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Your ref: Docket No. 52-006
Our ref: DCP/NRC1644

October 28, 2003

SUBJECT: Transmittal of Revised Responses to AP1000 DSER Open Items

This letter transmits Westinghouse revised responses to Open Items in the AP1000 Design Safety Evaluation Report (DSER). A list of the revised DSER Open Item responses transmitted with this letter is Attachment 1. The non-proprietary responses are transmitted as Attachment 2.

Please contact me at 412-374-4728 if you have any questions concerning this submittal.

Very truly yours,

R. P. Vijuk

R. P. Vijuk, Manager
Passive Plant Engineering
AP600 & AP1000 Projects

/Attachments

1. List of the AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses transmitted with letter DCP/NRC1644
2. Non-Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated October 28, 2003

D063

Attachment 1

List of

Non-Proprietary Responses

Table 1 "List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1644"	
21.5-1 Item ADS4K	

DCP/NRC1644
Docket No. 52-006

October 28, 2003

Attachment 2

AP1000 Design Certification Review
Draft Safety Evaluation Report Open Item Non-Proprietary Responses

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 21.5-1 Item ADS4 K Sensitivity

Original RAI Number(s): 440.164

Summary of Issue:

In the October 2, 2003, NRC / Westinghouse meeting on AP1000 thermal/hydraulic open items the NRC requested NOTRUMP (SBLOCA) and WCOBRA/TRAC (LTC) sensitivity analyses to the form loss factors used in modeling the AP1000 ADS4 flow paths.

Westinghouse Response:

Sensitivity analyses have been performed with NOTRUMP for the DEDVI line break and with WCOBRA/TRAC for long term cooling at the beginning of sump recirculation. These analyses are discussed below.

NOTRUMP Sensitivity Analysis

To determine the impact of increasing the ADS-4 flow path form loss coefficients on the AP1000 plant analyses, a DEDVI line break sensitivity study was performed. The process applied was to utilize the detailed momentum flux model FLOAD4 to determine the adjustments required to be made to the NOTRUMP model. This involved performing a FLOAD4 calculation with the form loss coefficients increased by a factor of two. The results of this FLOAD4 simulation was then compared to the reference case FLOAD4 simulation utilized for the DCD simulations. The effective increase in ADS-4 resistance, at near atmospheric conditions where momentum is negligible, was determined to be approximately a factor of 1.64. This effective increase in overall loss coefficient was then applied to the reference NOTRUMP ADS-4 flow paths.

The revised FLOAD4 calculation, in which the form loss coefficients were increased by a factor of two, resulted in an effective increase in ADS-4 resistance of 1.56 to account for momentum flux effects at IRWST injection conditions. This compares to the reference DCD simulations which determined this factor to be 1.7. As expected, the increase in form loss coefficients reduces the effective flow through the ADS-4 path and subsequently results in a reduction in the importance of momentum flux under these conditions.

	DCD Case	Sensitivity Case	Increase vs. DCD
ADS-4 Form + Friction Loss	1.0	1.64 (2*form losses)	64%
ADS-4 Form + Friction Loss + Momentum	1.7	2.56 (1.56*1.64)	50%

The NOTRUMP DEDVI, with the adjusted ADS-4 flow paths, simulation was performed in the same fashion as the DCD cases. The event times for this transient are shown in Table-1. The transient results are shown in Figures 1 through 7 for the base DCD case and for the

sensitivity case. The results indicate that the increased ADS4 resistance slows the system depressurization after ADS4 opens and delays the start of IRWST injection. The IRWST is delayed until after the intact CMT has drained. The inner vessel mixture level reaches its minimum just prior to sustained IRWST injection for the sensitivity case but is still well above the top of the core.

The base DCD analysis includes conservatism in the ADS4 form losses in the method used to determine these losses for the ADS4 flow paths. This sensitivity analysis indicates that the DCD analysis is not highly sensitive to the ADS4 flow path form losses.

WCOBRA/TRAC Sensitivity Analysis

This subsection presents the results of a sensitivity study investigating the impact of the ADS Stage 4 flow path resistance on the AP1000 DEDVI line break long term cooling analysis from DCD Subsection 15.6.5.4C.2. WCOBRA/TRAC window mode cases are performed at the most limiting time during LTC, immediately after the switchover to sump recirculation (earliest time/highest decay heat at low recirculation water level). The WCOBRA/TRAC calculation from the DCD is restarted at 6500 seconds problem time, then continued for approximately one hour of additional transient time. The sensitivity calculations use the boundary conditions from the DCD analysis of this event. In all analyses, one of the two ADS Stage 4 valves in the PRHR loop is assumed to have failed. The core makeup tanks do not contribute to the DVI injection during this phase of the transient, and the levels and temperatures of the liquid in the containment sump as well as the containment pressure are based on WGOTHIC calculations of the conservative minimum pressure during this long term cooling transient. There is little flow out of ADS Stages 1, 2, and 3 even when the IRWST liquid level falls below the sparger elevation, so they are not modeled in this calculation.

During long term cooling the venting provided by the ADS-4 paths enables liquid to be injected by gravity through the DVI lines. This study includes a case in which the ADS Stage 4 flow path resistances have been increased by a factor of two greater than design values (for form and friction resistances from the hot leg up to but not including the exit loss after the ADS4 valve) to determine the effect on performance. In the DCD analysis, the values used for the ADS Stage 4 flow path resistances are significantly greater than the design values (which are also the ITAAC values) to assure conservatism in the DCD analysis. In the execution of the sensitivity study, cases were performed using the design resistances of the ADS-4 piping, and also with double those resistances. Comparison plots of the WCOBRA/TRAC DCD results with the double resistance case are presented in the attached Figures 7-12; the solid line curve is the double resistance case, the dashed line curve is the DCD analysis from the beginning of long term cooling onward. The predicted ECCS performance is quite similar for these two cases because the DCD analysis has nearly the same factor of conservatism. Water flows from containment into the downcomer and up through the core, into the upper plenum. Steam produced in the core and liquid flow out of the reactor coolant system via the ADS Stage 4 valves. The quality of the ADS Stage 4 mass flows varies as water is carried out of the hot legs. This periodically increases the pressure drop across the ADS Stage 4 valves and the upper plenum pressure; the higher

pressure in the upper plenum reduces the injection flow, but it quickly recovers. No clad temperature excursion occurs during the double ADS-4 resistance case. Overall, the venting provided by the ADS-4 paths enables the liquid flow through the core to maintain acceptable core cooling even if the design resistances of the ADS-4 paths are increased by a factor of two.

Figures 13-18 compare the AP1000 long term post-LOCA performance with the design ADS-4 resistances and double the design resistances. Again the solid line curve is the double resistance case, while in these figures the dashed line curve is the design resistance case analysis. The results are similar except that the downcomer level throughout the window is about two feet higher in the design resistance case, with a value of about 19 feet (Figure 13).

The comparison of the two-times resistance case to the DCD case indicates that the DCD analysis includes conservatism similar to increasing the ADS4 design resistances by a factor of two. The comparison of the two-times resistance case to the one-times resistance case indicates that long term cooling performance is not highly sensitive to the ADS4 resistances.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Table-1 Double-Ended Injection Line Break Sequence of Events

Event	AP1000 (Reference)	AP1000 (Sensitivity)
	Time (seconds)	Time (seconds)
Break opens	0.0	0.0
Reactor trip signal	13.1	13.1
Steam turbine stop valves close	19.1	19.1
"S" signal	18.6	18.6
Main feed isolation valves begin to close	20.6	20.6
Reactor coolant pumps start to coast down	24.6	24.6
ADS Stage 1	182.4	182.4
ADS Stage 2	252.4	252.4
Intact accumulator injection starts	255	255
ADS Stage 3	372.4	372.4
ADS Stage 4	492.4	492.4
Intact accumulator empties	600.7	601.5
Intact loop IRWST injection starts*	1440	2120
Intact loop core makeup tank empties	2350	2000

Note:
*Continuous injection period

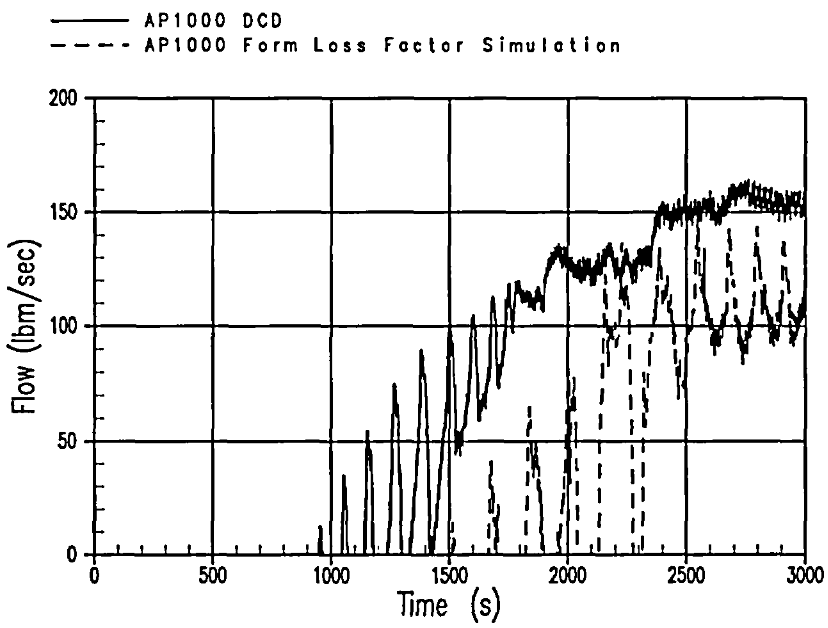

Figure-1 **DEDVI – IRWST Injection**

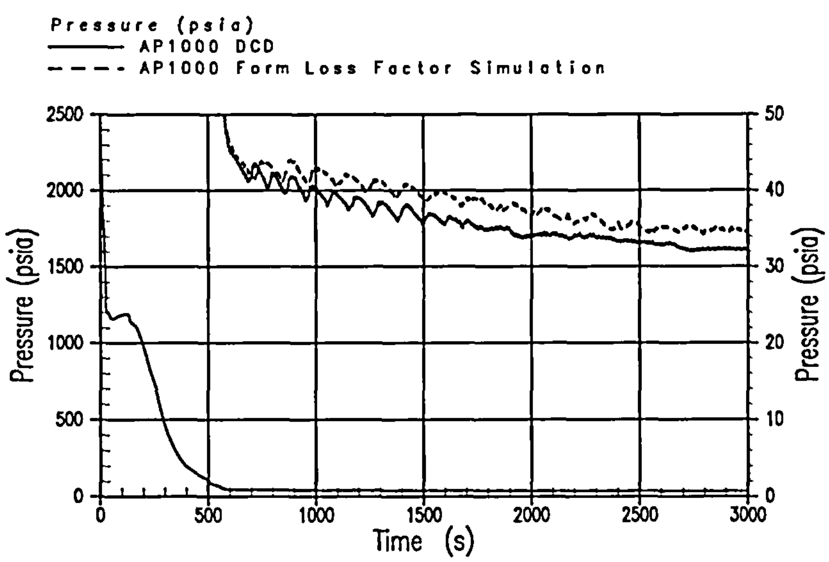

Figure-2 **Upper Plenum Pressure**

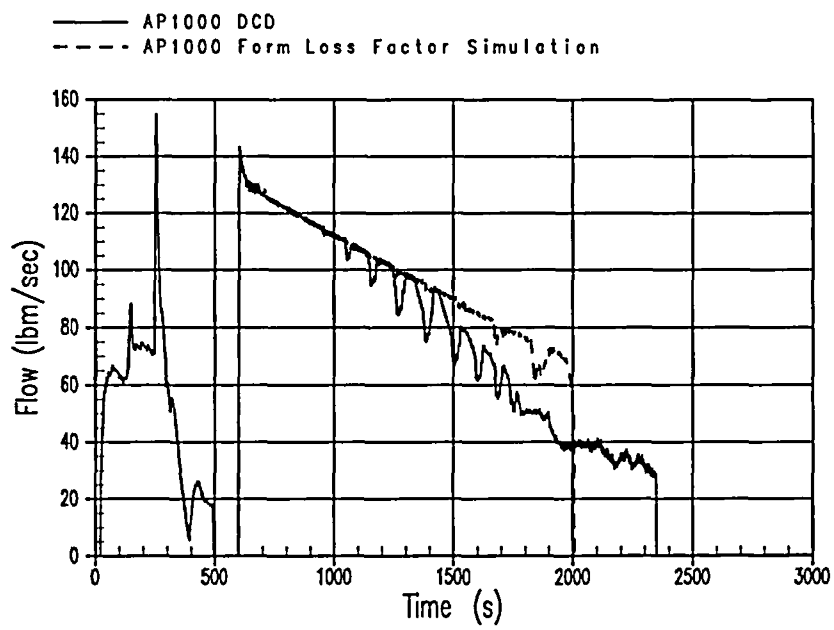

Figure-3 **DEDVI – Intact CMT Injection Rate**

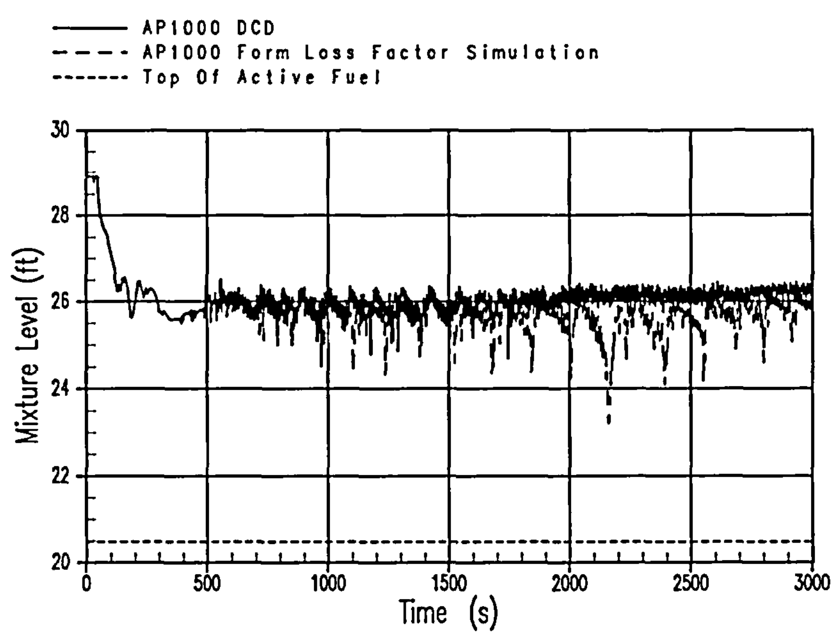

Figure-4 **DEDVI - Core/Upper Plenum Mixture Level**

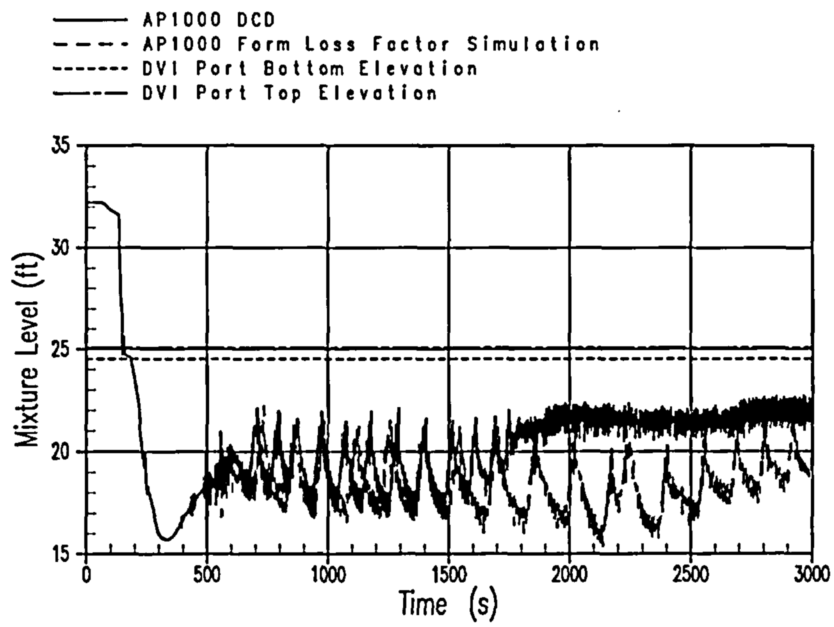

Figure-5 DEDVI - Downcomer Mixture Level

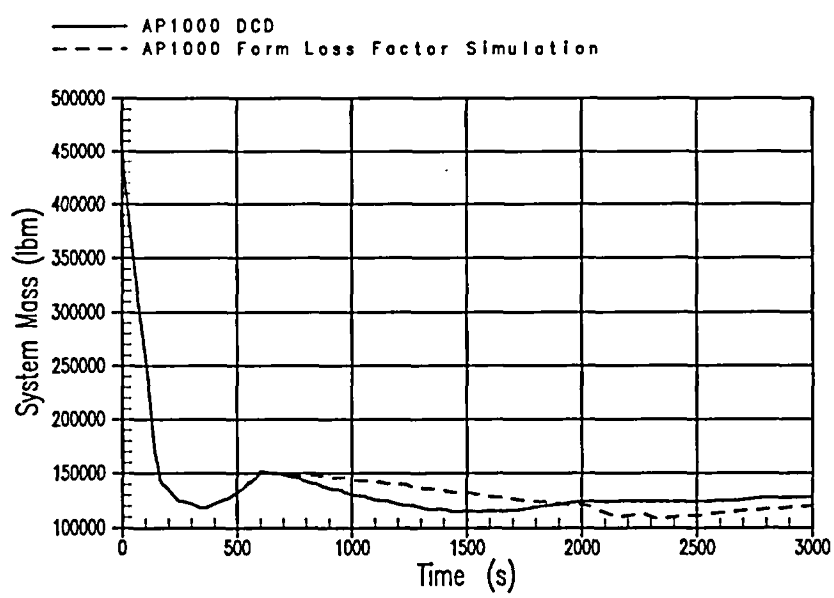

Figure-6 DEDVI - RCS System Inventory

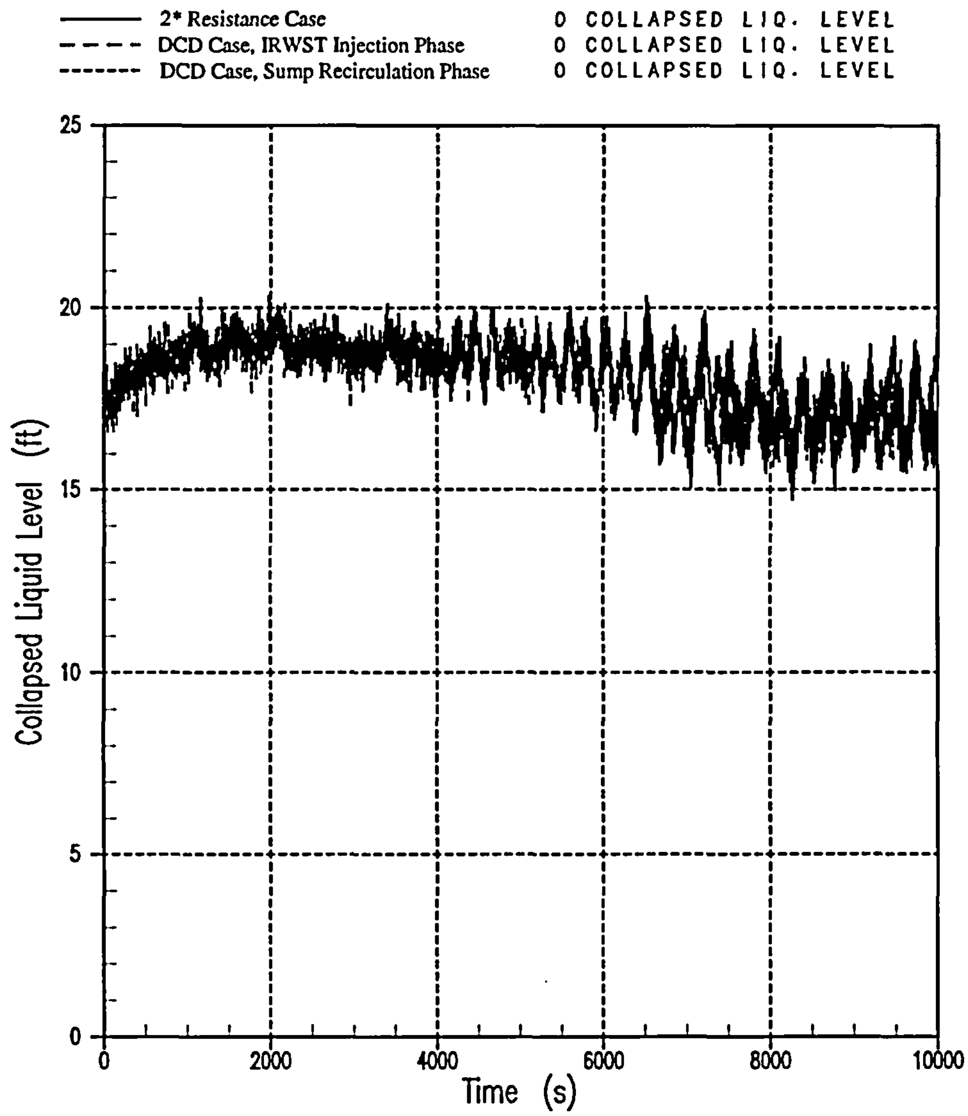

Figure 7: Downcomer Level

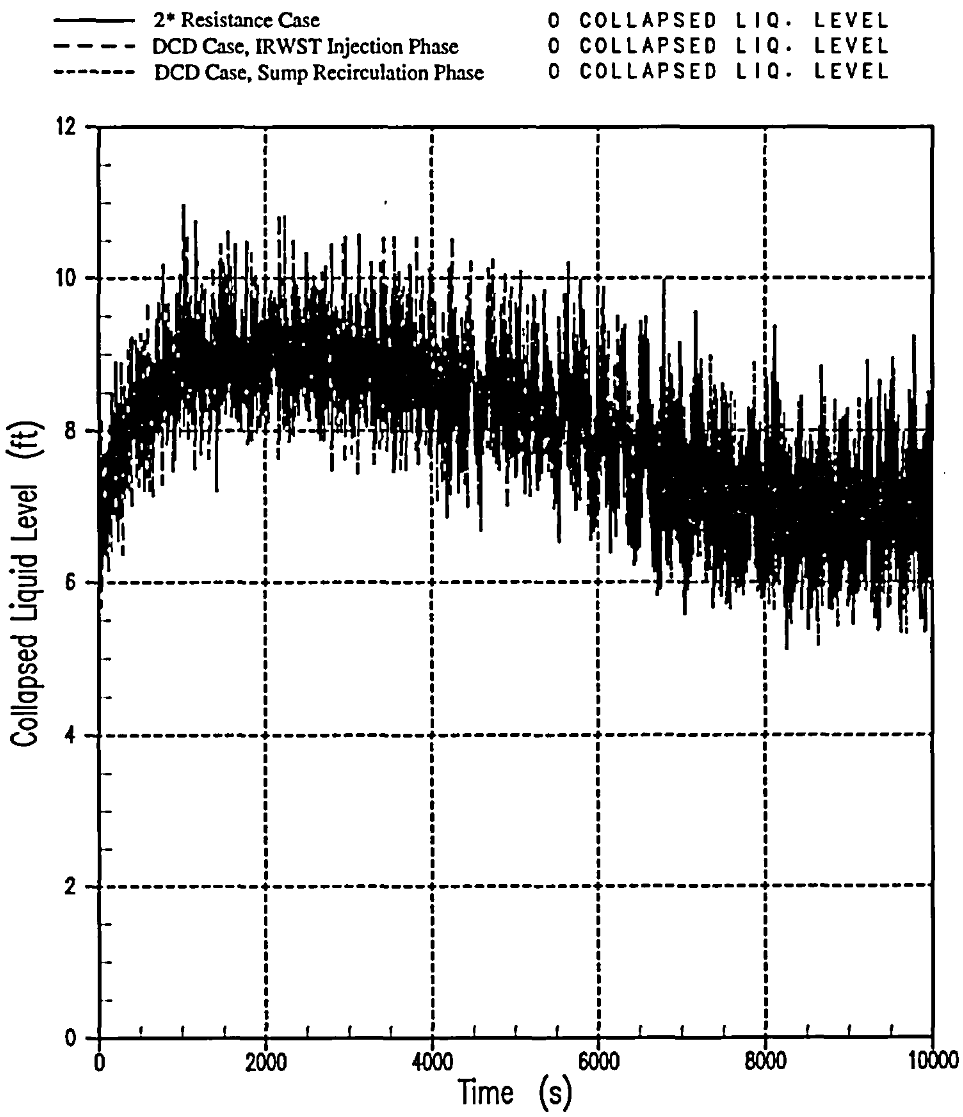

Figure 8: Core Collapsed Level

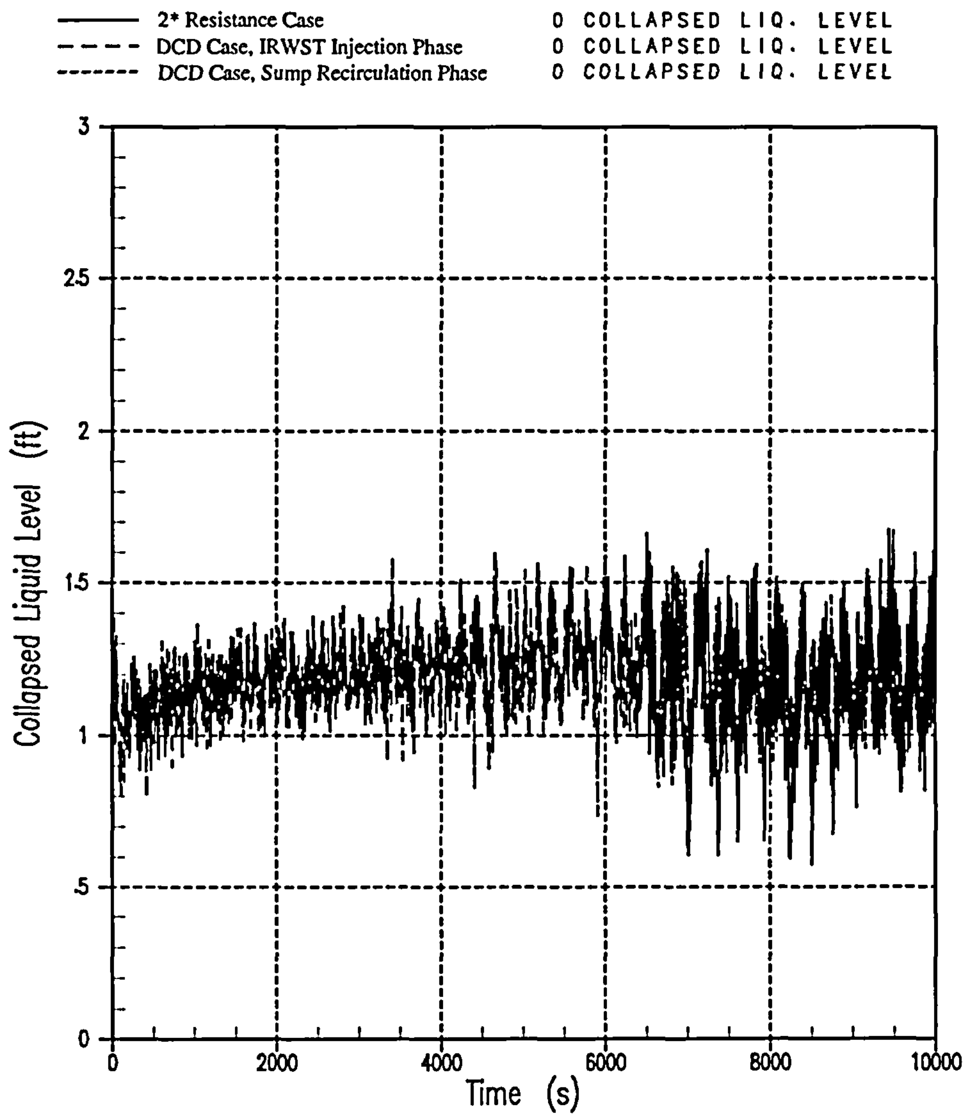

Figure 9: Hot Leg Collapsed Level

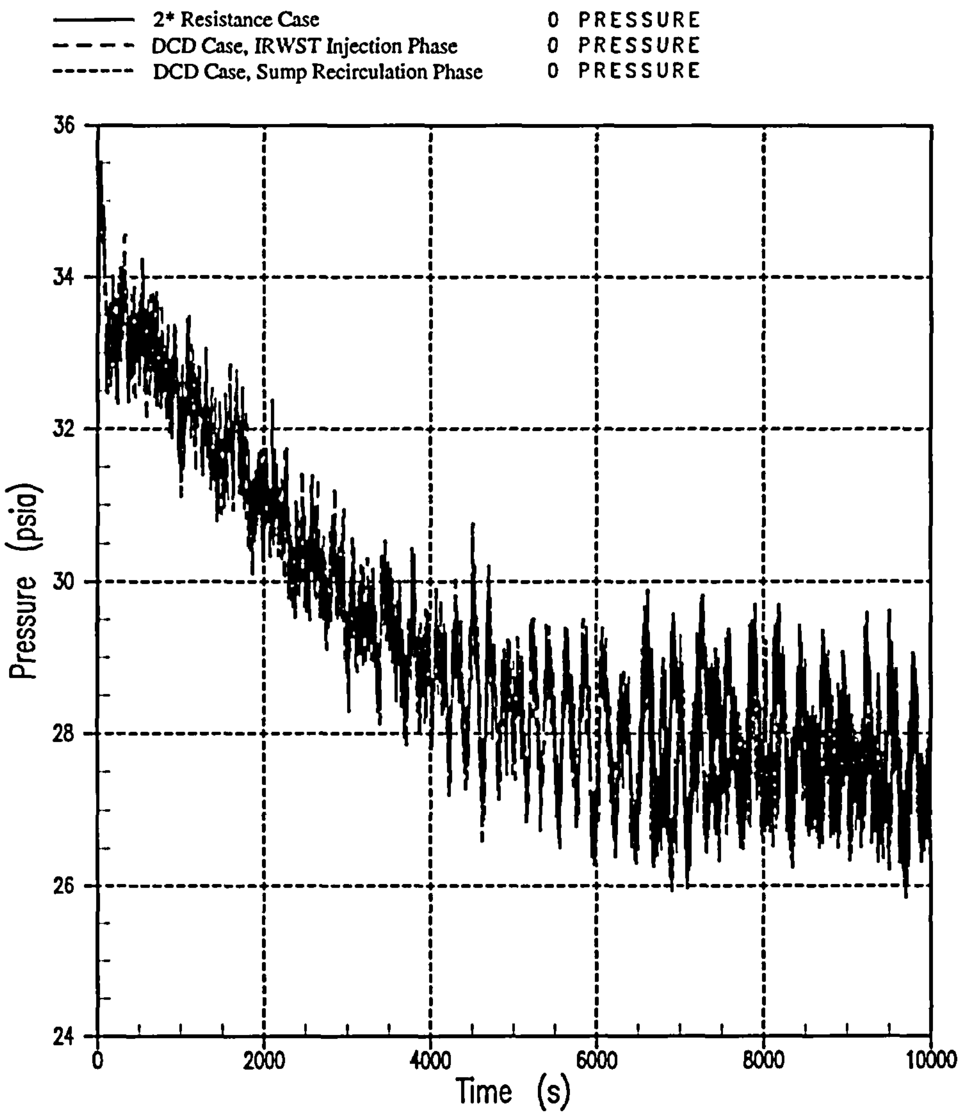

Figure 10: Upper Plenum Pressure

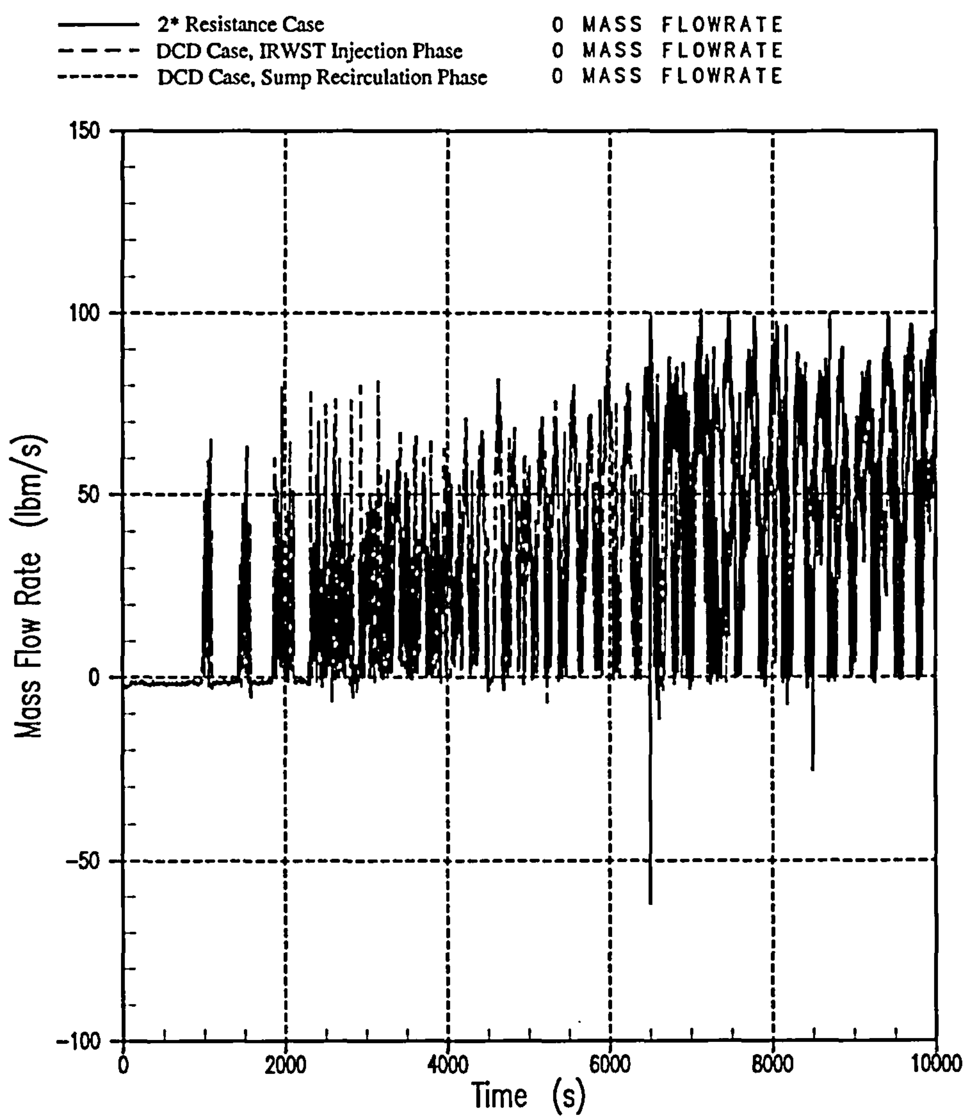

Figure 11: Broken DVI Line Injection

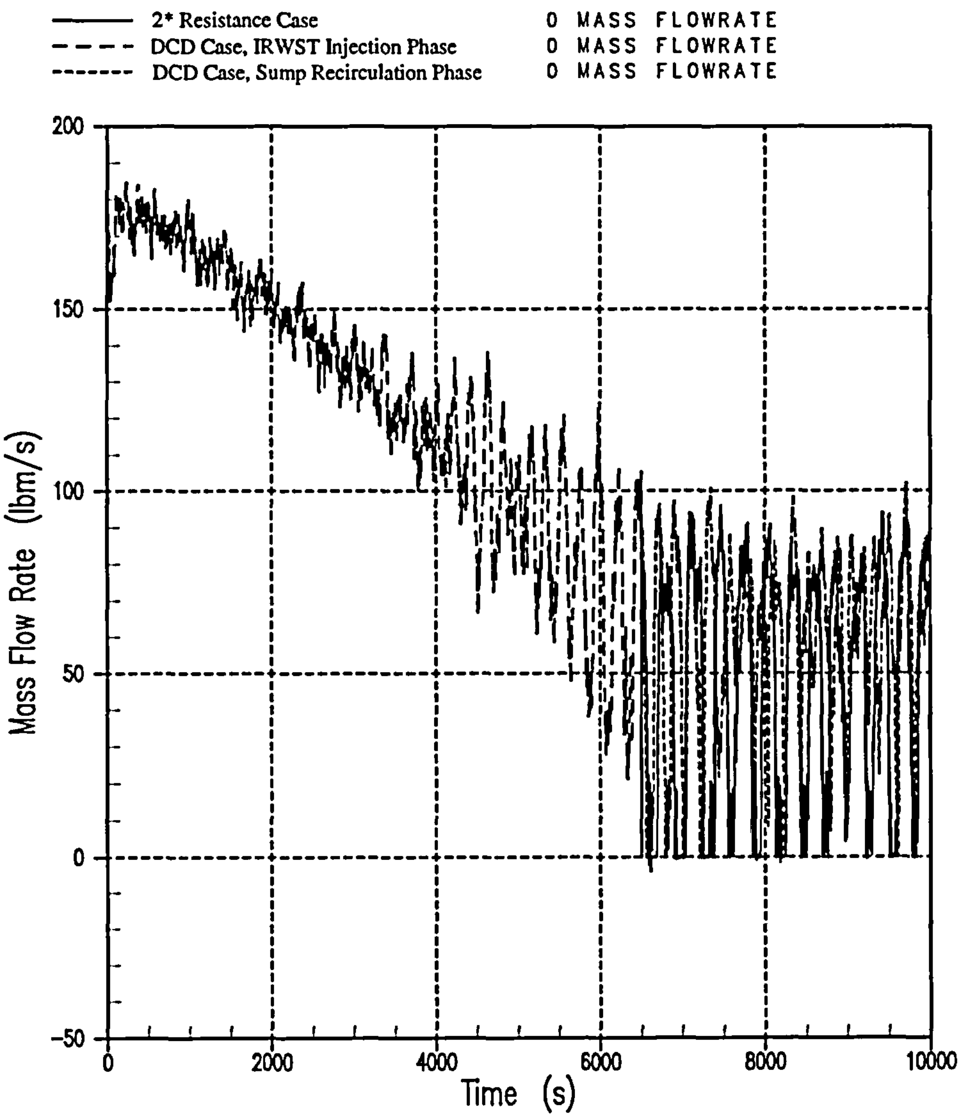

Figure 12: Intact DVI Line Injection

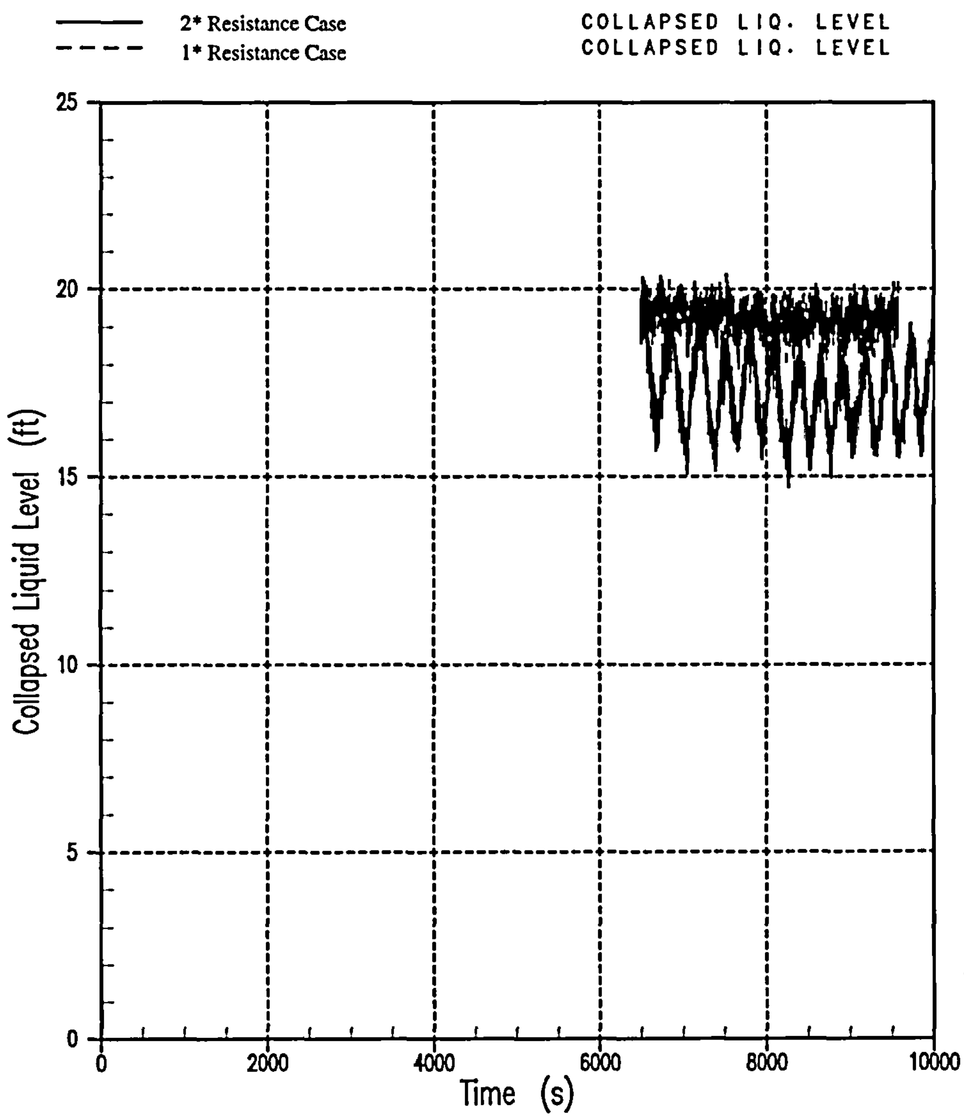

Figure 13: Downcomer Level

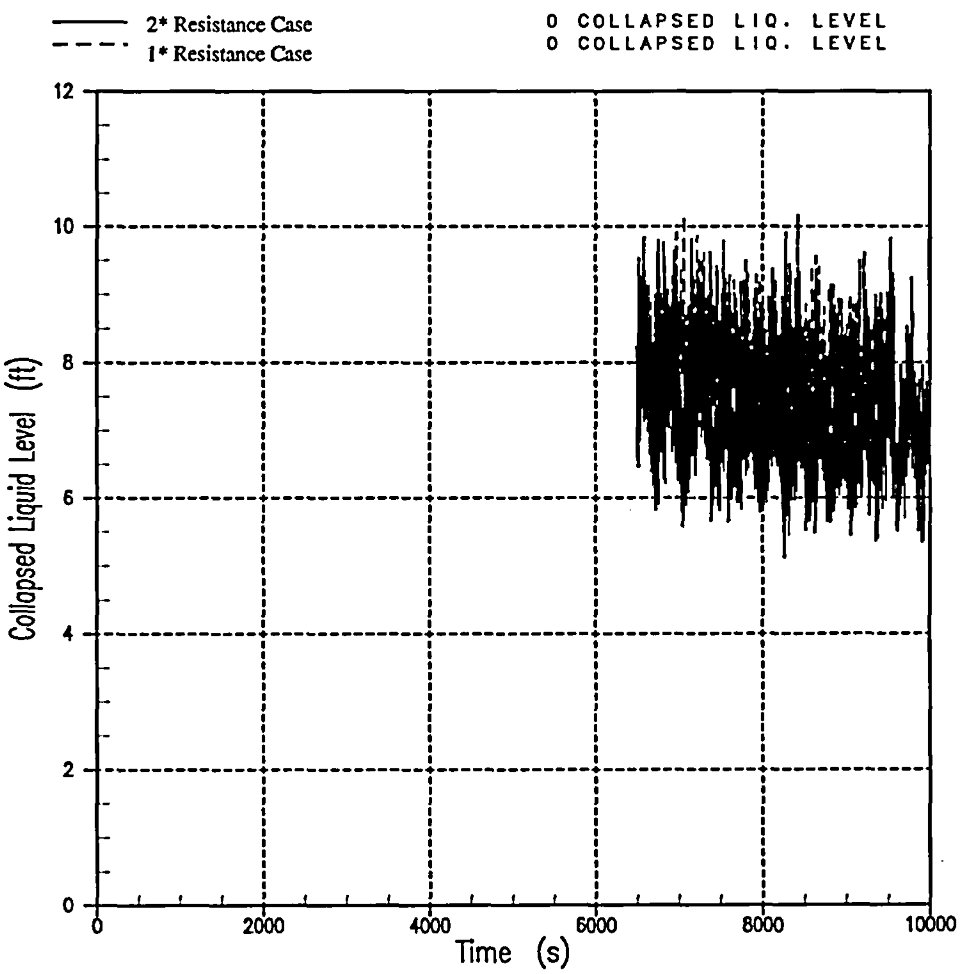

Figure14:Core Collapsed Level

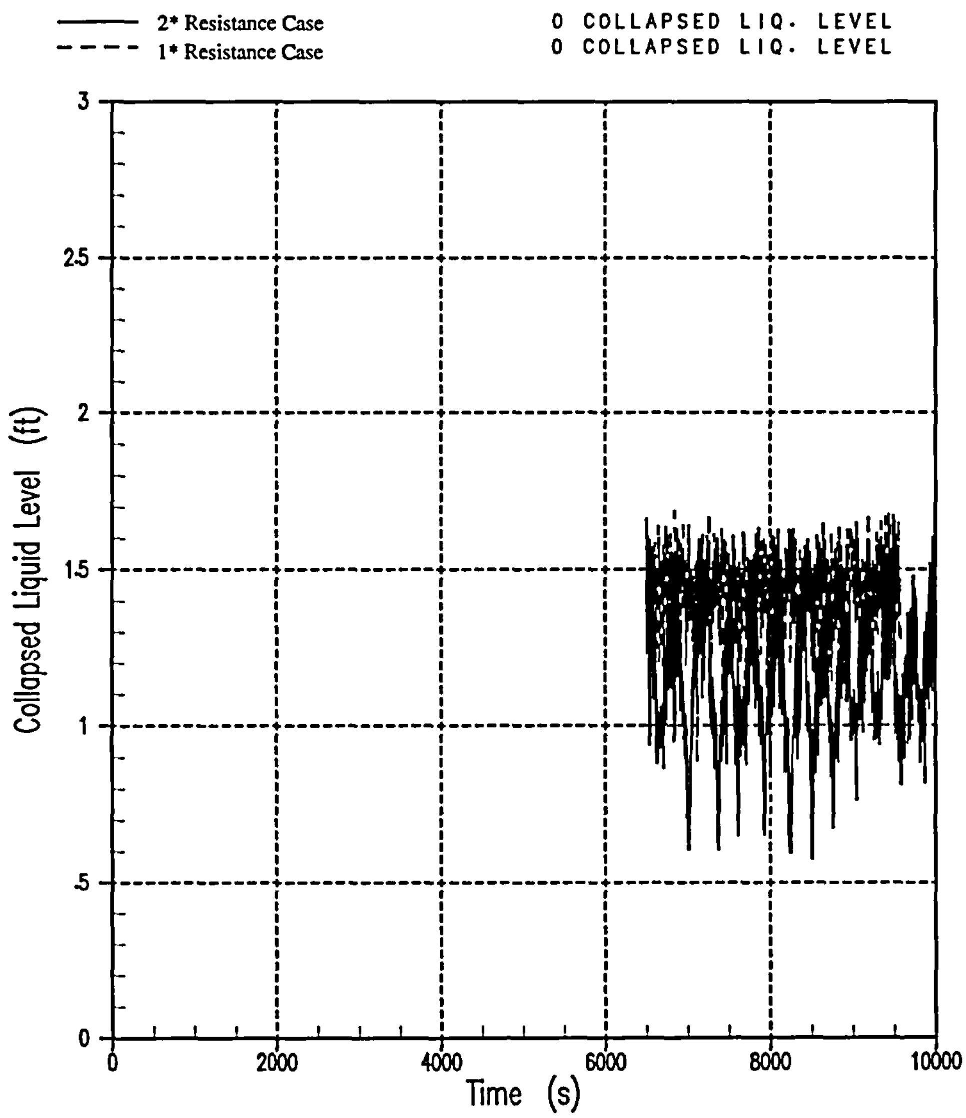

Figure 15: Hot Leg Collapsed Level

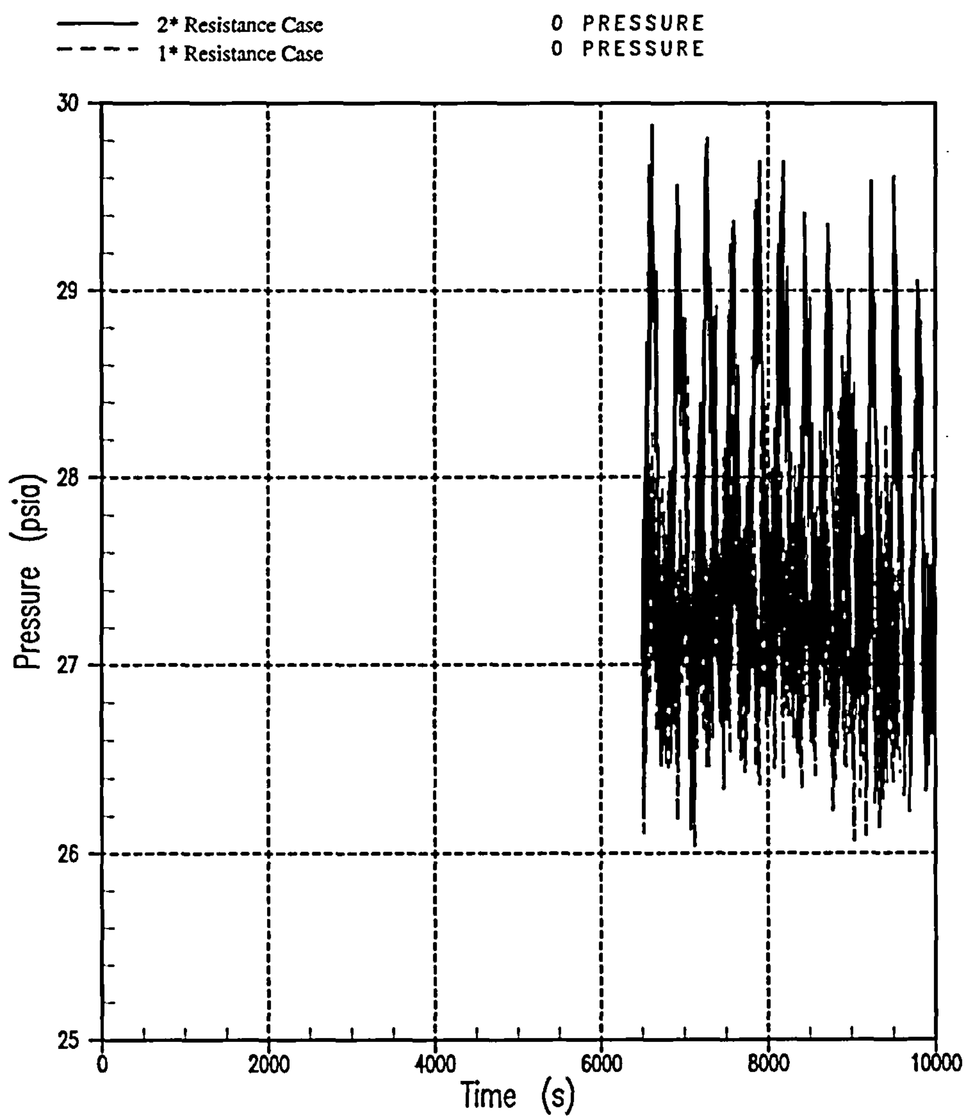

Figure 16: Upper Plenum Pressure

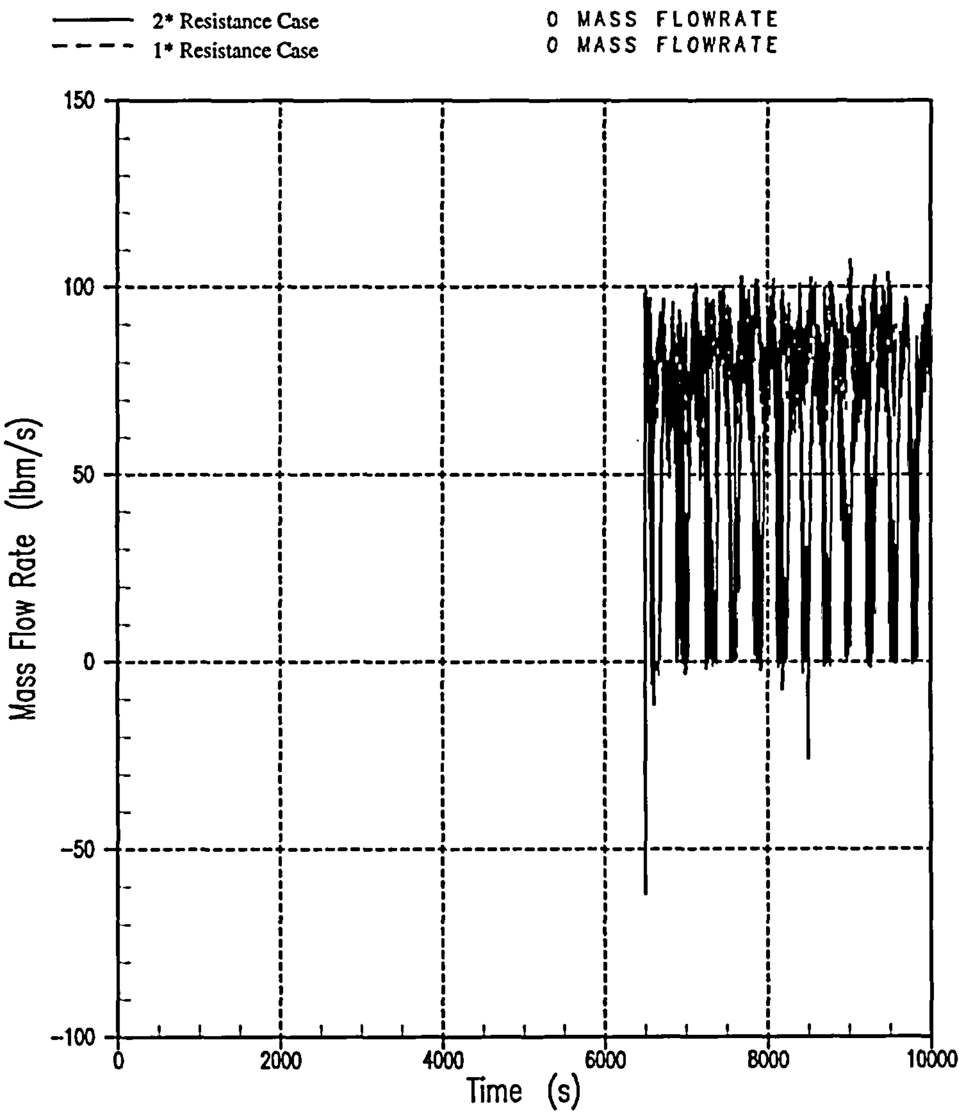

Figure 17: Broken DVI Line Injection

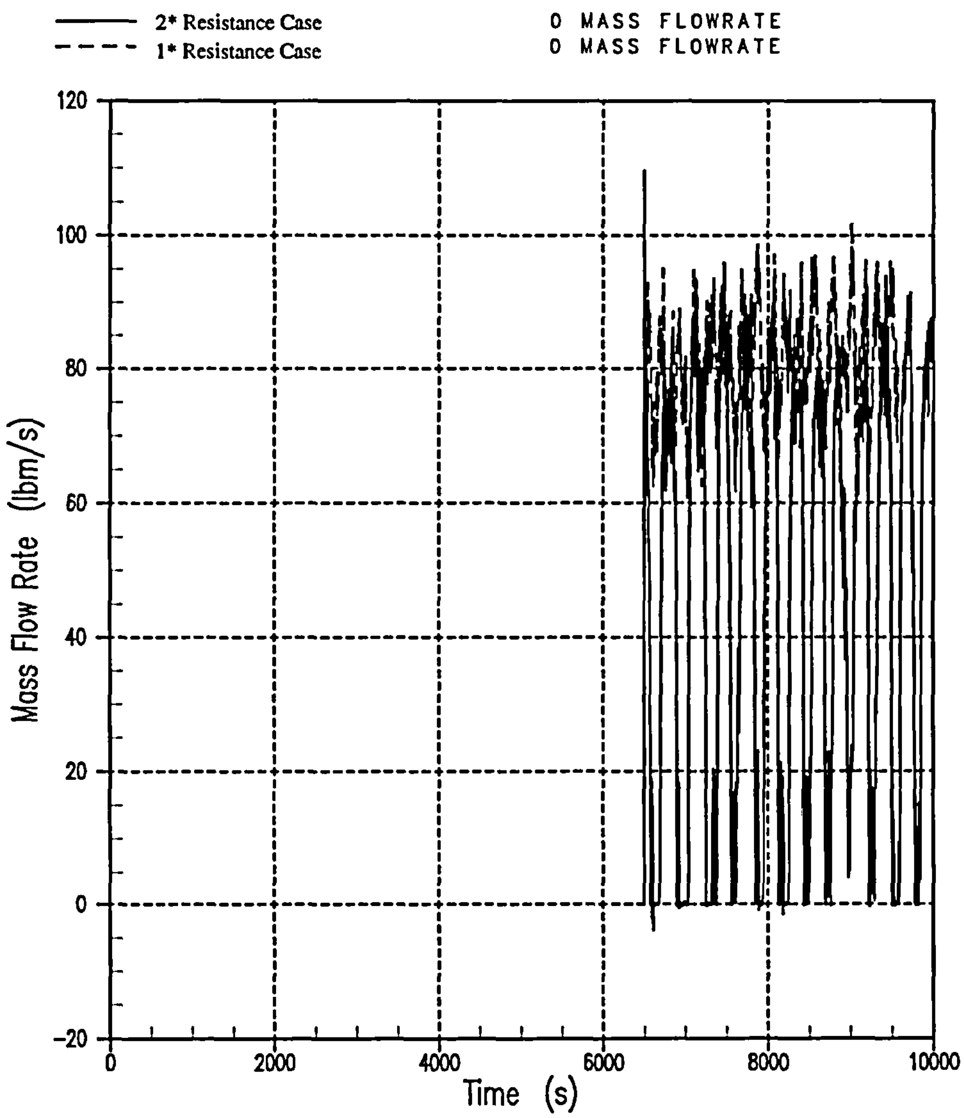

Figure 18: Intact DVI Line Injection