"EVALUATION OF TRANSIENT BEHAVIOR AND SMALL REACTOR COOLANT SYSTEM BREAKS IN THE 177 FUEL ASSEMBLY PLANT"

VOLUME 1 SECTION 6.0 - SUPPLEMENT 2

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"SMALL BREAK IN THE PRESSURIZER (PORV) WITH NO AUXILIARY FEEDWATER AND SINGLE FAILURE OF THE ECCS WITH REALISTIC DECAY HEAT"

Small Break in the Pressurizer (PORV With No Auxiliary Feedwater and a Single Failure of the ECCS With Realistic Decay Heat

1. Introduction

The evaluation of small breaks in the pressurizer in Chapter 6.2.3 of the main report covered the following two cases:

1. Loss of main feedwater resulting in a stuck open PORV, no loss of offsite power, and one HPI train available for emergency core cooling.
2. Stuck open PORV with loss of offsite power and one HPI train.

This supplement provides the additional analysis of a small break of the PORV without feedwater availability and a single failure in the emergency core cooling system with realistic decay heat. For this assumption, the 177 fuel assembly lowered-loop plants fall into two categories:

1. Oconee will have one HPI pump injecting through one train for 10 minutes and two HPI pumps injecting through two trains thereafter.
2. All others will have one HPI pump injecting through one train for 10 minutes and one HPI pump injecting through two trains thereafter.

This evaluation is based on the flow equivalent to <u>one</u> HPI pump. Consideration of the results for Oconee is given in Section 4.

The evaluation shows no core uncover and no cladding temperature excursion. By the end of the analysis long term cooling has been established via HPI injection and the criteria of 10 CFR 50.46 are met.

2. Method of Analysis

The analysis method used for the evaluation is that described in Chapter 5 of reference 4, BAW-10104, Rev. 3, "B&W's ECCS Evaluation Model," along with the model modifications of reference 5. As dictated by reference 6, the Bernoulli correlation was used for subcooled flow rather than the modified Zaloudek correlation as proposed in reference 5. The following conditions and system responses were assumed during the transient.

a. The reactor is operating at 102% of a steady-state power level of 2772 MWt. Decay heat is based on 1.0 times the 1971 ANS 5.1 standard for infinite reactor operation (realistic decay heat).

b. The leak occurs instantaneously, and a discharge coefficient of 1.0 is used for the entire analysis. Bernoulli's equation was used for the subcooled portion of the transient, while Moody's correlation was used in the two-phase portion.

c. No offsite power is available.

d. The reactor trips on low pressure (1900 psig).

e. The safety rods begin entering the core after a 0.5 second delay from the time the reactor trip signal is reached.

f. The RC pumps trip and coastdown coincident with reactor trip.

g. One complete train of the emergency safeguards system fails to operate, leaving two CFTs and only one HPI and one LPI system available for pumped injection to mitigate the consequences of the LOCA.

h. The auxiliary feedwater (FW) system is assumed not to be available during the transient.

i. The ESFAS trip, including signal errors, occurs at a RC pressure of [illegible] psia.

3. Results

Figures 2 through 15 show the evolution of several key reactor coolant system variables for this event. The CRAFT2 noding diagram for this analysis is presented in Figure 1. The following table presents key results of the analysis:

Sequence of events	Time, s
Break occurs (1.05 in.^{2} @ top of pressurizer equal to a PORV break)	0.0
Reactor trip	58.0
Loss of offsite power, RC pumps coastdown occurs	58.0
Main feedwater coastdown ends	72.0
HPI injection starts	210.0
Natural circulation essentially lost	1690.0
Maximum repressurization reached	1590 psia @ 4630 sec
Long term cooling established	~4700
Minimum core mixture level	16.9 ft @ 2290 sec
Peak cladding temperature	720F (initial value)

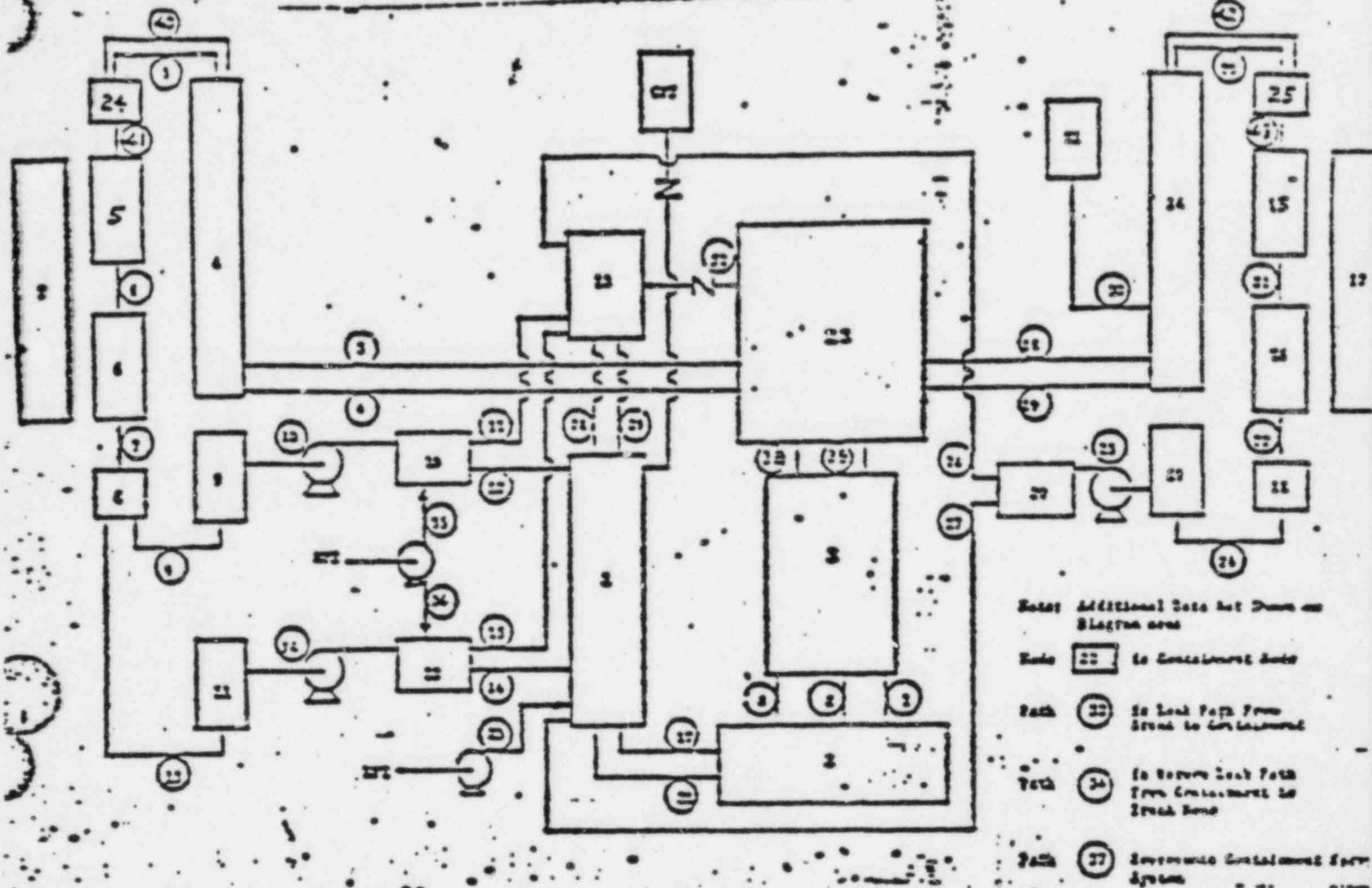
The RCS depressurizes with the initiation of the break as shown in Figure 2. Since the break is in the steam space of the pressurizer, the RCS depressurizes rapidly to the ESFAS setpoint, thus initiating the HPI injection. At 1000 seconds into the transient, the RCS repressurized because the pressurizer goes solid as shown in Figure 3. As shown in Figure 4, the SG secondary side liquid volume goes dry (approximately 950 sec) just prior to the pressurizer going solid. The reduced primary to secondary heat transfer also precipitates the increase in RCS pressure. The pressure continues to increase until the RCS net volume balance is met at 4700 seconds. This net volume balance is the difference between the HPI volume injected, leak volume, core boil-off

volume, and steam condensation by the HPI. Also, at this time, the HPI injection rate exceeds the core boil-off rate. Thereafter, system pressure will decrease proportional with decay power, thus firmly establishing long term cooling. Core covery is assured, thereby assuring no increase in cladding temperature. Thus, criteria of 10 CFR 50.46 is satisfied without the use of auxiliary feedwater or an additional HPI train.

4. Small Break in Oconee Pressurizer Steam Space Without Feedwater

The discussion of system response in sections 2 and 3 was based on one operating HPI pump. Even with a single active failure, Oconee will have two pumps available within 10 minutes following ESFAS actuation. The Oconee HPI pumps are approximately 10% lower in capacity than the generic HPI capacity used in sections 2 and 3. For the first 250 seconds up to ESFAS action system response will be identical. Following that, for 10 minutes, the Oconee system liquid inventory will lag the generic calculation slightly (maximum effect - 70 ft^3 at 950 seconds). At 950 seconds Oconee will establish two HPI pumps or about 180% of the injection used in the generic evaluation. Therefore, Oconee will achieve long term cooling much earlier than the generic evaluation and the remainder of that evaluation will bound the results for Oconee.

Figure 1. System Noding



Node No.	Identification
1	Downcomer
2	Lower Plenum
3	Core
4,14	Hot Leg Piping
5,15	SG & Upper Head
6,16	Steam Generator Tubes
7,17	Secondary, SG
8,18	SG Lower Head
9,11,19	Cold Leg Piping
10,12,20	Cold Leg Piping
13	Upper Downcomer
21	Pressurizer
22	Containment
23	Upper Plenum
24, 25	SG Upper Head

Path No.	Identification
1,2	Core
3,4,18,19	Hot Leg Piping
5,20,40,42	Hot Leg, Upper
6,21	SG Tubes
7,22	SG Lower Head
8	Core Bypass
9,13,24	Cold Leg Piping
10,14,25	Pumps
11,12,15,16,26,27	Cold Leg Piping
17,31	Downcomer
23	LPI
28,29	Upper Downcomer
30	Pressurizer
32	Vent Valve
33,34	Leak & Return Path
35,36	HPI
37	Containment Sprays
41,43	SG Upper Head

Figure 2. Core Pressure

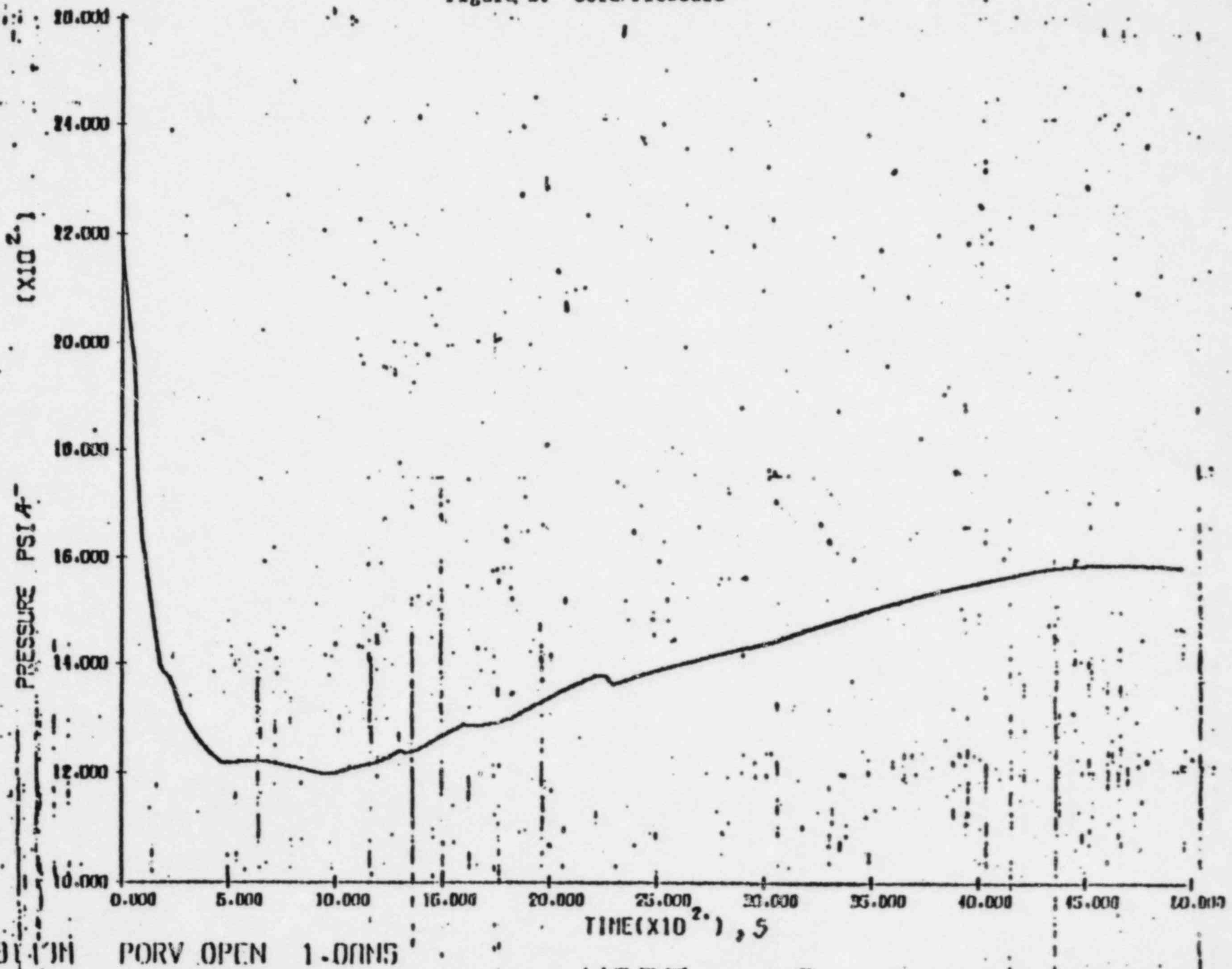


Figure 3. Pressurizer Liquid Volume Vs. Time

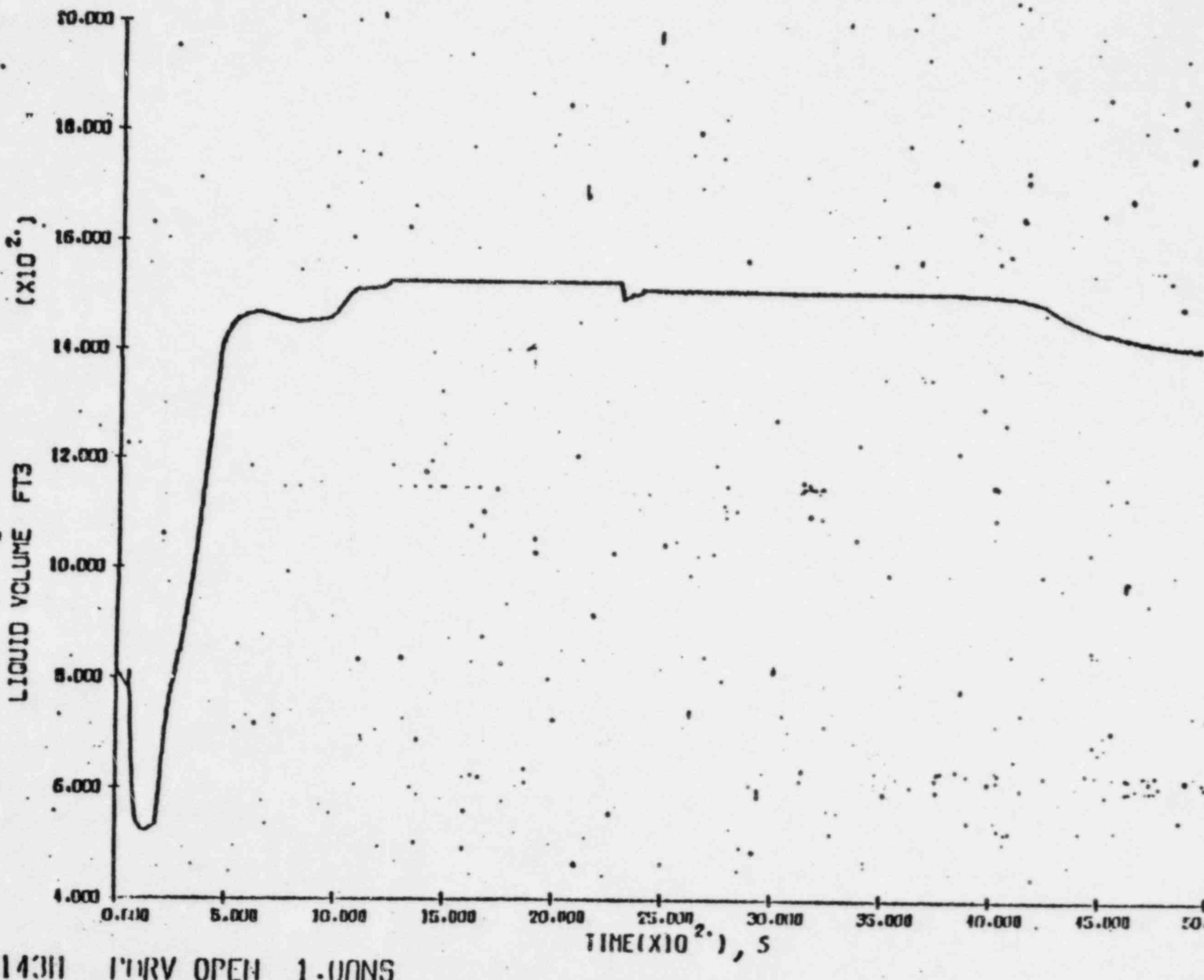


Figure 4. Steam Generator Liquid Volume Vs. Time
(SECONDARY SIDE)

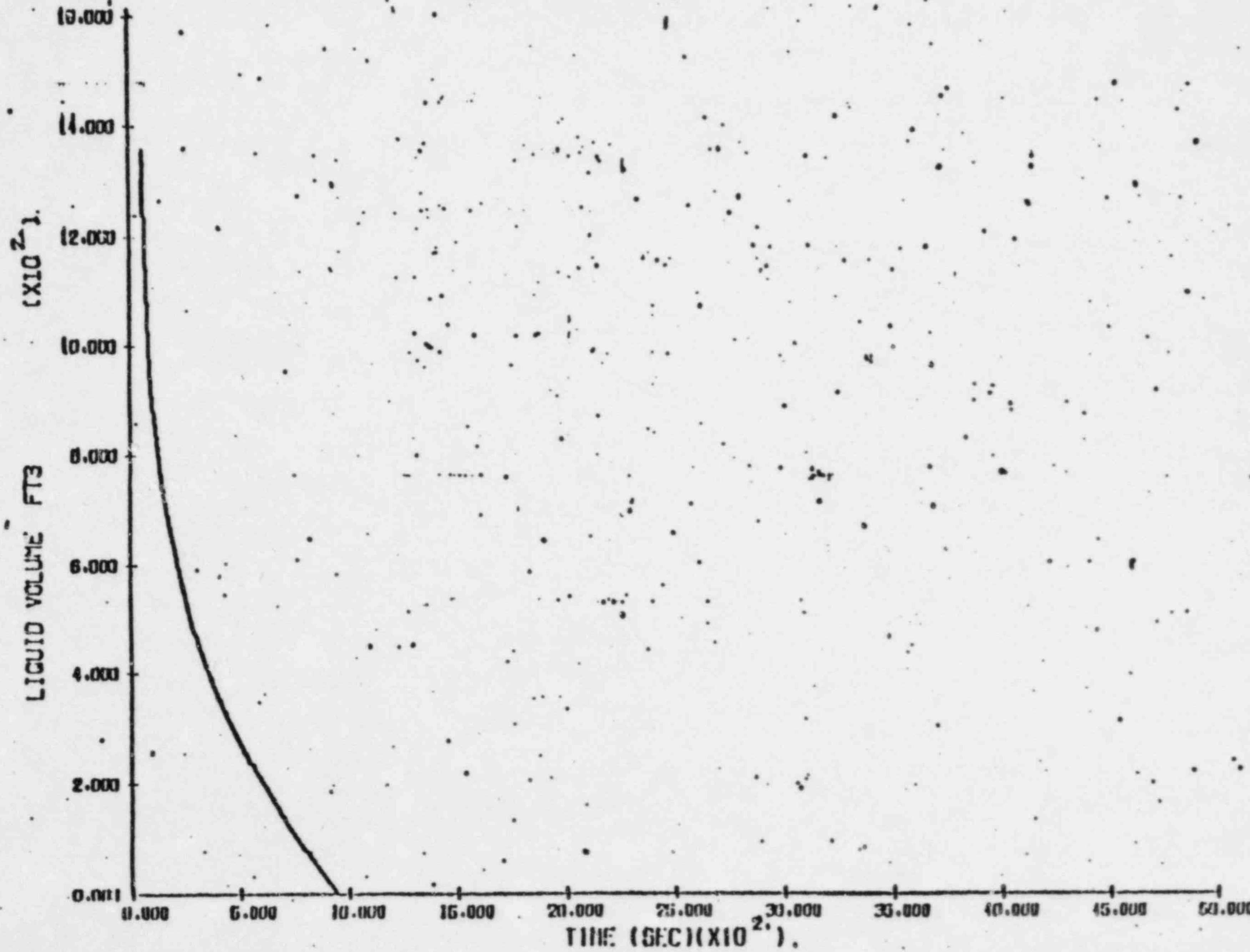


Figure 5. Reactor Vessel Mixture Height

1.05 in.^{2} Break in Pressurizer Steam Space

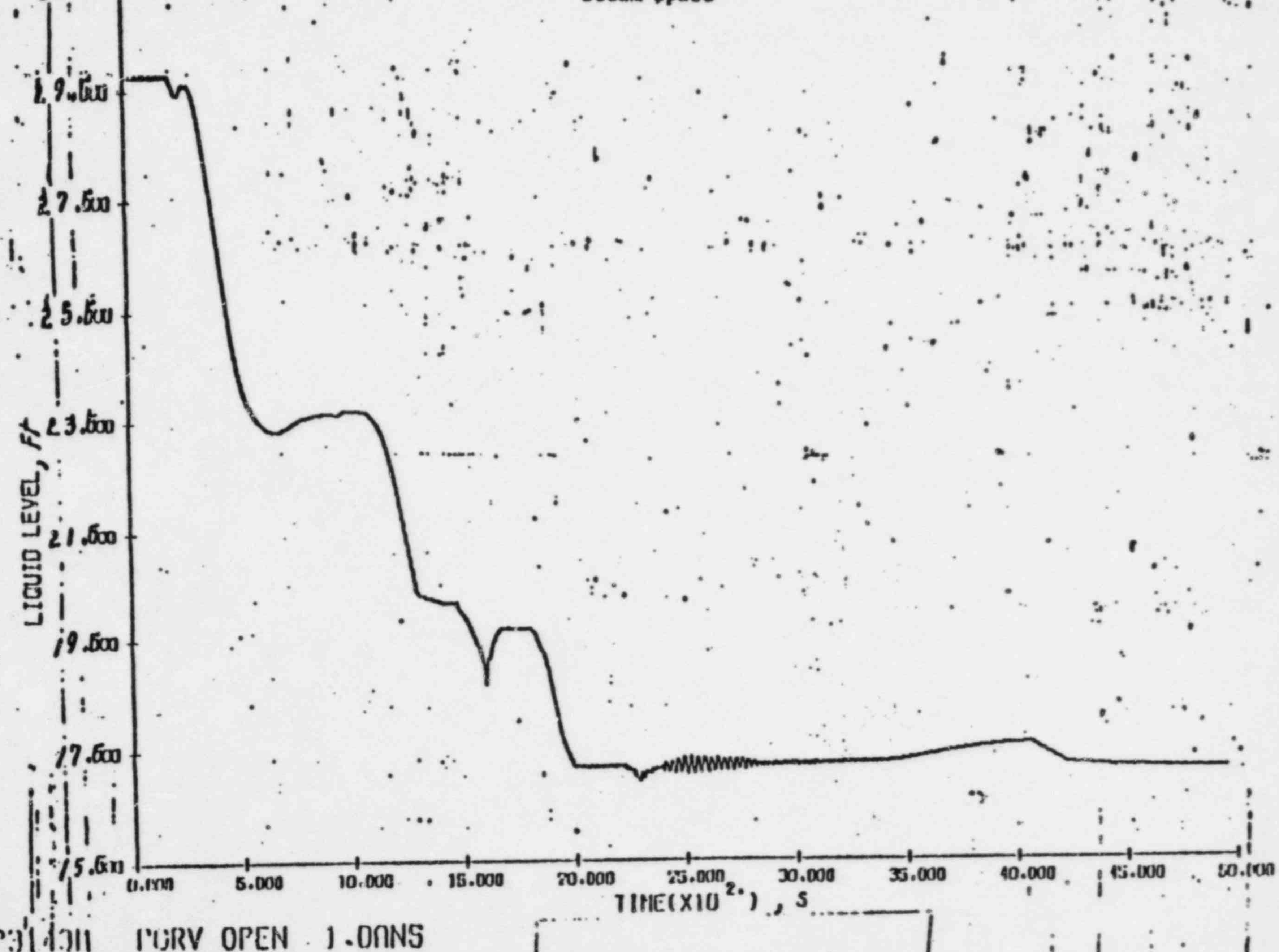


Figure 6. Core Liquid Volume Vs. Time

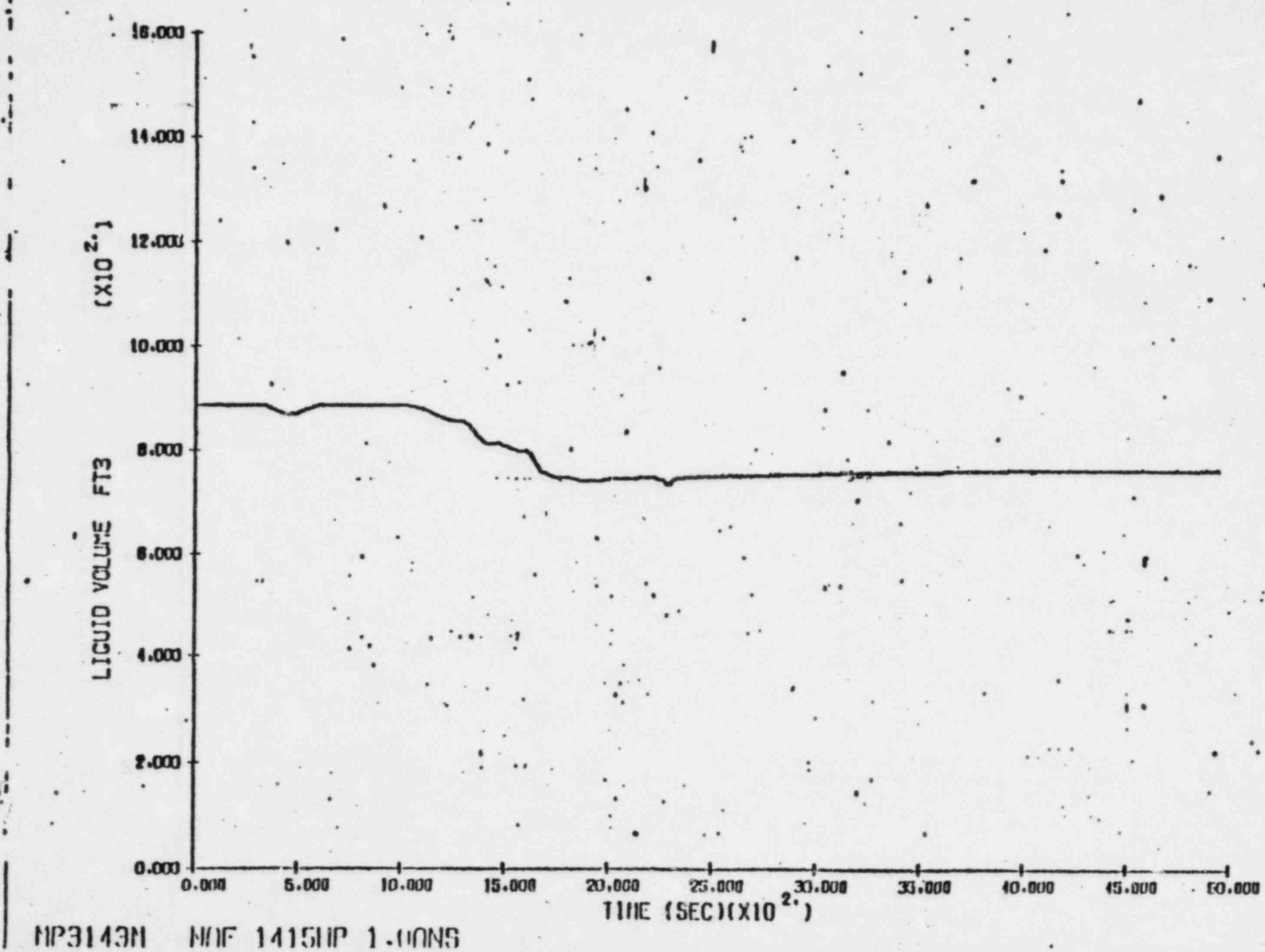


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Figure 7. Hot Leg Liquid Volume Vs. Time

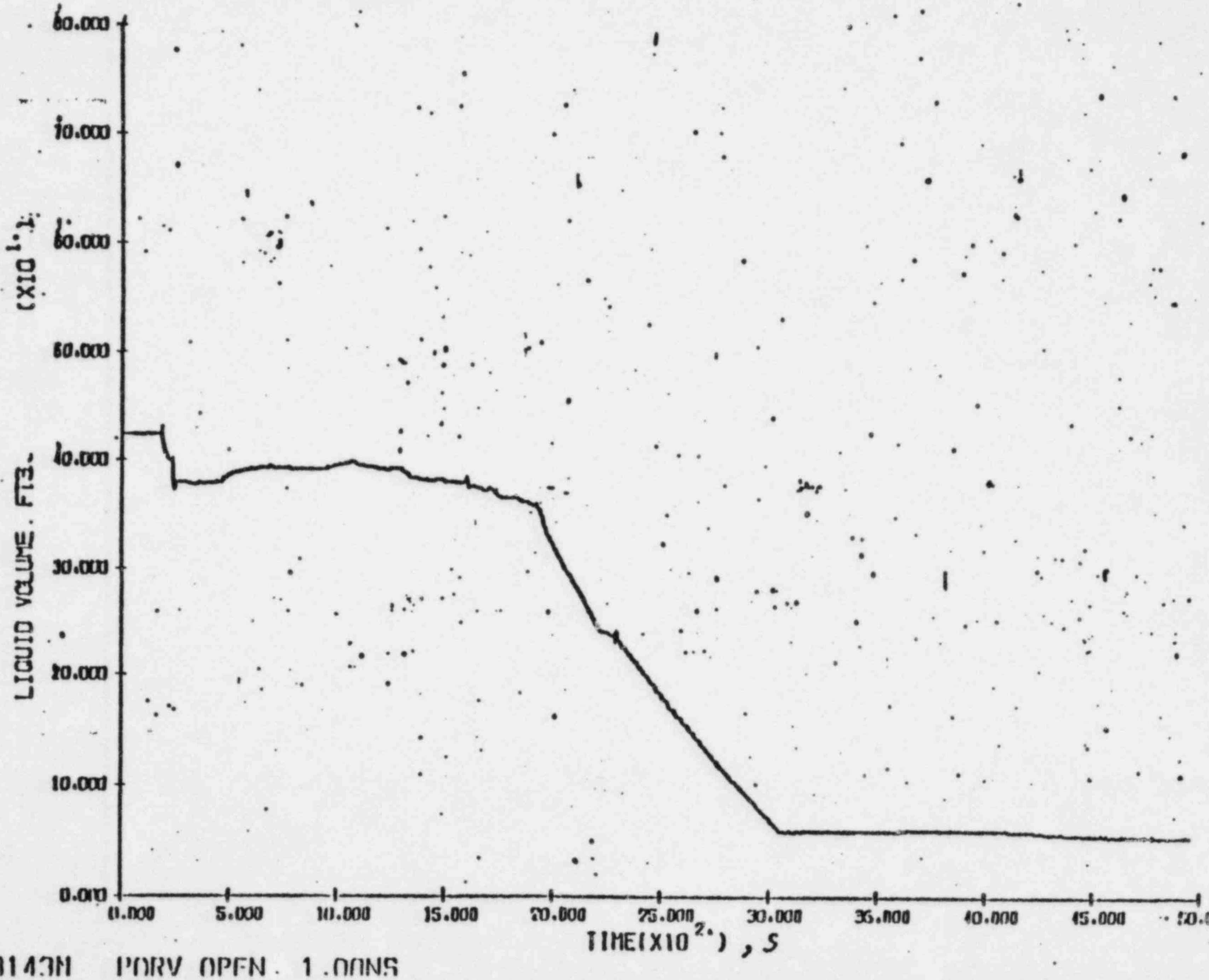


Figure 8. Lower Half of Steam Generator Liquid Volume

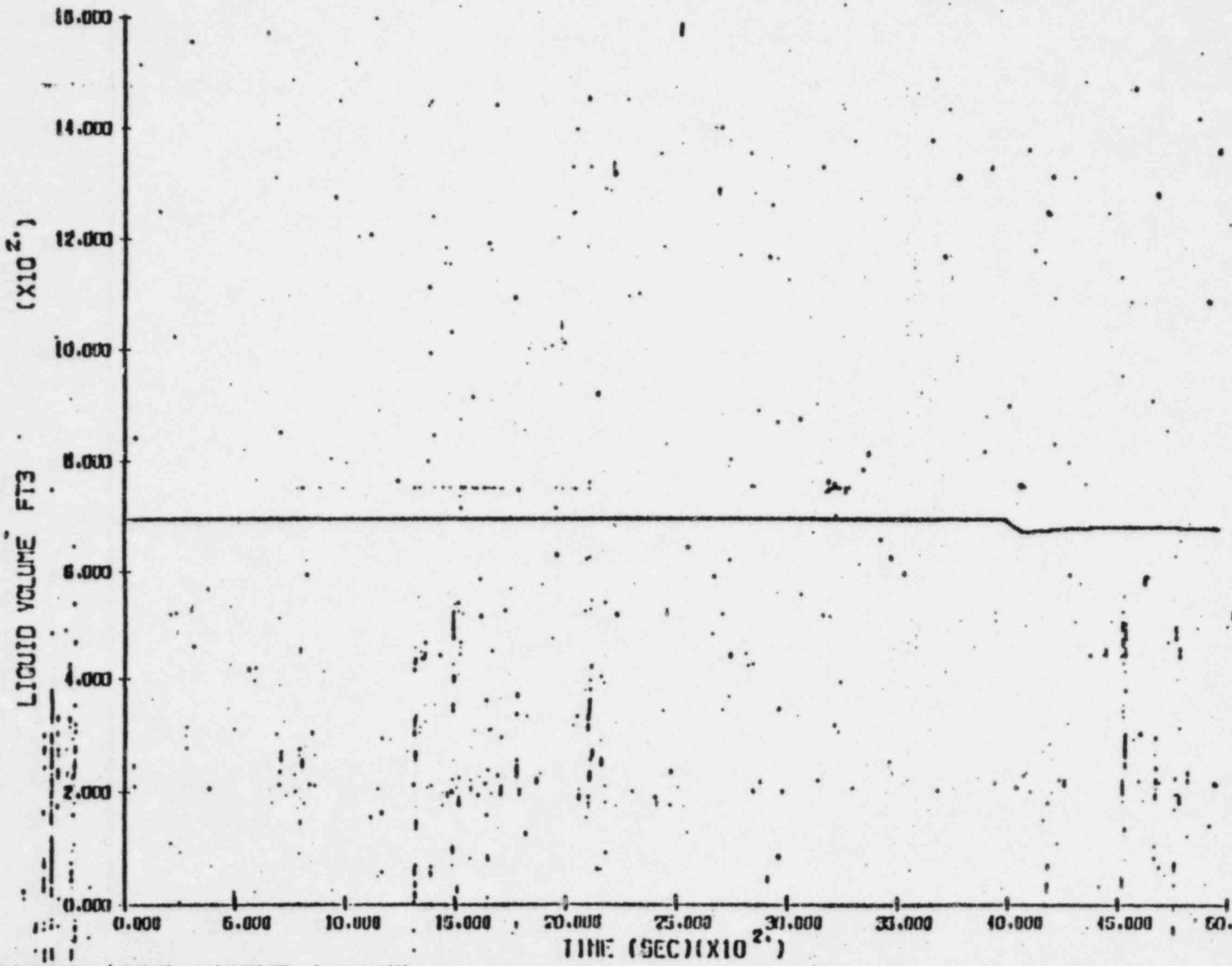


Figure 9. Cold Leg Liquid Volume

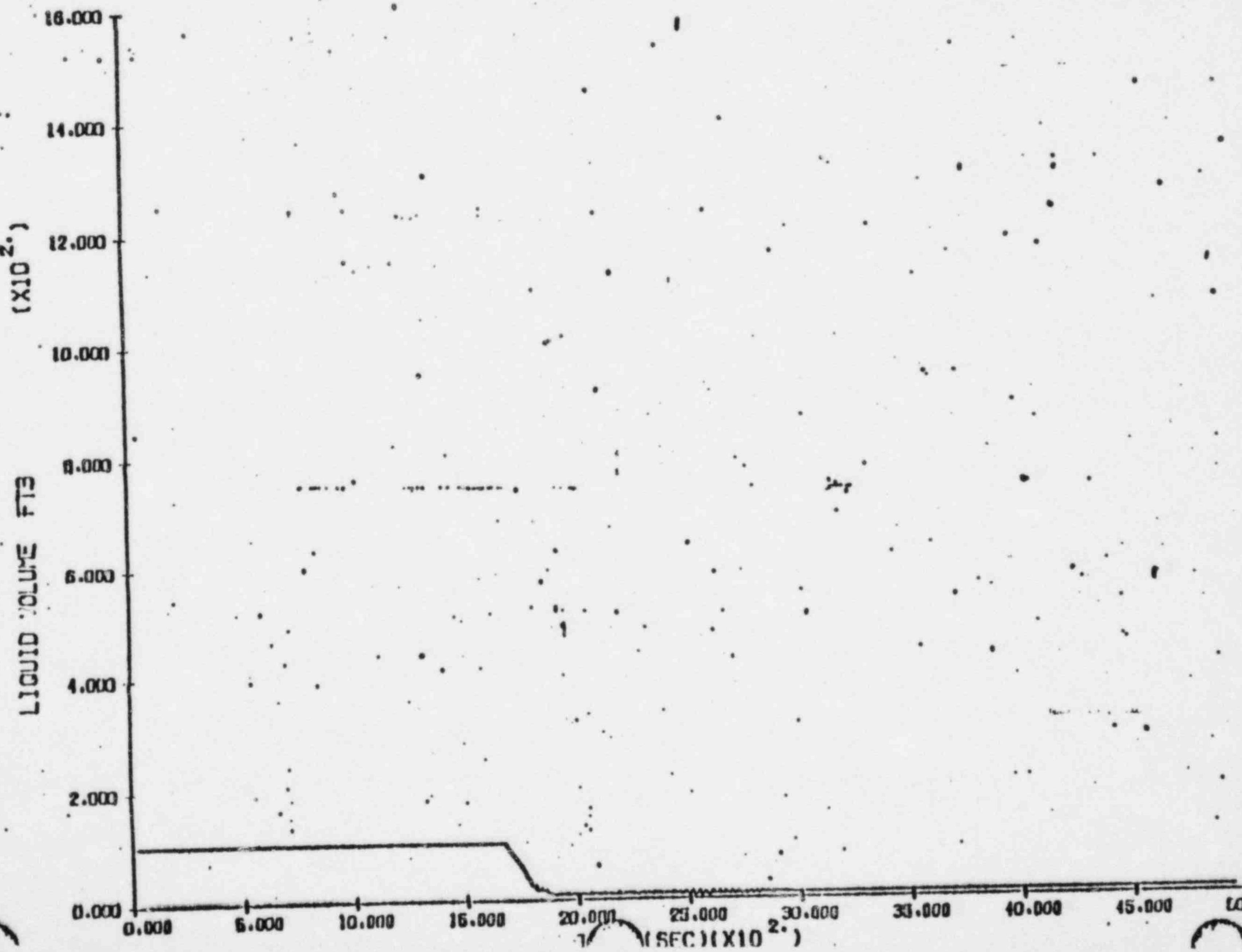


Figure 10. Downcomer Region Above Vessel Nozzles
Liquid Volume

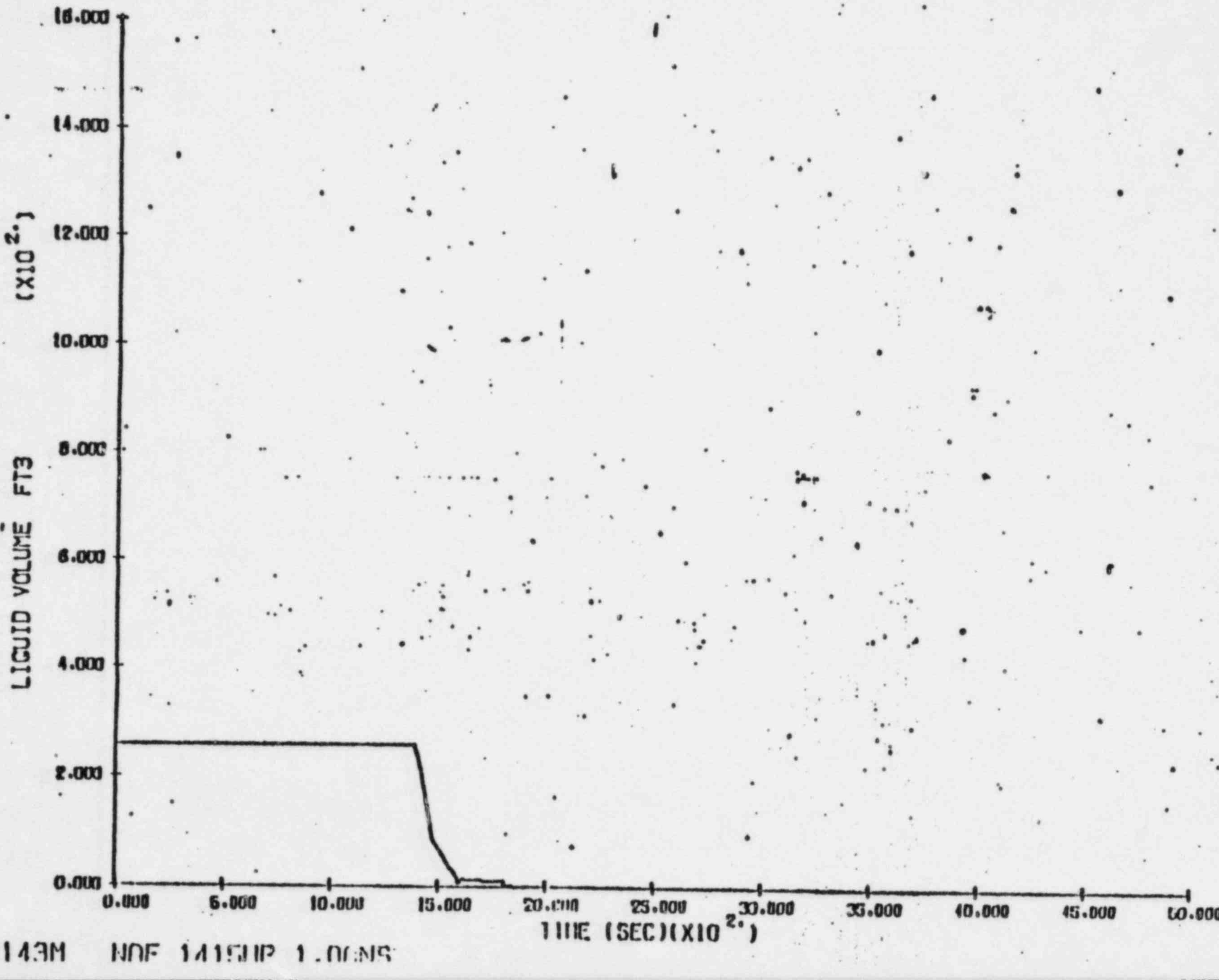


Figure 11. Lower Head Liquid Volume

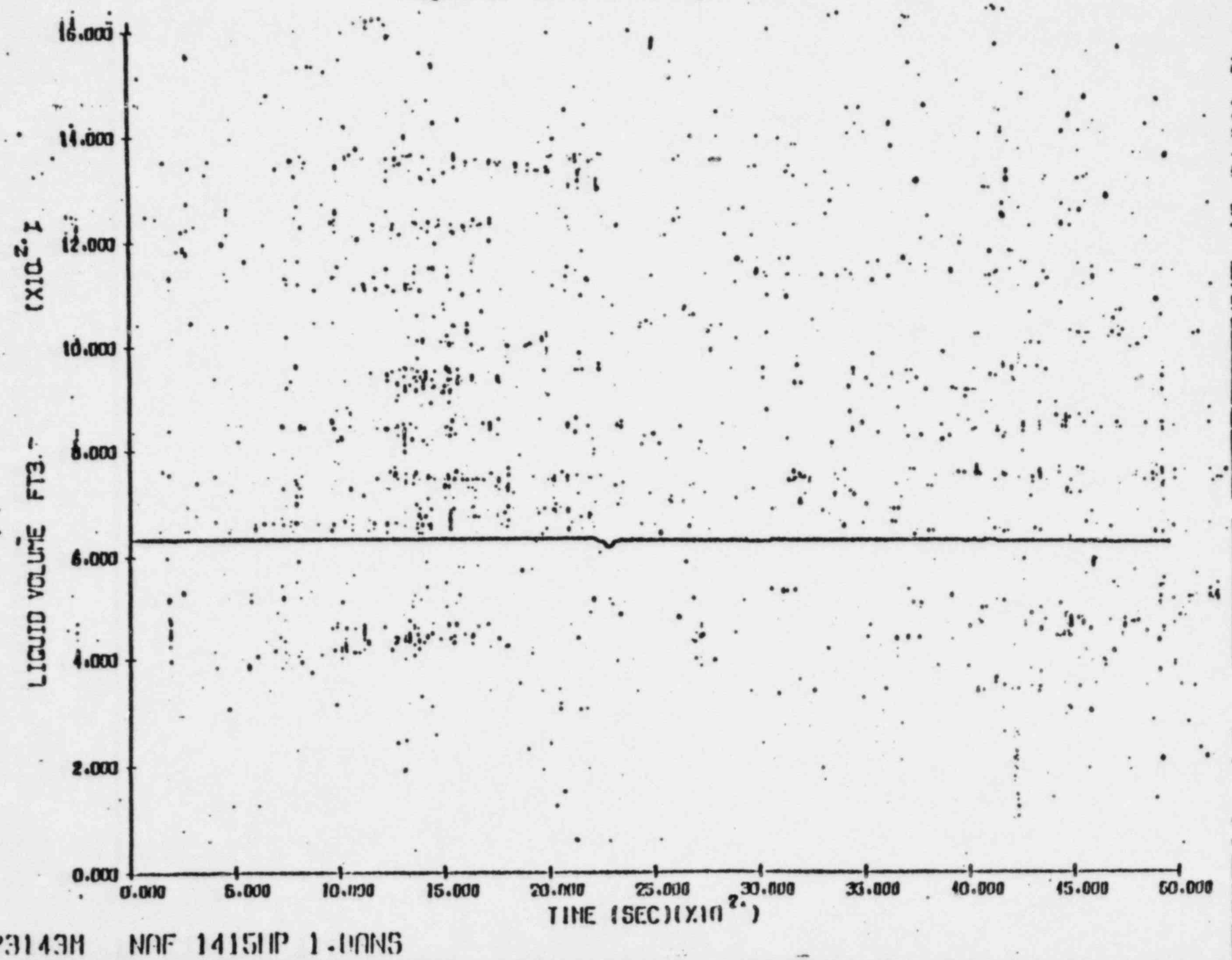


Figure 12. Downcomer Region Below Vessel Nozzles
Liquid Volume

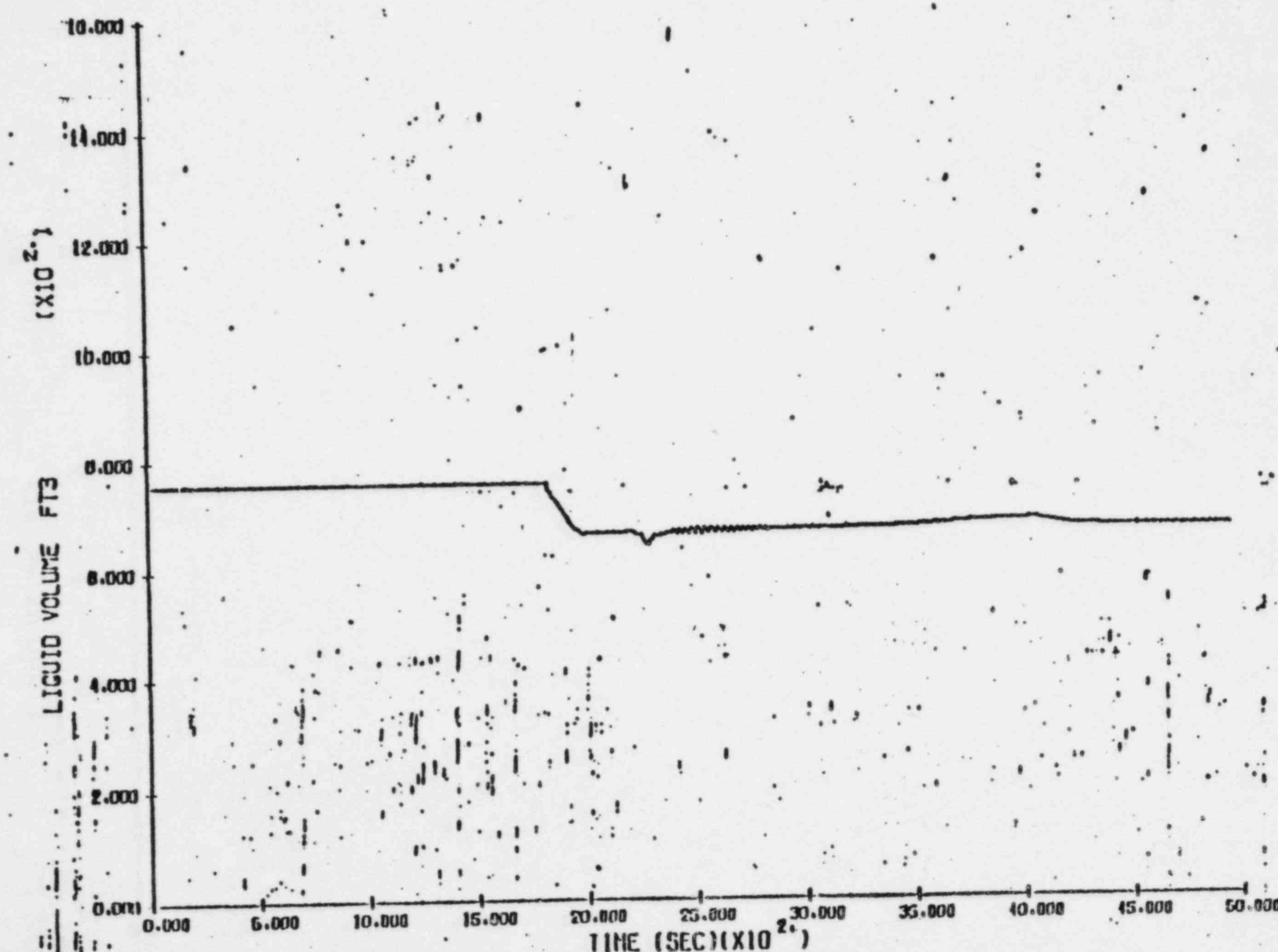
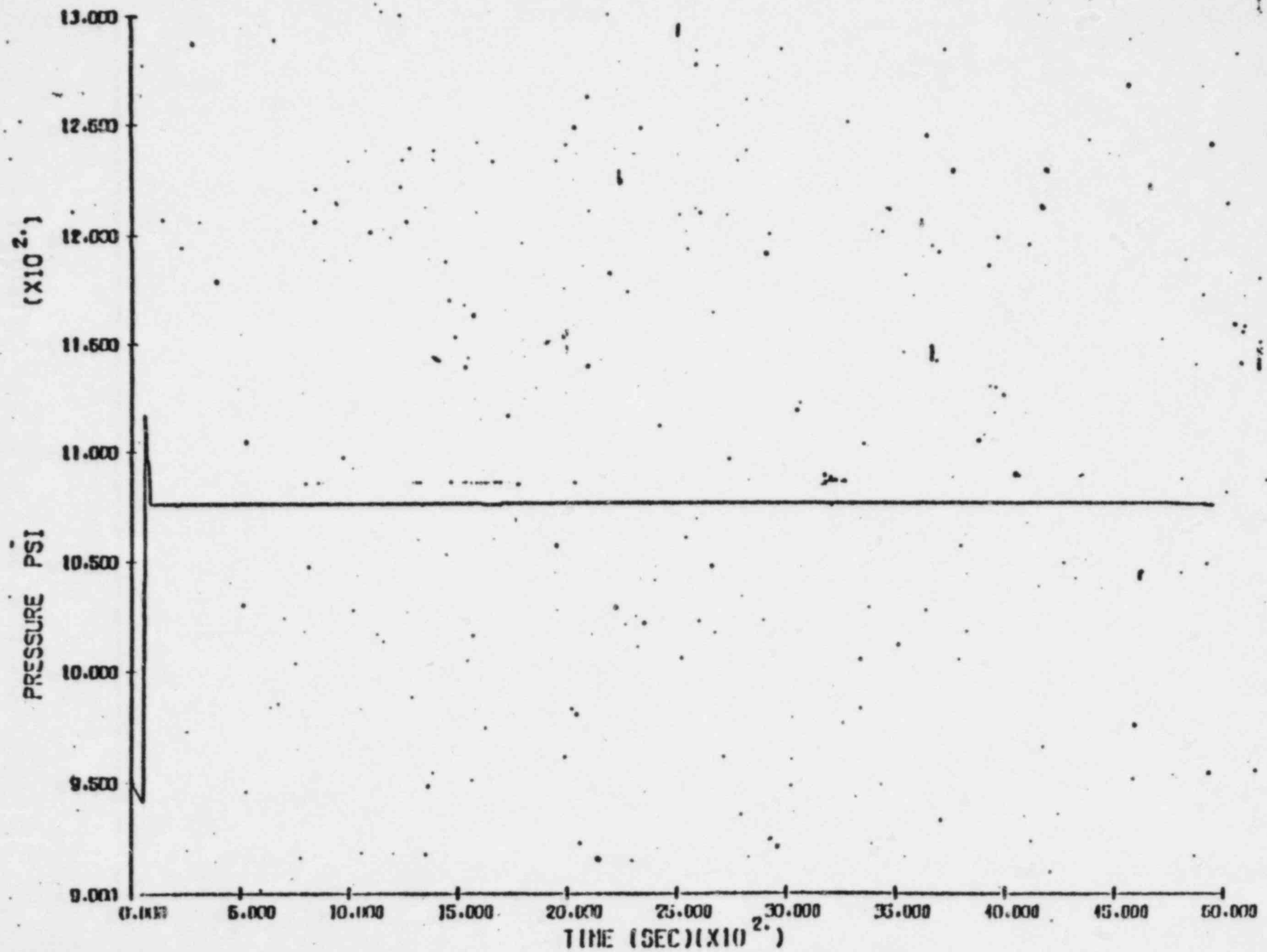


Figure 13. Secondary Side Steam Pressure



MP3143M HOF 1415HP 1.00NS

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