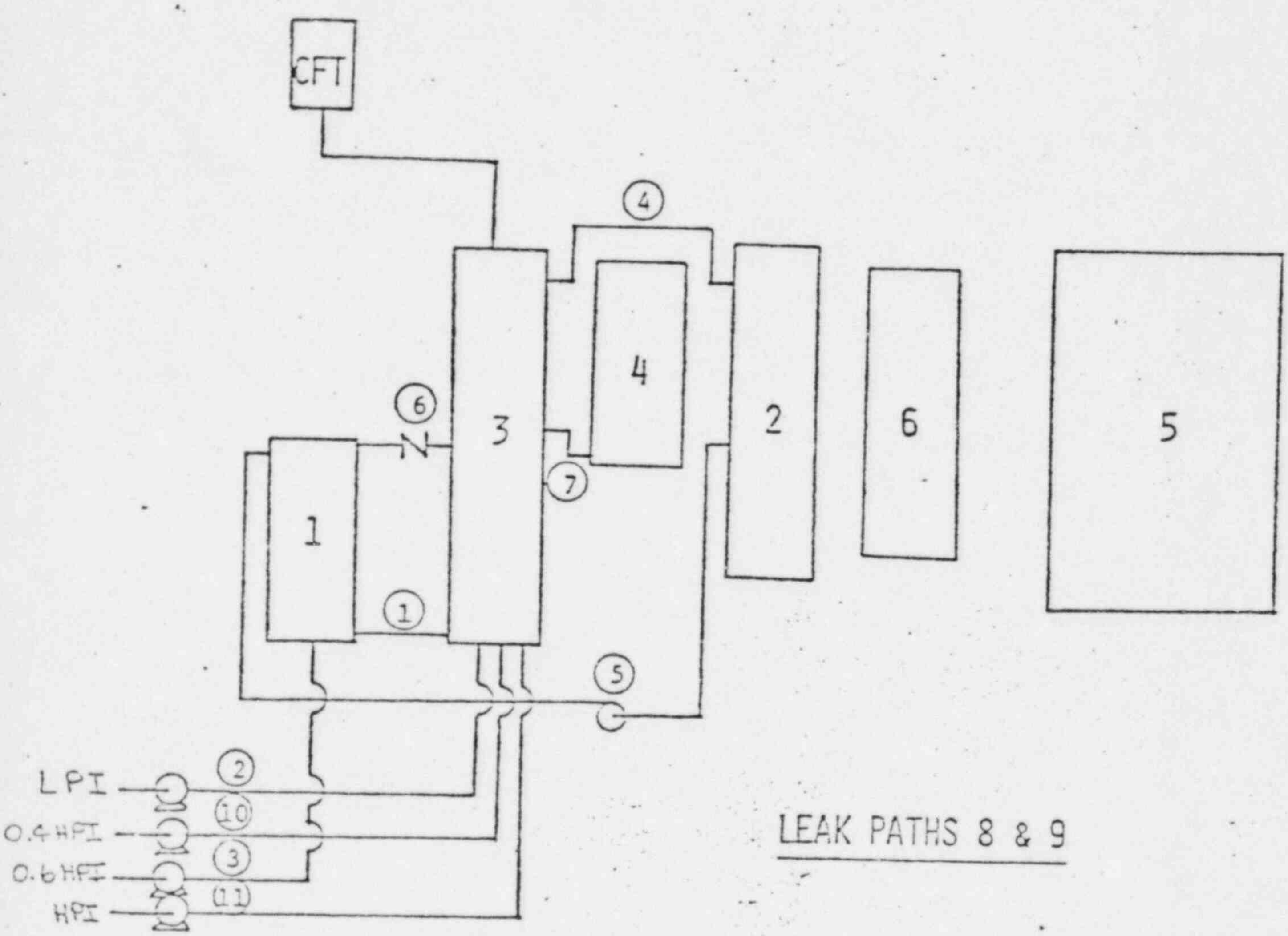
Figure 3 shows the pressurizer mixture level response for this accident. The initial pressurizer response follows the same behavior as the system pressure transient. Due to the loss of heat sink at 100 seconds, the pressurizer starts to refill and becomes solid at 350 seconds. At 2180 seconds, the liquid level in the primary system falls below the surgeline entrance and steam passes into the pressurizer. Shortly thereafter, the pressurizer mixture level drops slightly and steam exits through the code safety valves. The pressurizer remains in this condition for the remainder of the transient.

The RCS liquid inventory, with the exclusion of the pressurizer, during this transient, is given in Figure 5. Makeup to the RCS was initiated at 1200 seconds via operator action to start one HPI train. The RCS reached saturated conditions at 1725 seconds, and rapidly starts decreasing in inventory. With the liquid level in the primary system falling below the pressurizer surgeline nozzle at 2180 seconds, the loss rate in system inventory slows. At 8900 seconds, the HPI flow exceeds the core boil-off and the system starts to refill. At no time does the core uncover. Thus, the cladding temperatures will be maintained within a few degrees of the saturated fluid temperature and no cladding ruptures nor metal-water reaction will occur.

FIGURE 1

CRAFT2 NODING DIAGRAM FOR SMALL BREAKS

(6 NODE MODEL)



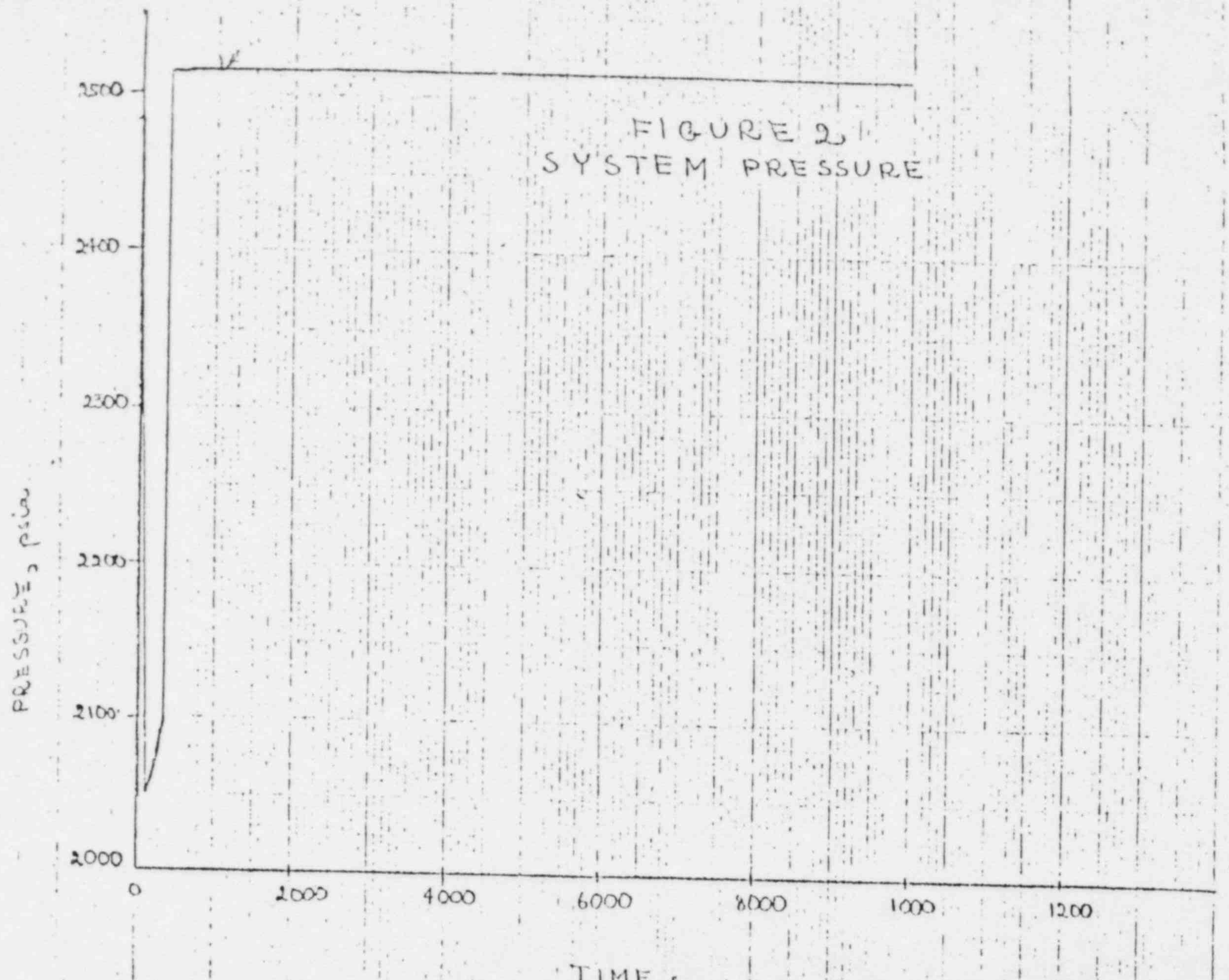


FIGURE 2
SYSTEM PRESSURE
PRESSURE, psia
2500
2400
2300
2200
2100
2000
0
2000
4000
6000
8000
1000
1200
TIME, s

FIGURE 3

PRESSURIZER MIXTURE LEVEL

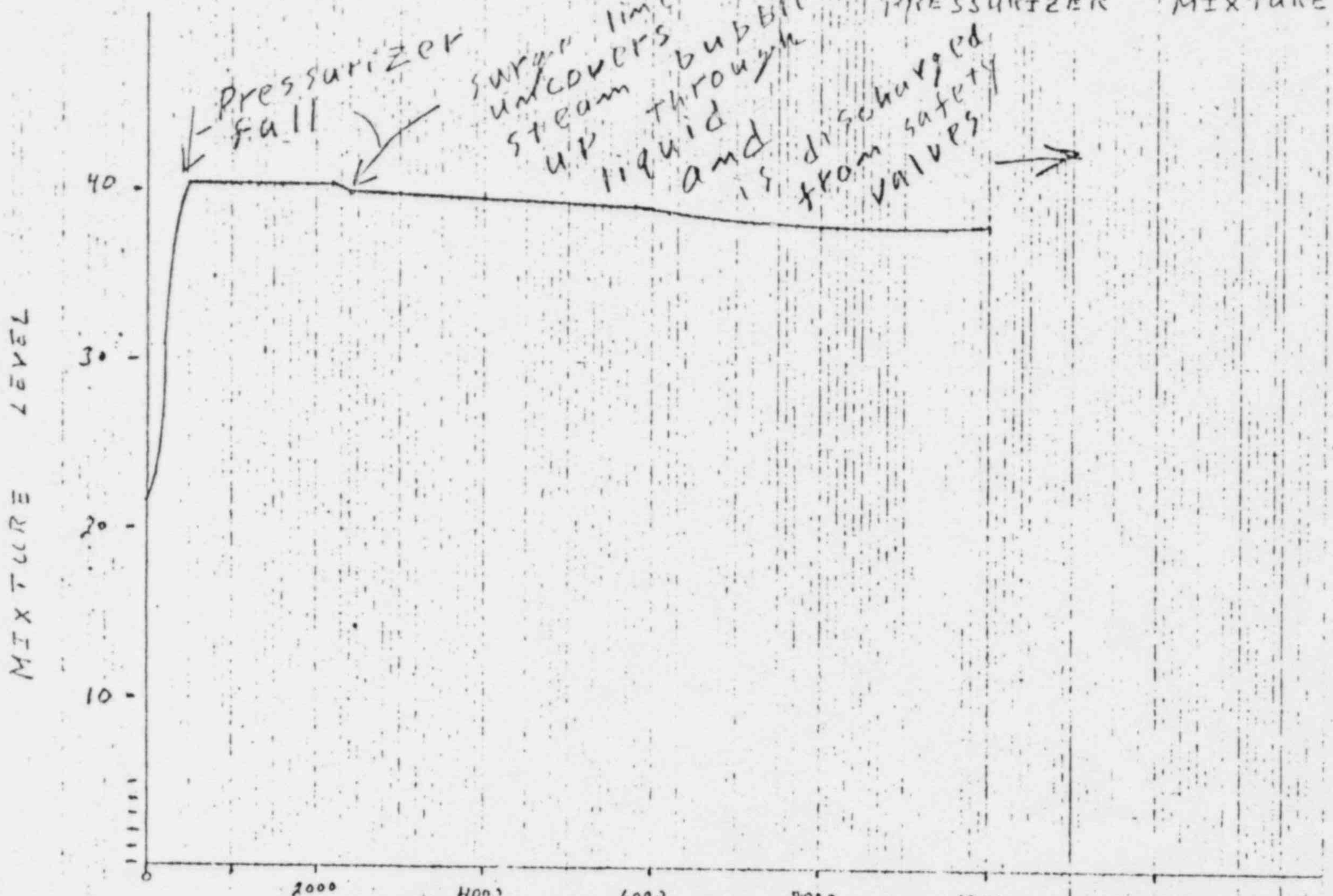


FIGURE 4
INTEGRATED PRESSURIZER SAFETIES FLOW

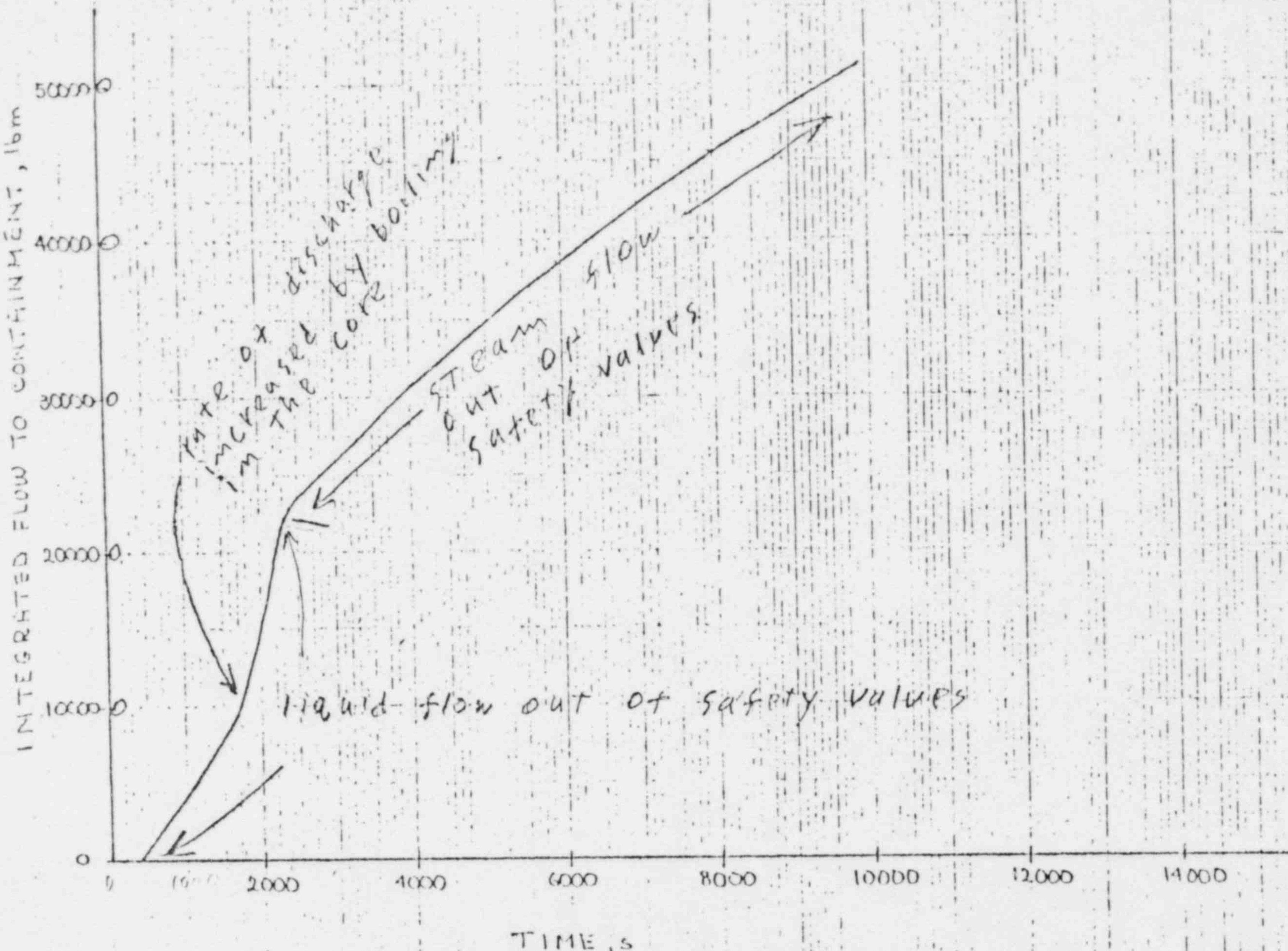
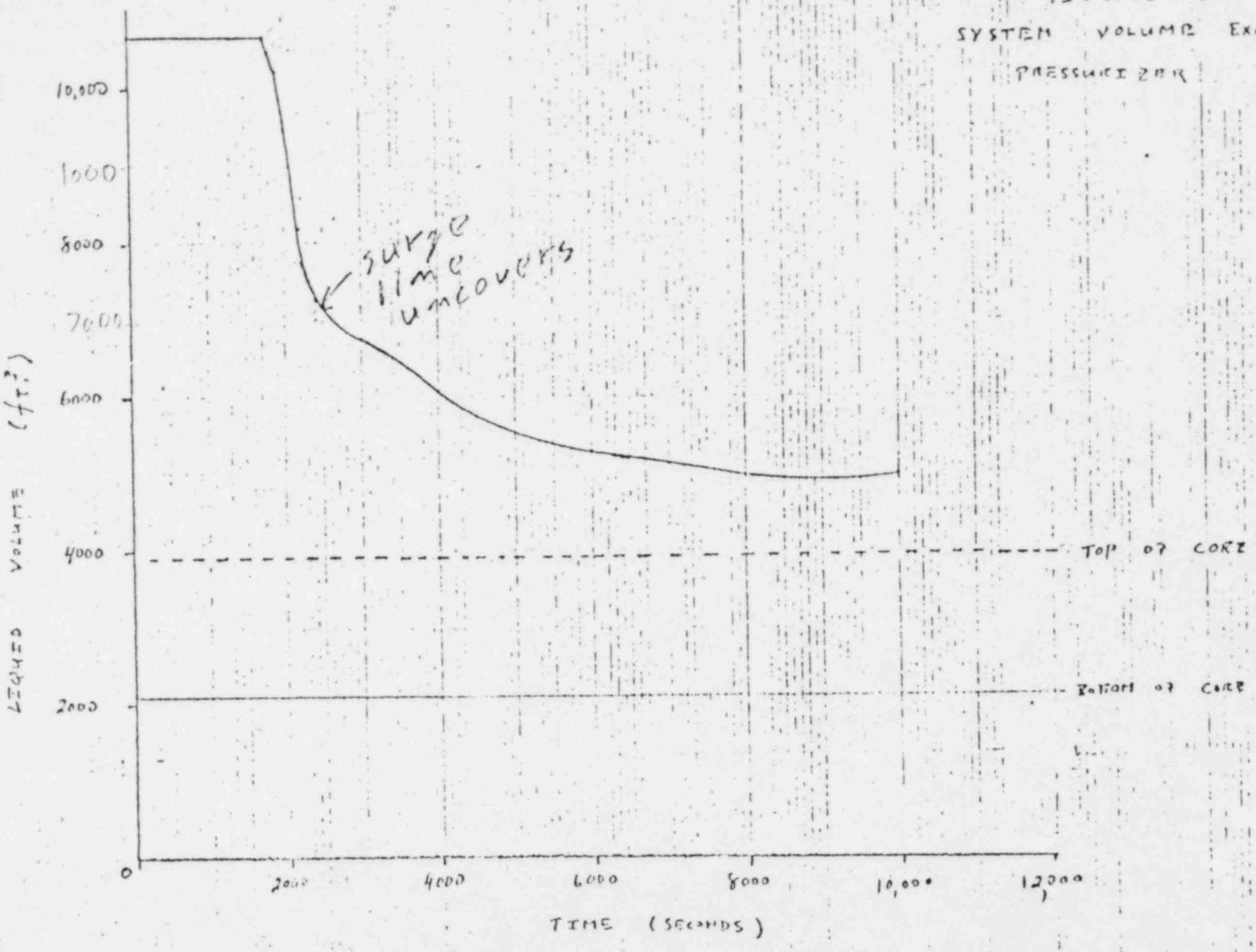


FIGURE 5

SYSTEM VOLUME EXCLUDING PRESSURIZER



86-110585-00