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Your ref: Docket No. 52-006
Our ref: DCP/NRC1643

October 27, 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
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/Attachments

1. List of the AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses transmitted with letter DCP/NRC1643
2. Non-Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated October 27, 2003

D063

DCP/NRC1643
Docket No. 52-006

October 27, 2003

Attachment 1

List of

Non-Proprietary Responses

Table 1 **"List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1643"**	
19.1.10.1-5, Revision 1	

DCP/NRC1643
Docket No. 52-006

October 27, 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: **19.1.10.1-5 (Response Revision 1)**

Original RAI Number(s): **720.009, 720.012, 720.013, 720.014, 720.017, 720.021, 720.024, 720.025**

NRC Follow-on Comments:

A teleconference was held on 8/25/2003 to discuss the Westinghouse response to 19.1.10.1-5. The following provides a summary of the NRC issues that were discussed.

Staff comments on items related to Open Issue 19.1.10.1-5

(a) Additional justification is needed for long-term cooling analyses for which the initial and boundary conditions were obtained from analyses using MAAP4 for input into WCOBRA/TRAC (RAI 720.013):

This issue remains open. In the revised response to RAI 720.013, Westinghouse performed long term cooling analyses for bounding conditions in the PRA. (Case F DEDVI, 1 CMT, 1 *recirc line*, 3/4 ADS4 and CI) and (Case G DEDVI, 1 CMT, 1 *recirc line*, 4/4 ADS4 and CI failure). The WCOBRA/TRAC code was used for LTC calculations with input conditions derived from MAAP4 analyses. As discussed in the DSER the staff has not reviewed MAAP4 except for its use in screening studies. These are analyses using minimum equipment sets as discussed in the DSER. The staff believes that only a methodology the staff has reviewed should be utilized. In addition, as a result of staff and ACRS questions, the WCOBRA/TRAC long term cooling model has been changed. The staff believes that the revised model should be used in these bounding calculations.

(b) Additional justification should be provided that a large break LOCA can be mitigated if one of the two CMTs fail (RAI 720.012-2):

This issue remains open. In the revised response to RAI 720.012, Figure 2-1, Westinghouse listed large break LOCA sequences as success sequences (OK7 sequences). Westinghouse should verify these conclusions by using a methodology that the staff has reviewed.

(c) Additional justification should be provided that adequate water can be maintained within the containment to provide for long term core cooling if containment isolation fails (RAIs 720.021 and 720.024):

This response is acceptable based on Westinghouse arguments on the relative elevations between the postulated RCS break and the postulated failed containment penetration and the tortuous path that would be involved.

(d) Additional justification should be provided that one of the two startup feedwater pumps can deliver adequate water to the two steam generators following an ATWS event (RAI 720.024):

This response is acceptable based on new analyses to be added to Appendix A of the PRA.

(e) Additional justification should be provided that evaluations made for AP600 are appropriate to be used in the AP1000 PRA Table 6-1 and in the response to RAI 720.025 where Westinghouse assumes that 30 minutes of core cooling is available following a small break LOCA, steam generator tube rupture or transient with no accumulator injection (RAIs 720.024 and 720.025):

References to AP600 have been removed and acceptable arguments applying to AP1000 have been added. This response is acceptable.

An analysis using MAAP4 was performed to demonstrate that a 30 minute delay in CMT injection is acceptable following a SBLOCA and multiple failures. The consequences were determined to be bounded by a MAAP4 analysis with automatic actuation. Westinghouse asserted that since this is not a limiting case a NOTRUMP analysis is not required. For the manual CMT case there is no ECCS for 2000 seconds after the break. For the automatic actuation case, CMT injection occurs about 200 seconds after the break. How can the automatic CMT actuation injection case be worse than the manual CMT actuation case which has a longer delay time?

(f) Additional justification should be provided that sequences which assume failure of one of the four ADS stage #4 valves and also assume failure of containment isolation, will end in successful core cooling (RAIs 720.012, 720.009 and 720.017):

This issue is unresolved. In the revised response to RAI 720.09, Westinghouse presented the results of an analysis using WCOBRA/TRAC with inputs determined from a MAAP4 analysis. The staff has the same issue with this analysis as is stated under Item a. In the revised response to RAI 720.17, Westinghouse argued that this case is not risk significant and therefore it is not necessary to perform a T&H uncertainty analysis. This argument is not valid since OK6 (See Figure 2-4 of RAI 720.012), OK2 and OK4 sequences (on Figure 2-5 of RAI 720.012) fall in this category. Are these OK sequences considered to be low risk?

(g) Additional Issue - Use of MAAP4 for MSGTR Calculation:

In its response to the staff RAI 440.043 regarding the AP1000 design features that mitigate or prevent steam generator safety valves challenges during an event of rupture of multiple steam generator tubes (MSGTR), Westinghouse provided a beyond-design-basis analysis of MSGTR using MAAP4. Two cases were analyzed: a passive system mitigation case with PRHR heat exchanger operation; and a minimum PRHR heat removal case with the assumption of steam generator safety valve (SGSV) failed open. Based on the MAAP4 analysis, Westinghouse concluded that for the MSGTR, the core remains covered and

cooled, and thus no significant fission product release occurs. In DSER Section 5.4.2.3.2, the staff stated that the staff's evaluation of the use of MAAP4 for the AP1000 PRA evaluation is discussed in Chapter 19 of DSER. In DSER Chapter 19 the staff gave conditions for the use of MAAP4 as described in the above excerpt.

In light of Open Item 19.1.10.1-5 and the concern described in the DSER that MAAP4 does not provide a rigorous solution of reactor system conditions during transients and accidents, the staff requests that Westinghouse confirm the beyond-design-basis MSGTR results of no core uncovery described in response to RAI 440.043 with a methodology reviewed by the staff.

Westinghouse Response:

The following provides Westinghouse responses to the NRC follow-on comments:

(a) The long term cooling success criteria analysis case and the thermal hydraulic uncertainity cases F and G have now been performed using the revised WCOBRA/TRAC model and using input conditions from WGOTHIC. The revised cases replace the previous cases as shown below in the revision to PRA Appendix A.

(b) In addition to our previous justification, it is noted the AP1000 large-break LOCA analysis performed for Chapter 15 using WCOBRA-TRAC includes a sensitivity study that determines the PCT without credit for operation of the CMTs. Results of these calculations show that the maximum PCT without operation of the CMTs is within the regulatory limits. This sensitivity study is identified in AP1000 DCD subsection 15.6.5.4A. This study provides additional justification that the PRA success criteria is acceptable.

(c) As noted in the NRC follow-on summary, the previous Westinghouse response is acceptable.

(d) As noted in the NRC follow-on summary, the previous Westinghouse response is acceptable.

(e) The case in question (2 inch break, 1 CMT, 0 ACC, 0 ADS1-3, 0 PRHR, ¾ ADS4) has now been performed using NOTRUMP, for automatic CMT actuation and for manual CMT actuation. Comparison plots of these two NOTRUMP cases are shown in Figures 19.1.10.1-5e-1 through 19.1.10.1-5e-6. For the automatic CMT case the CMT draindown starts earlier and leads to earlier actuation of ADS4. For the automatic case the CMT recirculates from the early part of the event and its water inventory becomes heated before draindown begins, whereas for the manual case CMT draindown occurs shortly after CMT actuation and therefore is injecting subcooled liquid during its draindown. When ADS4 actuation occurs in the automatic case the vessel inventory and CMT injection are near saturation and the rapid depressurization results in sufficient voiding to cause the vessel mixture level to fall into the core region before it recovers as a result of IRWST injection. In the manual case the CMT injection just prior to and following ADS4 actuation is still highly

subcooled so the depressurization causes less voiding and the vessel mixture remains in the upper plenum region during the ADS4 to IRWST transition.

These NOTRUMP results confirm the behavior seen in the previous MAAP4 analyses.

(f) The long term cooling success criteria analysis in the revised response to RAI 720.09 (3 of 4 ADS4, containment isolation failure) has now been performed using the revised WCOBRA/TRAC model and using input conditions from WGOTHIC. The revised analysis replaces the previous one as shown below in the revision to PRA Appendix A. This confirms the success criteria for this case. With respect to the statement we made in RAI 720.017 rev 1 about a T&H uncertainty case with 3 ADS-4 valves and failure of containment isolation, we have the following response. Such a sequence is not risk important with the current expanded event trees. The question regarding sequences that we identified as OK sequences with 3 ADS-4 valves and CI failure is a new / different question. These sequences are less severe than the success criteria case in that they have some ADS 2/3 valves opening and have 1 CMT (in addition to 1 Accumulator). The addition of the CMT will compensate for the water lost out of the containment through a failed CI. In addition, these OK sequences have probabilities of ~ E-10 / yr, or less. The highest UC sequence with 3 ADS-4 and failed CI is UC8/sad27, see PRA Appendix A Table A5.1-2. This sequence has a CDF probability of 2 E-10 and is not risk important.

(g) As discussed with the NRC in the teleconference, the use of the MAAP4 code for AP1000 is the same as was approved for AP600. Westinghouse uses MAAP4 to perform analyses of accident sequences from the PRA. For those cases with large margin (i.e. little or no core uncovery), the MAAP4 results are used to validate the PRA success criteria. For low margin success sequences that are also high risk, Westinghouse performs additional analyses with the approved design basis analysis computer codes to demonstrate success.

For both AP600 and AP1000, Westinghouse has submitted results of the analysis of a multiple steam generator tube rupture. For both AP600 and AP1000, there is a large margin to core uncovery, and the results have been accepted for the purpose of demonstrating the plant response to this beyond design basis accident. The previous analysis results provided for AP1000 did not identify the top of the active fuel, and the staff was unable to assess the large margin in the analysis results. The attached figures 19.1.10.1-5g-1 through 4 show the results of the multiple steam generator tube rupture for AP1000. The MAAP4 code is applied appropriately for this large margin case.

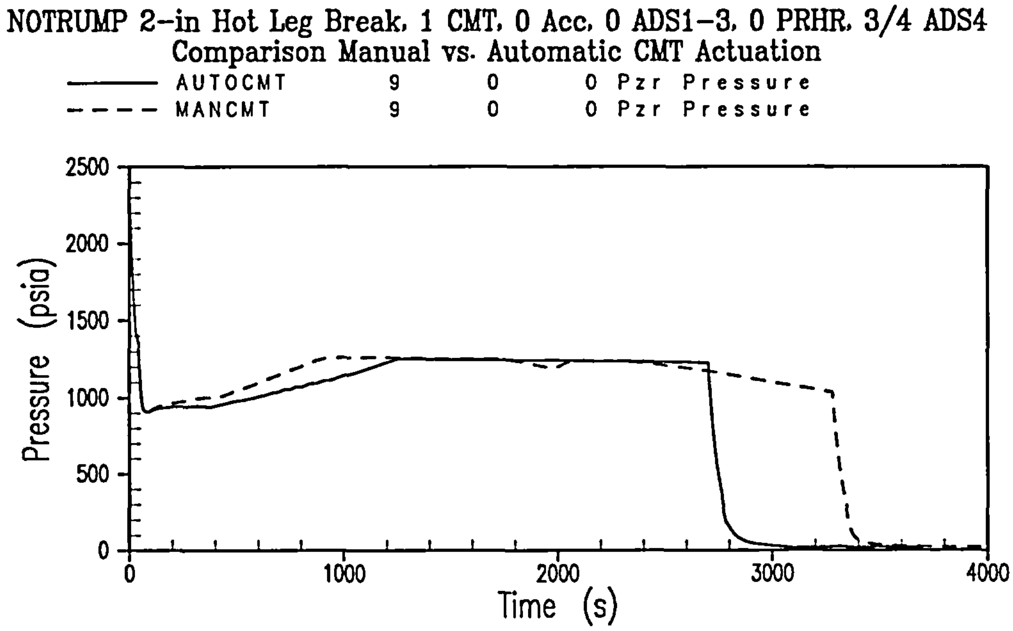

Figure 19.1.10.1-5e-6- 1 Pressurizer Pressure for 2-inch Hot Leg Break PRA Case - NOTRUMP

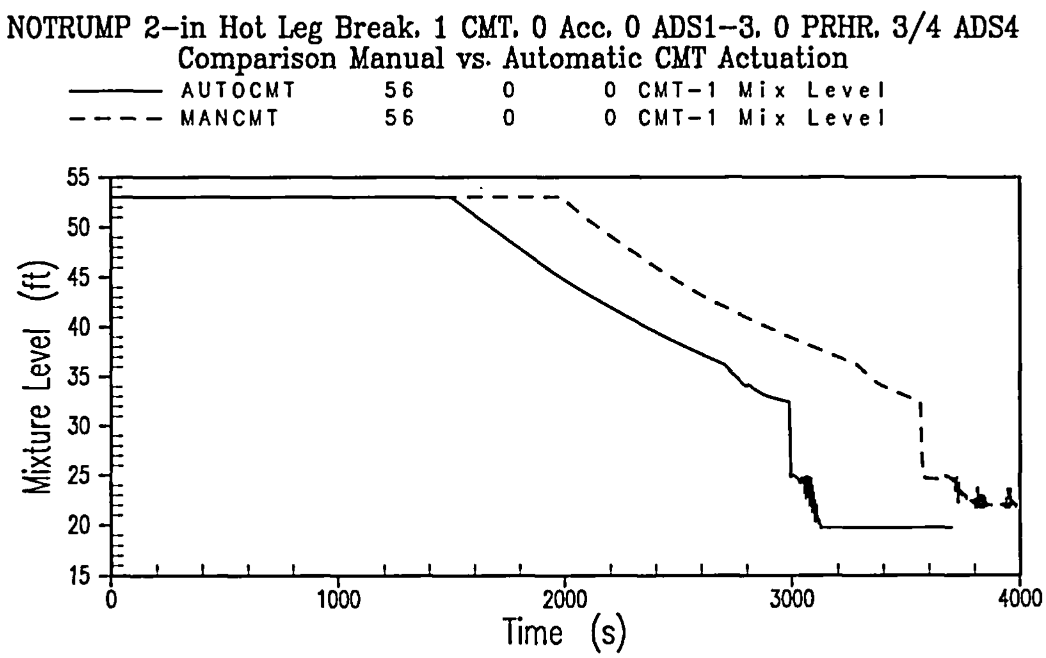

Figure 19.1.10.1-5c-6- 2: CMT Level for 2-inch Hot Break Leg PRA Case - NOTRUMP

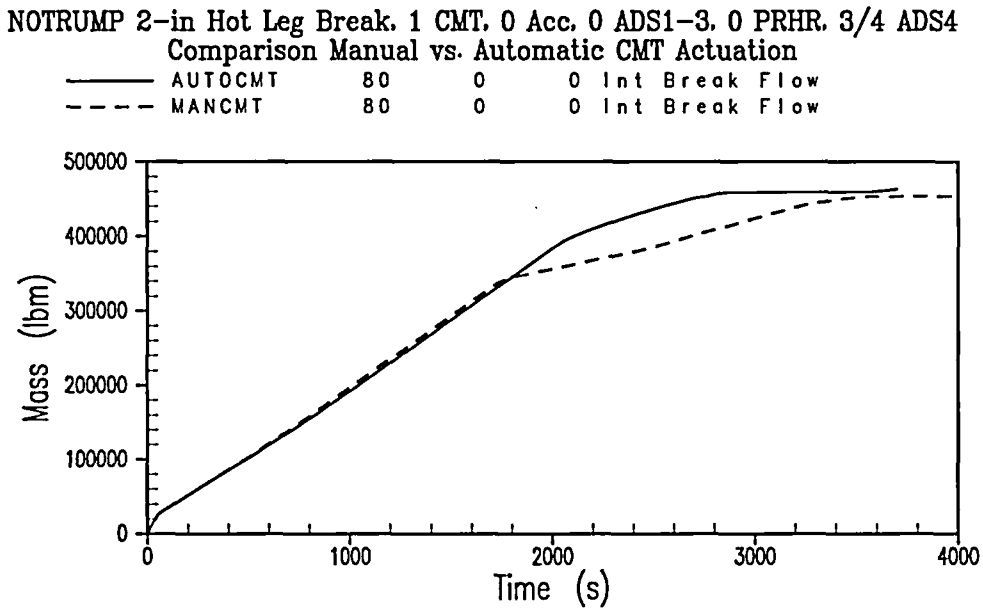

Figure 19.1.10.1-5c-6- 3: Integrated Break Flow for 2-inch Hot Leg Break PRA Case - NOTRUMP

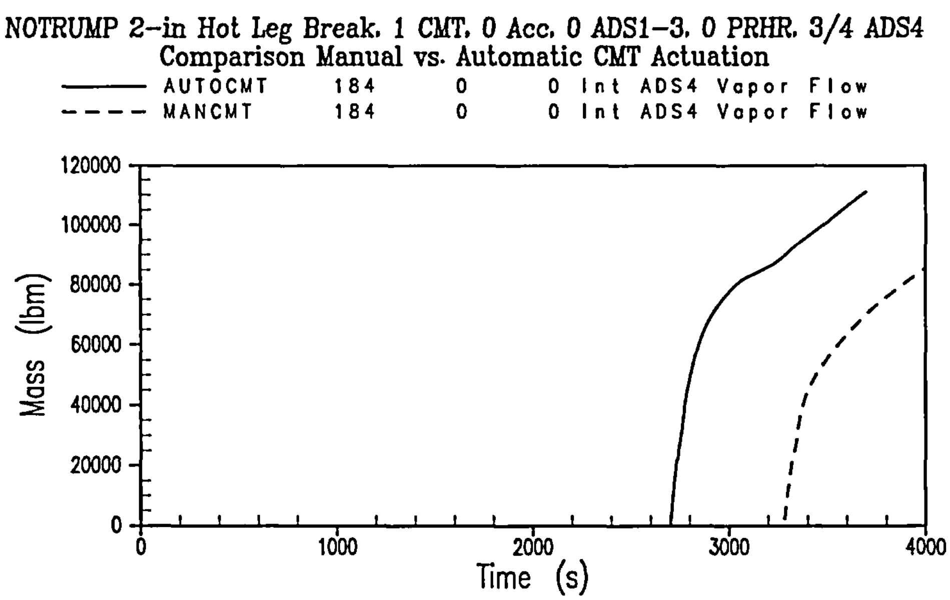

Figure 19.1.10.1-5c-6- 4: Integrated ADS4 Vapor Flow for 2-inch Hot Leg Break PRA Case - NOTRUMP

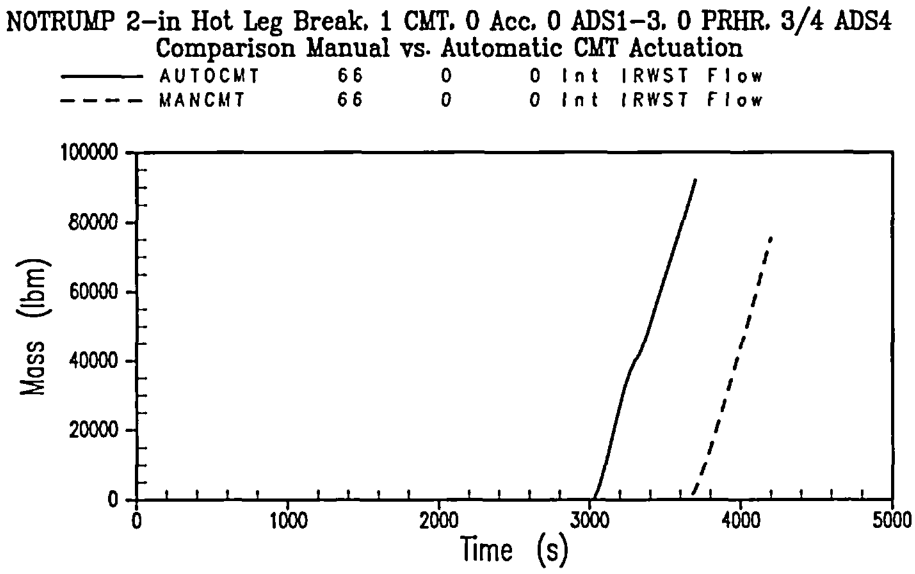

Figure 19.1.10.1-5c-6- 5: Integrated IRWST Flow for 2-inch Hot Leg Break PRA Case - NOTRUMP

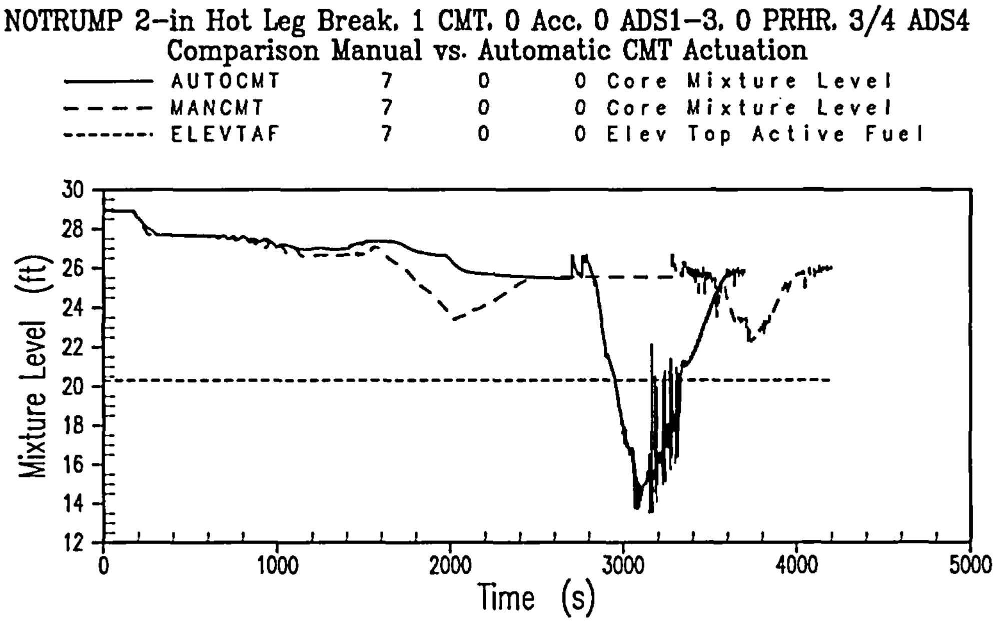

Figure 19.1.10.1-5e-6- 6: Core Mixture Level for 2-inch Hot Leg Break PRA Case - NOTRUMP

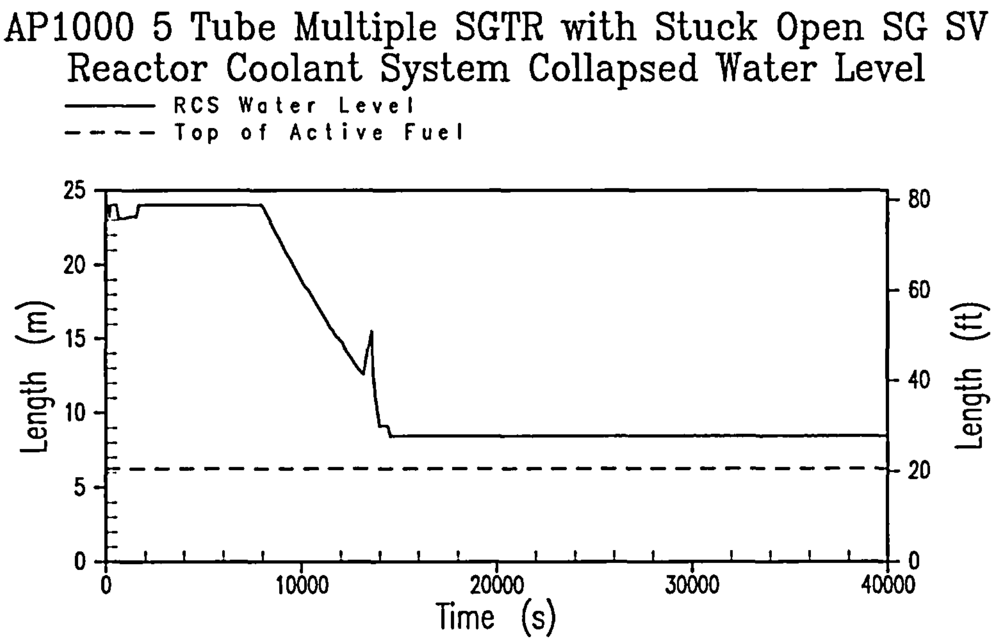

Figure 19.1.10.1-5g-1

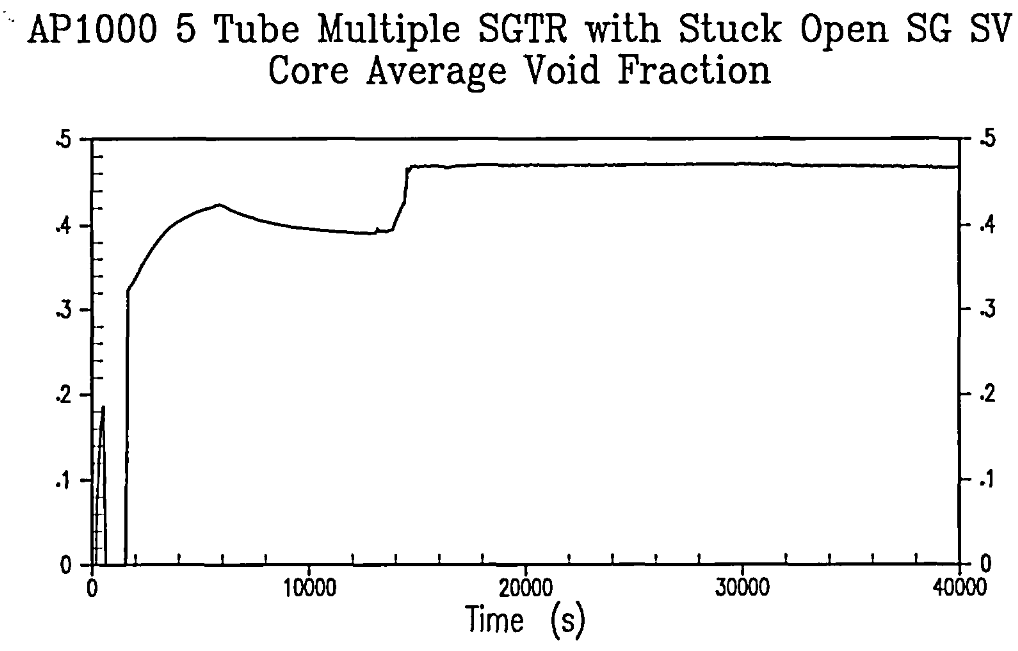

Figure 19.1.10.1-5g-2

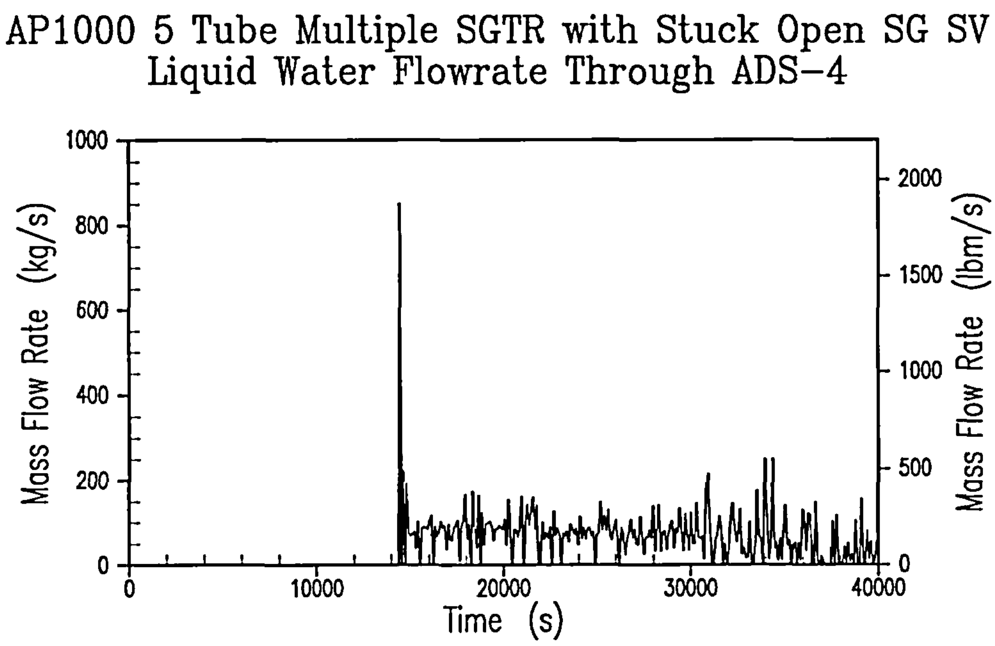

Figure 19.1.10.1-5g-3

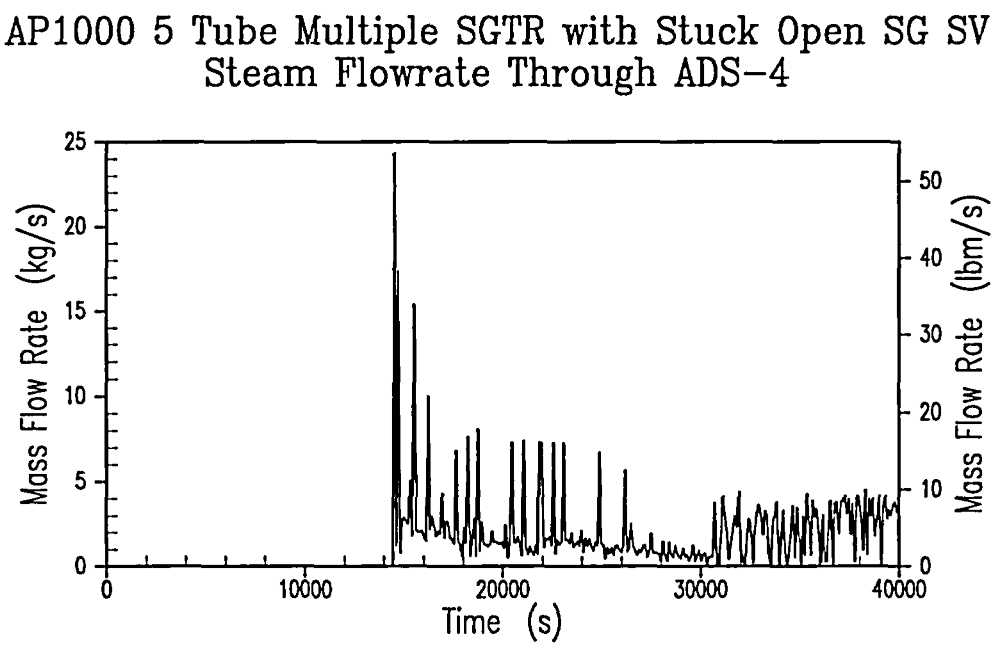

Figure 19.1.10.1-5g-4

Design Control Document (DCD) Revision:

None

PRA Revision:

~~None~~ PRA Appendix A will be revised as shown below.

A3.5 Success Criteria Analysis for Long-Term Cooling

This analysis considers the AP1000 long-term core cooling (LTCC) behavior following a guillotine double-ended direct vessel injection (DEDVI) line break to support the PRA success criteria evaluations. The limiting success criteria scenario is analyzed in order to perform a bounding case. This analysis is performed with WCOBRA/TRAC using the long-term cooling code version with realistic inputs.
The DEDVI line break LTCC scenario analyzed conservatively assumes that the break occurs in the PXS-B room. Since the size of this room is bigger than PXS-A, the containment water level during the transient is reduced. A short summary follows of the boundary conditions for the case analyzed herein:

- DEDVI LOCA in line B
- Available equipment – 1/1 ~~CMT-~~ACC (A), both IRWST injection lines open with 1/2 valves open in each, 1/2 recirculation lines available with both valves open in the line attached to DVI-B, 3/4 ADS-4, PCS water drain with 1/3 valves open
- Unavailable equipment – no ADS 1/2/3, **CMT,** PRHR, RNS injection/spill, IRWST gutter
- Containment isolation assumed to have failed (~~16~~18-inch HVAC line remains open)

A3.5.1 WCOBRA/TRAC LTCC Modeling Methodology

The simulation methodology used in the current analysis is essentially the same as the one used for the AP600 design certification process (Reference A-4).

- The T/H analysis is performed using the WCOBRA/TRAC T/H computer code (Reference A-27).
- The WCOBRA/TRAC AP1000 model is the same as the one used in the AP1000 **DCD** Post-LOCA Long-Term Cooling analysis (Reference A-26).
- The AP1000 LTCC simulations are performed using WCOBRA/TRAC in a ~~transient~~ **window** mode. The ~~transient-~~window mode approach has been validated by the Oregon State University Tests and was used in the AP600 Design Certification (Reference A-4).
- For each case, the AP1000 ~~initial and boundary~~ conditions are provided by a ~~MAAP4~~ **combined WGOTHIC analysis and hand calculation.** ~~MAAP4 is capable of simulating the behavior and the interaction between the AP1000 primary system, the passive safety systems, the containment, and the~~ **WGOTHIC can predict the performance of** containment systems – a feature not available with WCOBRA/TRAC.
- ~~Like the corresponding MAAP4 case, the following~~ **The** WCOBRA/TRAC success criteria simulation is performed with the following general assumptions:
  - 100-percent core power
  - ANS 1979 standard best-estimate decay heat
  - Nominal hydraulic resistance of the passive safety systems

A3.5.2 Methodology Implementation

The ~~transient~~-window mode calculation using WCOBRA/TRAC allows simulation of long transients with reasonable computer resources. As was shown in the validation of methods used in the DCD analysis (Reference A-26), the calculation may be initiated from an arbitrary set of initial conditions. After an initial period of 500 to 1000 seconds, the plant reaches a quasi-steady-state that depends only on the system boundary conditions. During this "steady-state" period, the boundary conditions are kept constant. After that, they are set as a function of time depending on the time window being simulated.

For the AP1000 Success Criteria analysis, a ~~transient~~-window mode calculation was performed for ~~a segment of the time period covered by the MAAP4 calculation for the same case. It was observed that WCOBRA/TRAC predicts higher ADS Stage 4 flows resulting in better depressurization of the primary system. Consequently, the predicted IRWST injection rates were higher when using WCOBRA/TRAC. Because of the faster IRWST drain prediction, it is estimated that the IRWST would reach its lowest level about 1.6 hours earlier than is predicted by MAAP4. Therefore, the IRWST level calculated by MAAP4 was adjusted to account for the more rapid draining predicted by WCOBRA/TRAC. The adjusted IRWST level was then used as a boundary condition for the case. The containment pressure, PXS-B level, IRWST, and PXS-B temperatures calculated by MAAP4, together with the adjusted IRWST level, were used to define the limiting boundary conditions for the WCOBRA/TRAC assessment of the performance of the AP1000 passive safety systems. The following subsection documents the results of the WCOBRA/TRAC simulation.~~**the limiting time period, as identified in the DCD LTC analysis of the DEDVI break immediately following the switchover to sump recirculation. The containment water level is computed considering the mass discharged through the open purge line as calculated by WGOTHIC.**

The containment~~pressure, PXS-B level~~**sump**, IRWST, and PXS-B temperatures calculated by ~~MAAP4, together with the adjusted IRWST level, were used to define the limiting boundary conditions for~~ **WGOTHIC in the AP1000 DCD analysis are used in** the WCOBRA/TRAC assessment of the performance of the AP1000 passive safety systems. The following subsection documents the results of the WCOBRA/TRAC simulation.

A3.5.3 Predictions for a DEDVI Line Break in PXS-B Room with Three of Four ADS Stage 4, Containment Isolation Failed

This subsection presents the simulation results of the Success Criteria Case – a DEDVI line break located in the PXS-B room with three out of four ADS Stage 4 valves open and failure of the containment to isolate. The initial conditions are based on the ~~MAAP4 calculation results of the same~~**DCD analysis of the PXS "B" room break** accident scenario. They are selected such that the WCOBRA/TRAC simulation begins ~~4096~~**9300** seconds ~~(approximately 1 hour, 8 minutes)~~ after the break ~~– after IRWST injection has been fully established~~**the time at which switchover to sump recirculation occurs.**

For the WCOBRA/TRAC transient, the ~~initial IRWST~~**containment water** level is ~~126~~**107.2** feet~~and the liquid temperature is 120°F. The level in the PXS-B room at this time is 96.95 feet~~. The available ADS Stage 4 paths are open, and the containment pressure is set to ~~the MAAP value of~~ 14.7 psia. With these conditions, a 1000-second calculation is performed to ensure that a proper initial condition is achieved in the system, **and the window mode**~~. After that, the transient~~ calculation is initiated with ~~time-dependent~~**fixed** boundary conditions ~~taken from the MAAP4 calculation, but using an adjusted IRWST level function, as discussed earlier~~.

~~Initially, the only injection comes from the IRWST into the reactor vessel through the intact DVI injection line (Figure A3.5-14). At the beginning of the analysis, the liquid level in the PXS-B room is below the DVI injection nozzle elevation and steam from the downcomer is vented out through the break (Figure A3.5-13). Water starts to flow back into the downcomer through the broken DVI line during the transient when the liquid level in the PXS-B room becomes high enough to provide sufficient driving head. With the onset of this flow, additional water supplied~~

into the downcomer through the DVI break supplements the IRWST injection. As this flow path becomes established, tThe levels in the downcomer (Figure A3.5-1), the reactor core (Figure A3.5-2), and the upper plenum (Figure A3.5-8) **are sufficient to maintain core cooling**increase. The effect of this injection flow increase is also seen in Figures A3.5-3 and A3.5-4, which show a void fraction decrease in the upper half of the core.

The three available ADS Stage 4 valves provide enough venting capacity that adequate depressurization capability exists to achieve successful performance of the passive safety systems (Figures A3.5-9 and A3.5-10). The fuel remains covered throughout the transient, and adequate core cooling is provided to remove the decay heat. The hot rod cladding temperature **at the top of the core** is slightly above saturation temperature (Figure A3.5-12) throughout the transient.

As the transient proceeds, the IRWST drains to a minimum level slightly above 107 feet. After that time, the level continues to decrease slightly due to loss of fluid from the containment, as predicted by MAAP4. The transient is terminated at about 4.2 hours after the break occurs with no additional leakage from the containment, and with system pressure constant, stable DVI injection flows, and decreasing decay heat.

A5.6 T/H Uncertainty Analysis for Long-Term Cooling

The objective of these analyses is to analyze the AP1000 long-term core cooling (LTCC) behavior following a guillotine double-ended direct vessel injection (DEDVI) line break to support the PRA T/H uncertainty evaluations. In order to bound the T/H uncertainty, this analysis is performed using the DCD code and conservative methods.

Two cases of LTCC following a DEDVI line break are analyzed. These cases were determined by T/H uncertainty evaluations performed for AP1000 (in Section A5). One of these cases considers that the containment is isolated (Case F), and the other case considers that the containment isolation has failed (Case G). It is conservatively assumed that the DEDVI line break occurs in the PXS-B room. Since the size of this room is bigger than PXS-A, it reduces the containment water level during recirculation. It also takes more time for the water to fill it to the DVI nozzle elevation, where water can start flowing into the downcomer through the broken DVI line. In both cases, the general assumptions and methodology of the calculations are essentially the same. Conservative boundary and initial conditions are applied consistent with these multiple failure PRA-based scenarios to ensure that the T/H uncertainties contained within the success criteria are bounded.

A short summary follows of the two T/H uncertainty cases described herein.

- Case F:
  - DEDVI LOCA in line B
  - Available equipment – 1/1 CMT-ACC (A), both-one IRWST injection lines open with 1/2 valves open in eachit, only 1 recirculation line available with both-one valves open and this is the line attached to DVI-B, 3/4 ADS-4, PCS water drain with 1/3 valves open
  - Unavailable equipment – no ADS 1/2/3, PRHR, CMT, RNS injection/spill, IRWST gutter
  - Containment isolation is assumed to have worked.

- Case G:
  - DEDVI LOCA in line B
  - Available equipment – 1/1 ~~CMT~~ ACC (A), ~~both~~ one IRWST injection lines open with 1/2 valves open in ~~each~~ it, 1/2 recirculation lines open with both valves open (line B), 4/4 ADS-4, PCS water drain with 1/3 valves open
  - Unavailable equipment – no ADS 1/2/3, PRHR, CMT, RNS injection/spill, IRWST gutter
  - Containment isolation is assumed to have failed (18-inch HVAC line remains open).

A5.6.1 WCOBRA/TRAC LTCC Modeling Methodology

The simulation methodology used in the current analyses is ~~essentially the same as the one used for the AP600 design certification process (Reference A-4).~~ as follows:

- The T/H uncertainty analyses are performed using the WCOBRA/TRAC thermal hydraulic computer code (Reference A-27).
- The WCOBRA/TRAC AP1000 model is the same as the one used in the AP1000 DCD Post-LOCA Long-Term Cooling analysis (Reference A-26)
- The AP1000 LTCC simulations are performed using WCOBRA/TRAC in a ~~transient~~-window mode. The ~~transient~~-window mode approach has been validated by the Oregon State University Tests and was used in the AP600 Design Certification (Reference A-4).
- For each case, the AP1000 ~~initial and~~ boundary conditions are provided by a ~~MAAP4~~ combined WGOTHIC analysis and hand calculation. ~~MAAP4 is capable of simulating the behavior and the interaction between the AP1000 primary system, the passive safety systems, the containment, and the~~ WGOTHIC can predict the performance of containment systems – a feature that is not present in WCOBRA/TRAC.
- Like the ~~MAAP4, the~~ DCD LTC analysis, these WCOBRA/TRAC simulations ~~is~~ are performed with the following conservative general assumptions:
  - 102-percent core power
  - Appendix K decay heat
  - Maximum hydraulic resistance of the passive safety systems

A5.6.2 Methodology Implementation

The ~~transient~~-window mode calculation using WCOBRA/TRAC allows simulation of long transients with reasonable computer resources. As was shown in the validation of methods used in the DCD analysis (Reference A-26), the calculation may be initiated from an arbitrary set of initial conditions. After an initial period of 500 to 1000 seconds, the plant reaches a quasi-steady-state that depends mostly on the system boundary conditions. During this "steady-state" period, the boundary conditions are kept constant. After that, they are set as a function of time depending on the time window being simulated.

For the AP1000 T/H uncertainty analysis, a ~~transient-~~window mode calculation was performed for Case F and Case G. ~~-within the~~The time period covered by the ~~MAAP4-~~**WCOBRA/TRAC calculations for the cases is the plant condition identified as limiting in the DCD analysis transient simulation of the DEDVI break immediately following the switchover to sump.** ~~those cases. It was observed that WCOBRA/TRAC predicts higher ADS Stage 4 flows resulting in better depressurization of the primary system. Consequently, the predicted IRWST injection rates were higher when using WCOBRA/TRAC. Because of the faster IRWST draining, it was estimated that the IRWST would reach its lowest level about 2 hours earlier than as predicted by MAAP4.~~

For each of the cases analyzed here (Case F and Case G), the ~~IRWST~~-level **of water in containment is identified with due consideration of any mass discharged through any open containment vent path.** ~~calculated by MAAP4 was adjusted to account for the more rapid draining predicted by WCOBRA/TRAC. The adjusted IRWST levels were then used as boundary conditions for each of the cases, F and G.~~

The containment pressure, ~~PXS-B level,~~ IRWST, sump, and PXS-B temperatures calculated by ~~MAAP4, together with the adjusted IRWST level, were used to define the limiting conditions~~ **WGOTHIC in the AP1000 DCD analysis are used in Case F**~~used~~ to assess the performance of the AP1000 passive safety system. **For Case G, asmospheric pressure is specified, and the water level is adjusted to account for the water mass lost out of the unisolated containment as computed by WGOTHIC.**

The following two sections document the results of the WCOBRA/TRAC simulations for these limiting windows performed for Cases F and G.

A5.6.2.1 Case F – DEDVI Line Break in the PXS-B Room with Three of Four ADS Stage 4, Containment Isolated

This subsection presents the simulation results of T/H uncertainty Case F – DEDVI line break located in the PXS-B room with three out of four ADS Stage 4 valves opened and the containment isolated. The initial conditions are based on the ~~MAAP4~~-**DCD** calculation results of the **PXS "B" room break** ~~same~~-accident scenario. They are selected such that the WCOBRA/TRAC simulation begins ~~3992~~-**9300** seconds ~~(approximately 1 hour, 6 minutes)~~-after the break – ~~shortly after IRWST injection begins.~~**the time at which the switchover to sump recirculation occurs.**

For this transient, the ~~initial IRWST~~-**containment water** level is ~~126.4~~- **107.1** feet. ~~-and its~~ ~~t~~Temperature is ~~121~~**198°F in the sump and 142°F in** ~~. The initial level in~~ the PXS-B room ~~is 95.8 feet~~. The available ADS Stage 4 paths are opened, and the containment pressure is set to its initial value of ~~42.9~~-**24.5** psia. Under these conditions, a 1000-second calculation is performed to ensure that the initial steady-state conditions are achieved in the system~~. After that~~, **and** the ~~transient-~~window mode calculation is initiated with ~~time-dependent~~-**fixed** boundary conditions ~~taken from the MAAP4 calculation, but with adjusted IRWST level decrease, as discussed earlier.~~

~~Initially, the only injection comes from the IRWST into the reactor vessel through the intact DVI injection line (Figure A5.3-14). Since at the beginning of the analysis, the level in the PXS-B room is below the DVI injection nozzle elevation, only steam from the downcomer is vented out through the break (Figure A5.3-13). Water starts to flow back into the downcomer through the broken DVI line about 2 hours into the transient.~~This is the time when the level **is at a minimum in containment, yet decay heat remains relatively high**~~in the PXS-B room becomes high enough to provide sufficient driving head. At the onset of this event, the additional amount of water supplied into the downcomer through the DVI break supplements the IRWST injection. This leads to enhanced core cooling, and~~

~~momentarily, faster depressurization occurs at about 2.05 hours into the transient (Figure A5.3-11). Consequently, the IRWST injection is increased even further, and as a result, the~~ **The** levels in the downcomer (Figure A5.3-1), the reactor core (Figure A5.3-2), and the upper plenum (Figure A5.3-8) are ~~also increased. The effect of this injection flow increase can also be seen on Figure A5.3-4, which shows a sharp void fraction decrease in the upper half of the fuel region~~**adequate to maintain acceptable core cooling.**

The available three out of four ADS Stage 4 valves provide enough venting capacity to assure adequate depressurization and successful performance of the passive safety systems (Figures A5.3-9 and A5.3-10). The fuel remains covered throughout the transient and adequate core cooling is provided to remove the decay heat. The hot rod cladding temperature **at the top of the core** is about 20°F above saturation (Figure A5.3-12) and ~~is steadily decreasing~~**exhibits no excursions.**

~~As the transient proceeds, the IRWST drains to a minimum of 107 feet at about 3.9 hours after the break. After that time, the level is kept constant at 107 feet, as predicted by MAAP4. The transient is terminated at about 4.2 hours after the break with the system~~**The window mode demonstrates that AP1000 is** in a continuing depressurization phase with stable DVI injection flows, and decreasing decay heat, **for the limiting time in the Case F scenario.**

A5.6.2.2 Case G – DEDVI Line Break in the PXS-B Room with Four of Four ADS Stage 4, Containment Isolation Failed

This subsection presents the simulation results of T/H uncertainty Case G – DEDVI line break located in the PXS-B room with all ADS Stage 4 valves available and with containment isolation failure. The initial conditions are based on the ~~MAAP4~~-DCD calculation results of the **PXS "B" room break** ~~same~~ accident scenario. They are selected such that the WCOBRA/TRAC simulation begins ~~3298~~9300 seconds ~~(approximately 55 minutes)~~ after the break ~~—shortly after IRWST injection begins~~**the time at which the switchover to sump recirculation occurs.**

For this transient, the ~~initial IRWST~~ **containment water** level is ~~127.9~~ 106.7 feet. ~~and its~~ **t**Temperature is ~~120.5~~198°F **in the sump and 142°F**~~. The initial level~~ in the PXS-B room ~~is 93.1 feet~~. All the ADS Stage 4 paths are opened, and the containment pressure is set ~~to its initial value of 17.08 psia, as calculated by MAAP4. Under~~ 14.7 psia. **Under these conditions,** first a 1000-second calculation is performed so that the ~~initial~~ **proper** steady-state is achieved in the system, **and.** ~~After that,~~ the ~~transient~~ **window** mode calculation is initiated with ~~time-dependent~~ **fixed** boundary conditions ~~taken from the MAAP4 calculation, but with the adjusted IRWST level decrease~~.

~~Initially, the only injection comes from the IRWST into the reactor vessel through the intact DVI injection line (Figure A5.3-28). Since at the beginning of the analysis, the level in the PXS-B room is below the DVI injection nozzle elevation, only steam from the downcomer is vented out through the break. Water starts to flow back into the downcomer through the broken DVI line about 2 hours into the transient.~~ This is the time when the level **has about reached its minimum value in containment, yet decay heat is still relatively high** ~~in the PXS-B room becomes high enough to provide sufficient driving head for this to happen. This time, unlike the Case F DVI break scenario, the transition into reversed injection of water through the break into the downcomer occurs a little earlier, and is somewhat softer. As a result, the increased depressurization rate observed in Case F does not occur.~~ Still, the levels in the downcomer (Figure A5.3-15), the reactor core (Figure A5.3-16) and the upper plenum (Figure A5.3-22) are maintained high enough by the available DVI injection **to provide acceptable core cooling.**

The availability of all ADS Stage 4 valves provides enough venting capacity to assure adequate depressurization and successful performance of the passive safety systems (Figures A5.3-23 and A5.3-24). The fuel remains covered throughout the transient, and adequate core cooling is provided to remove the decay heat. The hot rod cladding temperature **at the top of the core** is about 20°F above saturation (Figure A5.3-26) ~~and steadily decreasing~~.

~~As the transient proceeds, the IRWST drains to a minimum of 106.9 feet at about 3.7 hours after the break. After that time, the level is kept constant at 106.9 feet, as predicted by MAAP4. The transient is terminated at about 4.4 hours after the break with~~ **The window mode calculation** shows the system being in a phase with stable DVI injection flows, adequate ADS 4 flows, and decreasing decay heat **for the limiting time in the Case G scenario.**

The following figures will replace the existing ones in PRA Appendix A.

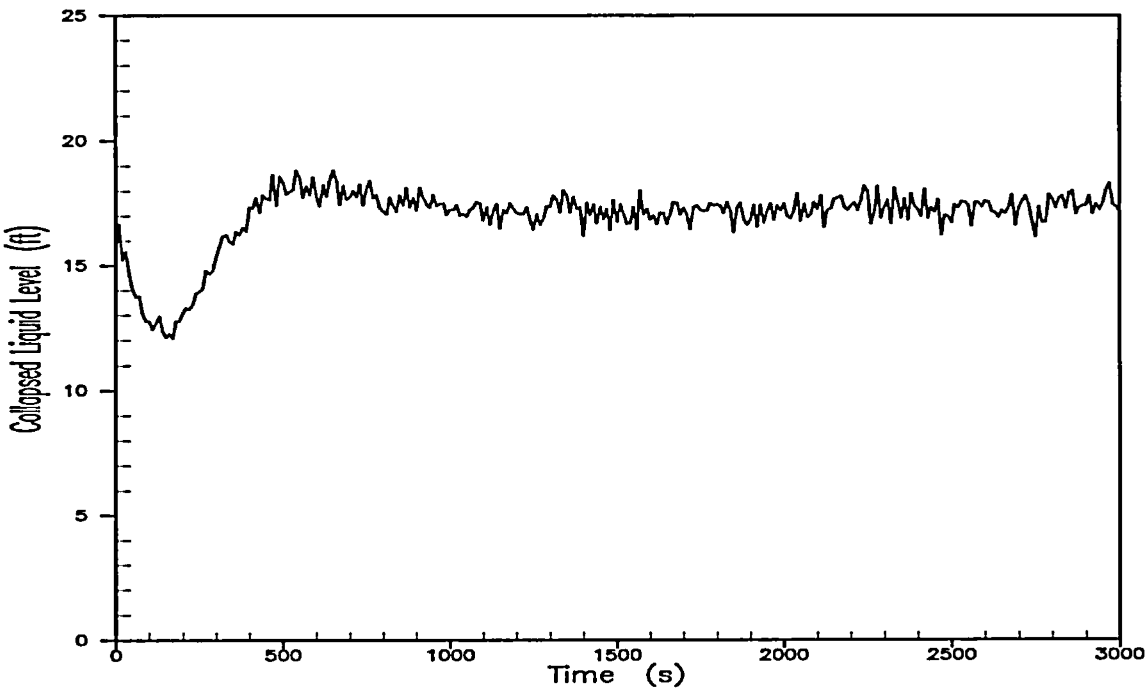

Figure A3.5-1

LTCC DEDVI Break Success Criteria – Collapsed Level of Liquid in Downcomer

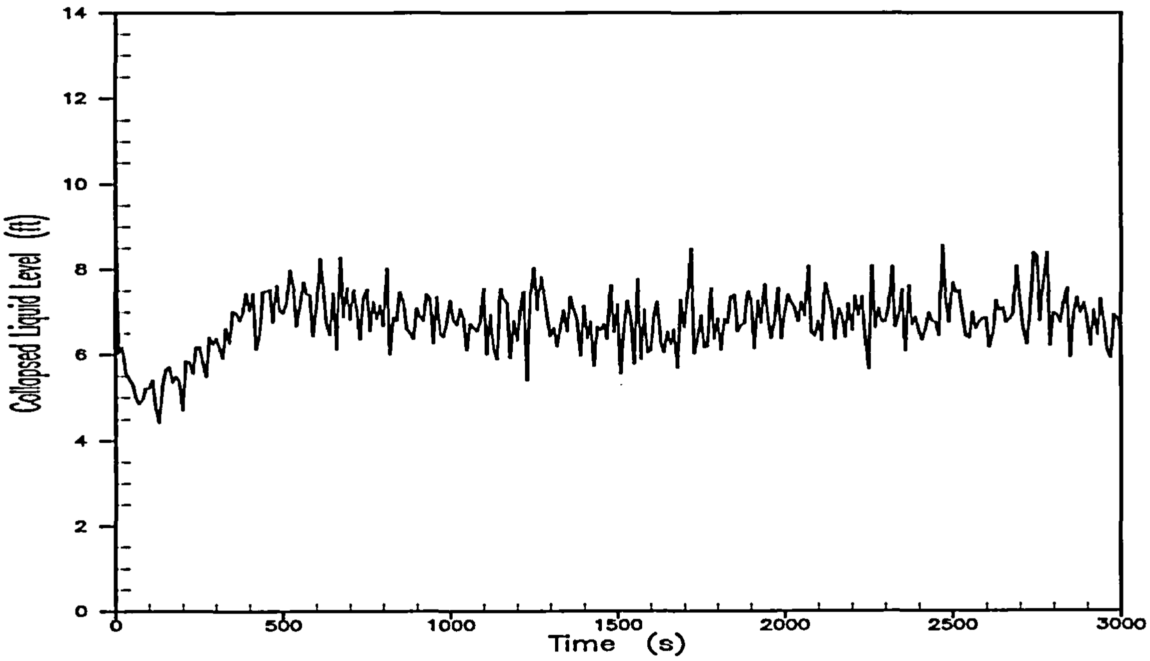

Figure A3.5-2

LTCC DEDVI Break Success Criteria – Collapsed Level of Liquid Over Heated Length of Fuel

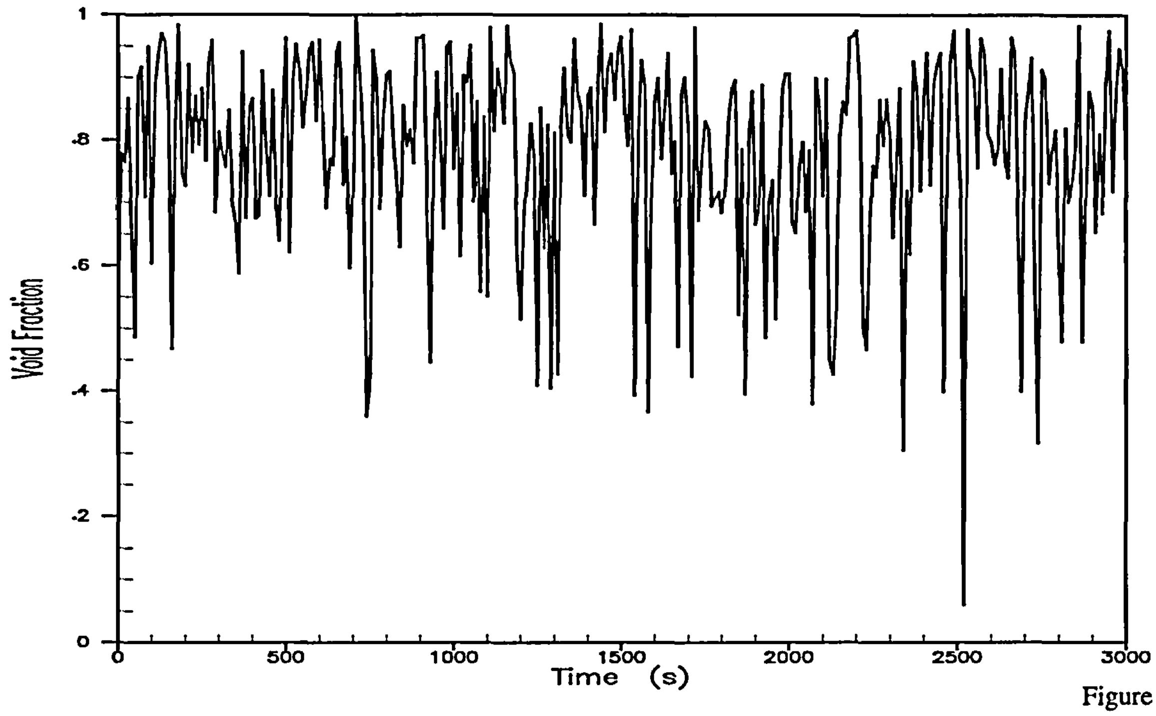

Figure A3.5-3

LTCC DEDVI Break Success Criteria – Void Fraction in Core Cell Level 16 of 17

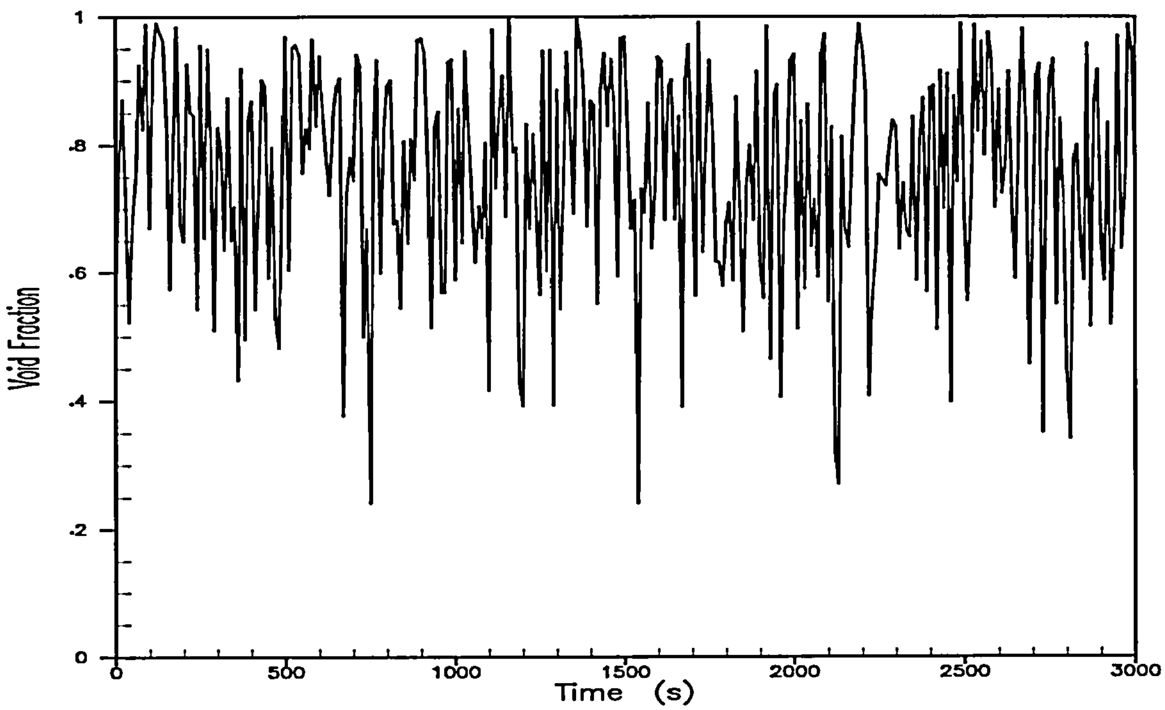

Figure A3.5-4

LTCC DEDVI Break Success Criteria – Void Fraction in Core Cell Level 17 of 17

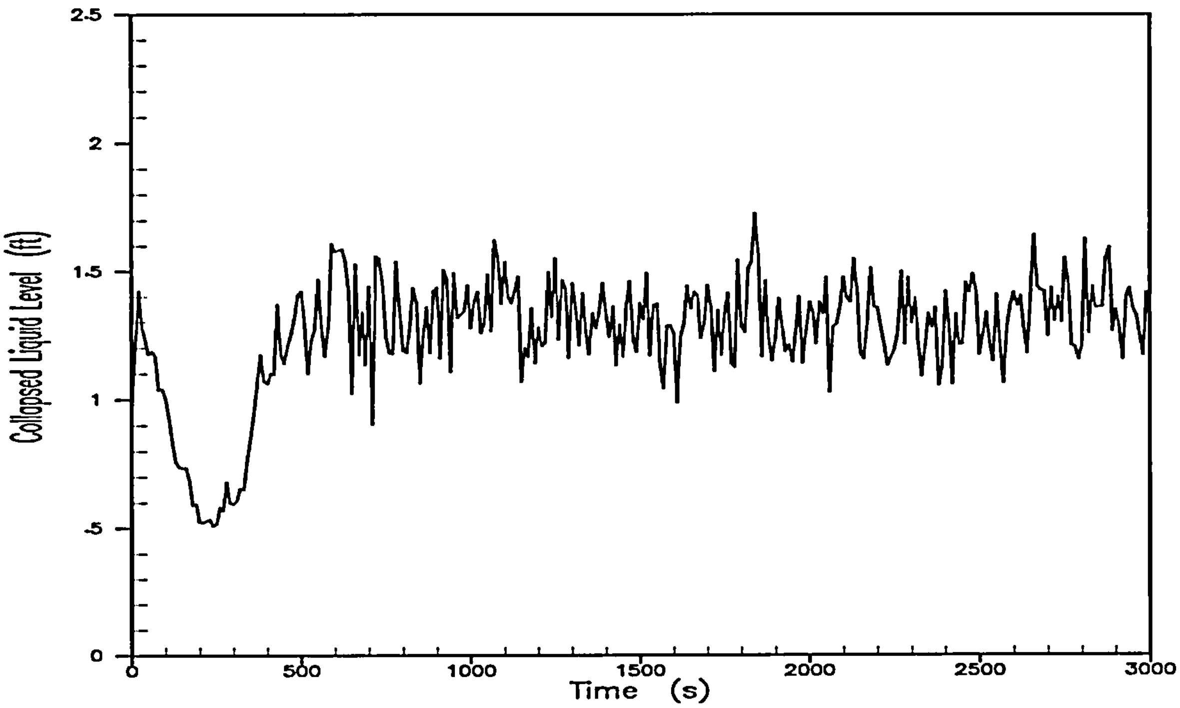

Figure A3.5-5

LTCC DEDVI Break Success Criteria -
Collapsed Liquid Level in the Hot Leg of Pressurizer Loop

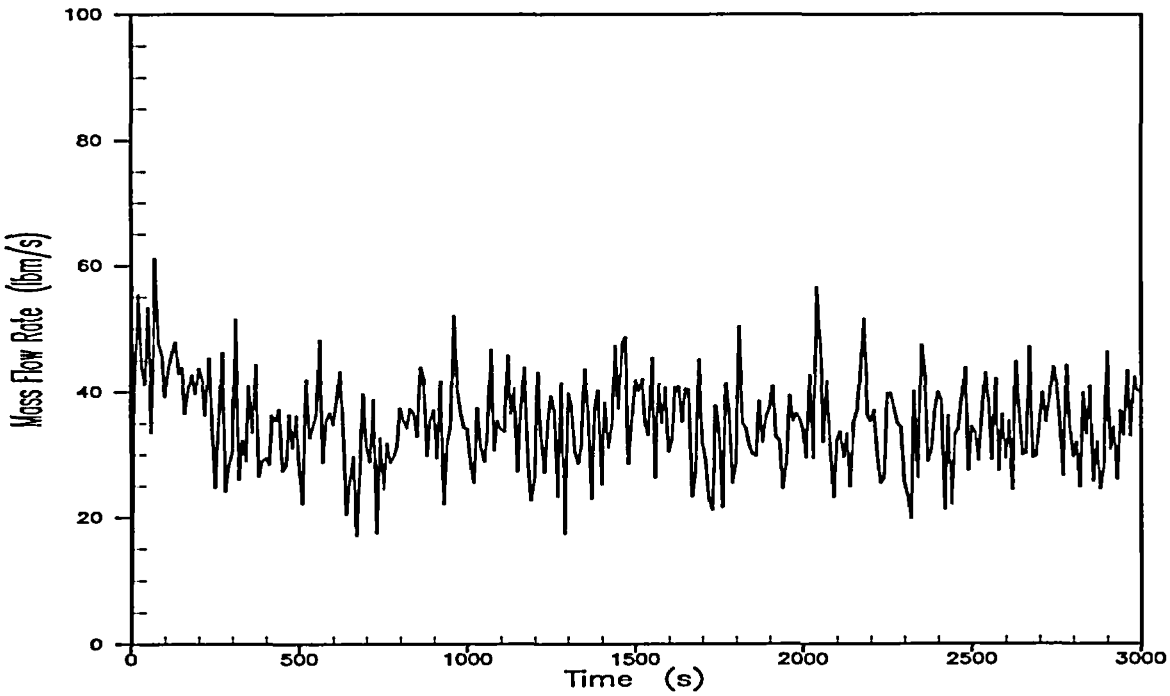

Figure A3.5-6

LTCC DEDVI Break Success Criteria - Vapor Rate Out of Core

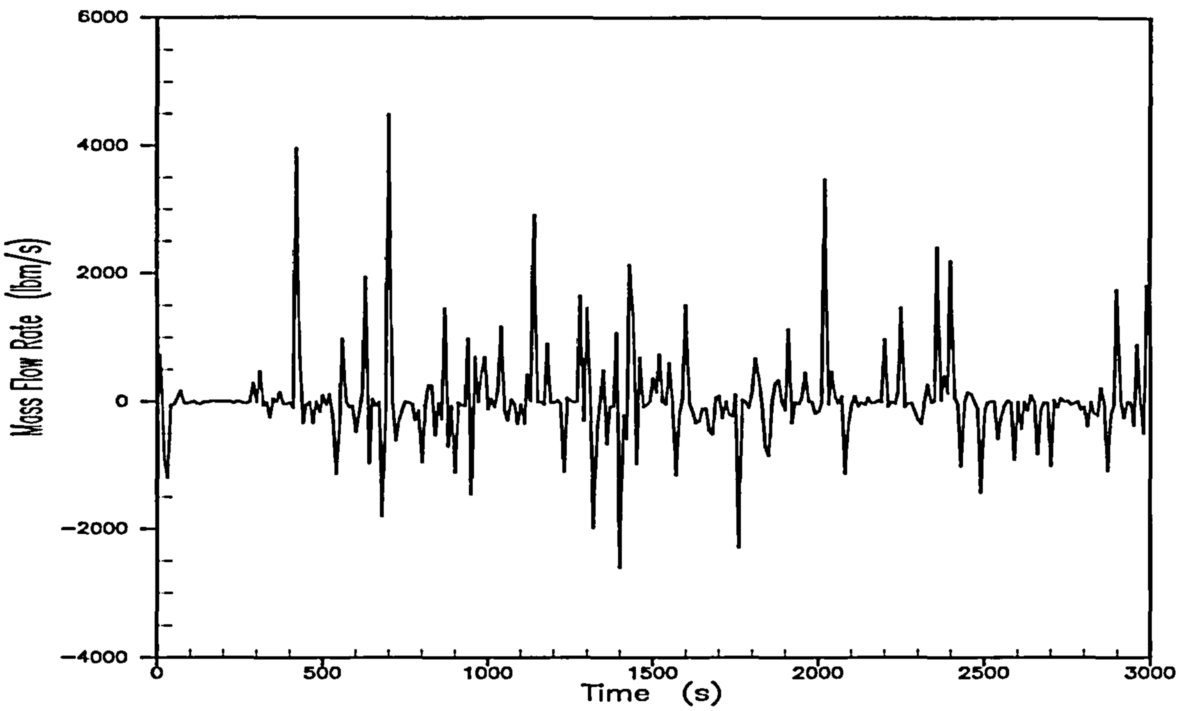

Figure A3.5-7

LTCC DEDVI Break Success Criteria –
Liquid Flow Rate Out of the Core

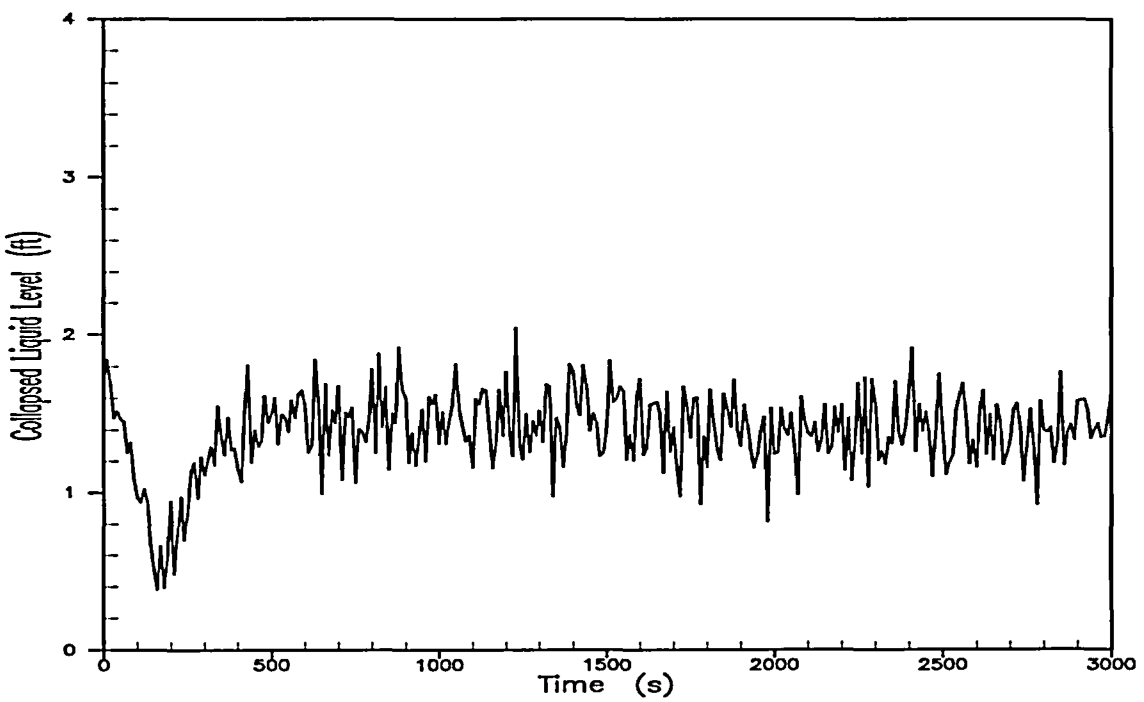

Figure A3.5-8

LTCC DEDVI Break Success Criteria – Collapsed Liquid Level in the Upper Plenum

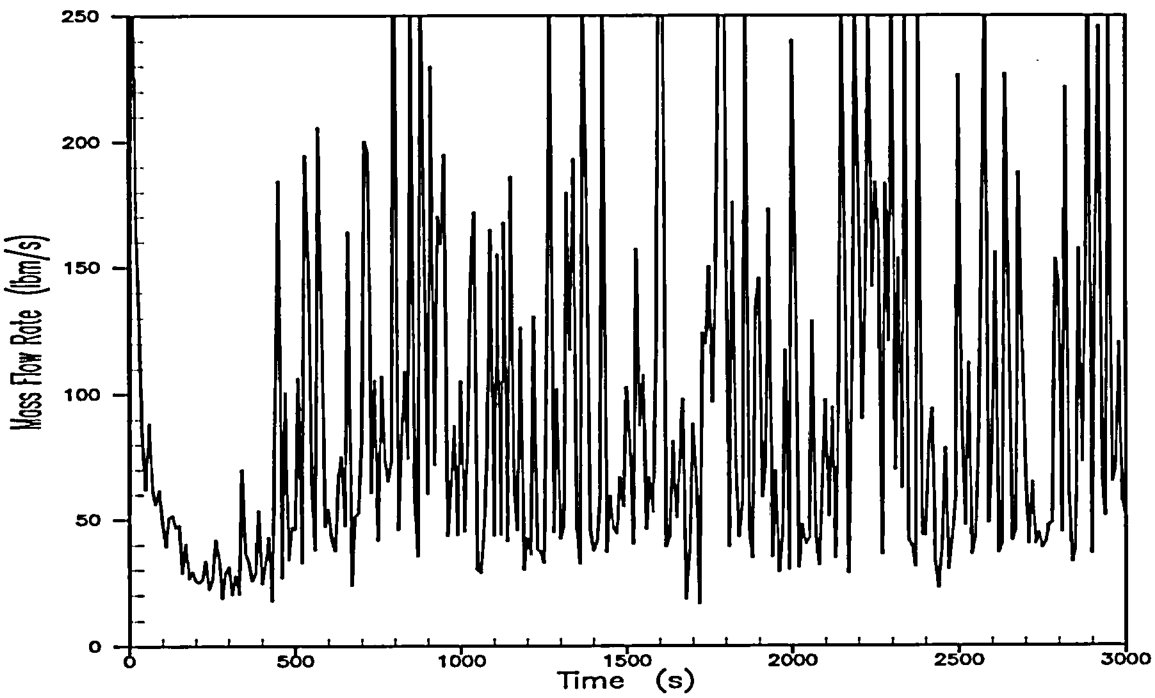

Figure A3.5-9

**LTCC DEDVI Break Success Criteria –
Mixture Flowrate Through ADS Stage 4A Valves**

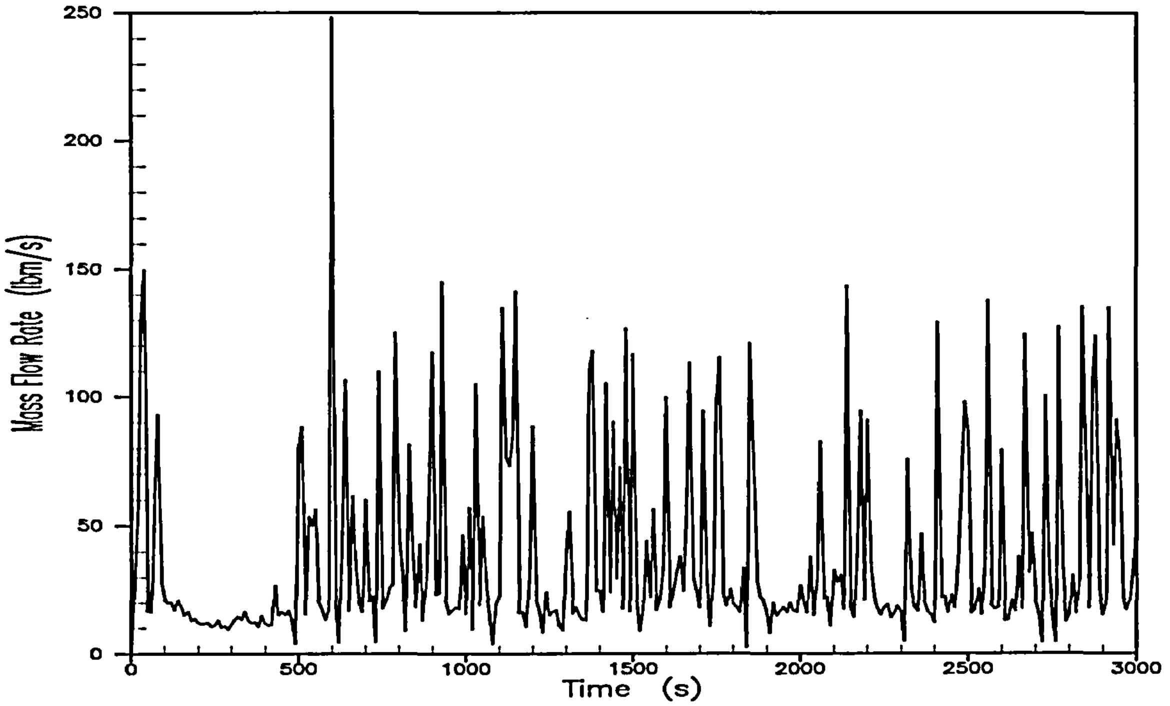

Figure A3.5-10

**LTCC DEDVI Break Success Criteria –
Mixture Flowrate Through ADS Stage 4B Valves**

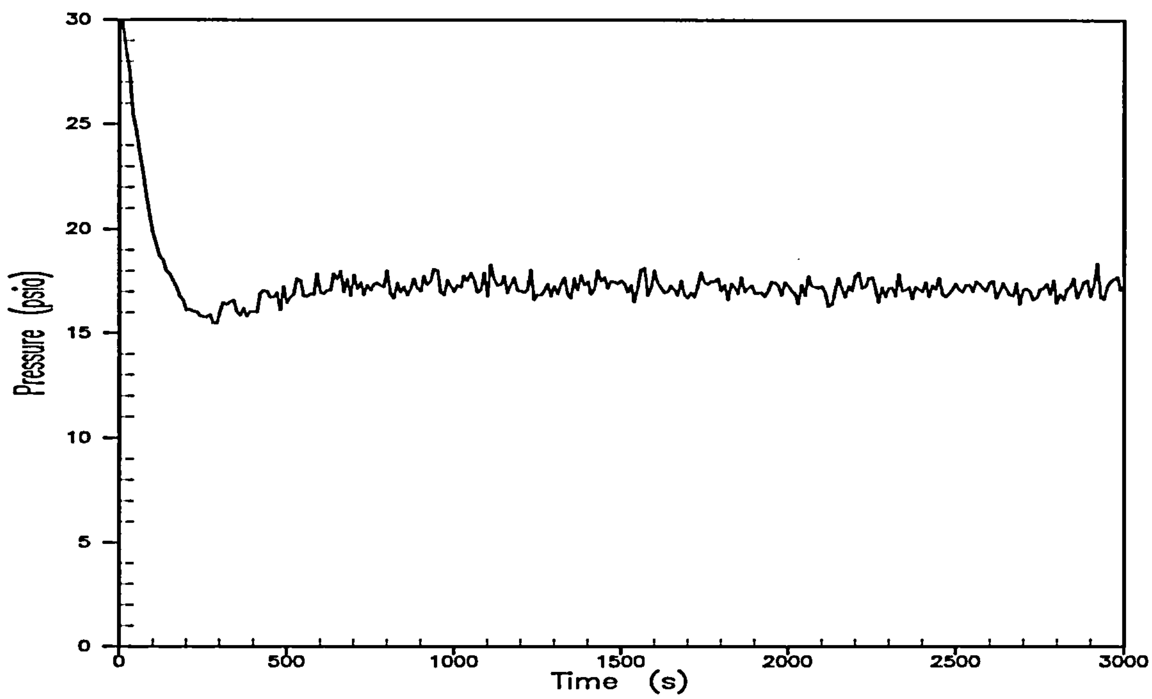

Figure A3.5-11

LTCC DEDVI Break Success Criteria – Upper Plenum Pressure

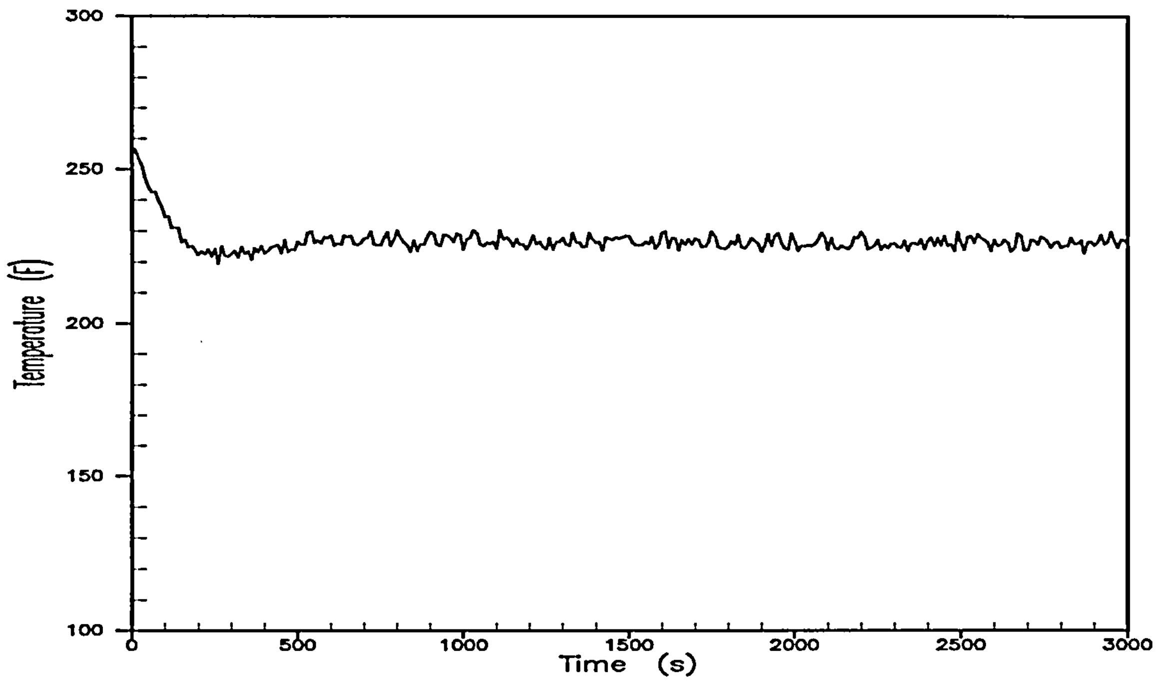

Figure A3.5-12

LTCC DEDVI Break Success Criteria – Hot Rod Clad Temperature in Cell 17

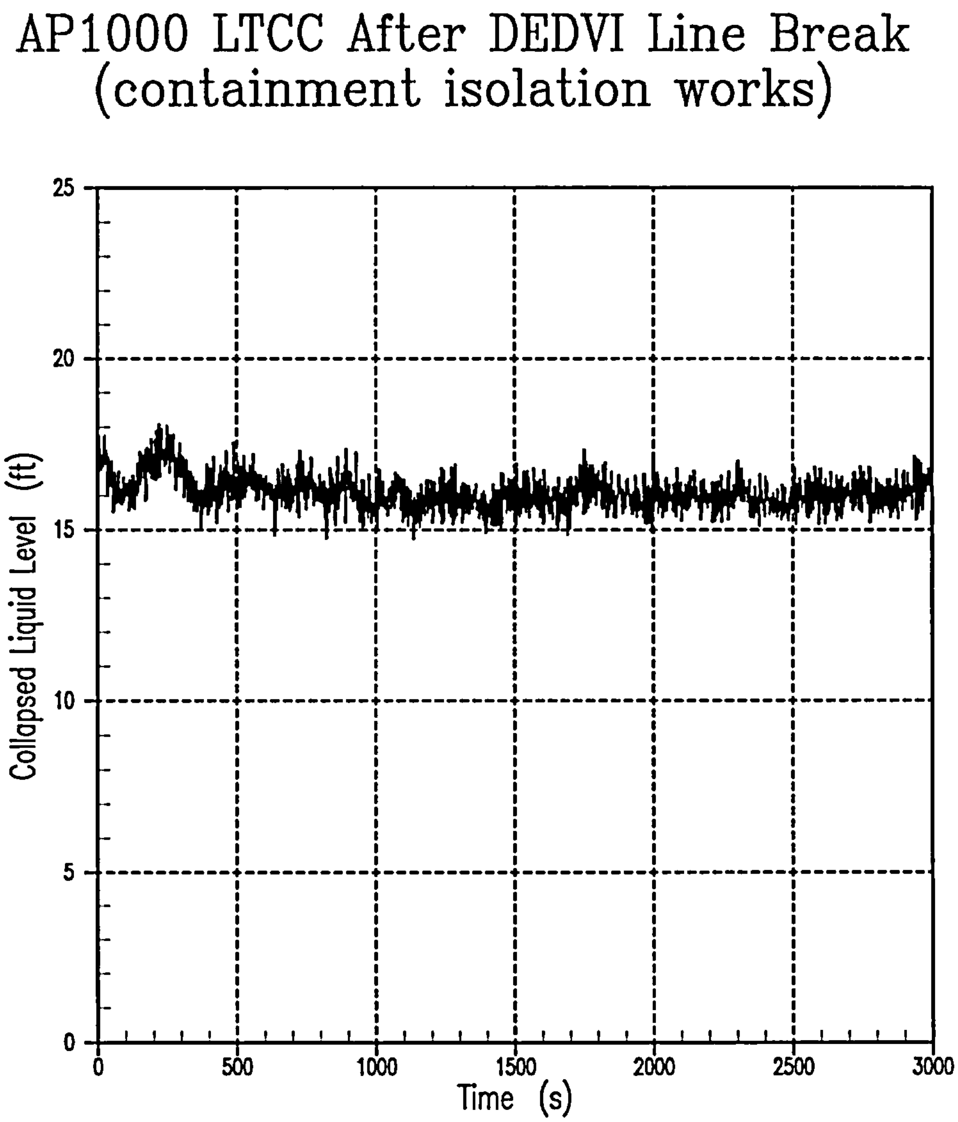

Figure A5.3-1

Case F – Collapsed Level of Liquid in the Downcomer

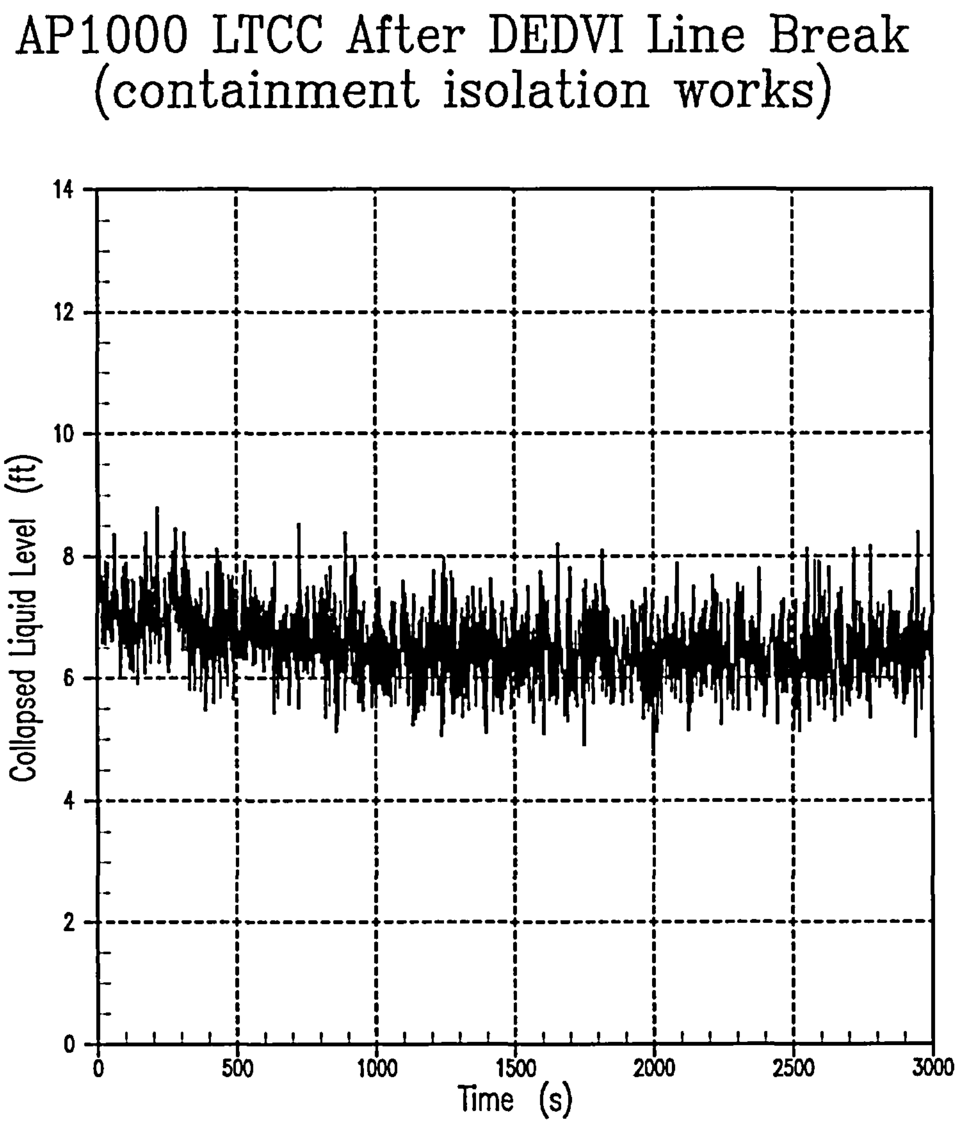

Figure A5.3-2

Case F – Collapsed Level Liquid Over the Heated Length of the Fuel

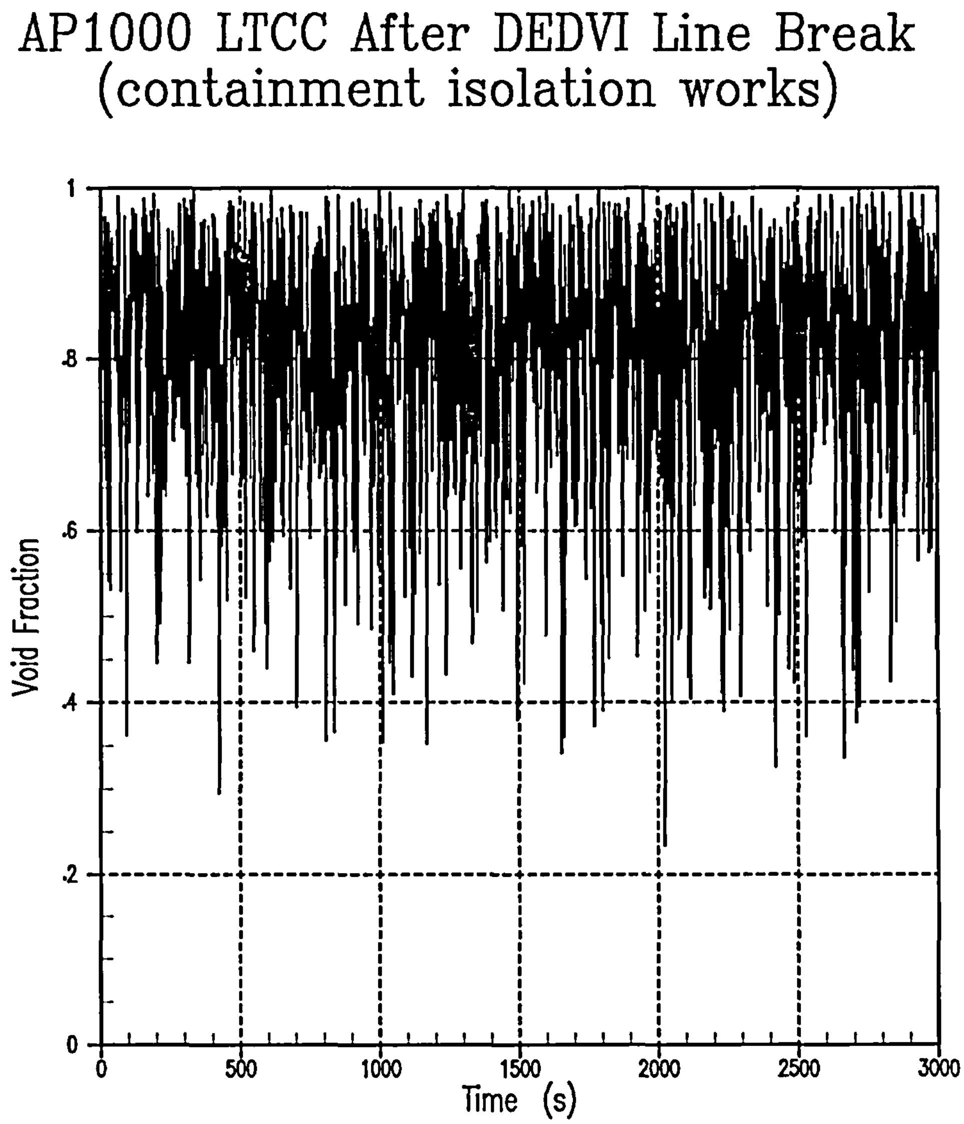

Figure A5.3-3

Case F – Void Fraction in Core Cell Level 16 of 17

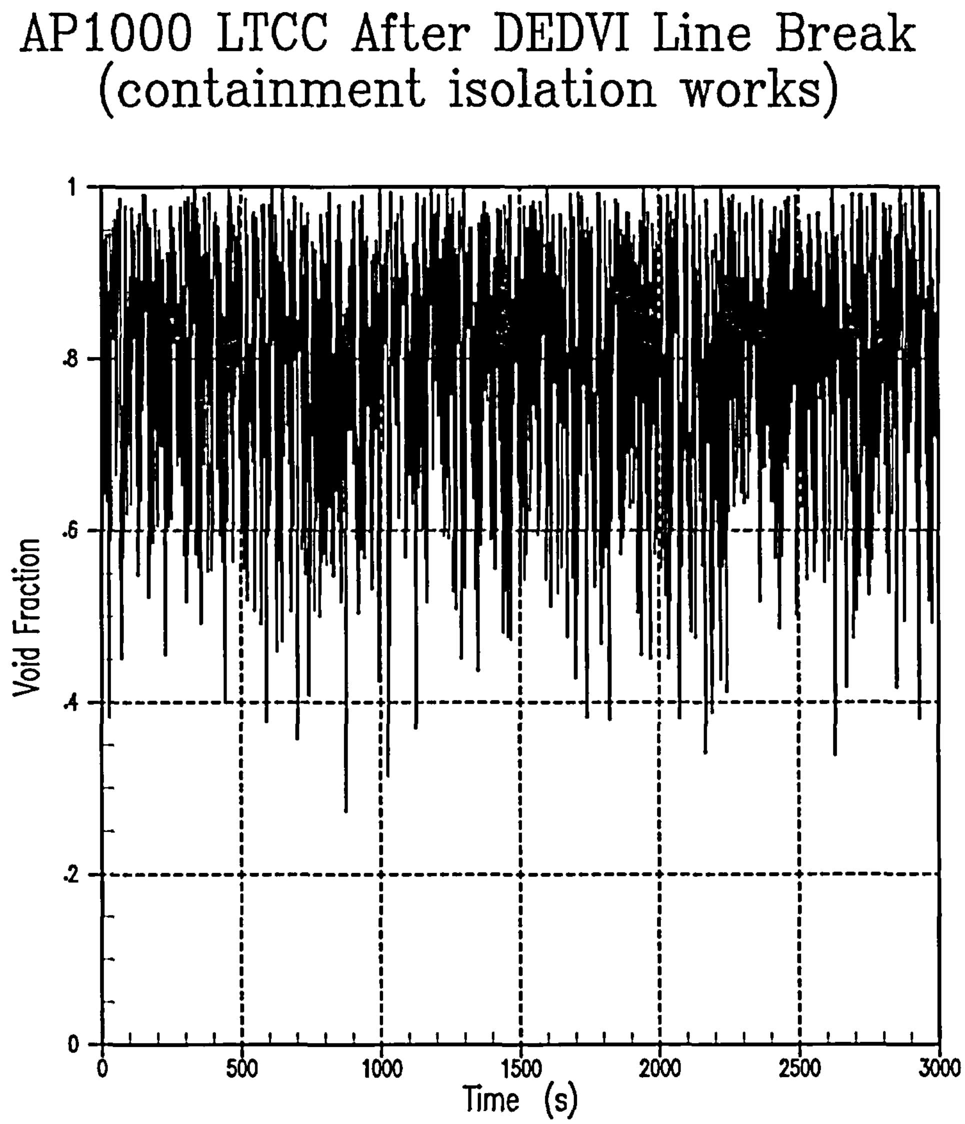

Figure A5.3-4

Case F – Void Fraction in Core Cell Level 17 of 17

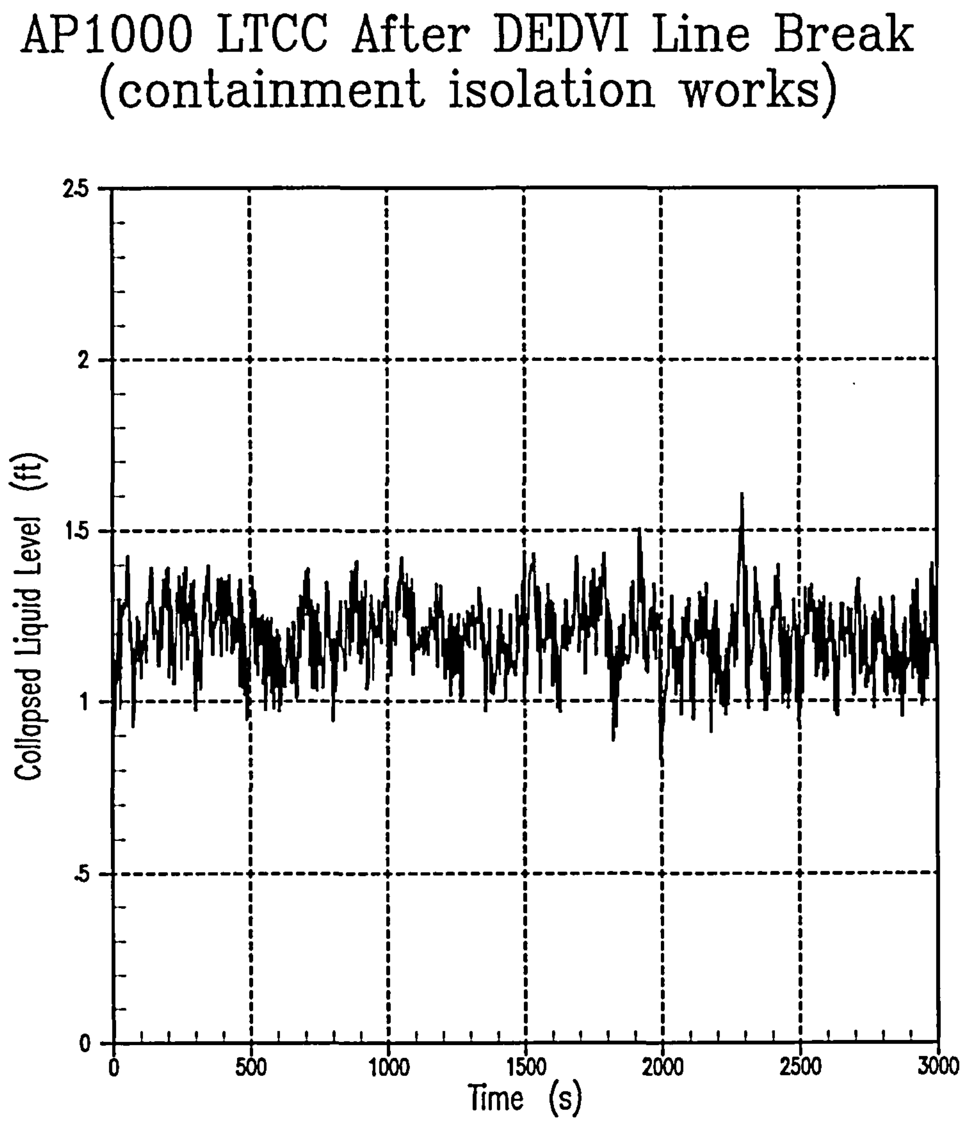

Figure A5.3-5

Case F – Collapsed Liquid Level in the Hot Leg of Pressurizer Loop

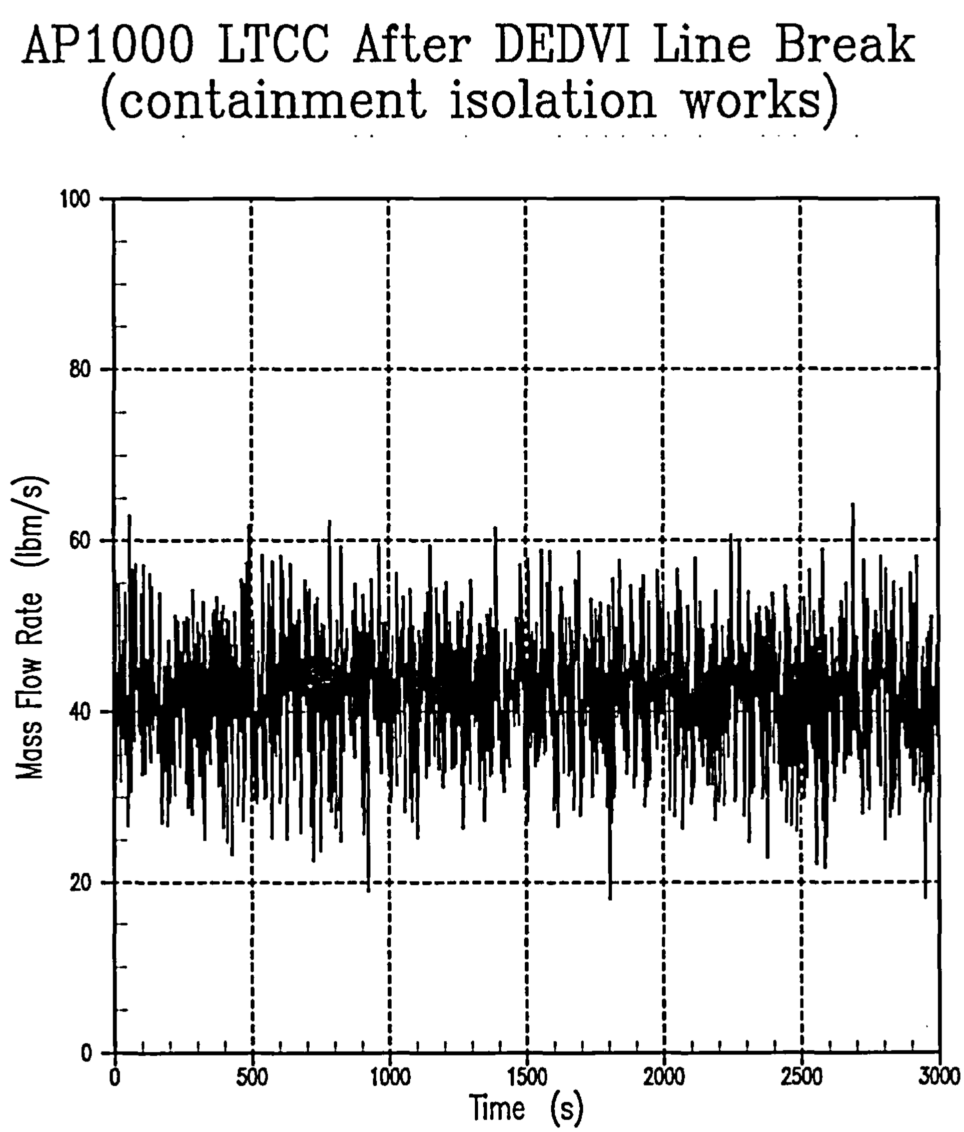

Figure A5.3-6

Case F – Vapor Rate out of the Core

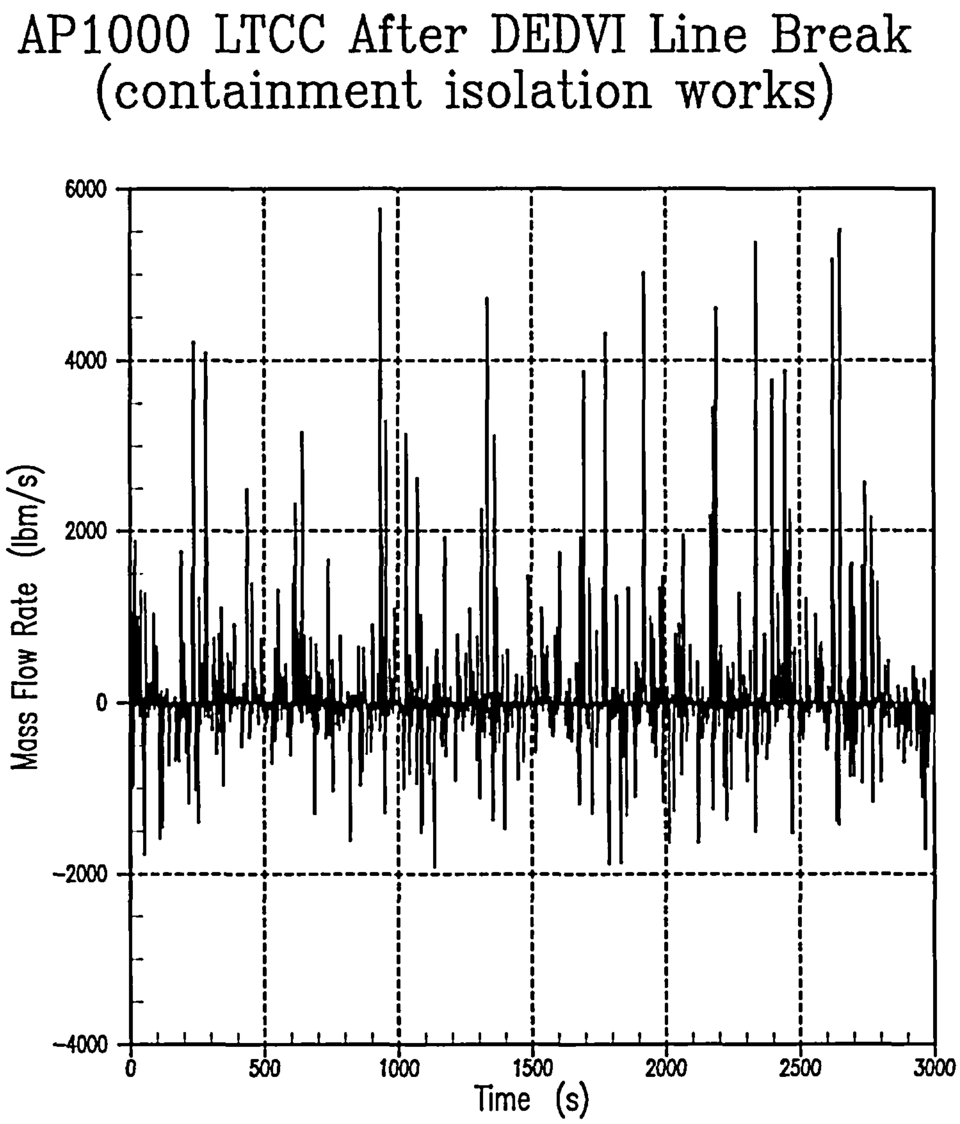

Figure A5.3-7

Case F – Liquid Flow Rate Out of the Core

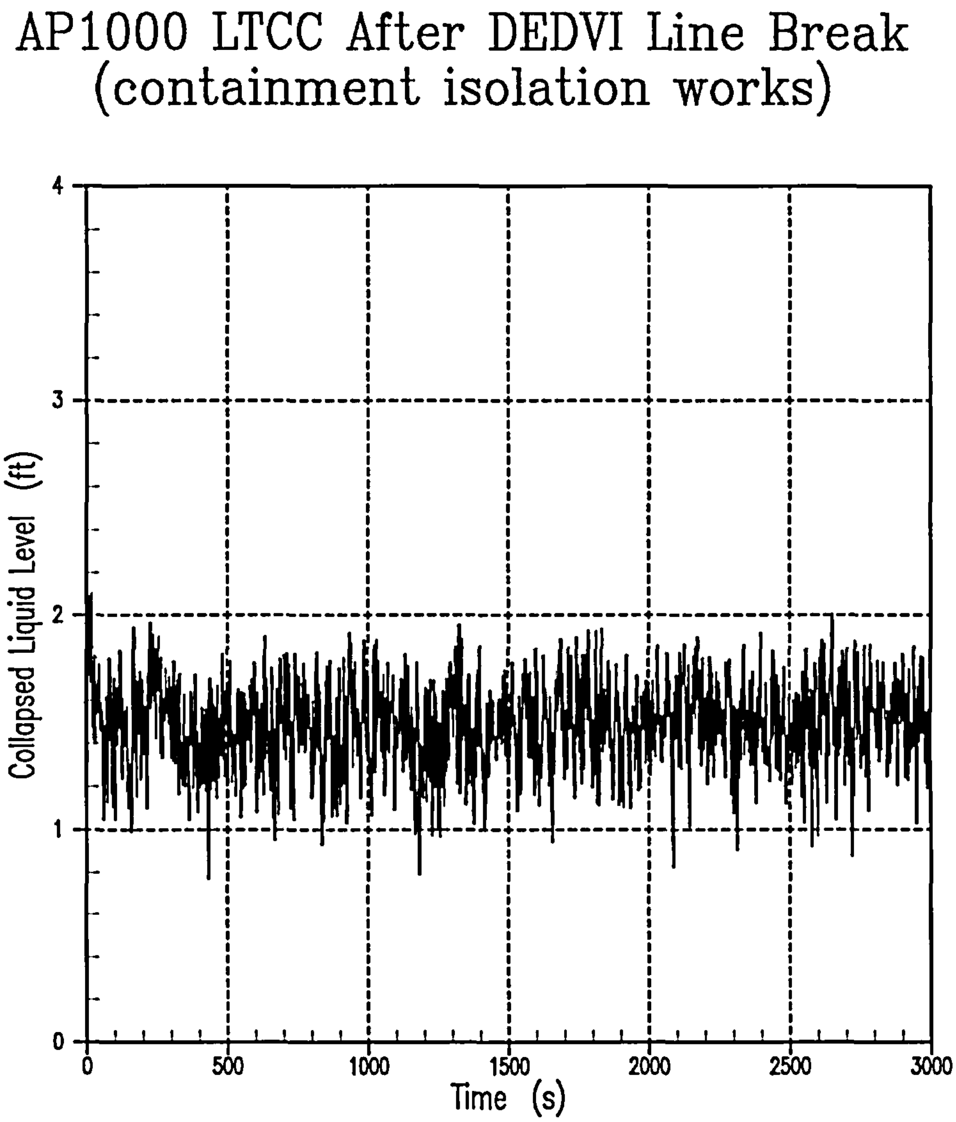

Figure A5.3-8

Case F – Collapsed Liquid Level in the Upper Plenum

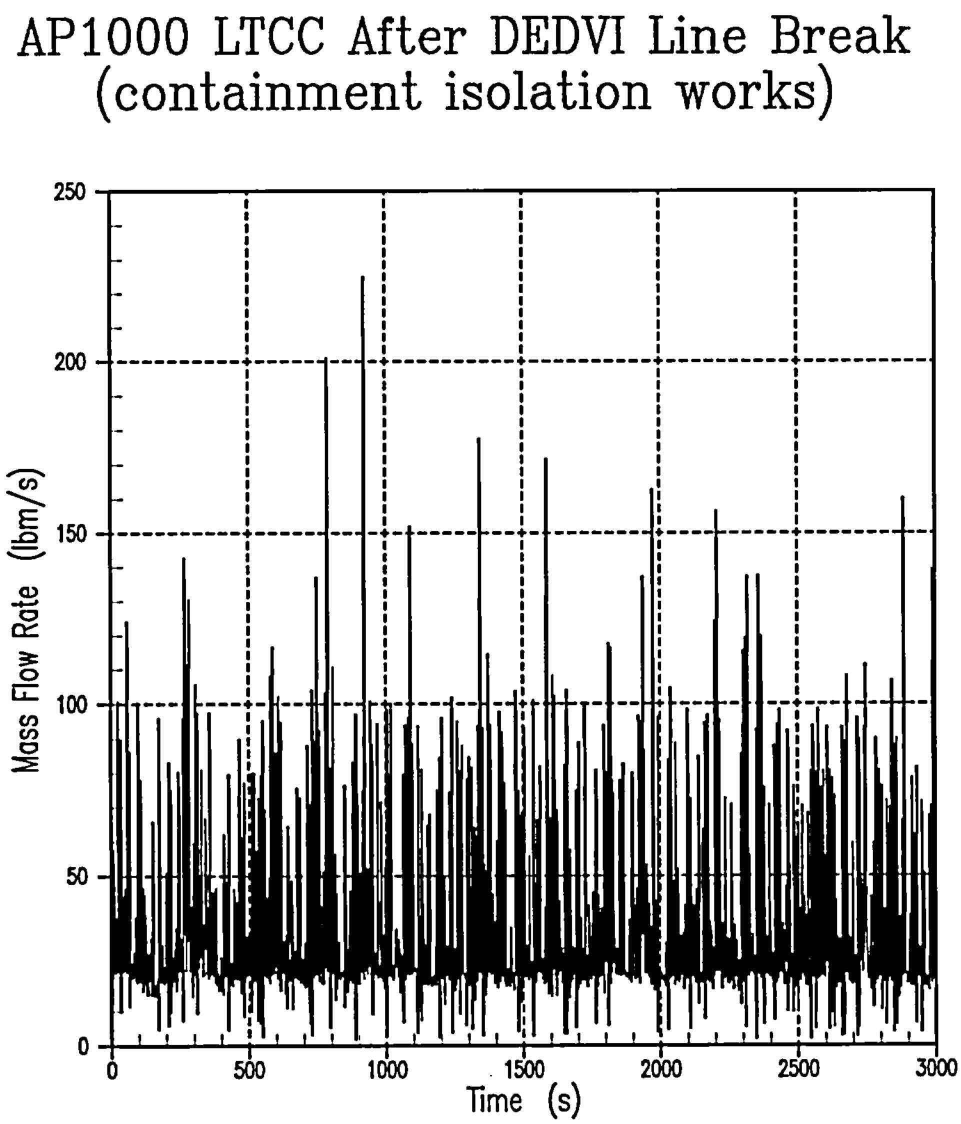

Figure A5.3-9

Case F – Mixture Flowrate Through ADS Stage 4A Valves

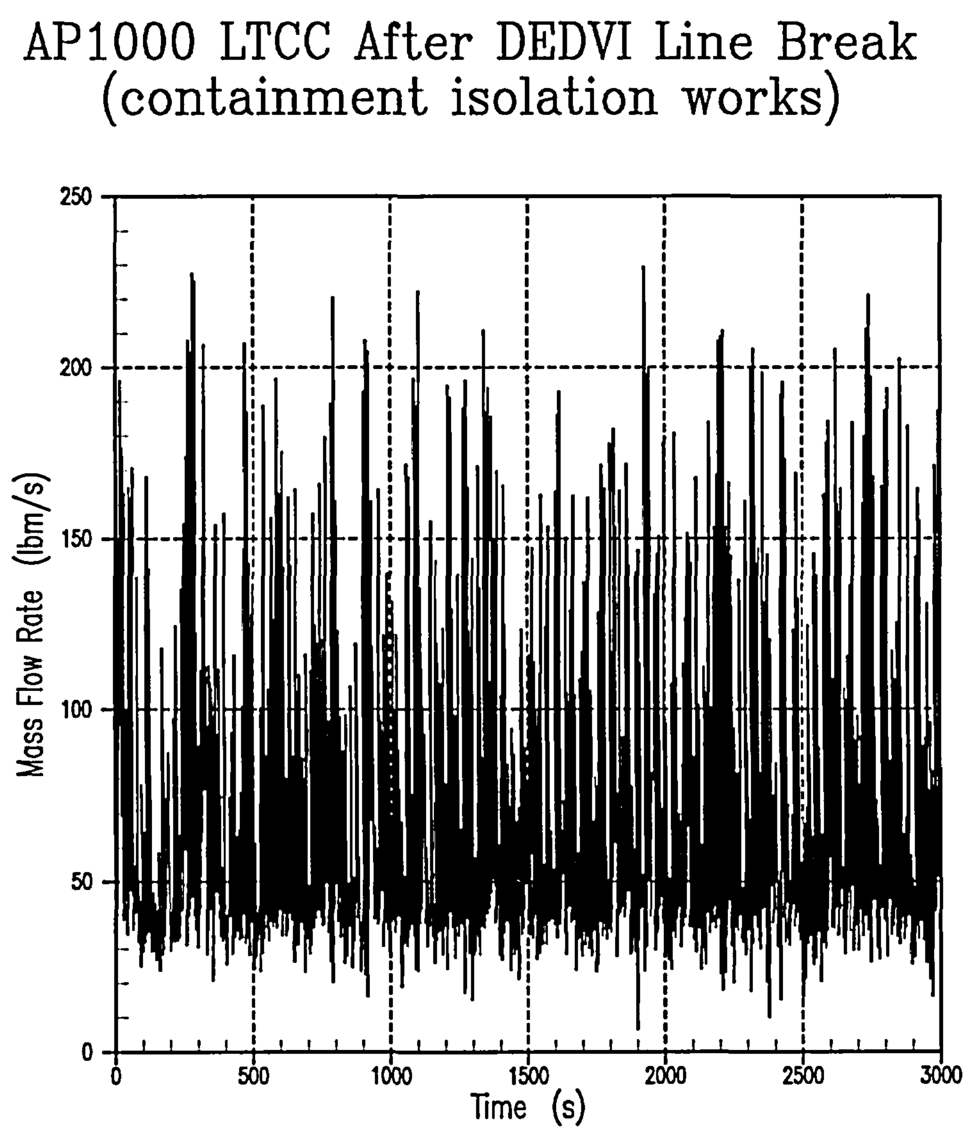

Figure A5.3-10

Case F – Mixture Flowrate Through ADS Stage 4B Valves

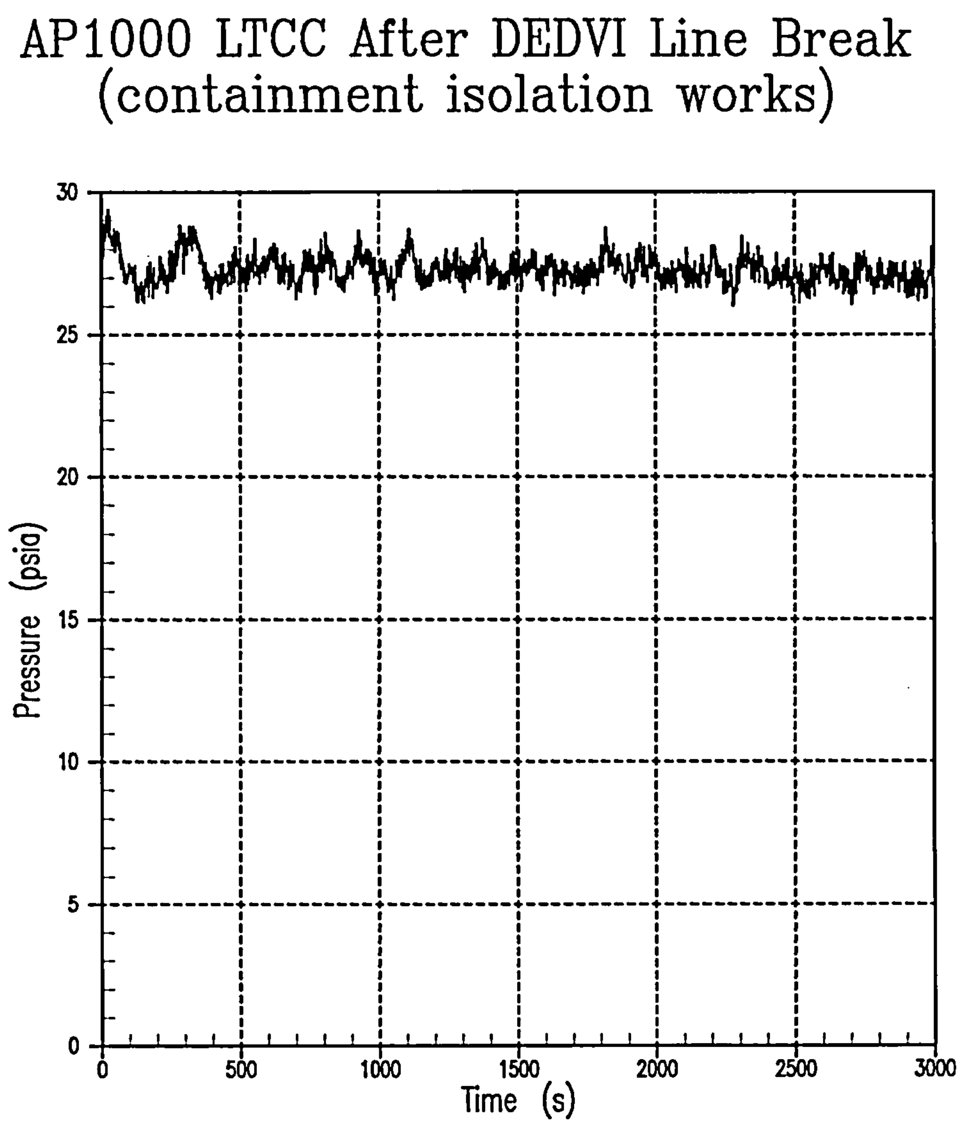

Figure A5.3-11

Case F – Upper Plenum Pressure

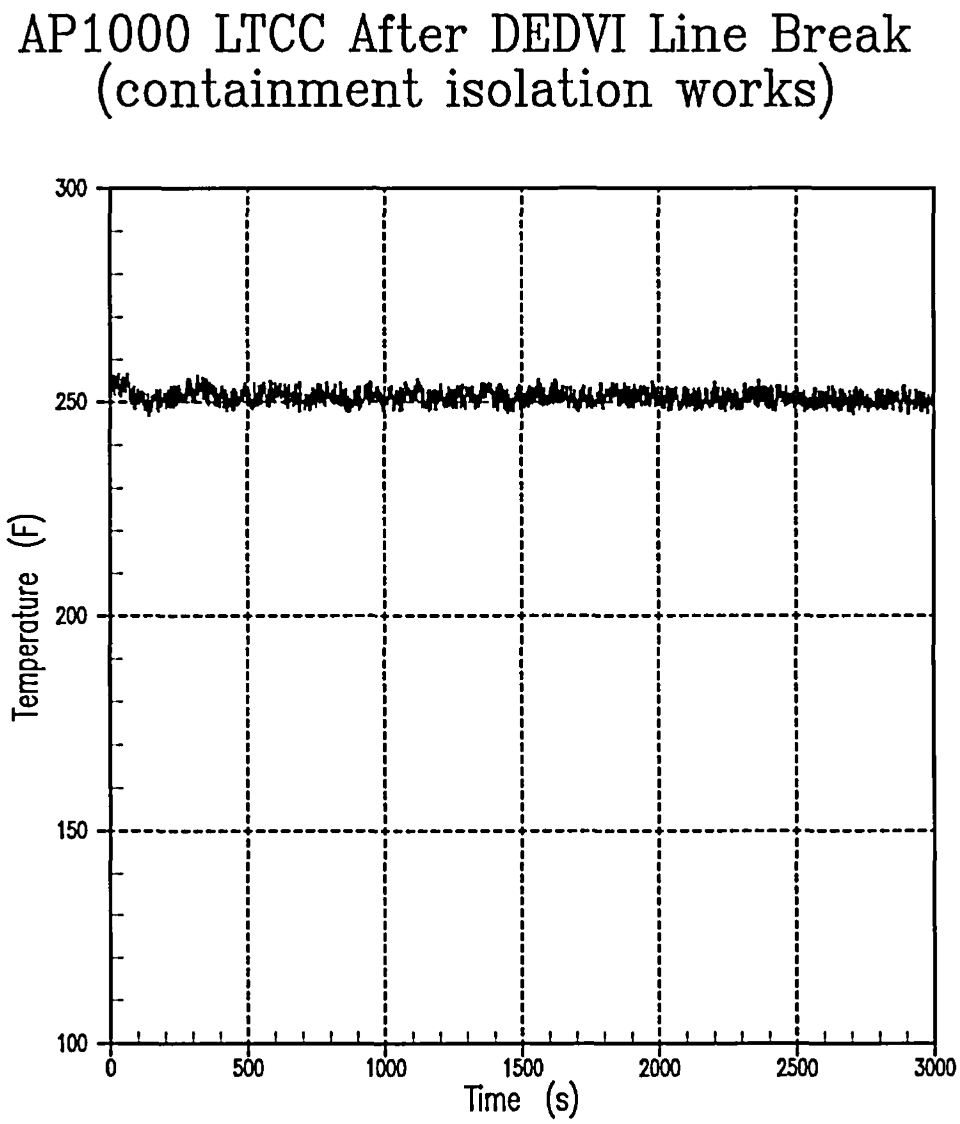

Figure A5.3-12

Case F – Hot Rod Clad Temperature in Cell 17

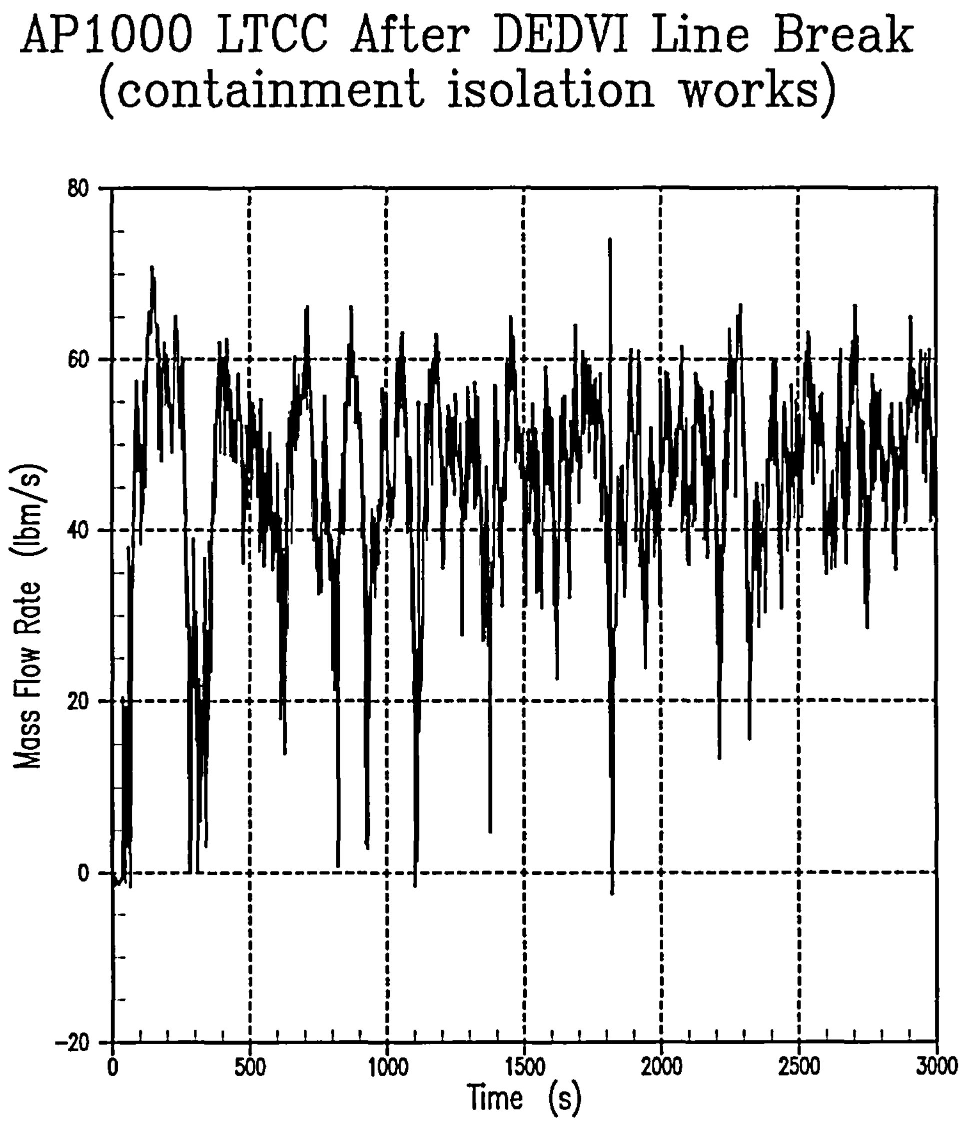

Figure A5.3-13

Case F – DVI-B Mixture Flow Rate

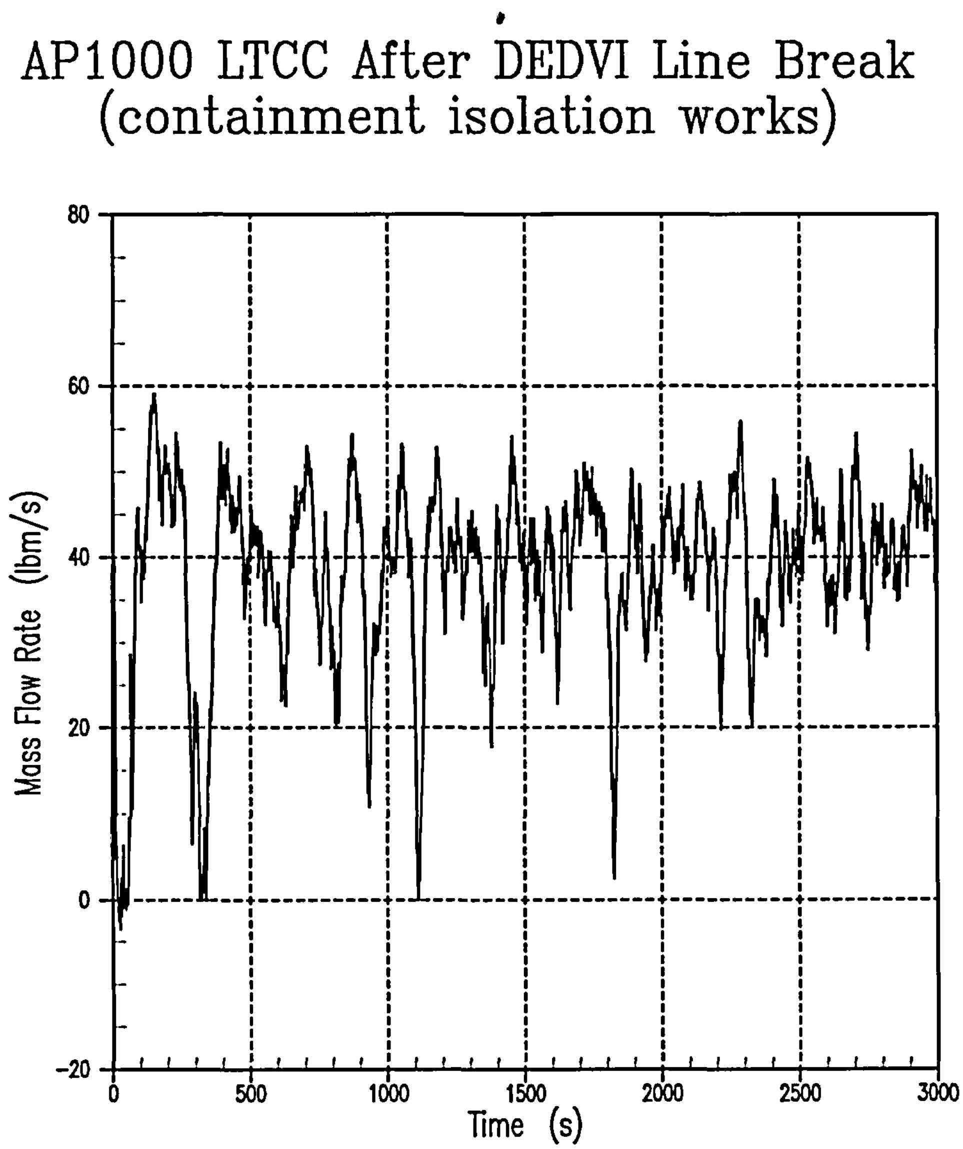

Figure A5.3-14

Case F – DVI-A Mixture Flow Rate

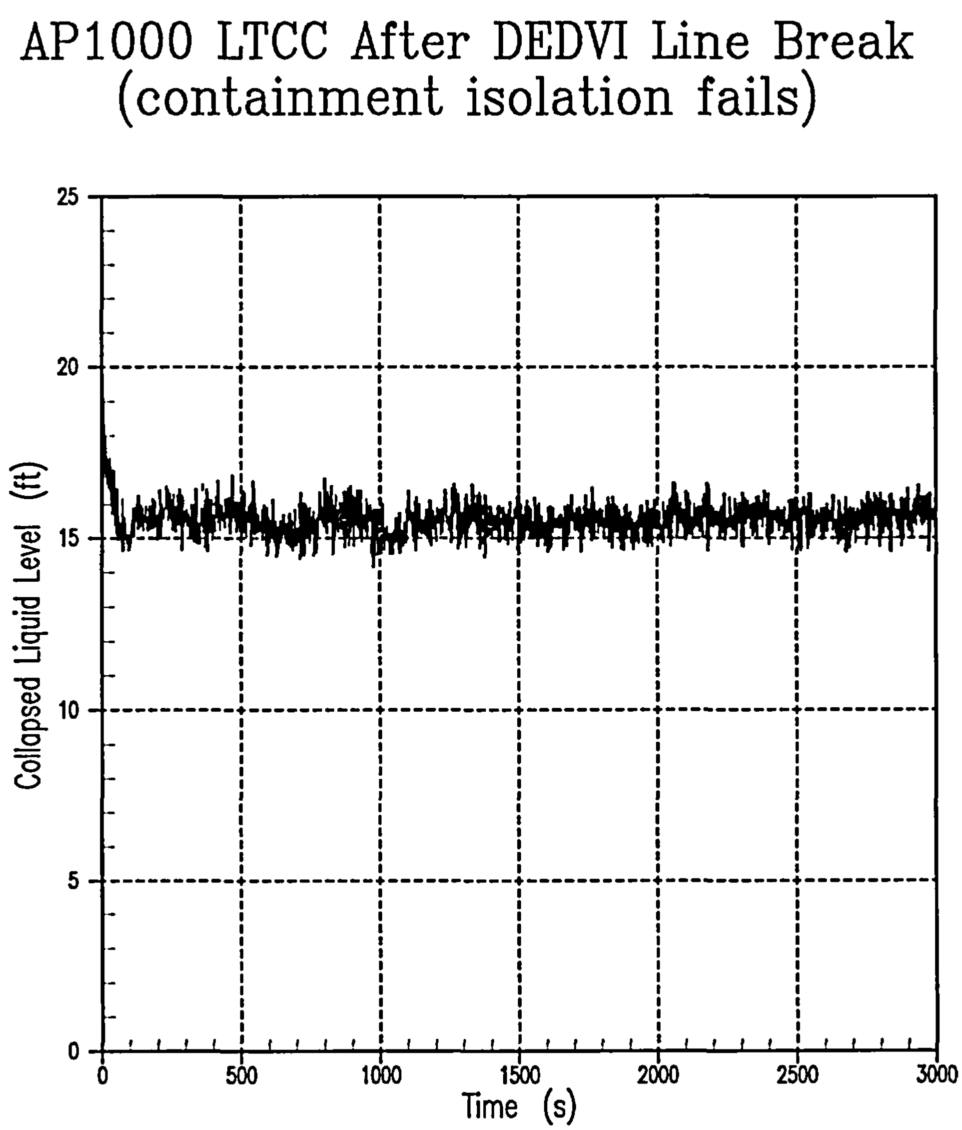

Figure A5.3-15

Case G – Collapsed Level of Liquid in the Downcomer

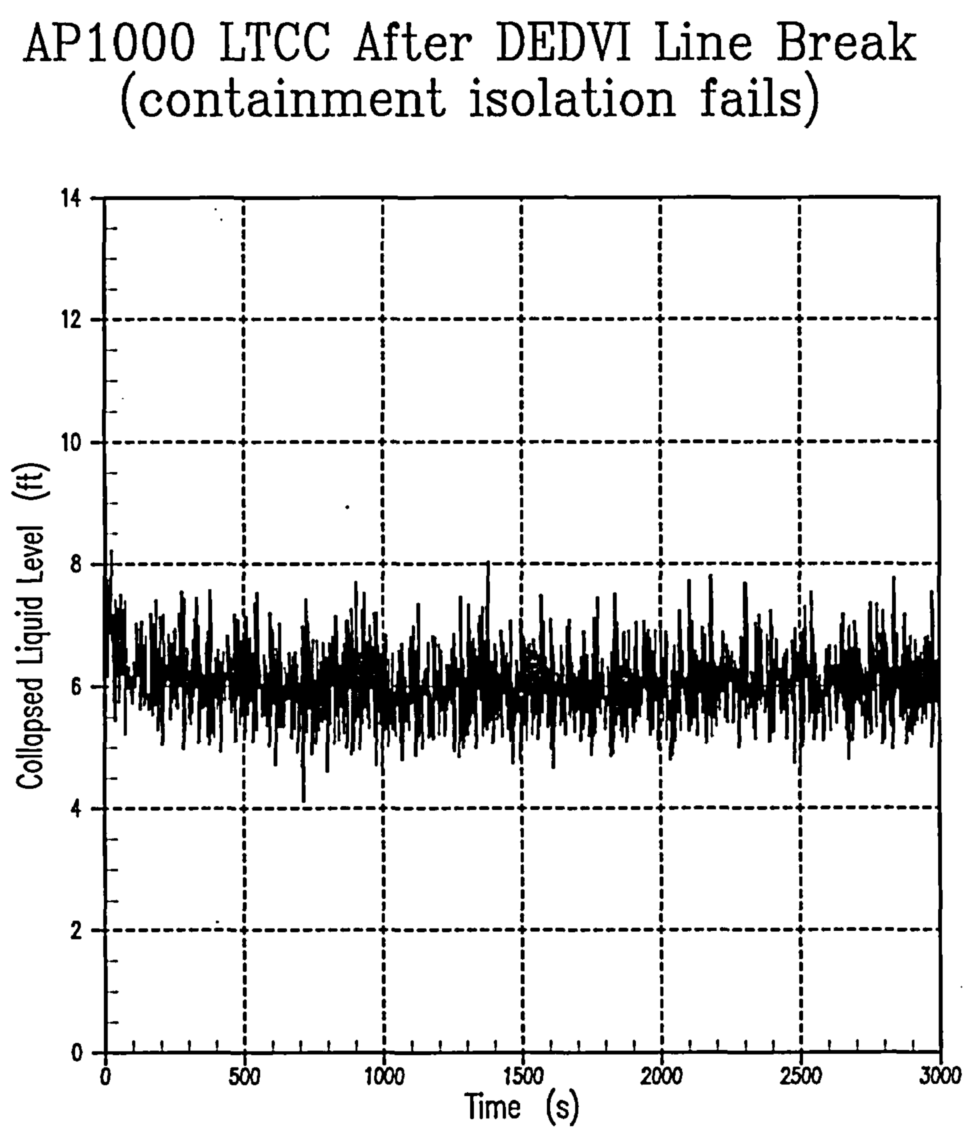

Figure A5.3-16

Case G – Collapsed Level of Liquid Over the Heated Length of the Fuel

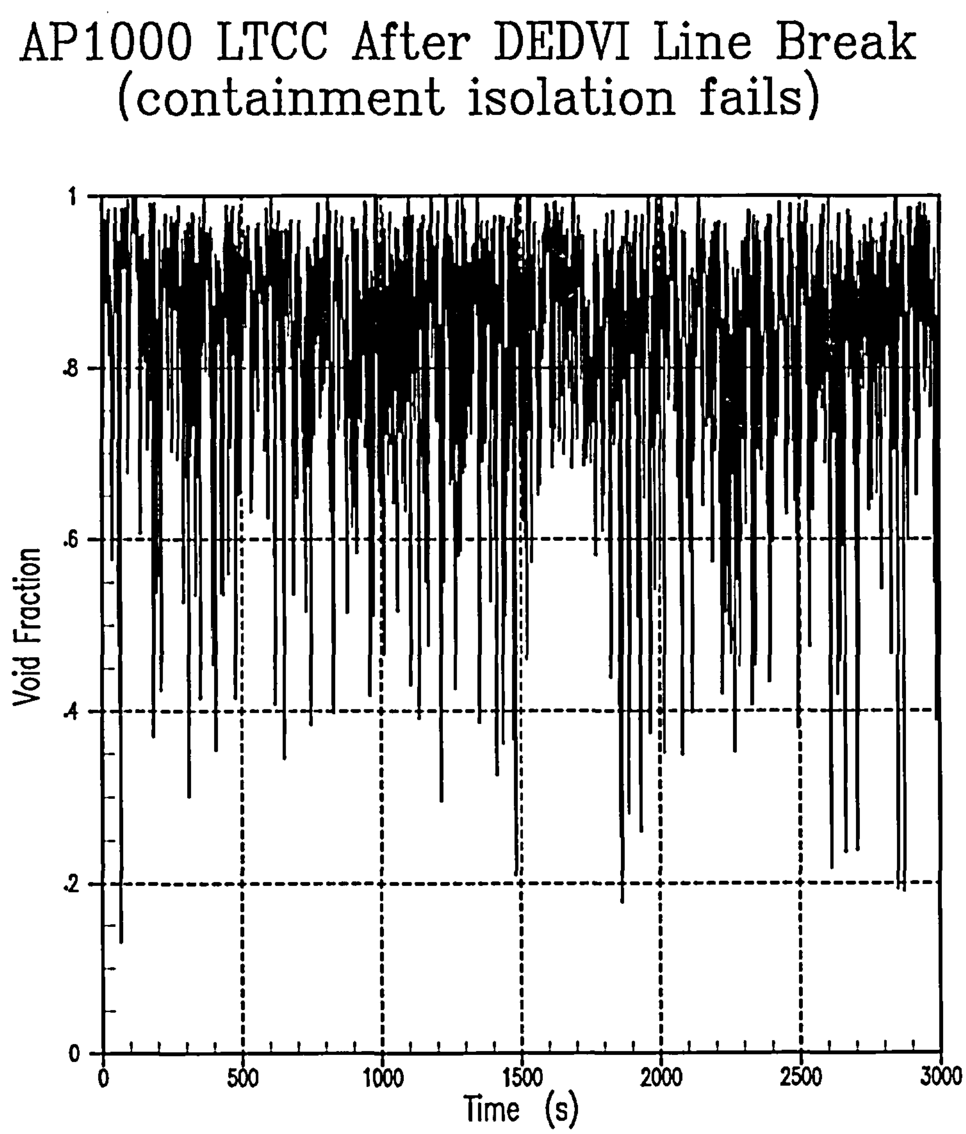

Figure A5.3-17

Case G – Void Fraction in Core Cell Level 16 of 17

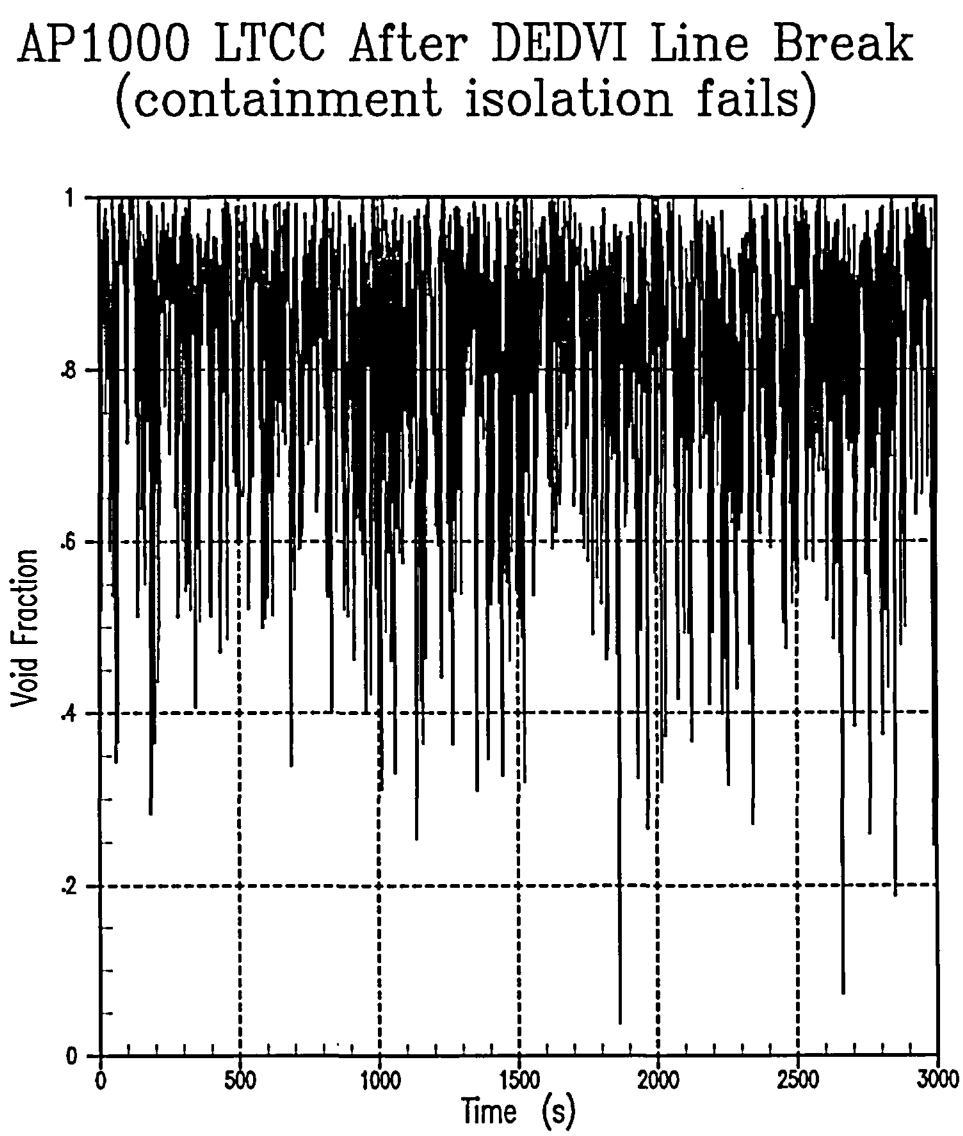

Figure A5.3-18

Case G – Void Fraction in Core Cell Level 17 of 17

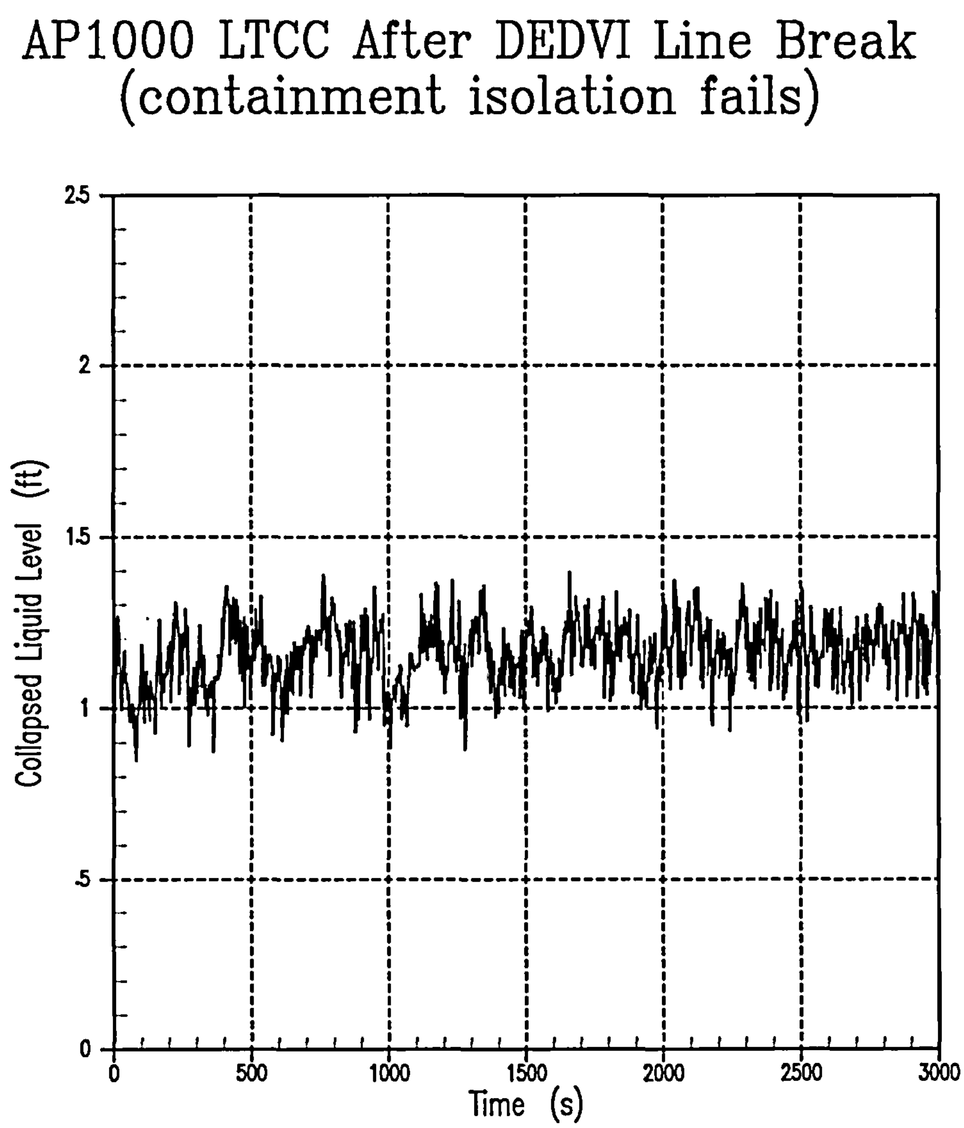

Figure A5.3-19

Case G – Collapsed Liquid Level in the Hot Leg of Pressurizer Loop

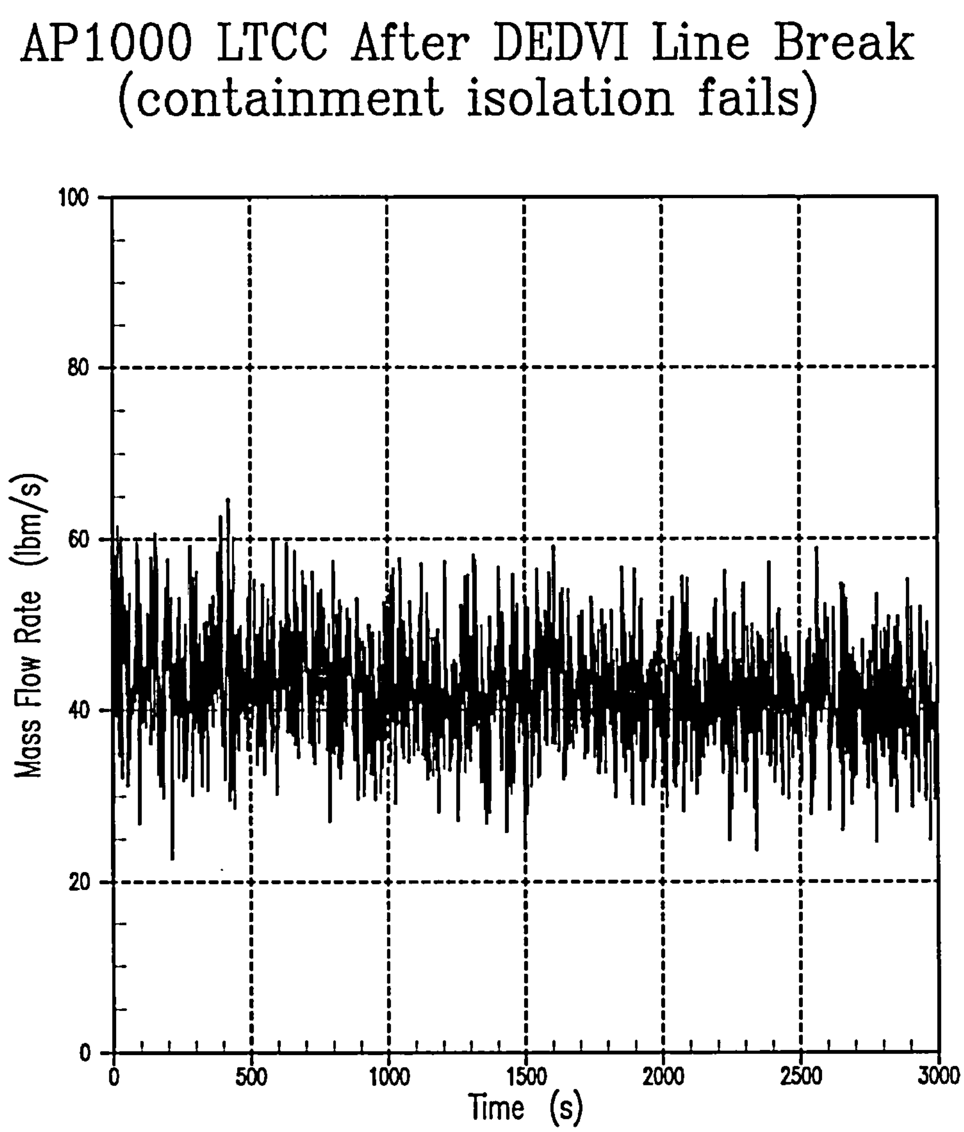

Figure A5.3-20

Case G – Vapor Rate out of the Core

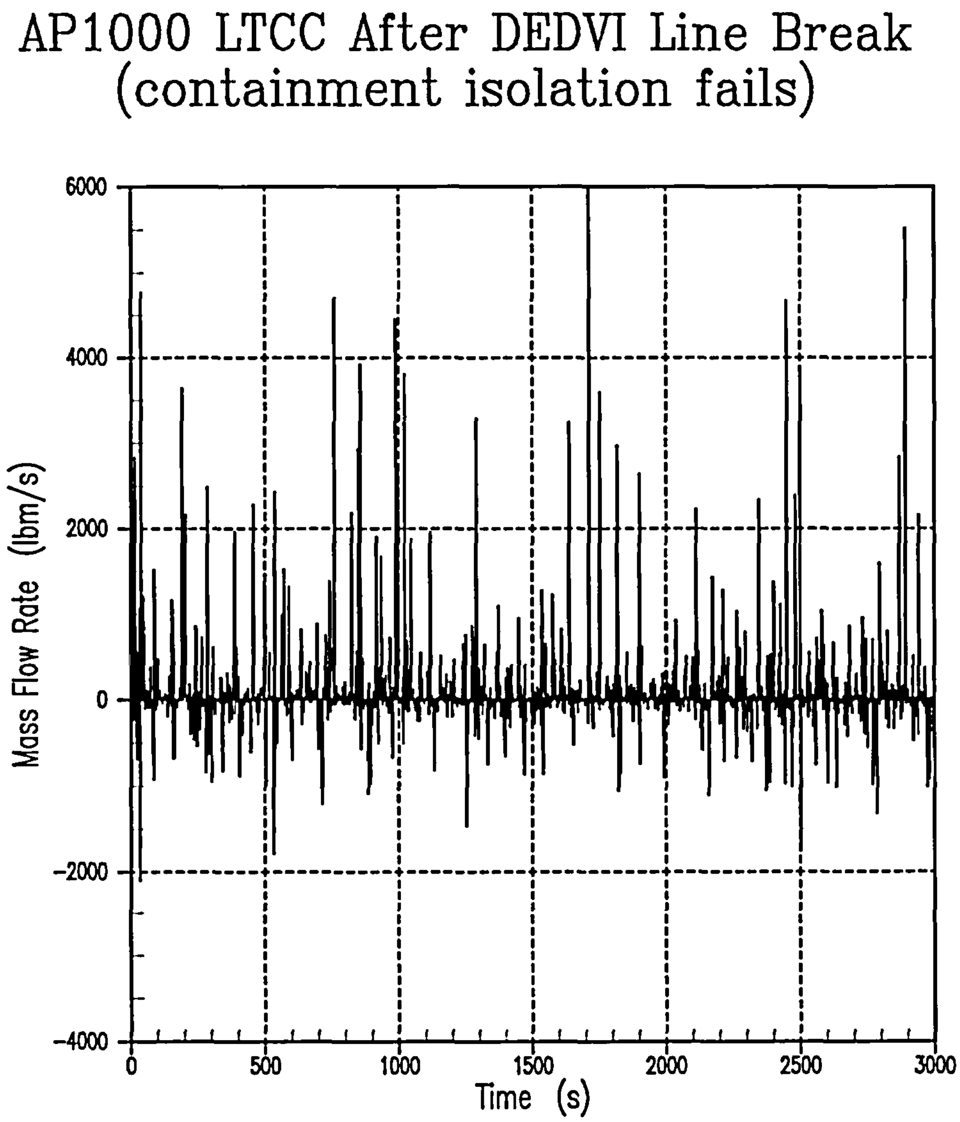

Figure A5.3-21

Case G – Liquid Flow Rate Out of the Core

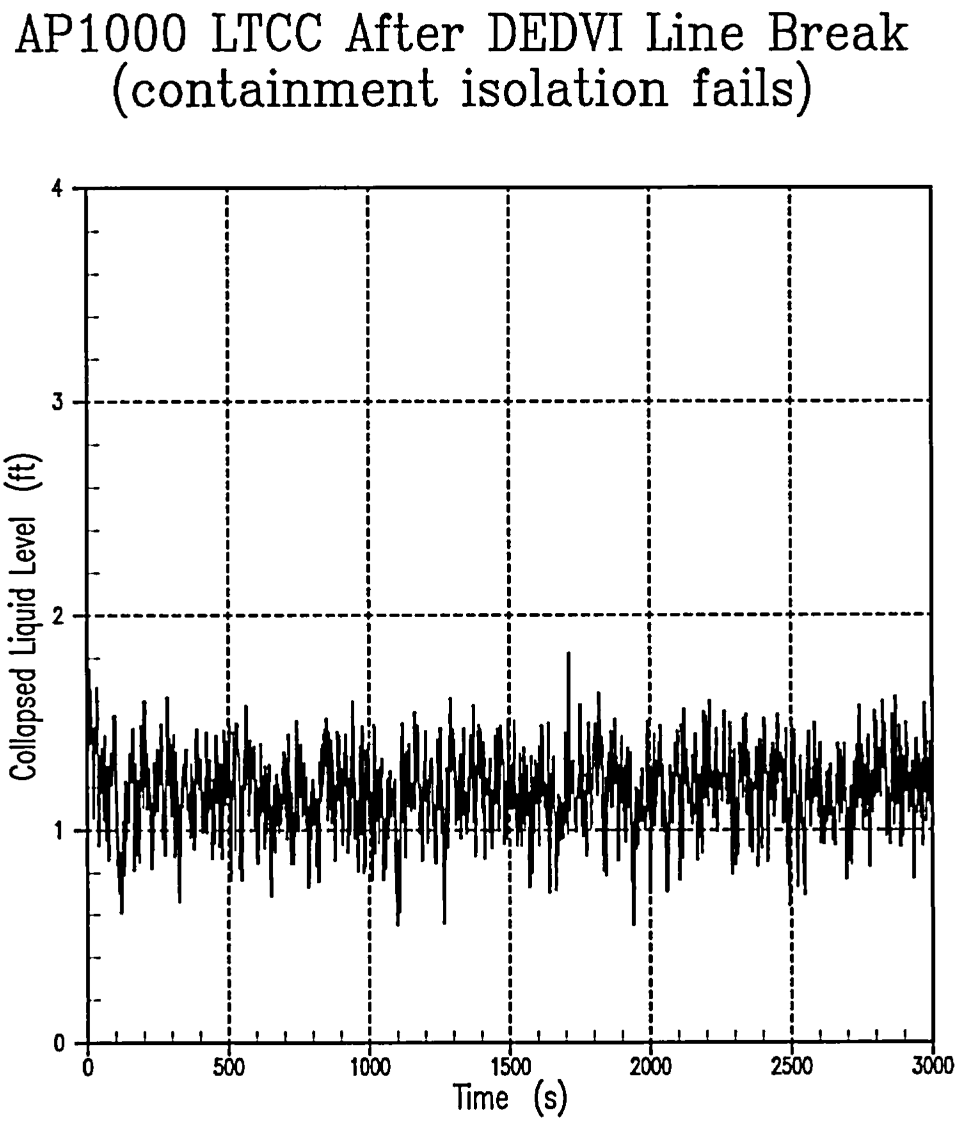

Figure A5.3-22

Case G – Collapsed Liquid Level in the Upper Plenum

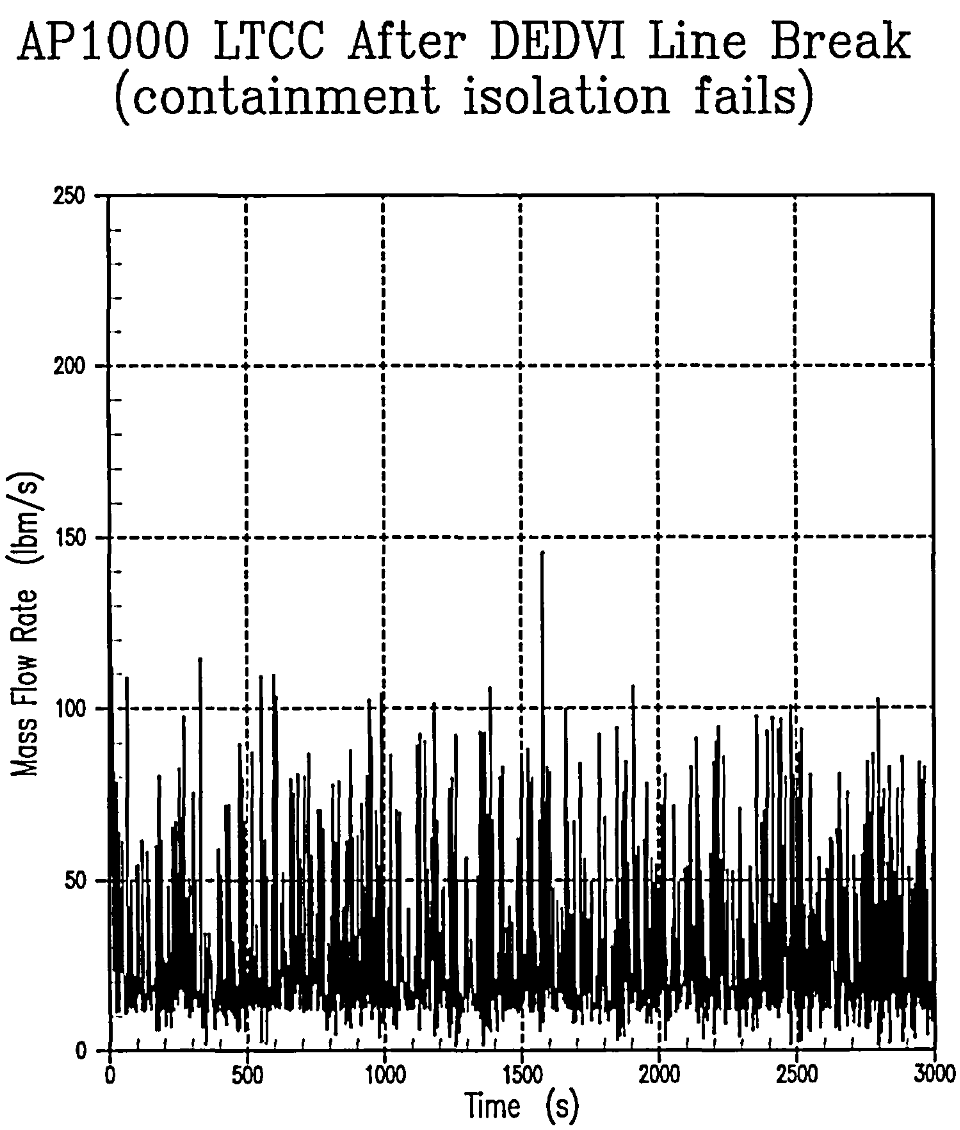

Figure A5.3-23

Case G – Mixture Flowrate Through ADS Stage 4A Valves

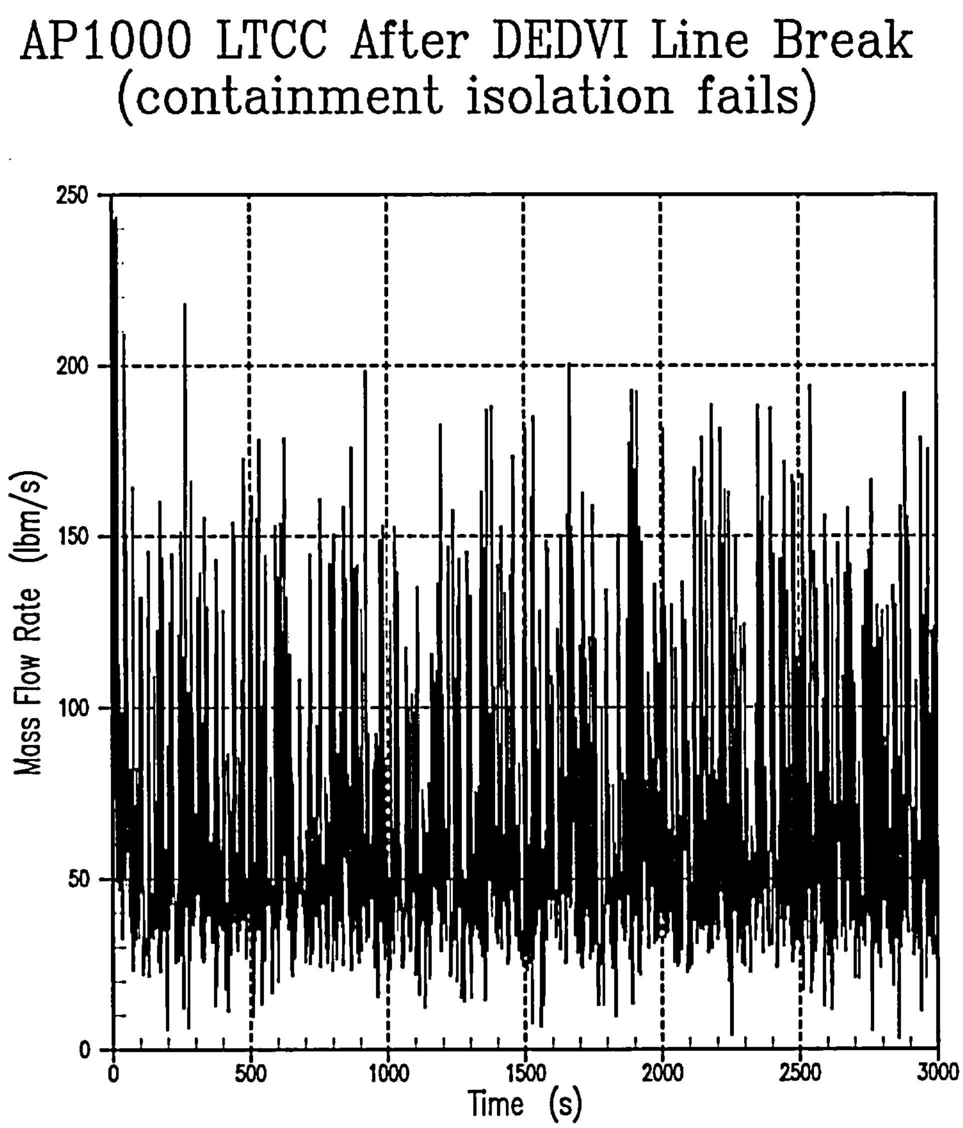

Figure A5.3-24

Case G – Mixture Flowrate Through ADS Stage 4B Valves

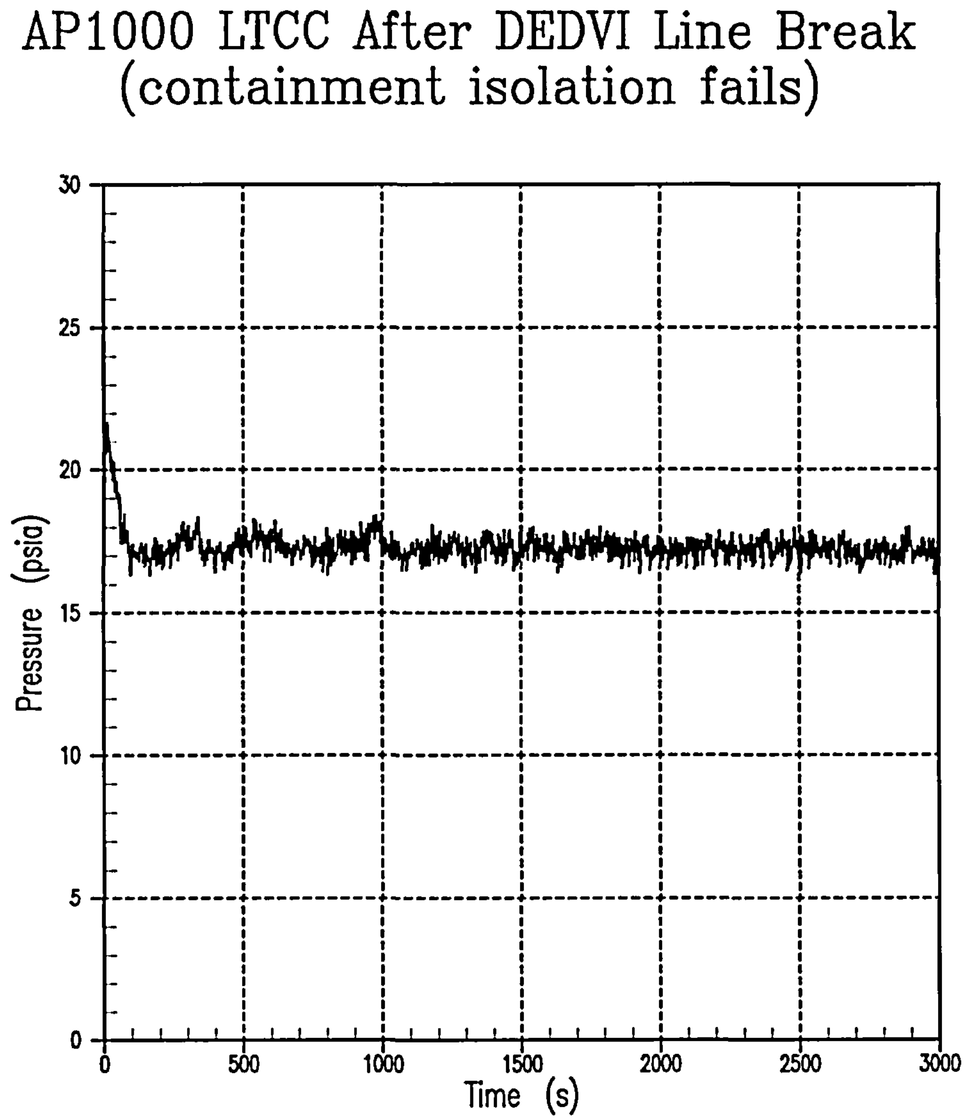

Figure A5.3-25

Case G – Upper Plenum Pressure

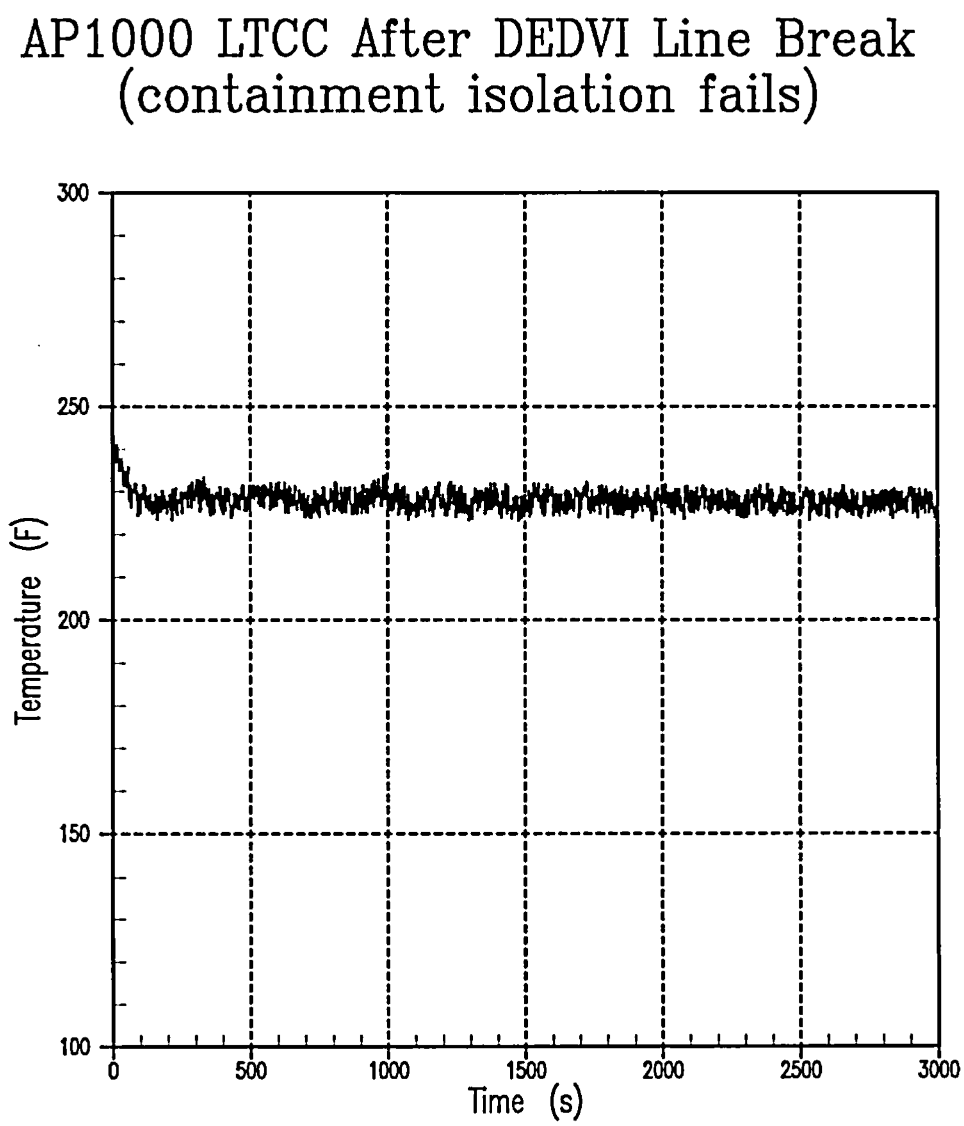

Figure A5.3-26

Case G – Hot Rod Clad Temperature in Cell 17

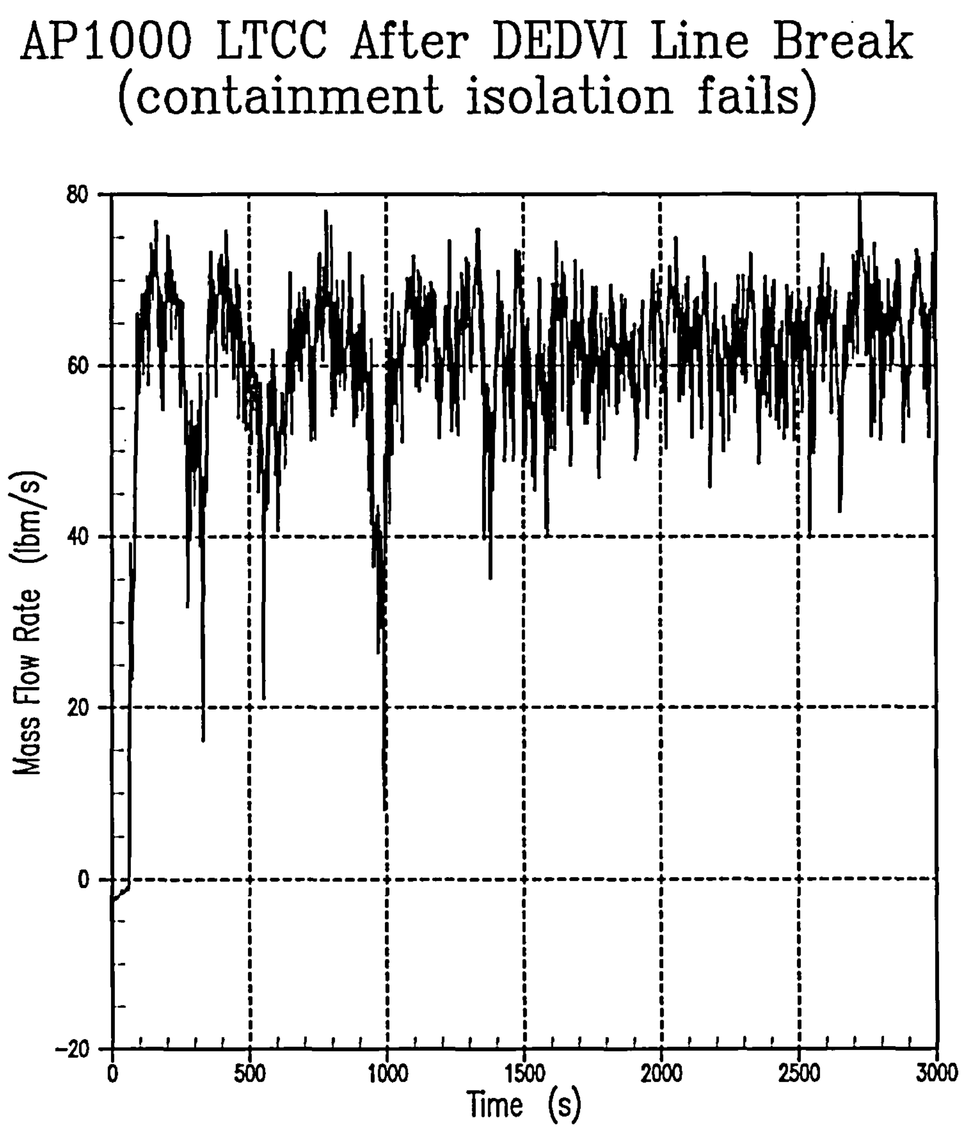

Figure A5.3-27

Case G – DVI-B Mixture Flow Rate

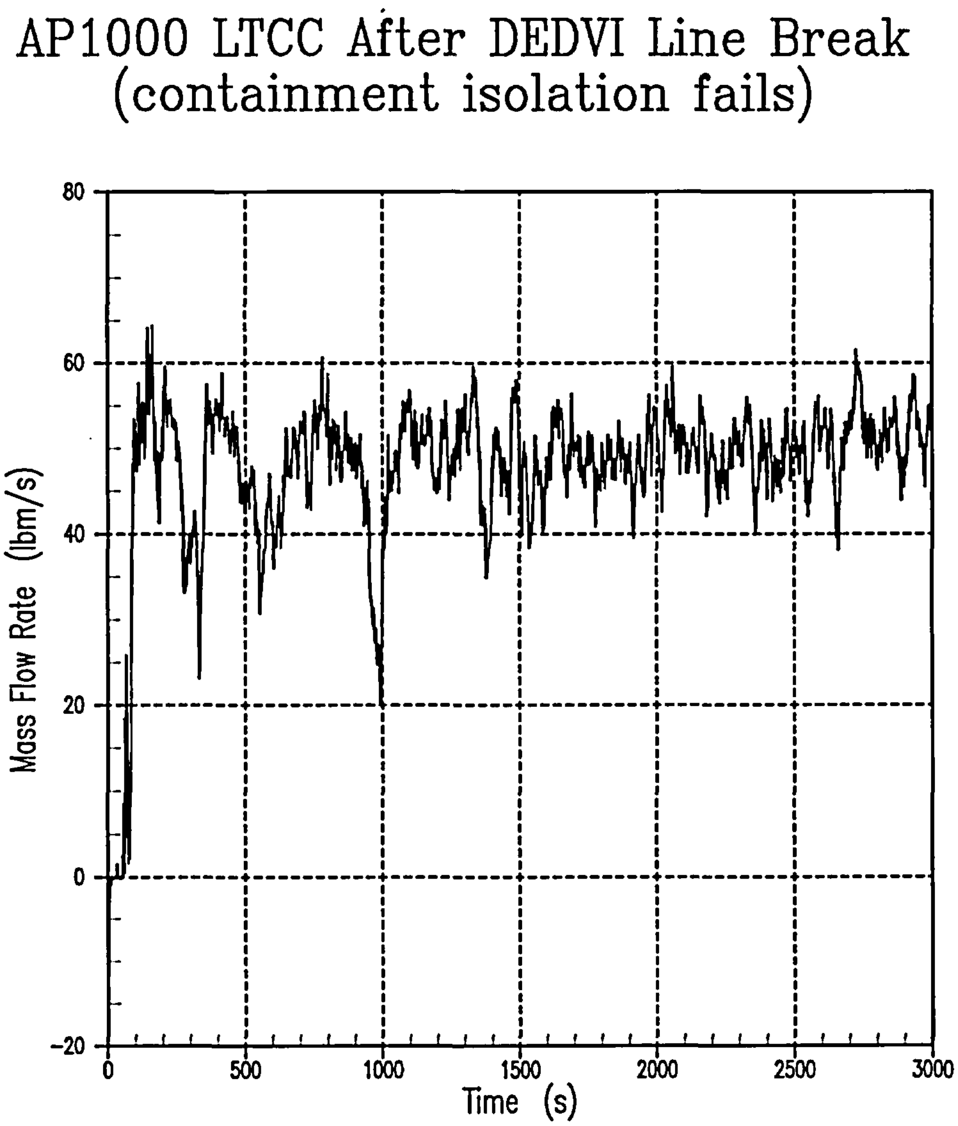

Figure A5.3-28

Case G – DVI-A Mixture Flow Rate