Docket No. 50-289
(Restart)
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B&W Document 86-1117679-000, "Small Break With Failed PORV," (February 11, 1980)

SMALL BREAK WITH FAILED PORV

1. INTRODUCTION

It has been established in reference 1, that very small cold leg breaks (<0.01) will repressurize to the PORV setpoint of 2465 psia if the auxiliary feedwater is delayed significantly. Since there is a probability of the PORV sticking open after being actuated, concerns have been raised regarding the impact of this consequential failure. This report presents the results of an analysis of a 0.01 ft^2 cold leg break with the subsequent failure of the PORV to close.

2. SUMMARY & CONCLUSIONS

As has been demonstrated by the analyses presented in Section 6 of reference 1, small breaks in the primary system will not cause a repressurization to the PORV setpoint unless all feedwater is lost to the steam generators. Under this situation, there exists a class of very small breaks, (less than 0.01 ft^2) wherein the system will repressurize to the PORV setpoint. An analysis is presented herein for a 0.01 ft^2 break, without feedwater to the steam generator, which results in a repressurization to approximately the PORV setpoint. At 20 minutes, the PORV was actuated and was assumed to stick open.

As is demonstrated in Section 4, for the 177-FA lowered-loop plants, operator action by 20 minutes to manually actuate the two high pressure injection trains will keep the core covered. A qualitative analysis is also presented which demonstrates that reestablishment of auxiliary feedwater by 20 minutes, for both the 177-FA raised and lowered loop plants, will prevent core uncovery. Therefore, a 0.01 ft^2 break with no auxiliary feedwater can be mitigated safely with B&W's present operator guidelines. These operator guidelines require establishing feedwater to the steam generator as soon as possible, if the AFW is not available initially, and manual initiation of the HPI upon loss of the steam generator heat sink or saturated conditions in the primary system.

3. METHOD OF ANALYSIS

Evaluations of very small breaks which result in repressurization phenomena are presented in reference 1. These analyses demonstrate that if auxiliary feedwater is delivered to the steam generators, the primary system would not repressurize to the PORV setpoint. However, the analyses in reference 1 also demonstrate that if feedwater is not delivered to the steam generator within 20 minutes, there is a class of very small breaks, less than 0.01 ft^2, which will result in system repressurization to the PORV setpoint. Since the PORV might stick open after being actuated, concerns have been raised regarding the impact of this consequential failure.

An analysis of a 0.01 ft^2 break in the cold leg pump discharge piping, without auxiliary feedwater to the SG, was performed wherein the PORV was actuated and assumed to stick open. As has been demonstrated in reference 1, larger breaks will result in automatic actuation of the HPI system and will not repressurize. While smaller breaks will repressurize to the PORV setpoint earlier, less inventory would be lost out the break. Therefore, the 0.01 ft^2 small break with the subsequent failure of the PORV is expected to be the worst case for transients of this type.

The analysis was performed using the B&W ECCS evaluation model for the 177-FA lowered-loop plants.[2] The analysis was performed using the same model and assumptions listed in Section 6.2.1.3.5 of reference 1 with the only changes being those made to reflect the PORV sticking open. Key assumptions of the analysis are listed below.

1. The initial core power level is 102% of 2772 MWt.
2. The core decay heat is based on 1.2 times the ANS standard.
3. Operator action was taken at 20 minutes to manually actuate both HPI pumps.
4. The PORV was modeled as a leak path on the top of the pressurizer. The orifice area of .0073 ft^2 was used, however, a C_D of 0.72 was utilized in order to reflect the proper relief characteristics of the PORV with the Moody critical flow model.
5. The PORV was opened at 20 minutes. This is consistent with the operator guidelines for a LOCA with no feedwater to the steam generators. However, if the operator had not acted within this time frame, approximately a 2 minute delay in operator action would have resulted in the PORV being actuated automatically.

4. RESULTS

Figures 1 through 7 show the system response during the transient and Table 1 presents a sequence of events for this accident. The resultant system pressure response of a 0.01 ft^2 cold leg break with no AFW is shown in Figure 1. This particular response is due to (1) the loss of the SG heat sink; (2) no automatic HPI actuation prior to the loss of the steam generator heat sink; and (3) the opening of the PORV and actuation of the HPI at 20 minutes. As seen in Figure 1, the pressure initially decreases following the break opening. During this depressurization period, the reactor trips, the pumps trip, the pressurizer empties, and the steam generator secondary inventory boils off. With the loss of the SG heat sink, the primary system starts to repressurize before the ESFAS signal is reached. Therefore, the HPI is not automatically actuated. The system repressurizes to 2350 psia by 20 minutes at which time the PORV was assumed to open. This is only 115 psi below the PORV setpoint which would have been reached approximately 2 minutes later. However, the operator is instructed to manually open the PORV if the system repressurizes and the SG heat sink is lost. Thus, the opening at 20 minutes is not totally arbitrary. During the system repressurization the pressurizer level increases (Figure 2) and when the PORV is opened the pressurizer rapidly fills with two phase mixture. At the time of the PORV opening, the two HPI pumps are manually actuated, and due to the addition of the cold makeup water and the additional leak path area, the RCS depressurizes.

The inner vessel mixture height is shown on Figure 3. As can be seen, operator action by 20 minutes to manually actuate the HPI prevents core uncovery and a minimum two-phase mixture level of 4.5 feet above the top of the core is maintained. Long term cooling is established at 25 minutes as the injected HPI fluid exceeds the core boil-off. Thus, the acceptance criteria of 10 CFR 50.46 are satisfied.

While the analysis performed herein addressed the effect of operator action to manually actuate the HPI by 20 minutes, the effect of operator action to manually restore the auxiliary feedwater within 20 minutes can be qualitatively assessed. As has been shown in Section 6.2.1.3.5 of reference 1, actuation of the auxiliary feedwater system at 20 minutes for a 0.01 ft^2 break results in a rapid system depressurization and the subsequent actuation of the HPI. For the case analyzed herein, the depressurization effect of the auxiliary feedwater would be faster than that shown in reference 1 due to the effect of the loss of inventory through the PORV. Thus, the HPI would be actuated earlier and long term cooling would be established faster than that shown in reference 1. Therefore, no core uncovery is expected if the operator only actuates the auxiliary feedwater system within 20 minutes and, contrary to the guidelines, does not manually actuate the HPI.

5. APPLICABILITY TO DAVIS-BESSE 1

The analysis presented herein required that no auxiliary feedwater is delivered to the SG during the small break transient. This situation is considered highly unlikely for Davis-Besse 1 because the auxiliary feedwater system is safety grade. However, it is expected that the Davis-Besse 1 plant can safely mitigate the accident if auxiliary feedwater is restored within 20 minutes.

The analysis presented herein was performed assuming operator action at 20 minutes to manually actuate the HPI. Due to the low shutoff head of the HPI pump at Davis-Besse 1, this operator action would not provide adequate protection for this event at Davis-Besse 1. However, as previously discussed, restoration of the auxiliary feedwater system by 20 minutes is expected to prevent core uncovery for the lowered-loop plants. Because of the raised-loop arrangement of the Davis-Besse unit, more of the loop water is available to drain into the vessel. Thus, operator action by 20 minutes to restore auxiliary feedwater at Davis-Besse would provide more margin relative to core uncover than would exist for the lowered-loop plants and compliance with 10 CFR 50.46 would be easily assured.

Table 1. Sequence of Events

Event	Time, s
1. 0.01 ft^2 cold leg break occurs	0.0
2. Reactor trip, loss of feedwater, and RC pump trip	54.5
3. Main feedwater coastdown ends	60.0
4. SG secondary boils dry	270.0
5. PORV opened	1200.0
6. HPI is manually initiated	1200.0
7. Long term cooling established	1510.0

REFERENCES

[1] Letter J.H. Taylor (B&W) to S.A. Varga (NRC), "Evaluation of Transient Behavior and Small Reactor Coolant System Breaks in the 177-Fuel Assembly Plant," May 7, 1979.

[2] B.M. Dunn, et. al, "B&W's ECCS Evaluation Model," BAW-10104, Rev. 3, Babcock & Wilcox, May 1975.

Figure 1

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - NODE 14 PRESSURE VS TIME

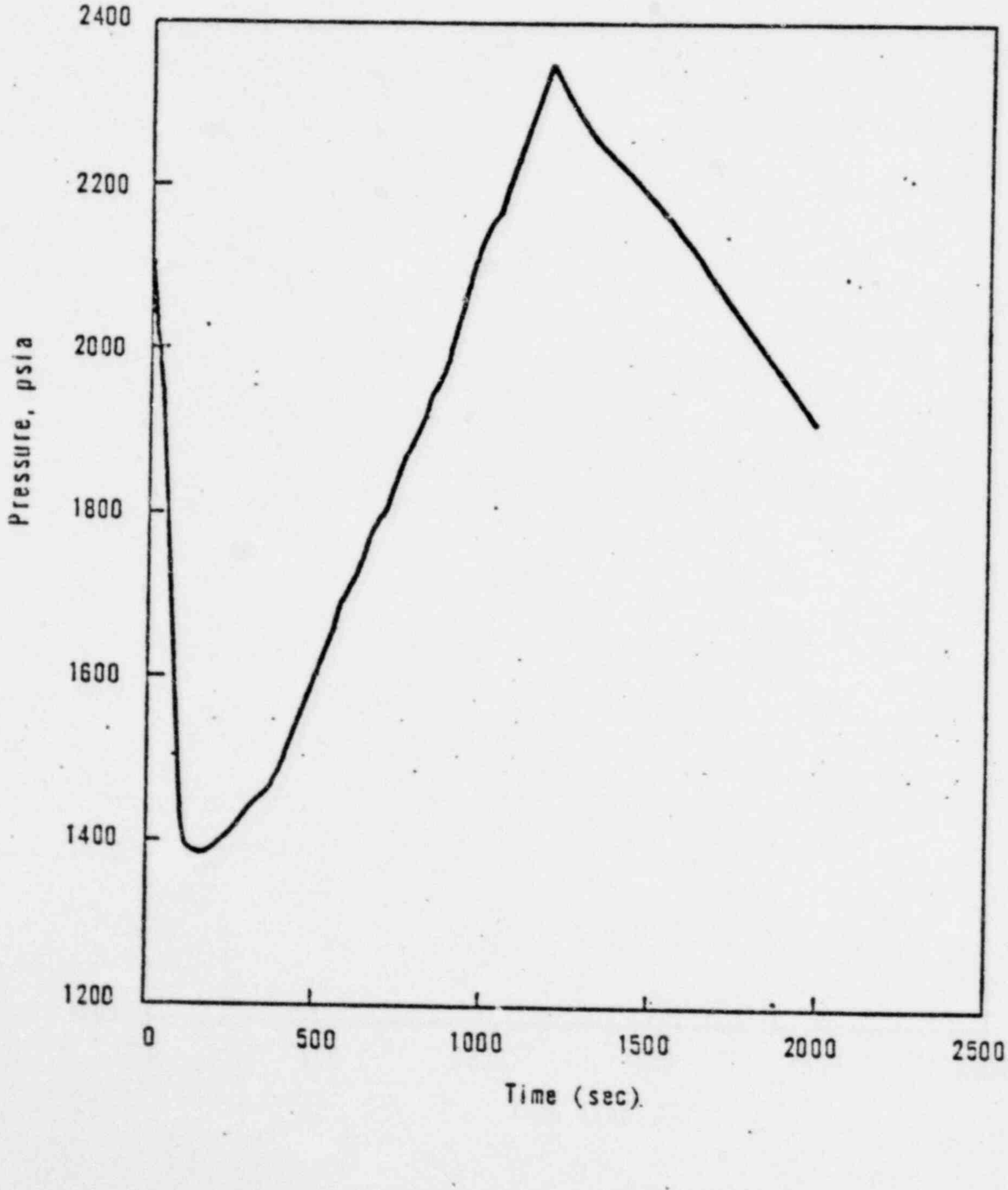

Figure 2

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - PRESSURIZER LIQUID LEVEL

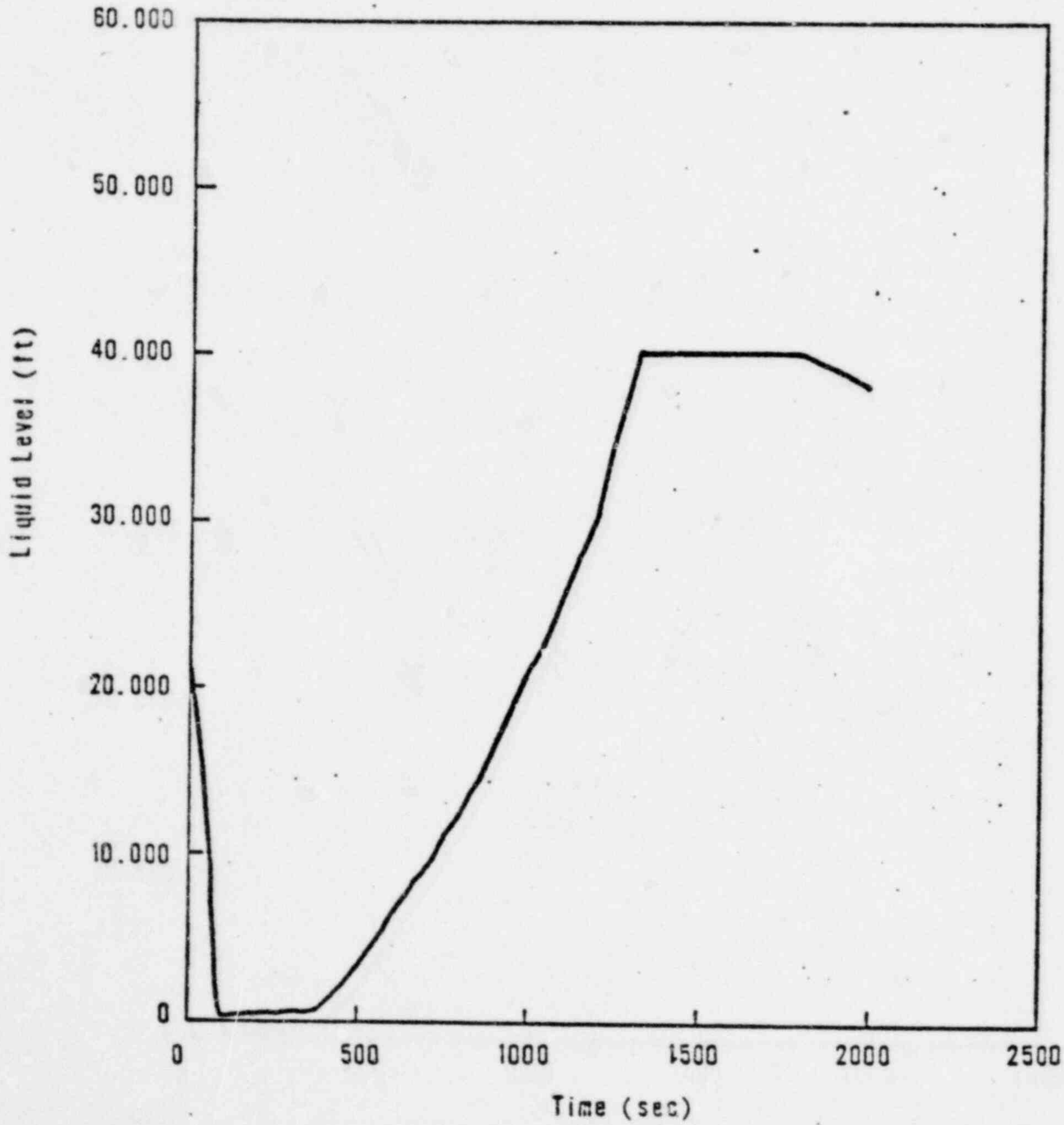

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Figure 3

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - UPPER PLENUM LIQUID LEVEL

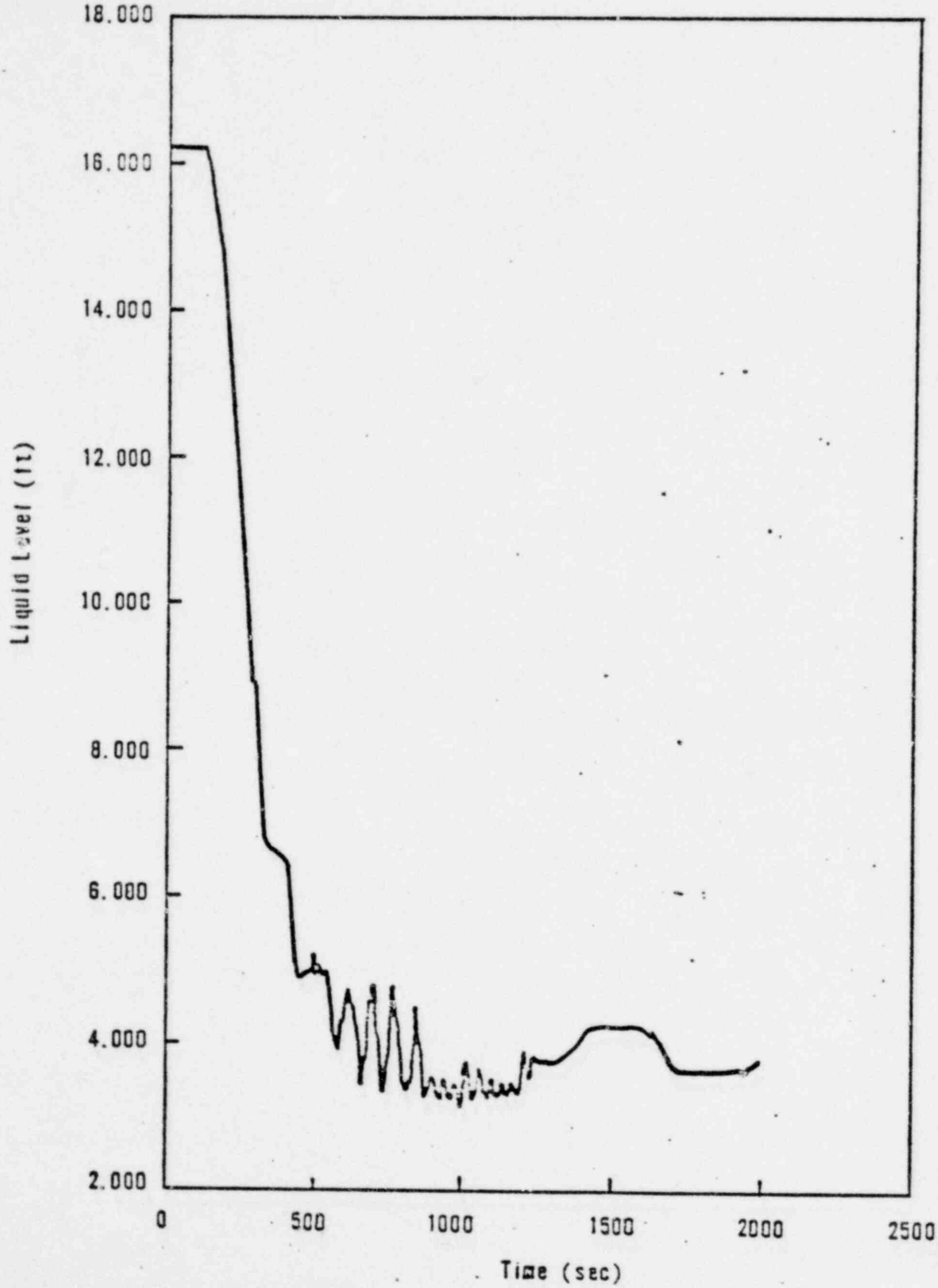

Figure 4

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV
AT 20 MIN. - PORV LEAK FLOW

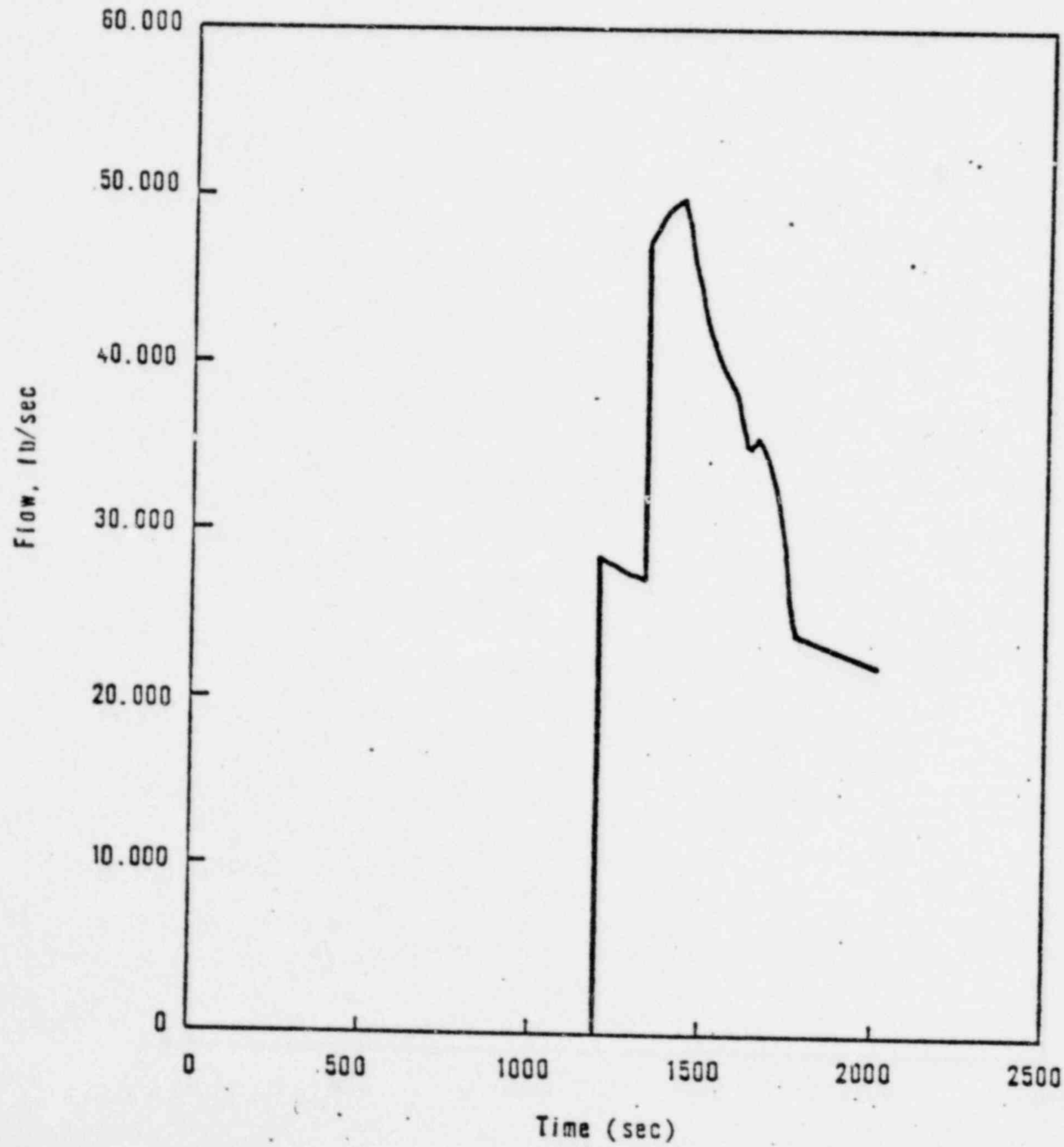

Figure 5

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - PORV LEAK FLOW QUALITY

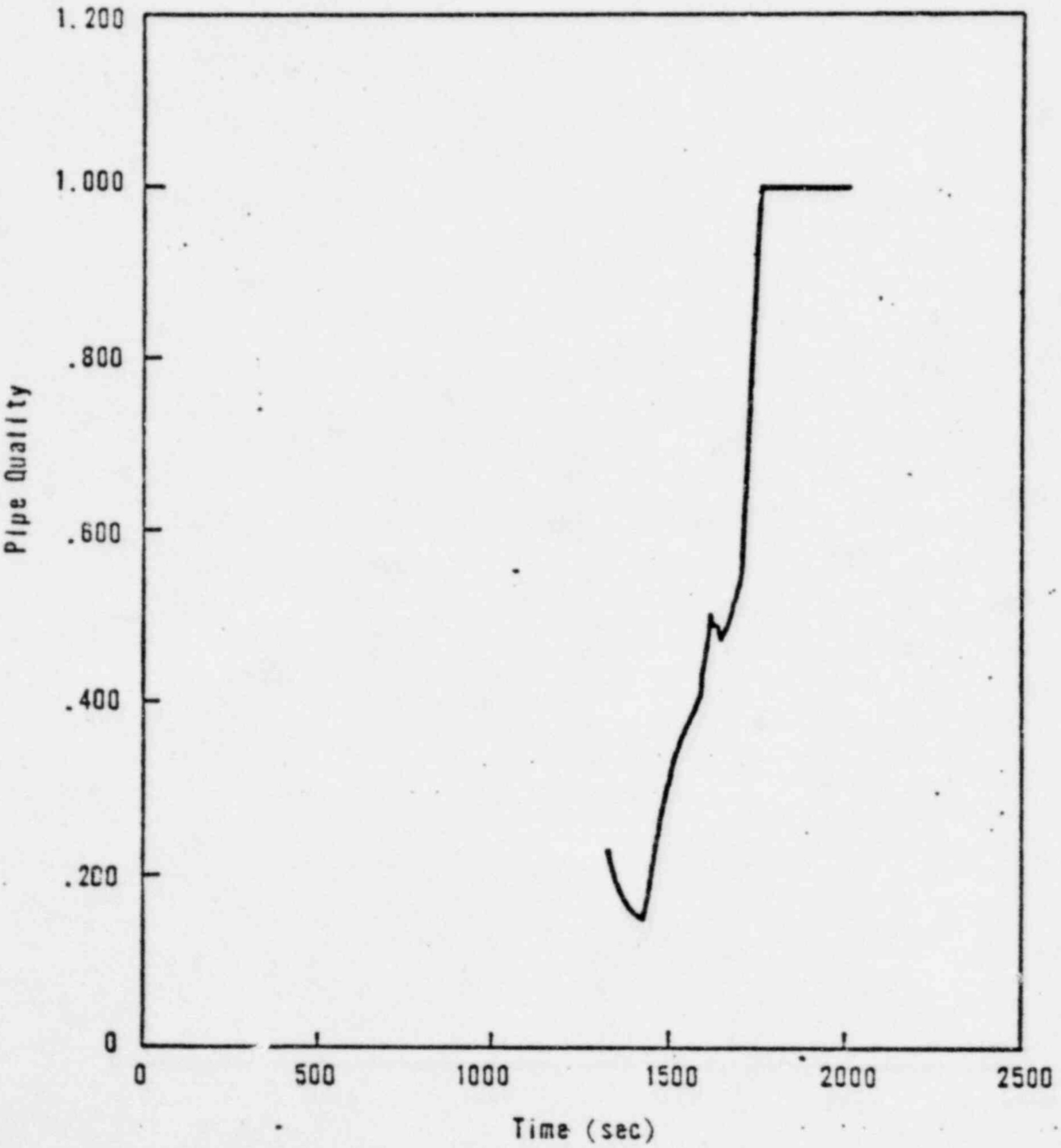

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Figure 6

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - COLD LEG BREAK FLOW

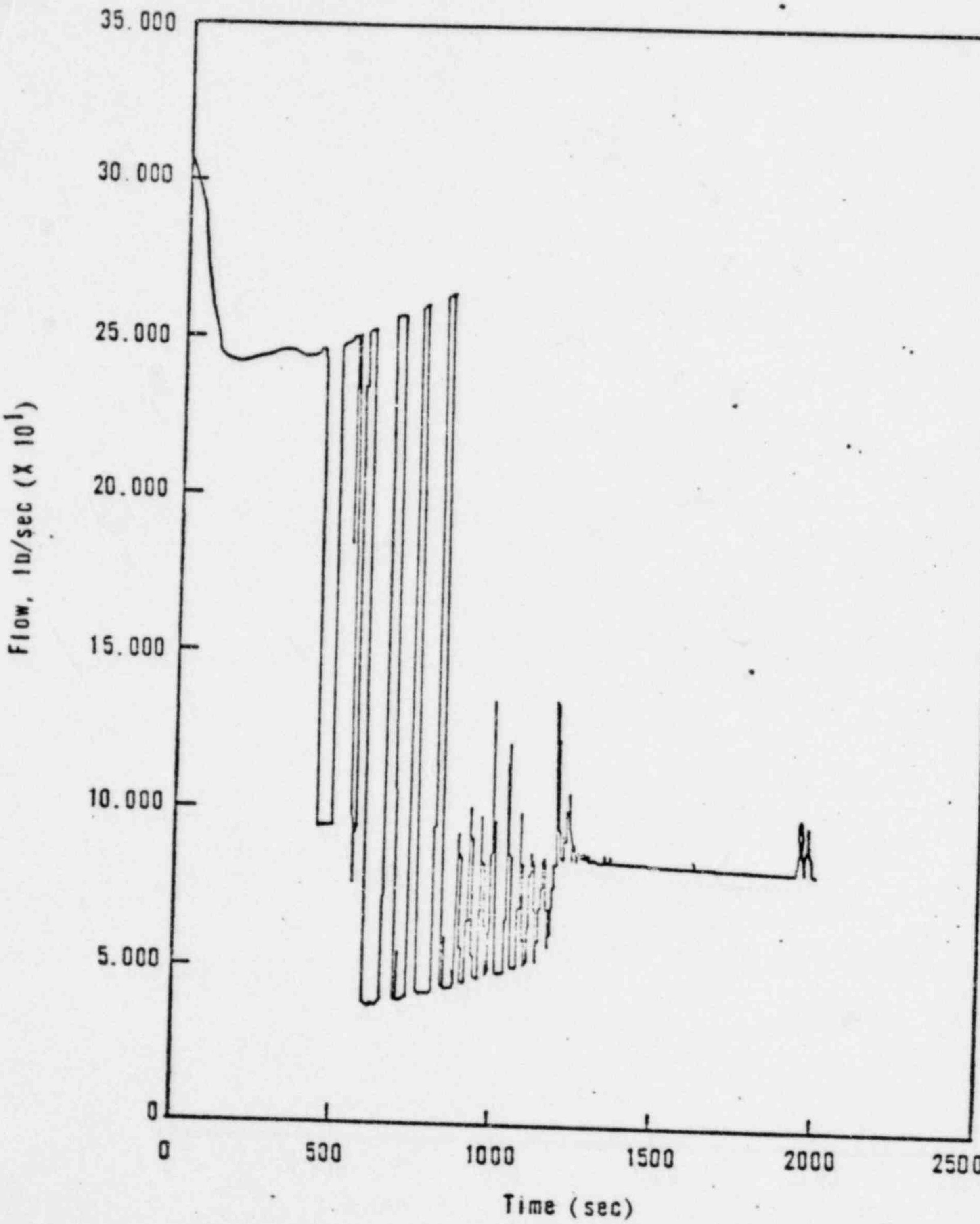

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Figure 7

.01 FT^2 COLD LEG BREAK W/NO AFW 2 HPI'S & STUCK PORV AT 20 MIN. - COLD LEG BREAK LEAK FLOW QUALITY