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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. R. W. BORCHARDT

SUBJECT: AP600 LOCA ANALYSIS SENSITIVITY TO CONTAINMENT PRESSURE, ACTION ITEM FROM MAY 10, 1994 SENIOR MANAGEMENT MEETING

Dear Mr. Borchardt:

The attachment to this letter contains the results of a sensitivity analysis performed to investigate the sensitivity of AP600 LOCA analysis results to containment pressure. This sensitivity study was performed in response to an action taken at the May 10, 1994 meeting between Westinghouse and NRC at Oregon State University.

The results of the sensitivity study demonstrate that a conservative representation of the AP600 ECCS performance can be computed for postulated small break LOCA events by applying a 14.7 psia containment boundary cordition.

Please contact Brian A. McIntyre on (412) 374-4334 if you have any questions concerning this transmittal.

N. J. Liparulo, Manager
Nuclear Safety Regulatory And Licensing Activities

/nja

Enclosure
Attachment

cc: R. Hasselberg, NRC
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AP600 Loss of Coolant Accident
Containment Back Pressure Sensitivity Study

Introduction

The AP600 SSAR LOCA analysis is a spectrum of postulated break sizes ranging from a one-inch equivalent diameter break to double-ended hot leg (DEHLG) and cold leg (DECLG) guillotine breaks. All LOCA cases to date have been performed using a constant containment pressure boundary condition of 14.7 psia. Appendix K to 10CFR50 identifies that a minimum containment pressure should be applied in design basis ECCS performance analyses to obtain conservative calculated peak cladding temperature (PCT) values. In this study the effect of applying a computed containment pressure transient rather than 14.7 psia upon the calculated ECCS performance is determined for the AP600 two inch equivalent diameter cold leg break case.

The two-inch cold leg break is chosen as a representative SSAR spectrum case to study the pressure boundary condition impact on the AP600 accident sequence of events and the passive safety system performance of the core makeup tanks, ADS, and the achievement of IRWST injection. The NOTRUMP computer code, which was used in the SSAR small break LOCA analysis, was utilized in this analysis. Only passive safety- related systems were modeled. The NOTRUMP AP600 input model used for the SSAR analyses complies with the standard Westinghouse Small Break LOCA Evaluation Model methodology (References WCAP-10079 and 10054). For better representation of the AP600, the following changes have been made to the original SSAR model:

1) The double-link horizontal stratified flow links between the reactor coolant pump and cold leg fluid nodes are abandoned and replaced with single links. The purpose of applying double links was to properly consider the possible spillover of liquid from the cold legs into the standard plant loop seals. Since AP600 pumps do not possess loop seals it is more appropriate to use a single link model.

2) The double-link horizontal stratified flow links are no longer used for the surge line connections. Rather, single links with a side entry into the pressurizer node are utilized because they more appropriately model the surge line flow path.

3) The AP600 design changes identified in the February 15, 1994 and June 30, 1994 design change reports (References) were incorporated into the model.

4) A multi-node PRHR representation of the heat exchanger is used. PRHR HX actuation occurs on a Safeguards ("S") signal. Standard condensation heat transfer correlations are applied when primary side steam condenses in the PRHR.

The timer-based actuation of ADS stages two and three means that individual ADS stage characteristics are not crucial for the ADS stage 1-3 depressurization of the RCS in the two inch cold leg break case. Therefore, the single active failure assumed herein is the failure of one of the four fourth-stage ADS valves to open.

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Two-Inch cold leg break Results

A break two inches in equivalent diameter is modeled in one of the Loop 1 (pressurizer loop) cold legs, the same location as analyzed in the SSAR. Only safety-related systems are assumed to operate in this analysis. The second and third stage ADS valves actuate based on the design time delays. At the 20 percent mixture level in the core makeup tank, the fourth stage ADS valves, which are on the hot legs, receive signals to open. Three of the four fourth stage ADS paths are assumed to open; one of the paths fails to open as the assumed single active failure. The two-inch break scenario analyzed is the same as in the SSAR, except that an additional sensitivity calculation to the containment boundary condition is performed. The containment pressure response of the AP600 to a two-inch cold leg break LOCA event as computed by WGOTHIC (Figure 1) is modeled in the sensitivity case. Sequences of events for the transients are given in Table 1 for each containment boundary condition assumption.

The break initially depressurizes the RCS, and the reactor trip, reactor coolant pump trip and safeguards "S" signals are generated via the pressurizer low pressure signals with appropriate delays. Upon generation of the reactor trip signal the main steam isolation valves begin to close. Five seconds after an "S" signal the main feedwater isolation valves begin to close. The differing containment boundary conditions have no impact as long as flow through the break and the open ADS paths remain choked. Therefore, the original case performed with a 14.7 psia boundary condition was restarted at 1350 seconds and continued thereafter with the WGOTHIC pressure. As Table 1 demonstrates, events are virtually identical for the two cases beyond the 1500 second transient time.

Figure 2 illustrates the reactor coolant system (RCS) pressure transient for the 14.7 psia containment pressure boundary condition. Figure 3 presents the pressurizer pressure comparison for the two cases once the impact of the pressure boundary condition becomes significant; in this and the other comparison plots presented the curve marked with boxes is from the WGOTHIC pressure boundary condition case. Because ADS flow from the pressurizer is diminished, as shown in Figures 4 and 5, more mass is retained in the RCS in the 1500-1850 second time span. In particular, the core makeup tank level is established at a higher value under the WGOTHIC boundary condition during this interval. It retains its higher level throughout the remainder of the transient, as shown in Figure 6, leading to a later ADS stage 4 actuation than in the 14.7 psia boundary condition case. The difference in mixture level between the CMTs in the two cases remains almost constant as they drain during the rest of the transient after 1900 seconds.

Actuation of the PRHR on an "S" signal has a major impact on this postulated event. As Figure 1 indicates, the early PRHR actuation following an "S" signal depressurizes the RCS below the accumulator gas pressure setpoint before the automatic depressurization system is actuated. With this early actuation the accumulator drains before the difference in the containment boundary condition has any effect on the transient. Later, the higher WGOTHIC containment pressure means that less RCS depressurization is necessary to achieve pressure equilibration with the containment. As Table 1 shows, this enables IRWST injection to begin almost 90 seconds earlier than in the 14.7 psia case, before the CMT empties at 2723 seconds. With the 14.7 psia containment pressure the CMT is predicted to empty at 2626 seconds, before IRWST injection begins at 2713 seconds. The RCS mass inventory comparison plot presented in Figure 7 demonstrates that although the predicted system inventories are very similar in the 1900-2350 second time interval, the minimum system inventory is significantly higher when the WGOTHIC

pressure boundary condition is applied. When the calculated containment pressure during the two-inch break is simulated in NOTRUMP, there is continuous injection into the reactor vessel.

The mass discharge through the break is not greatly affected by the NOTRUMP containment boundary condition. Figures 8 and 9 illustrate that the break flow for the two cases is very similar throughout the entire transient. When the levels in the CMTs eventually reach the fourth stage ADS setpoint, vent paths opened from the hot legs begin discharging fluid. The single active failure assumed is that one of the four fourth stage ADS valves fails to open, minimizing the capability to depressurize the RCS to achieve IRWST injection. The liquid and vapor flow rates through the fourth stage ADS paths are presented in Figures 10 through 13. The ADS system of the AP600 capably depressurizes the RCS to the IRWST delivery pressure for the postulated two-inch cold leg break. The ADS vent area is sufficient to depressurize the RCS even assuming the failure of one fourth stage ADS valve to open and utilizing Appendix K decay heat when a 14.7 psia pressure containment boundary condition is applied for conservatism in place of a WGOTHIC-calculated response (Figure 13).

Conclusions

The two-inch cold leg break LOCA case from the AP600 SSAR has been reanalyzed with NOTRUMP to investigate the effect of the containment boundary condition on the predicted system response. The case utilizing the WGOTHIC-calculated containment pressure achieves IRWST injection earlier and results in a greater system mass inventory condition than does the case using the SSAR pressure of 14.7 psia. The minimum mass inventory is also greater when the WGOTHIC-defined containment boundary condition is applied to NOTRUMP. Overall, these cases demonstrate that a conservative representation of the AP600 ECCS performance can be computed for postulated small break LOCA events by applying the 14.7 psia containment boundary condition in NOTRUMP analyses.

TABLE 1: SEQUENCE OF EVENTS TABLE

Case	14.7 psi pressure	WGOTHIC pressure trace
Break open	0.0 seconds	0.0 seconds
Reactor trip signal	27.4 seconds	27.4 seconds
"S" signal	33.3 seconds	33.3 seconds
Reactor coolant pumps start to coast down	49.5 seconds	49.5 seconds
Accumulator flow starts	992 seconds	992 seconds
ADS stage 1 flow starts	1094 seconds	1094 seconds
ADS stage 2 flow starts	1164 seconds	1164 seconds
ADS stage 3 flow starts	1284 seconds	1284 seconds
Accumulator injection ends	1525 seconds	1525 seconds
ADS stage 4 flow starts	2324 seconds	2376 seconds
IRWST injection starts	2713 seconds	2626 seconds

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FIGURE 1
CONTAINMENT PRESSURE, 2 INCH COLD LEG BREAK

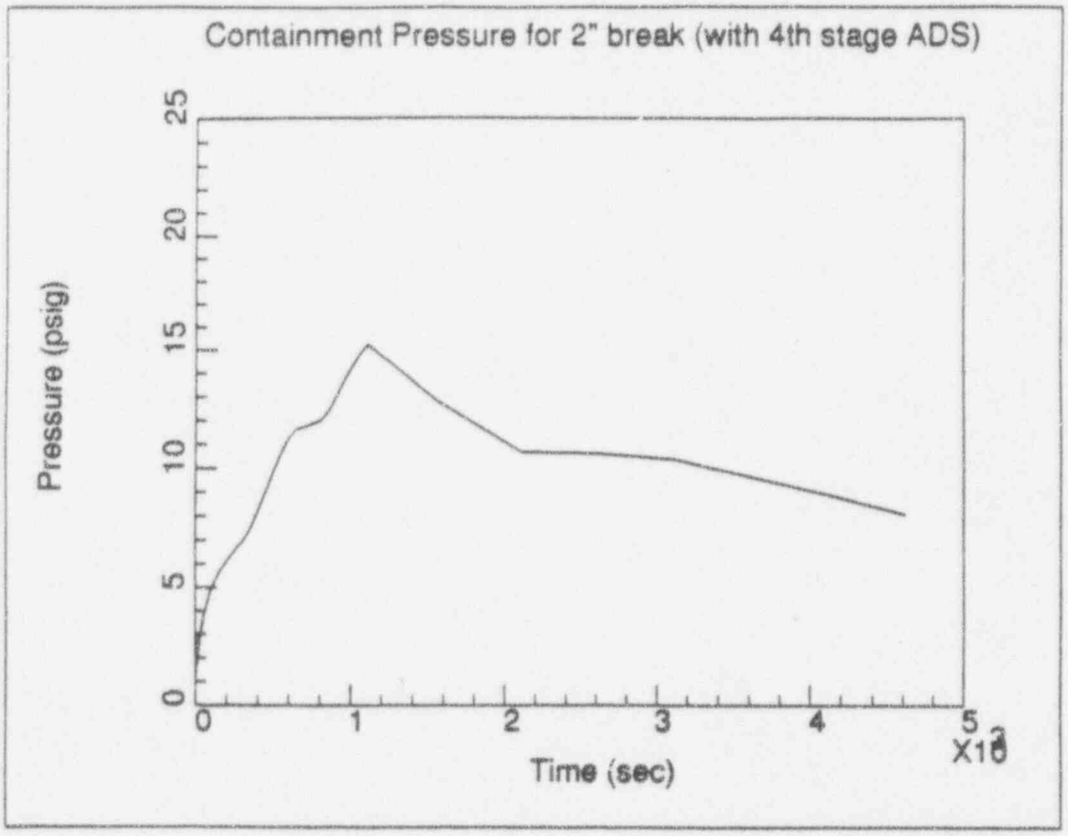

FIGURE 2
DOWNCOMER PRESSURE, TWO INCH COLD LEG BREAK

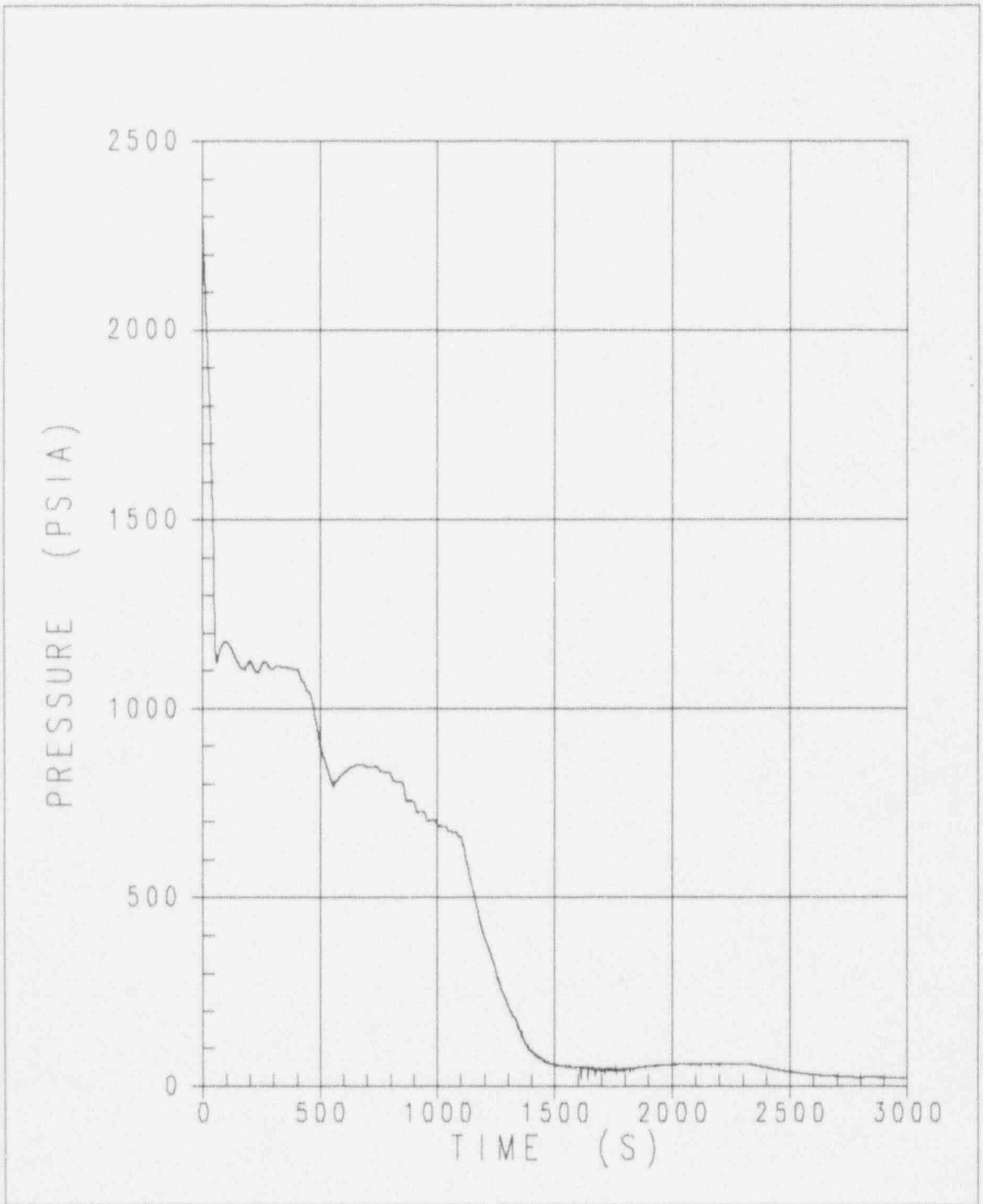

FIGURE 3
PRESSURIZER PRESSURE DETAIL, TWO INCH COLD LEG BREAK

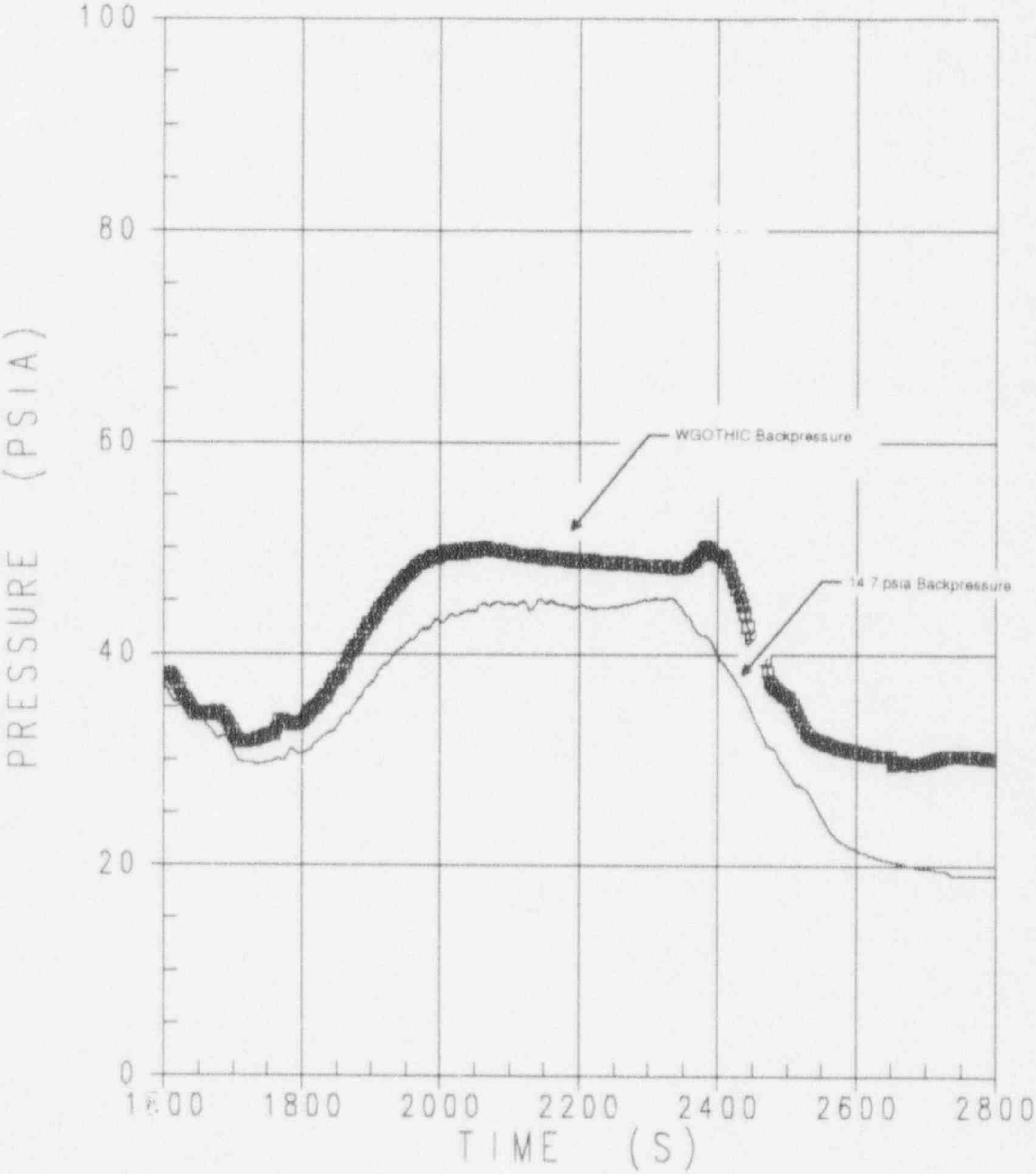

FIGURE 4
ADS VAPOR FLOW DETAIL, TWO INCH COLD LEG BREAK

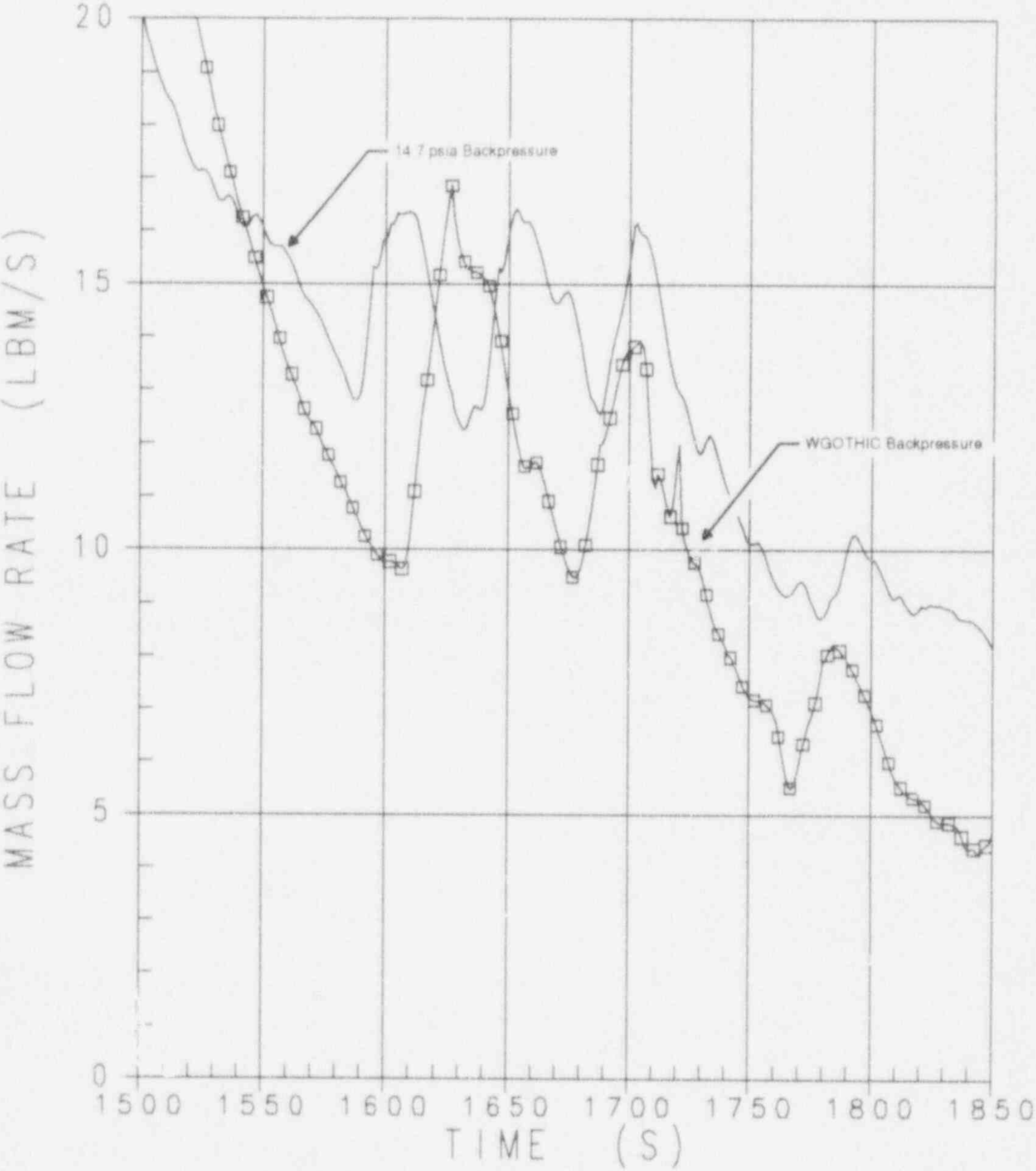

FIGURE 5
ADS LIQUID FLOW DETAIL, TWO INCH COLD LEG BREAK

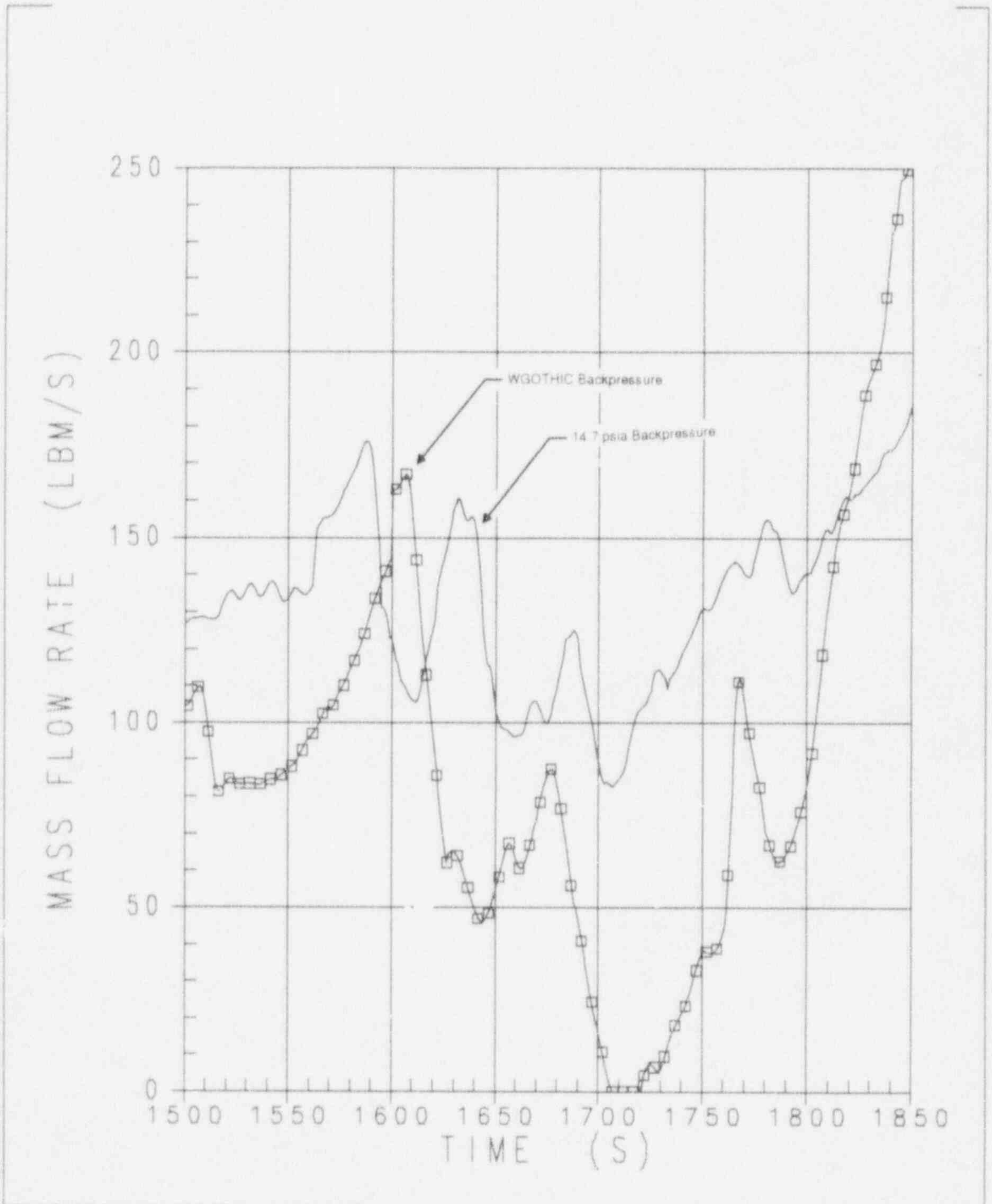

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FIGURE 6
CORE MAKEUP TANK MIXTURE DETAIL, TWO INCH COLD LEG BREAK

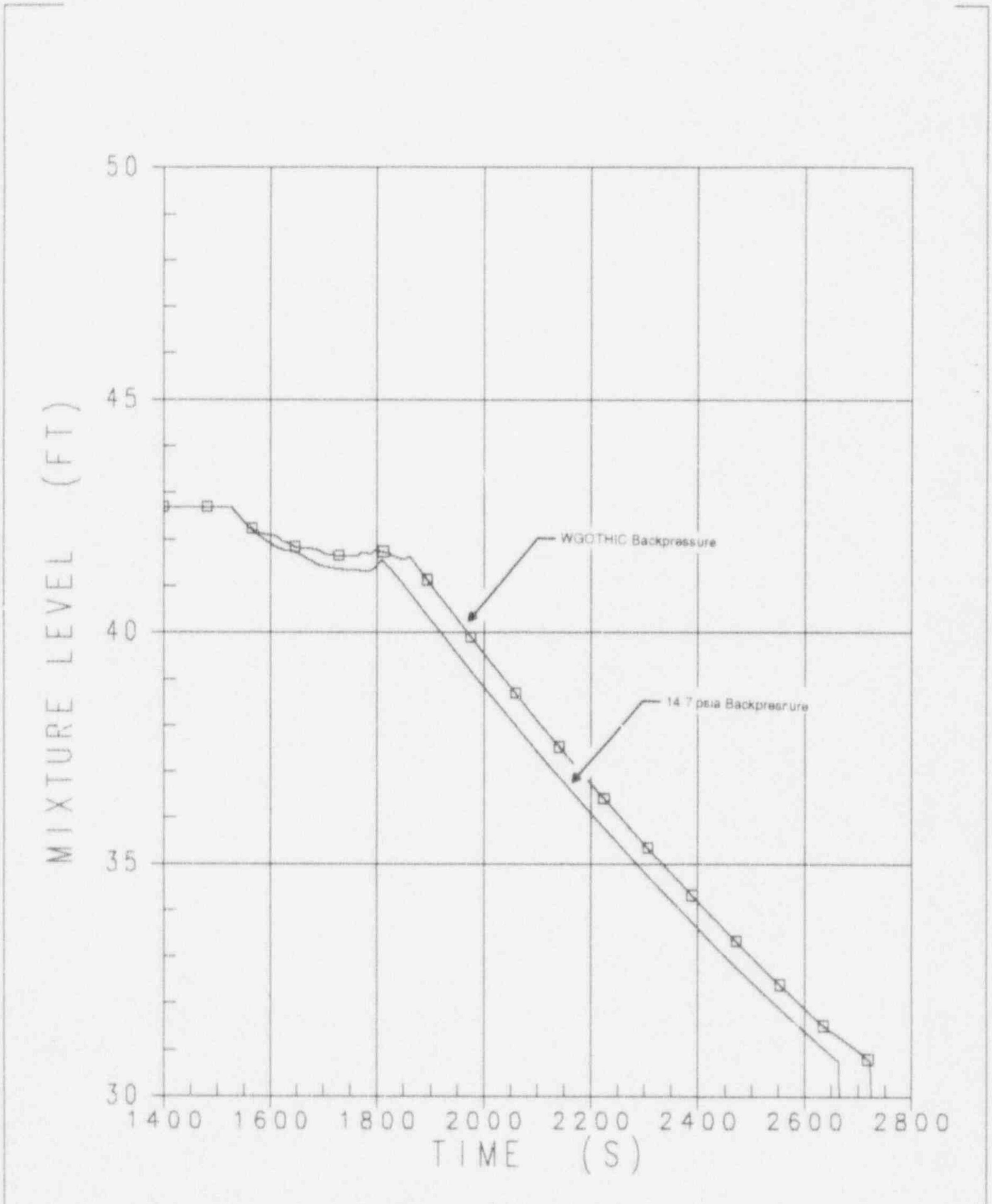

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FIGURE 7
RCS MASS INVENTORY DETAIL, TWO INCH COLD LEG BREAK

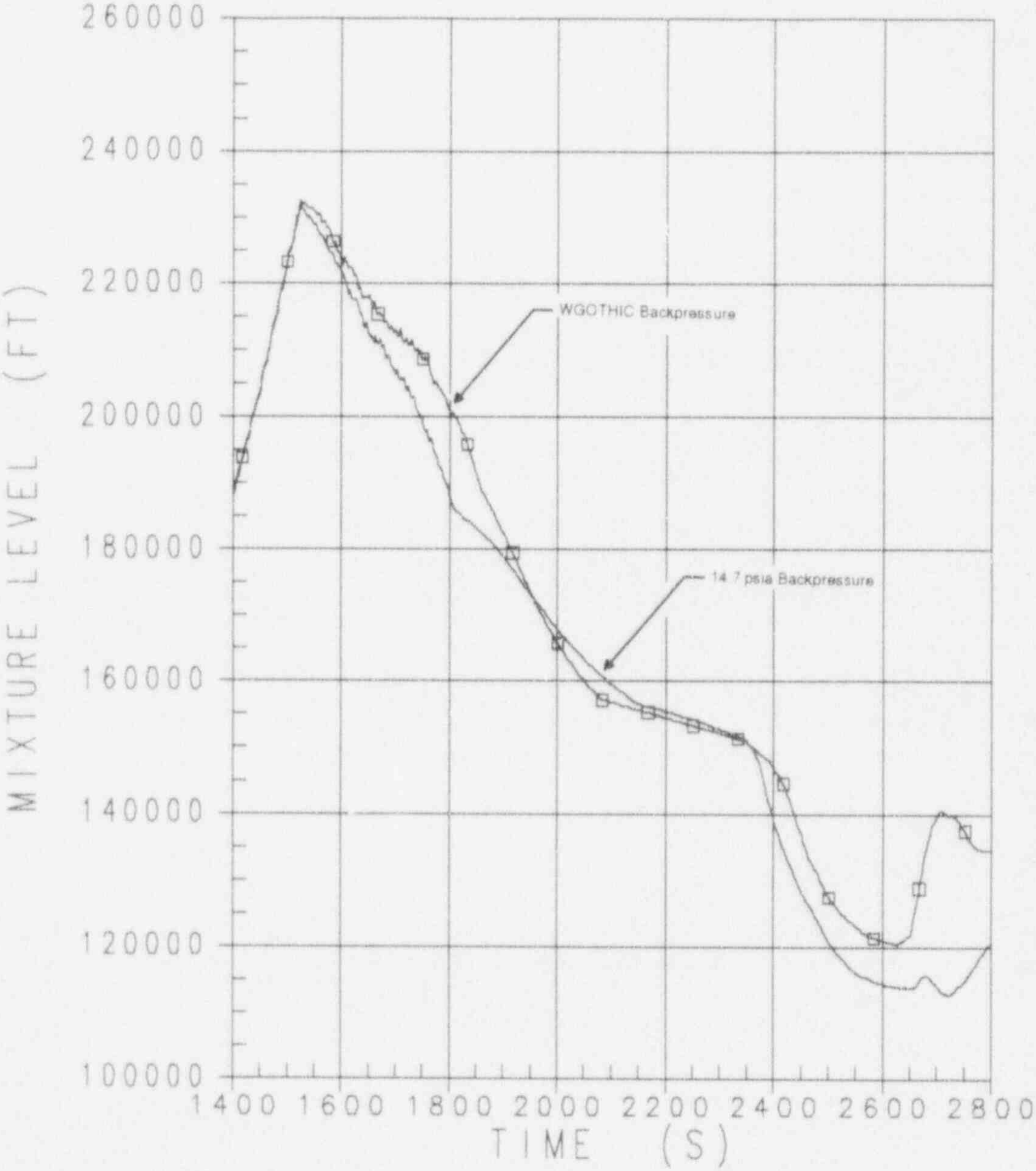

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FIGURE 8
TOTAL BREAK FLOW AT 14.7 CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK

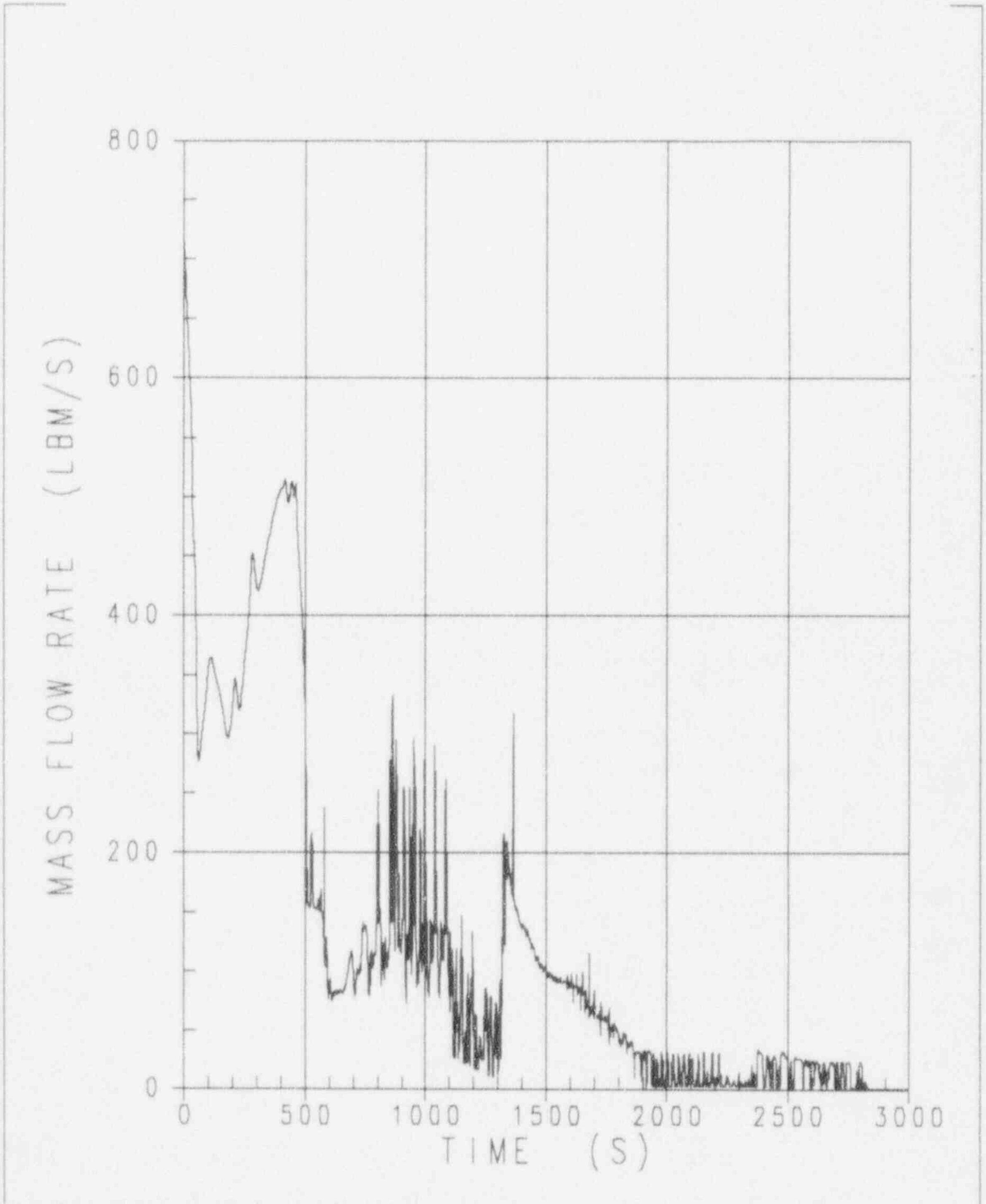

FIGURE 9
TOTAL BREAK FLOW AT WGOTHIC CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK

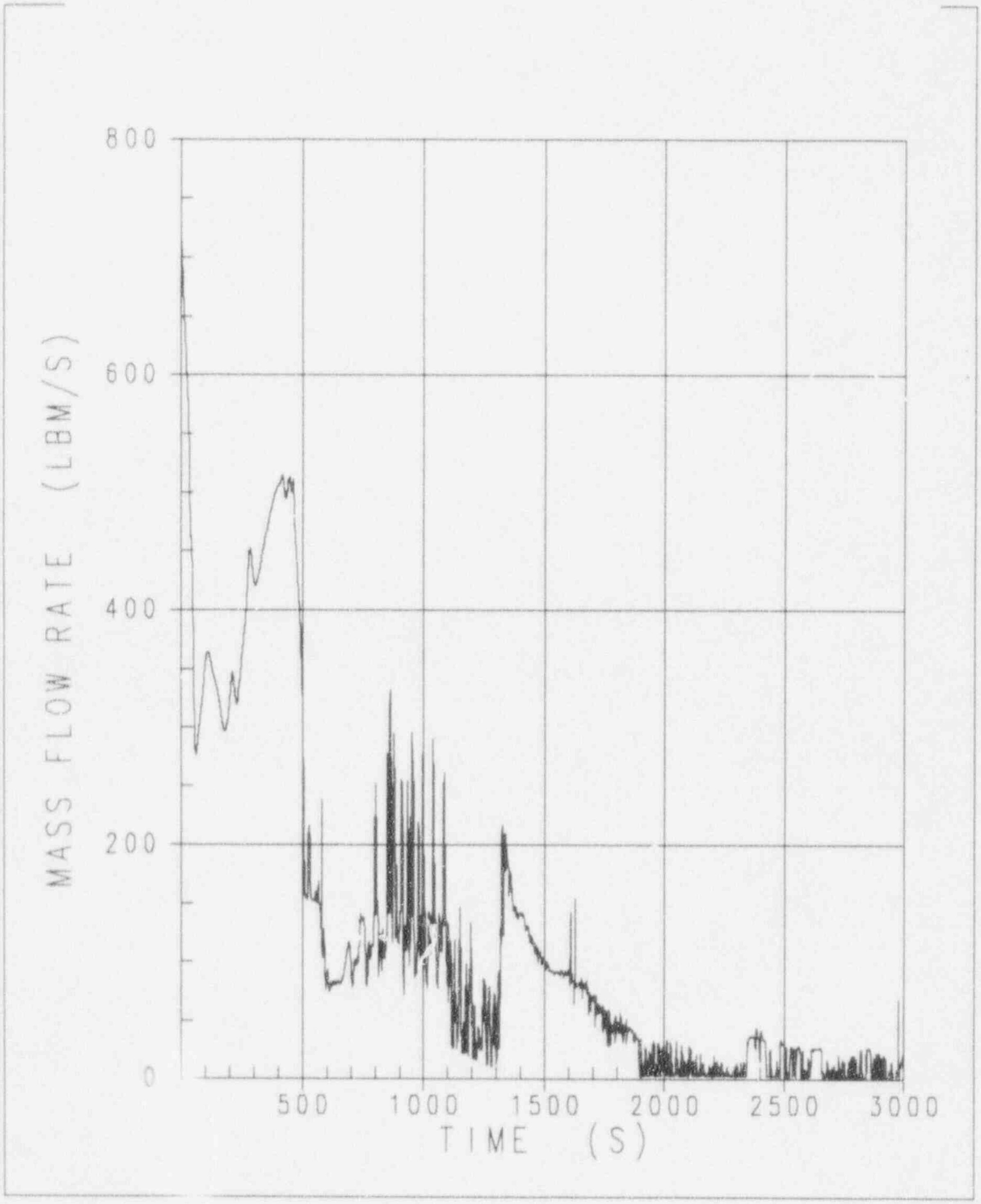

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FIGURE 10
ADS STAGE 4 LIQUID FLOW AT 14.7 CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK

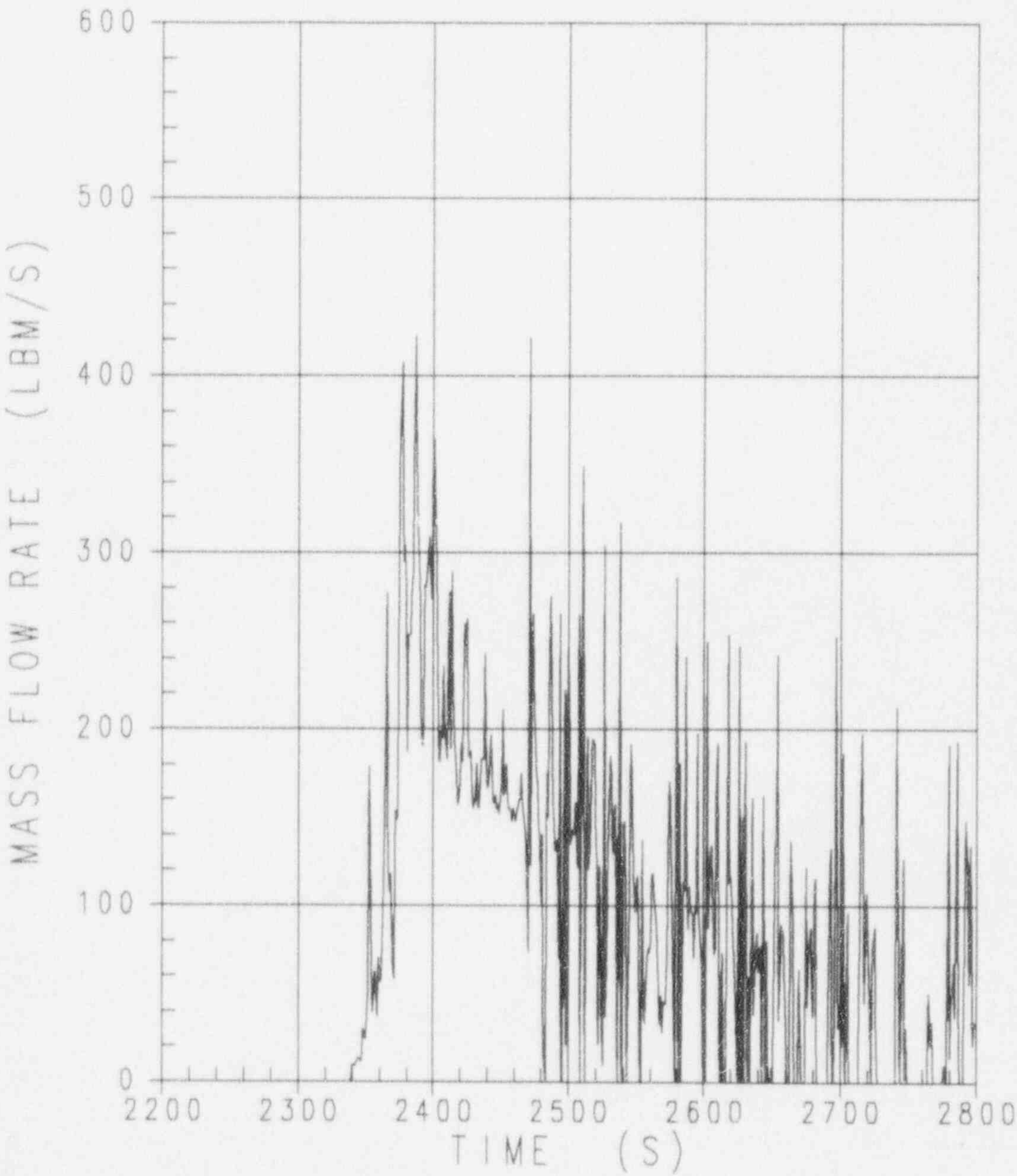

FIGURE 11
ADS STAGE 4 VAPOR FLOW AT 14.7 CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK

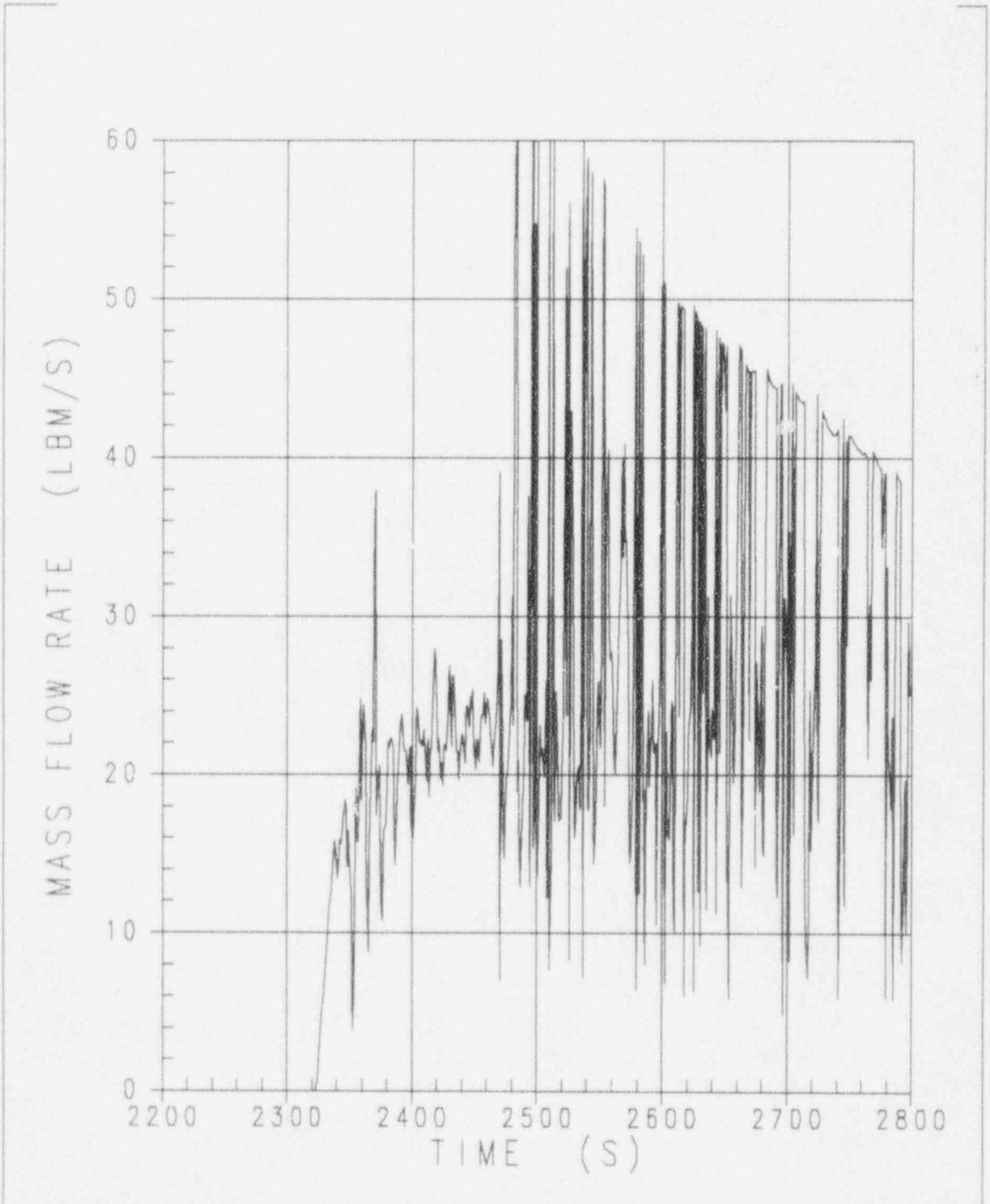

FIGURE 12
ADS STAGE 4 LIQUID FLOW AT WGOTHIC CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK

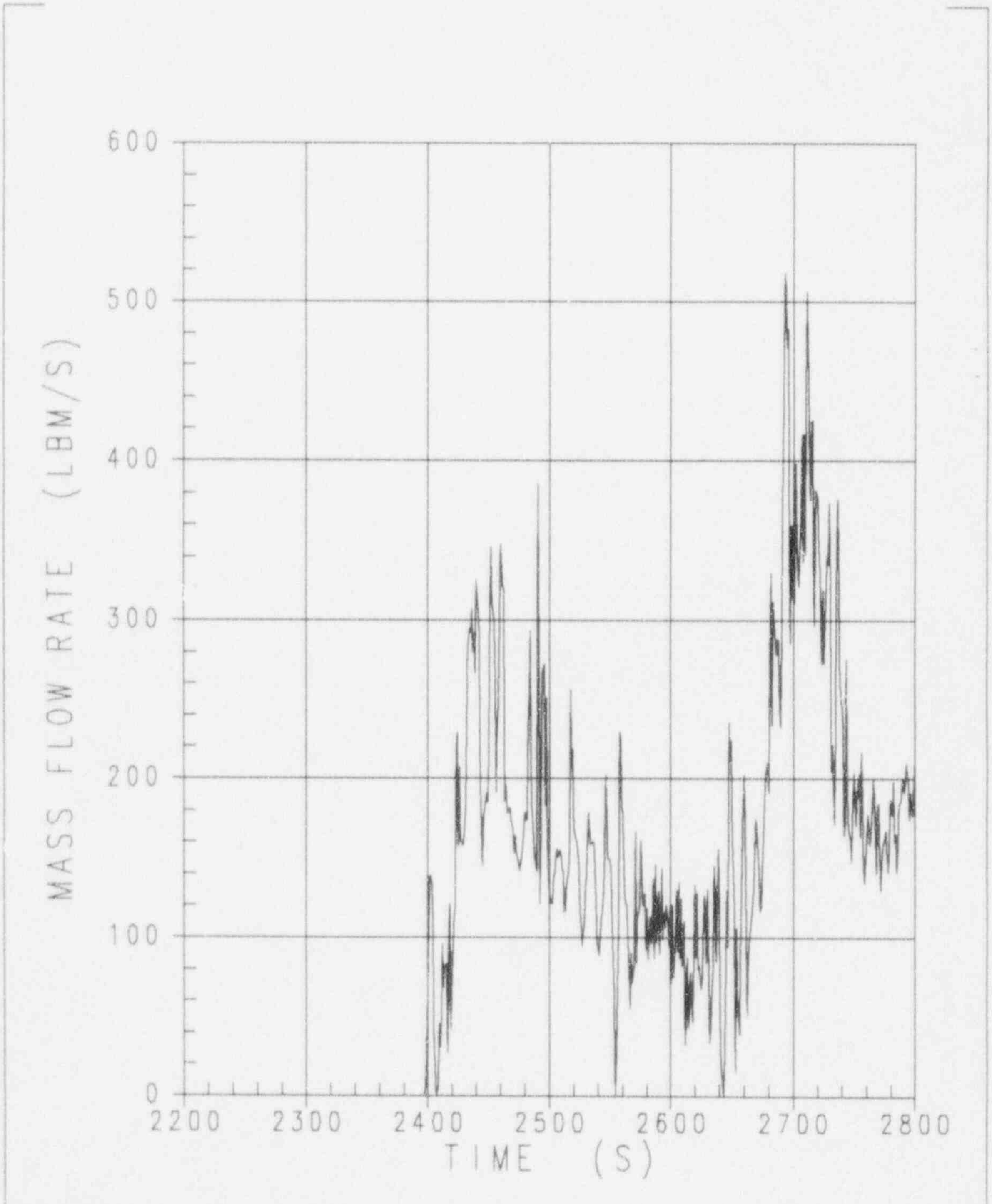

FIGURE 13
ADS STAGE 4 VAPOR FLOW AT WGOTHIC CONTAINMENT PRESSURE, TWO INCH COLD LEG BREAK