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Constellation Energy
Generation Group

January 11, 2006

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

ATTENTION: Document Control Desk

SUBJECT: **R.E. Ginna Nuclear Power Plant**
Docket No. 50-244

Supplemental Response to Requests for Additional Information Regarding Topics Described by Letters Dated August 24, 2005 and October 28, 2005

By letter dated December 9, 2005, R.E. Ginna Nuclear Power Plant, LLC (Ginna LLC) submitted a response to an October 28, 2005 request for additional information (RAI), (TAC NO. MC7382). In our letter we indicated that the responses denoted as "Post-LOCA Long-Term Cooling" RAIs #2, #3, and #5 would be submitted by January 16, 2006; the responses to that request are enclosed. Additionally, by letter dated August 24, 2005 (TAC NO. MC 7382) the NRC requested additional information regarding loss of coolant (LOCA) analysis. The response to that request is also enclosed.

Attachment 1 contains the list of regulatory commitments; specifically the response includes one new regulatory commitment:

> Prior to startup from the fall 2006 refueling outage, revise the Emergency Operating Procedures (EOPs), and the attendant basis background documents, to account for the maximum times available to complete operator actions to establish simultaneous reactor coolant system injection paths. As described in regulatory commitments made in our July 7, 2005 license amendment request for extended power uprate (EPU), the commitment to modify the procedures includes the commitment to provide operations staff training on these changes.

Attachment 2 contains the Ginna LLC supplemental response to the above referenced October 28, 2005 RAI.

Attachment 3 contains the Ginna LLC response to an August 24, 2005 RAI.

With this response Ginna LLC has provided responses to all remaining written requests for additional information related to the Ginna EPU.

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If you have any questions, please contact George Wrobel at (585) 771-3535 or george.wrobel@constellation.com.

Very truly yours,

Mary G. Korsnick

Mary G. Korsnick

STATE OF NEW YORK :
: TO WIT:
COUNTY OF WAYNE :

I, Mary G. Korsnick, being duly sworn, state that I am Vice President – R.E. Ginna Nuclear Power Plant, LLC (Ginna LLC), and that I am duly authorized to execute and file this response on behalf of Ginna LLC. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other Ginna LLC employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Mary G. Korsnick

Subscribed and sworn before me, a Notary Public in and for the State of New York and County of Monroe, this 11 day of January, 2006.

WITNESS my Hand and Notarial Seal: Sharon L. Miller
Notary Public

My Commission Expires: 12-21-06

SHARON L. MILLER
Notary Public, State of New York
Registration No. 01MI6017755
Monroe County
Commission Expires December 21, 2006

Attachments

Cc: S. J. Collins, NRC
P. D. Milano, NRC
Resident Inspector, NRC

Mr. Peter R. Smith
New York State Energy, Research, and Development Authority
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NYS Department of Public Service
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ATTACHMENT 1
R.E.Ginna Nuclear Power Plant
List of Regulatory Commitments

The following table identifies those actions committed to by R.E. Ginna Nuclear Power Plant, LLC in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

Regulatory Commitment	Due Date
Modify Emergency Operating Procedures (EOPs) and Bases to ensure operator actions account for the maximum times available to establish simultaneous RCS injection paths	Prior to Start up from 2006 RFO

ATTACHMENT 2

RESPONSES TO NRC RAIs 2, 3, 5 REGARDING POST-LOCA LONG-TERM COOLING

OCTOBER 28, 2005

Post LOCA LTC RAI #2

2. Small breaks were not addressed. The boric acid concentration for the limiting SBLOCA needs to be evaluated. Provide a summary of the results to show that the boric acid concentration is not sufficient to cause precipitation should the operators inadvertently depressurize the reactor coolant system (RCS) in a rapid manner.

Response

Breaks smaller than 4 inches require operator action to initiate cooldown and depressurization. A review of Emergency Procedures and simulator experience indicates that operators will begin RCS depressurization within 1 hour of the pipe break. If RCS depressurization to upper plenum injection (UPI) cut-in pressure occurs within the calculated "system depressurization time", flushing flow will be available and boric acid precipitation cannot occur. Using the results from a NOTRUMP Small Break LOCA Boric Acid Analysis, a "system depressurization time" was calculated using assumptions consistent with the longest RCS depressurization and the boric acid solution solubility limit corresponding to atmospheric conditions (29.27 wt%). For very small breaks (less than 1.1 inches) boric acid precipitation is not a concern because natural circulation will not be lost, or it will be restored within the system depressurization time. A comprehensive description of the boric acid precipitation phenomena and coping strategy for the full spectrum of break sizes, as well as a description of the NOTRUMP Small Break Post-LOCA Cooldown Analysis is provided in Attachment A.

Inadvertent RCS depressurization will not cause boric acid precipitation when it occurs before the "system depressurization time" since the boric acid atmospheric solubility limit will not be exceeded at any time. Operator coping strategies are such that, after the "system depressurization time" the UPI flow or natural circulation flow will be sufficient to flush the core with or without a full system depressurization.

Post LOCA LTC RAI #3

3. Provide information to show that for the largest break that does not actuate upper plenum injection (UPI) (where a cooldown is required) that there is sufficient time to perform this function given an appropriate precipitation time based on consideration of the four items in item 1 above.

Response

A Ginna EPU NOTRUMP Small Break Post-LOCA Cooldown Analysis showed that a 4 inch break or greater will depressurize the RCS to the UPI cut-in pressure without operator actions prior to reaching the boric acid atmospheric solubility limit (see discussion in Attachment A). For smaller breaks down to approximately 1.1 inches, the operators will depressurize the RCS in accordance with Emergency Procedure ES-1.2, Post LOCA Cooldown and Depressurization. The Small Break LOCA Boric Acid Analysis and the small break cooldown analyses described in Attachment A demonstrate that the plant will be depressurized and dilution flow will flush the core prior to the atmospheric solubility limit being reached.

For breaks smaller than 1.1 inches, analyses were performed to demonstrate that boric acid precipitation is not a concern because natural circulation will not be lost, or it will be restored within the system depressurization time calculated for the small break LOCA scenario. A comprehensive description of the boric acid strategy for the full spectrum of break sizes is provided in Attachment A.

Post LOCA LTC RAI #5

5. Once UPI initiates, at what time following an LBLOCA would the core steaming rate be insufficient to entrain the hot-side injection?

Response

UPI flow provides the core flushing flow for cold leg breaks. For a large break where the RCS depressurizes rapidly, the UPI will provide a flushing flow even though there is no significant buildup of boric acid in the core. For small breaks, where the RCS depressurization is delayed and core region boric acid can accumulate, the UPI will provide a flushing flow that will dilute the core. In either case, entrainment around the loops would reduce the volume of flushing flow that provides core dilution. The limiting condition for entrainment that would reduce the volume of flushing flow would be a condition where the top of mixture level is into the hot legs and steam flow through the loops carries liquid around the loop. A liquid entrainment threshold for this scenario is calculated below. Note that entrainment around the loops is not relevant to large break LOCA core cooling since the large break LOCA ECCS evaluation model demonstrates the capability to cool the core with UPI flow.

The liquid entrainment threshold in the hot leg can be established from applying the Ishii-Grolmes (Reference 1) or Wallis-Steen (Reference 2) liquid entrainment onset criteria as shown below. These entrainment correlations are valid for flow conditions where the liquid phase does not take up a significant volume of the pipe (such as in the hot legs in post-LOCA) and viscous effects in the liquid are not dominant, that is, that the liquid phase is in the turbulent regime. Note that the correlations have very similar form; however, the Ishii-Grolmes entrainment onset criterion uses liquid phase viscosity whereas Wallis-Steen uses gas phase viscosity.

Ishii-Grolmes Liquid Entrainment Onset Criterion

The liquid entrainment onset correlation per Reference 1 can be expressed as follows:

$$j_g \geq N_\mu^{0.8}\left(\frac{\rho_f}{\rho_g}\right)^{0.5}\left(\frac{\sigma}{\mu_f}\right) \quad \text{for} \quad N_\mu < \frac{1}{15}$$

where N_μ is the viscosity number and j_g is the superficial velocity of gas phase.

Wallis-Steen Liquid Entrainment Onset Criterion

The liquid entrainment onset correlation per Reference 2 can be expressed as follows:

$$j_g \geq \pi_2\left(\frac{\rho_f}{\rho_g}\right)^{0.5}\left(\frac{\sigma}{\mu_g}\right)$$

where π_2 represents dimensionless gas velocity. Steen suggested a value of 2.46E-04 for π_2, however, a more conservative value of 2.0E-04 will be used for this calculation.

The following properties of saturated liquid and gas phases of water at atmospheric conditions (14.7 psia) are used in the above correlations:

σ = surface tension of liquid = 4.03E-03 lbf/ft

μ_f = viscosity of liquid = 5.93E-06 lbf-s/ft^2

μ_g = viscosity of gas = 2.56E-07 lbf-s/ft^2

ρ_f = density of liquid = 59.8 lbm/ft^3

ρ_g = density of gas = 0.0373 lbm/ft^3

Liquid Entrainment Threshold in Terms of Hot Leg Superficial Steam Velocity

Using the above properties as input, the following results are obtained for the liquid entrainment threshold in terms of superficial steam velocity in the hot leg:

$j_{g,ISHII-GROLMES}$ = 86.6 ft/s with N_μ = 0.000756

$j_{g,WALLIS-STEEN}$ = 126 ft/s

Applying the lower value of 86.6 ft/s obtained from Ishii-Grolmes with comparable steam flow in each hot leg, the following total core steam mass flow rate at the entrainment threshold becomes:

$\dot{m}_{coresteam} = j_{g,ISHII-GROLMES} \cdot 2 \cdot A_{hotleg} \cdot \rho_g$ = 29.65 lbm/s

where for a single hot leg, A_{hotleg} = 4.59 ft^2.

The decay heat fraction can be related to the core steam mass flow rate as follows, where PWL is the licensed power of 1811 MWt (including calorimetric uncertainty) is applied.

$$\dot{m}_{coresteam} = \left[PWL \cdot P/P_0 \cdot \tfrac{948 Btu/s}{Mw}\right]/(h_{fg} + \Delta h_{sub})$$

For Ginna with no subcooling and atmospheric conditions, a decay heat fraction is obtained.

$P/P_0 = 0.0168$ Decay Heat Fraction

This decay heat fraction corresponds to approximately 4300 seconds after shutdown for Appendix K decay heat and approximately 2400 seconds for 1979 ANS+2σ decay heat. Therefore, steam flow in the hot legs should drop below the entrainment threshold at about 1 hr. 12 min. based upon the Appendix K decay heat function. Since the LOCA Boric Acid Analysis (see Attachment A) showed that hot side dilution flow (via UPI) is not needed until after 6 hours after the pipe break, the volume of flushing flow that provides core dilution will not be reduced due to hot leg entrainment.

References:

1. Ishii, M.; Grolmes, M. A., *Inception Criteria for Droplet Entrainment in Two-Phase Concurrent Film Flow*, AIChE Journal, Vol. 21, No. 2, pp. 308-319, 1975.

2. Wallis, G. B., *One-Dimensional Two-Phase Flow*, pp. 390-393, 1969.

Attachment A

Ginna EPU Long Term Cooling Boric Acid Precipitation Post-LOCA Strategy

Background/Summary

Ginna is an upper plenum injection (UPI) design, i.e., the low head safety injection pumps (RHR pumps) deliver flow directly to the upper plenum, while the high head SI pumps inject into the RCS cold legs. For this reason, the hot-leg switchover procedure that is applied to the typical three-loop and four-loop Westinghouse designs to ensure long term core cooling is not applied to Ginna. During a LOCA, safety injection signal starts both high head SI pumps and low head RHR pumps. When RCS pressure decreases below the low head RHR injection pressure (140 psia) simultaneous hot (UPI) and cold side (SI) injection will occur. Upon entering the sump recirculation phase operators are instructed to establish recirculation flow using the RHR pumps which will maintain UPI, and terminate flow from the high head SI pumps. After a period of time (less than 5 hours, 30 minutes), operators will be instructed to restart the high head safety injection pumps to re-establish simultaneous cold side and hot side (UPI) injection to provide long term core cooling for all LOCA scenarios.

Three categories of LOCA break sizes were considered for the boric acid precipitation evaluation: (1) large or intermediate breaks (greater than approximately 4" in diameter) where the RCS pressure rapidly decreases to the UPI initiation pressure (140 psia) with no operator action, (2) small breaks (between approximately 1.1" and 4" in diameter) where RCS pressure decreases but stabilizes above the UPI initiation pressure, and (3) very small breaks (approximately 1.1" in diameter and smaller) where high head safety injection refills the RCS and natural circulation is established.

For large or intermediate breaks in the cold leg, boric acid precipitation cannot occur since the RCS will depressurize quickly and upper plenum injection will provide flushing flow through the core.

For large or intermediate breaks in the hot leg, the core region boric acid concentration will only begin to increase with the termination of high head safety injection to the cold legs. Calculations for a large break LOCA scenario have shown that the boric acid solution will approach the solubility limit for atmospheric pressure conditions at 5 hours, 49 minutes after the termination of SI to the cold leg. For the EPU, the Ginna Emergency Operating Procedure ES-1.3, Transfer to Cold Leg Recirculation will be revised to instruct operators to re-establish cold leg SI (i.e. simultaneous injection) no later than 5 hours, 30 minutes after the termination of SI in the cold leg. In this case boric acid precipitation will be prevented. There are no limitations on early switchover to simultaneous injection.

For small breaks in the cold leg, RCS pressure will stabilize above the UPI initiation pressure and the core region boric acid concentration will begin to increase prior to upper plenum injection. Emergency Operating Procedure ES-1.2, Post-LOCA Cooldown and Depressurization directs the operators in this scenario to depressurize the RCS using the condenser steam dumps or SG atmospheric relief valves. Calculations for depressurization after a small break LOCA scenario have shown that the boric acid solution will not approach the solubility limit until approximately 6 hours, 48 minutes after the break. When the RCS is depressurized through operator action to below 140 psia, UPI using the RHR (low head SI) pumps will initiate and this will provide immediate core flushing flow. Operational experience, simulator training, and NOTRUMP small break LOCA cooldown/depressurization analyses indicate that operators will depressurize the RCS to less than 140 psia before 6 hours, 48 minutes after the break. Results from the NOTRUMP Small Break LOCA Boric Acid Analysis demonstrate that if UPI is initiated within 6 hours, 48 minutes after the break boric acid precipitation is precluded even for sudden RCS depressurization to atmospheric pressure.

For small breaks in the hot leg, RCS pressure will again stabilize above the UPI initiation pressure; however the core boric acid concentration will not increase until the high head cold leg SI is terminated. Operators are again directed to depressurize the RCS, and maintain UPI using the RHR pumps on recirculation and terminate the high head SI as necessary. Once high head SI to the cold leg is terminated, this scenario is bounded by the large hot leg break scenario where cold leg SI (i.e. simultaneous injection) will be re-established no later than 5 hours, 30 minutes after termination.

For very small hot leg or cold leg breaks (less than approximately 1.1" in diameter) the RCS remains pressurized such that natural circulation will not be lost, or if lost, will be re-established. Emergency Operating Procedure (EOP) actions will cooldown and depressurize the RCS under controlled conditions with eventual realignment to RHR normal shutdown cooling. Natural circulation or RHR normal shutdown cooling will dilute any buildup of boric acid in the core.

A summary of the GINNA EPU long term cooling post-LOCA boric acid control strategy for various size breaks is shown in Table 1.

To summarize the procedural requirements related to preventing boric acid precipitation:

1. During a small break LOCA when RCS depressurization to the UPI injection pressure does not occur without operator action, operators will take action to initiate a plant cooldown and depressurization at the maximum Technical Specification allowed cooldown rate within one hour after the break occurs.
2. During a small break LOCA the RCS will be depressurized to less than the UPI injection pressure within six hours and 30 minutes after the break occurs.
3. During a LOCA when SI flow to the cold leg is terminated upon entering sump recirculation, SI flow to the cold leg will be re-established within 5 hours and 30 minutes after initial termination.

These procedural requirements will be captured in procedure background documents and will be incorporated into the operator training program. The capability to meet these requirements will be verified prior to the startup for the EPU and periodically verified as part of operator re-qualification training thereafter.

BREAK SIZE	SCENARIO	ANALYSIS
DEG 1.0 FT^2 0.8 FT^2 0.6 FT^2 8.0 IN 6.0 IN 4.0 IN	<u>Large or Intermediate Breaks</u> Breaks of this size will depressurize to RHR cut-in pressure without operator action.	LB Mixing Volume Analysis and LB Boric Acid Analysis
2.0 IN 1.8 IN 1.4 IN 1.4 IN	<u>Small Breaks</u> For breaks of this size, operators will take action to depressurize RCS to RHR cut-in pressure before boric acid atmospheric solubility limit is reached.	SB Boric Acid Analysis and Depressurization/ Cooldown Analysis
1.3 IN 1.2 IN 1.1 IN 1.0 IN 0.9 IN 0.8 IN	<u>Very Small Breaks</u> Natural circulation is lost but regained before boric acid atmospheric solubility limit is reached.	
0.7 IN 0.6 IN 0.5 IN	<u>Very Small Breaks</u> Natural circulation is not lost.	SB Depressurization Analysis Natural circulation will keep the core diluted.
0.375 IN - Charging Flow Makeup Capacity		

Table 1GINNA EPU -Long Term Cooling Post-LOCA Boric Acid Control Strategy

Large Break LOCA Boric Acid Analysis

Description

A Large Break LOCA Boric Acid Analysis was performed to address the limiting large break LOCA scenario, that is, breaks in the hot leg where the core region boric acid concentration will begin to increase with the termination of high head safety injection to the cold legs.

The Large Break LOCA Boric Acid Analysis was based on calculations that used a time-varied mixing volume extracted from modified Ginna WCOBRA/TRAC Large Break LOCA Evaluation Model computer runs. The modifications to the Ginna WCOBRA/TRAC Large Break LOCA Evaluation Model were as follows:

- Appendix K decay heat was used (1971 ANS, Infinite Operation + 20%).
- A hot leg break was modeled (the limiting large break scenario for boric acid buildup).
- SI flows were adjusted to better represent long-term SI delivery including sump recirculation.
- Hot rod and hot assembly power was adjusted to allow code execution. However, total core power was preserved.
- The transient was extended to beyond switchover to sump recirculation.

The use of the WCOBRA/TRAC Large Break LOCA Evaluation Model in this analysis has the following advantages.

a) Appropriate capturing of system effects on core mixture level and core void fractions.

b) Appropriate capturing of UPI effects on core mixture level and core void fractions.

c) Direct source for mixing volume and core boiloff rates for the early part of the transient.

d) All other input assumptions were consistent to those used in 10 CFR 50.46 PCT calculations.

Items a) and b) above satisfy the NRC request to consider void fractions and system effects in the calculation of core mixing volume (Post-LOCA LTC RAI#1[a,b]). The significant assumptions in the large break boric acid precipitation calculations are as follows:

1. The core region mixing volume is limited to the region from the bottom of the active fuel to the bottom elevation of the hot legs plus 50% of the lower plenum (justified in Reference 1) volume (the region from the bottom of the active fuel to the bottom of the reactor vessel). Hot leg volume or barrel/baffle/former region volumes are not included.
2. Core boiloff rates are obtained in part from the Ginna WCOBRA/TRAC Large Break LOCA Evaluation Model computer runs. The core boiloff rate used in the calculations is given in Figure 3.
3. Time-based liquid mixing volume is extracted from the Ginna WCOBRA/TRAC Large Break LOCA Evaluation Model computer runs. The core and upper plenum average voiding assumed in the analysis is given in Figure 1. The associated mixing volume used in the calculations is given in Figure 2.
4. The calculations were based on a vessel pressure of 14.7 psia.

5. An atmospheric boric acid solution solubility limit of 29.27 wt% is assumed. This represents the solubility limit at the atmospheric boiling point of a boric acid and water solution (Reference 2). No credit was taken for containment overpressure. No credit was taken for the increased boric acid solution solubility limit due to the presence of containment sump PH additives.
6. Appendix K decay Heat (1971 ANS, Infinite Operation + 20%) was used in all calculations.

Item 5 above satisfies the NRC request to justify the boric acid precipitation limit (Post-LOCA LTC RAI#1[c]) Item 6 above satisfies the NRC request to use 10 CFR 50 Appendix K decay heat (Post-LOCA LTC RAI#1[d]).

Results

The results of the large break boric acid precipitation calculations are shown in Figure 3. As seen in Figure 3, for large hot leg breaks with no cold leg safety injection during an extended period in sump recirculation, boric acid precipitation will be prevented if cold leg safety injection (i.e. simultaneous injection) is re-established 5 hours, 49 minutes after the termination of safety injection in the cold leg. This is based on a calculated minimum time to terminate SI to the cold leg of 24 minutes after the break. Figure 3 also shows core boil-off, SI dilution flow, and the rate of dilution of core region if dilution flow is initiated at 5 hours, 30 minutes after the earliest expected termination of cold leg safety injection.

Small Break LOCA Boric Acid Analysis

Description

A Small Break LOCA Boric Acid Analysis was performed to address the limiting small break LOCA scenario, that is breaks in the cold leg where the RCS pressure will stabilize above the UPI initiation pressure and the core region boric acid concentration will begin to increase prior to upper plenum injection. This analysis provides the time available to depressurize the RCS to below 140 psia through operator action prior to reaching the boric acid solution solubility limit. Once the RCS is below 140 psia, the UPI will initiate and will provide immediate core flushing flow. The boric acid solution solubility limit is based on atmospheric conditions to account for an inadvertent, sudden RCS depressurization.

The Small Break LOCA Boric Acid Analysis was based on calculations that used a time-varied mixing volume and core boil-off extracted from extended Ginna NOTRUMP Small Break LOCA Evaluation Model computer runs. A 4 inch break was selected since the Ginna EPU NOTRUMP Small Break Post-LOCA Cooldown Analysis (discussed in the next section) showed that a 4 inch break or greater will depressurize the RCS to RHR cut-in pressure without operator actions prior to reaching the boric acid atmospheric solubility limit. The RCS pressure versus time for a 4 inch break is given in Figure 4. The modeling features of these runs were as follows:

- Appendix K decay Heat (1971 ANS, Infinite Operation + 20%).
- Cold Leg Break (the limiting small break scenario for boric acid buildup).
- Sump recirculation flows were modeled.
- Transients were run beyond switchover to sump recirculation.

The use of the Ginna NOTRUMP Small Break LOCA Evaluation Model in this analysis has the following advantages.

a) Capturing of system effects on core mixture level and core void fractions (credited only to bottom of hot leg).

b) Provided direct source for mixing volume and core boiloff rates.

c) Consistency with assumptions used in 10 CFR 50.46 PCT calculations.

Item a) above satisfies the NRC request to consider void fractions and system effects in the calculation of core mixing volume (Post-LOCA LTC RAI#1[a,b]). The significant assumptions in the small break boric acid precipitation calculations are as follows:

1. Time-based liquid mixing volume and core boiloff rates are extracted from the Ginna NOTRUMP Small Break LOCA Evaluation Model computer runs. The core and upper plenum average voiding assumed in the analysis is given in Figure 5. The associated mixing volume used in the calculations is given in Figure 6.
2. Core region boric acid concentrations are calculated assuming a 120 psia RCS pressure.
3. The core region mixing volume is limited to the region from the bottom of the active fuel to the bottom elevation of the hot legs plus 50% of the lower plenum (justified in Reference 1) volume (the region from the bottom of the active fuel to the bottom of the reactor vessel). Hot leg volume or barrel/baffle/former region volumes are not included.
4. An atmospheric boric acid solution solubility limit of 29.27 wt% is assumed. This represents solubility limit at the atmospheric boiling point of a boric acid and water solution (Reference 2). No credit was taken for containment overpressure. No credit was taken for the increased boric acid solution solubility limit due to the presence of containment sump pH additives.
5. Appendix K decay Heat (1971 ANS, Infinite Operation + 20%) was used in all calculations.

Item 4 above satisfies the NRC request to justify the boric acid precipitation limit (Post-LOCA LTC RAI#1[c]) Item 5 above satisfies the NRC request to use 10 CFR 50 Appendix K decay heat (Post-LOCA LTC RAI#1[d]).

Results

The results of the small break boric acid precipitation calculations are shown in Figure 7. As seen in Figure 7, for small breaks where delayed RCS depressurization would occur, the boric acid solution will not approach the solubility limit until approximately 6 hours, 48 minutes after the break. If the RCS is depressurized through operator action to below 140 psia, UPI using the RHR (low head SI) pumps will initiate and this will provide immediate core flushing flow. Cooldown/depressurization calculations show that operators could depressurize the RCS to less than 140 psia long before 6 hours, 48 minutes. Figure 7 also shows core boil-off, SI dilution flow, and the rate of dilution of core region once dilution flow is initiated.

Small Break Post-LOCA Cooldown Analysis

A range of break sizes from 0.75-inch to 1.5-inches were studied to identify the smallest cold leg break size for Ginna that would result in the loss of natural circulation and therefore

result in a situation that could potentially lead to inadvertent boric acid precipitation. The important modeling features are as follows:

1. Appendix K analysis assumptions consistent with those used for design basis Small Break LOCA analysis.
2. Operator action to start plant cooldown per emergency operating procedure ES-1.2 commences at 3,600 seconds (1 hour) into the transient using 1 atmospheric dump valve (ADV) per steam generator. The cooldown rate is limited to a maximum of 100ºF/hr.

Based on the results of these studies, it was determined that breaks approximately 0.8-inch equivalent diameter and less will not lose natural circulation, whereas larger ones will. It is quite possible that during the cooldown process these larger breaks could potentially regain natural circulation at some point; however, there will be some break size where this does not occur. For Ginna, this occurs for approximately a 1.1-inch equivalent diameter break. Figures 8 and 9 show the broken loop hot leg and cold leg liquid flow for the 0.8-inch and 1.1-inch breaks, respectively. The pressurizer pressure and broken loop hot leg mixture temperature for these same breaks are shown in Figures 10 and 11 and the inner vessel mixture level is shown in Figures 12 and 13.

The 1.1-inch break demonstrates the cooldown aspects for breaks where natural circulation is lost and not regained. This break size establishes the maximum time required to cooldown and depressurize the RCS to the UPI cut-in pressure. This analysis shows that the operators will be capable of depressurizing the RCS to the UPI cut-in pressure within approximately 5 hours, 15 minutes after the break occurs assuming the cooldown begins within 1 hour after the break occurs.

<u>Attachment A References</u>

1. Westinghouse Letter LTR-LIS-05-56, Revision 0, "Waterford 3 Uprate RAIs, Transmittal of Summary of MHI BACCHUS Tests," dated 02-03-05.MHI Tests.
2. P. Cohen, P., 1969, Water Coolant Technology of Power Reactors, Chapter 6, "Chemical Shim Control and pH Effect," ANS-USEC Monograph.

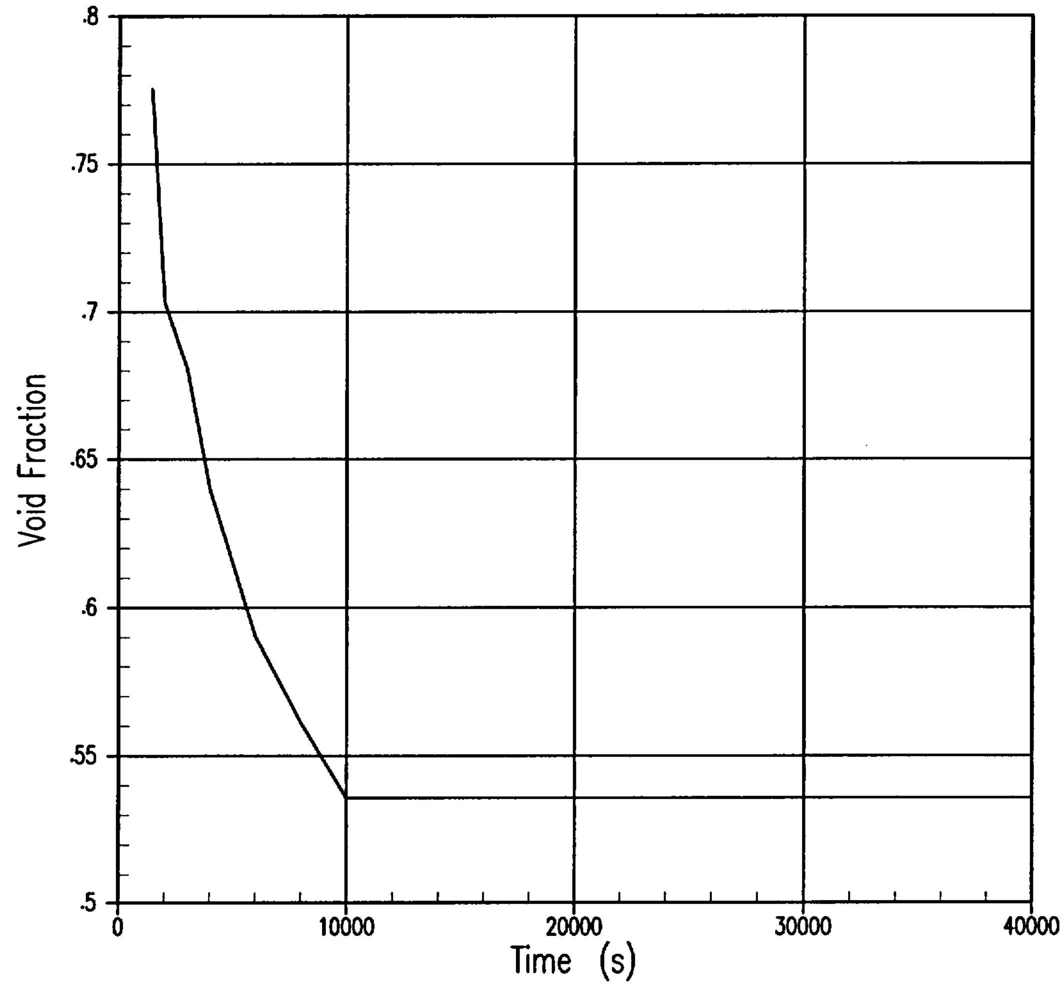


Figure 1 Large Break LOCA Boric Acid Concentration Analysis - Core/Upper Plenum Average Void Fraction versus Time

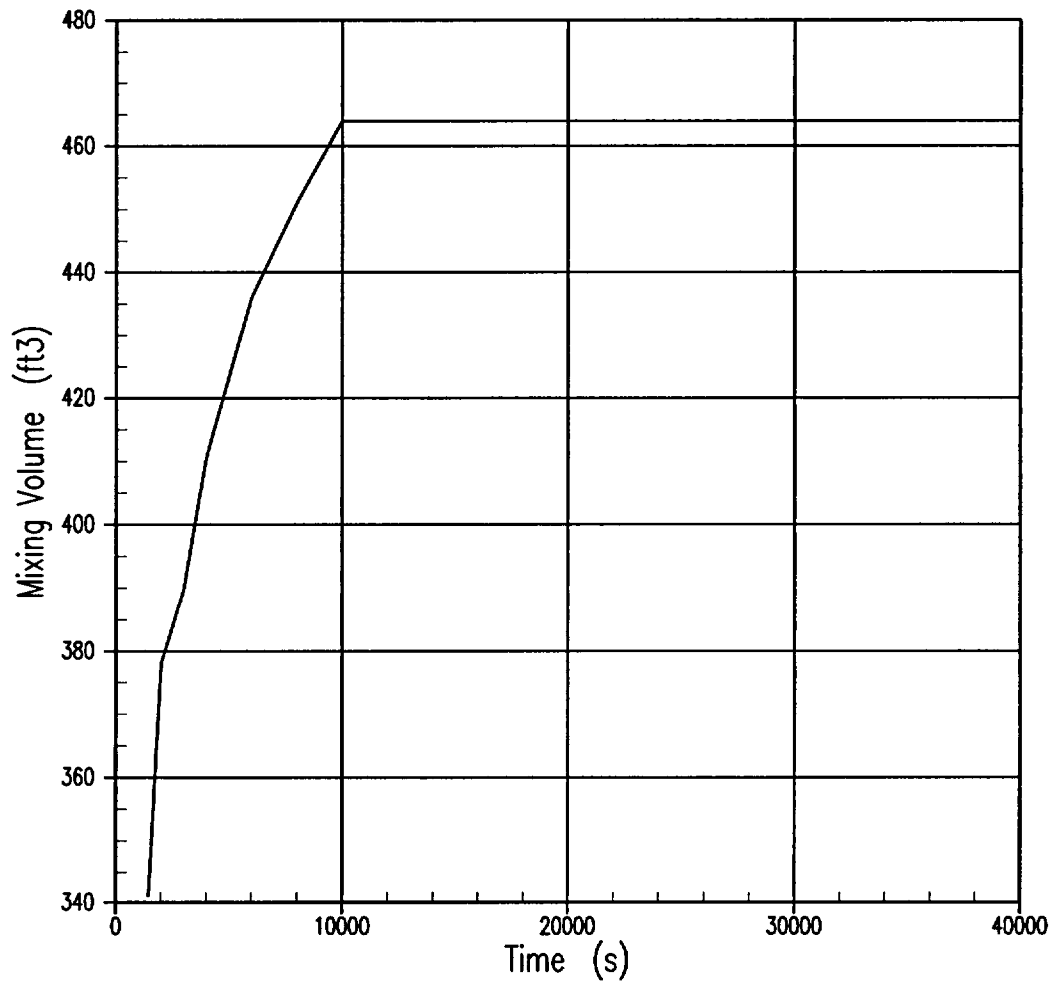


Figure 2 Large Break LOCA Boric Acid Concentration Analysis - Mixing Volume versus Time

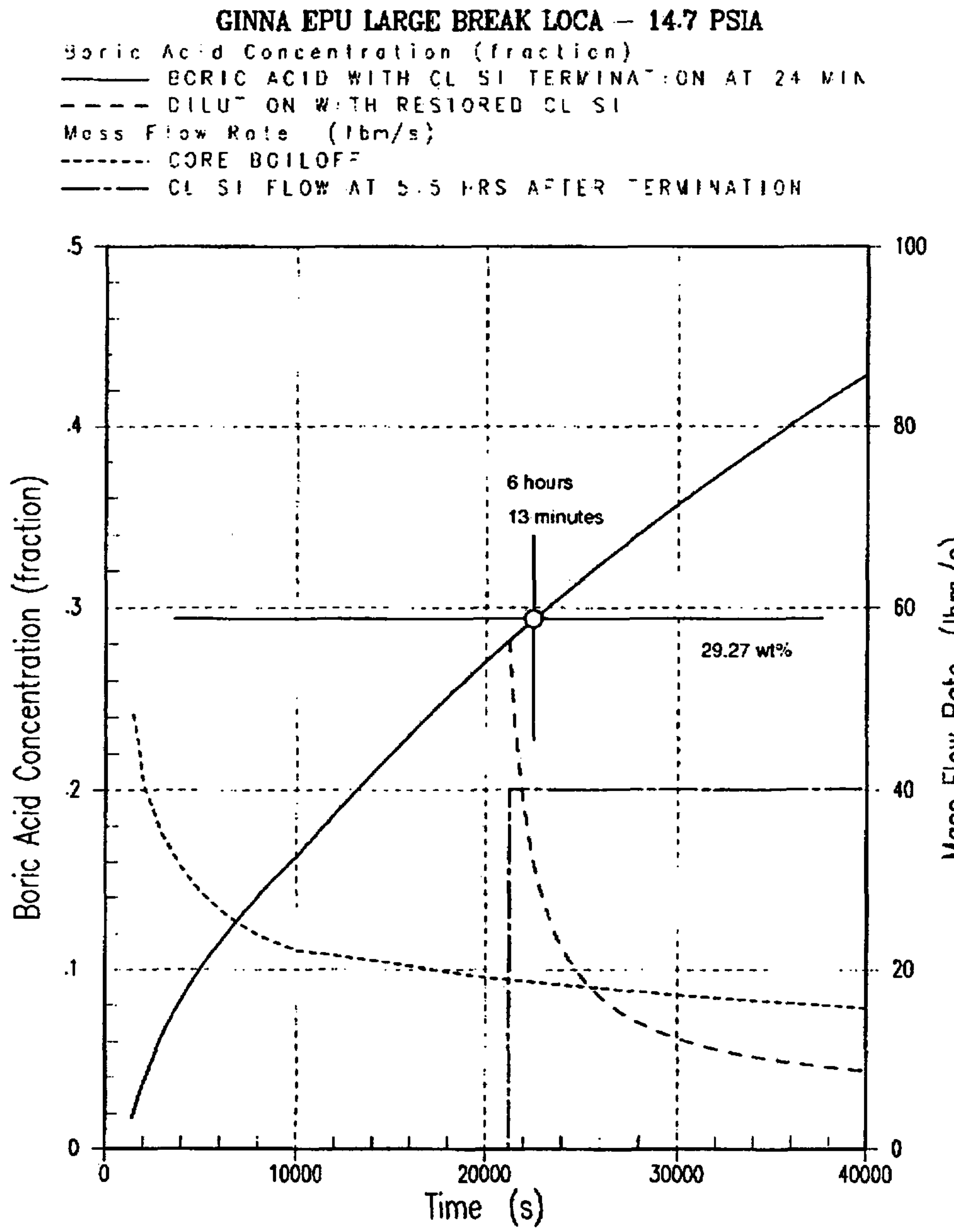


Figure 3 Large Break LOCA Boric Acid Concentration Analysis - Vessel Boric Acid Concentration / Boiloff and Dilution Flow versus Time

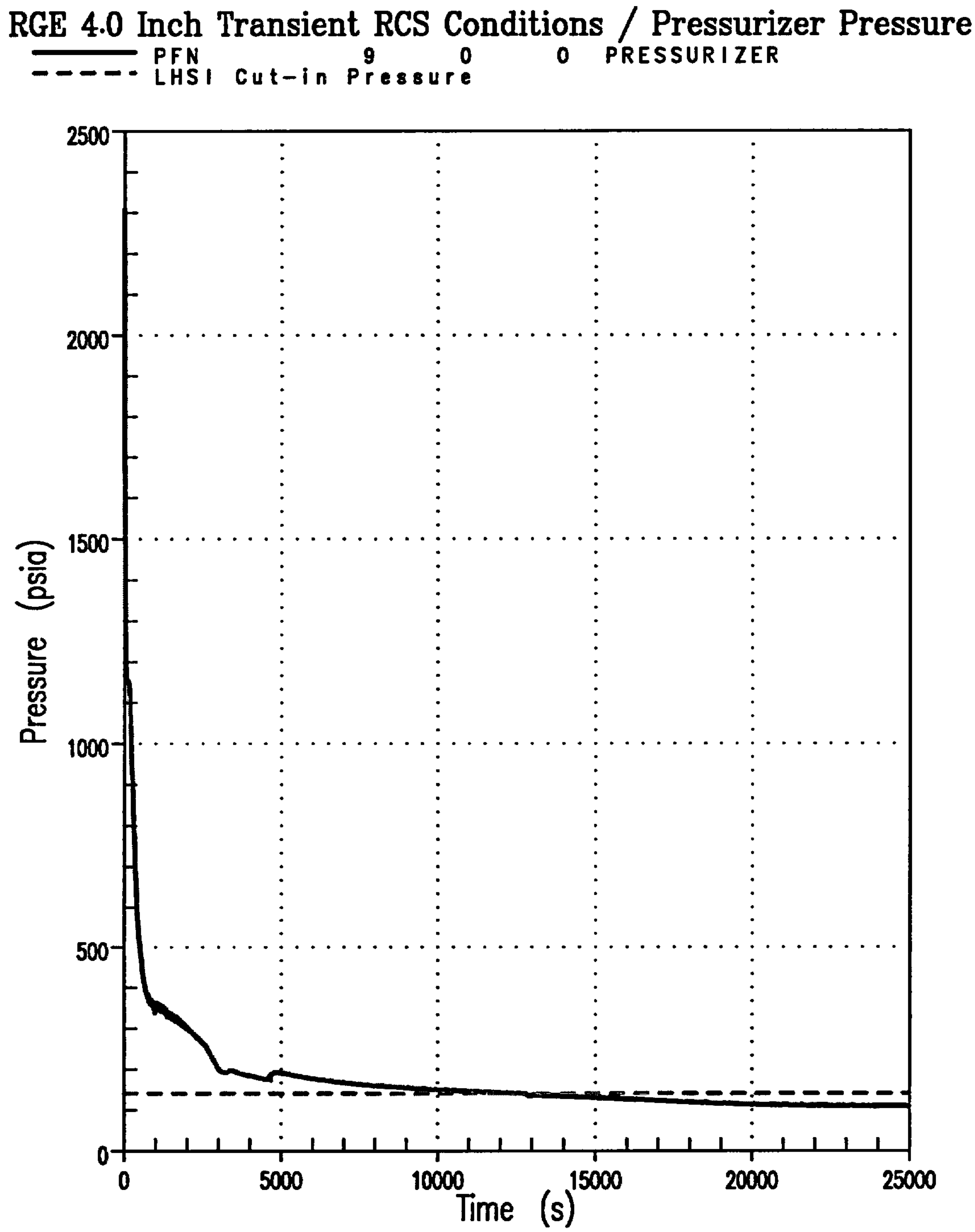


Figure 4 Small Break LOCA - 4-inch Break RCS Depressurization Without Operator Actions

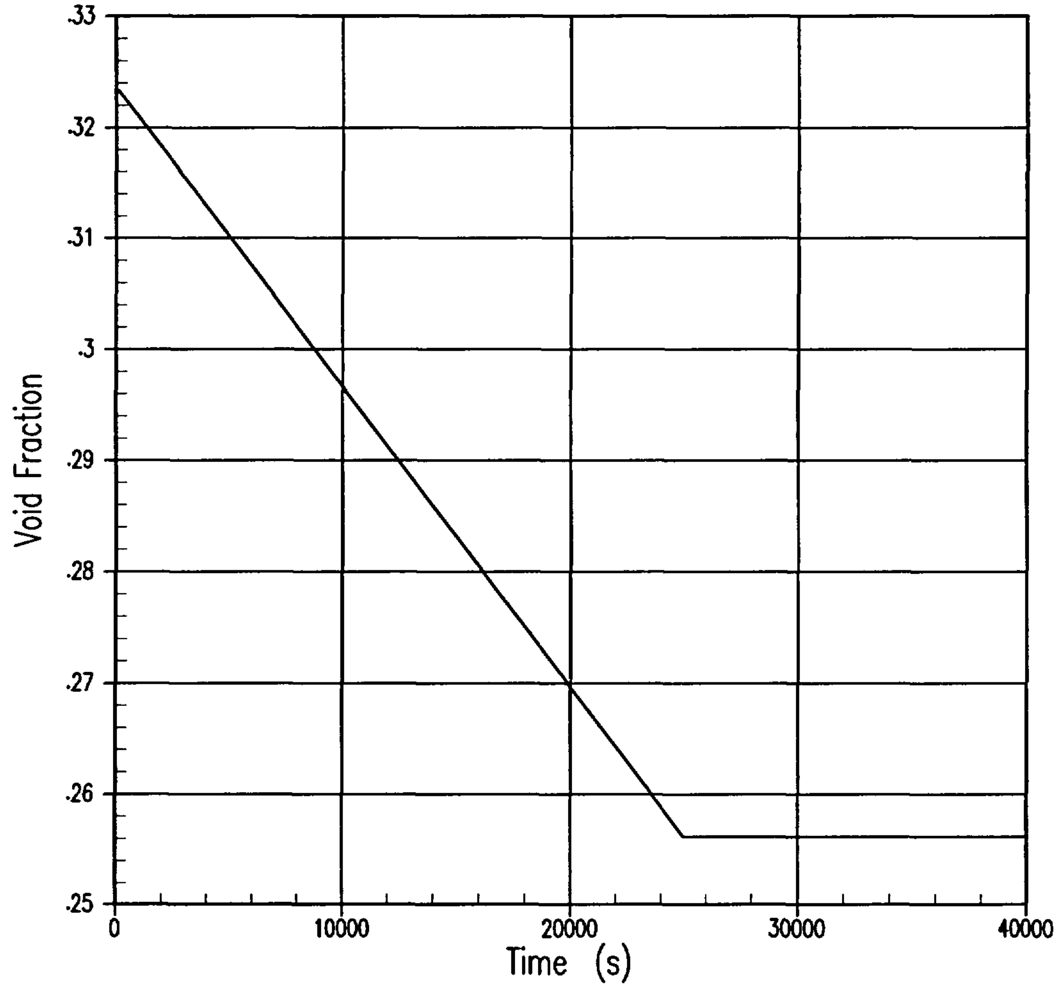


Figure 5 Small Break LOCA Boric Acid Concentration Analysis - Core/Upper Plenum Average Void Fraction versus Time

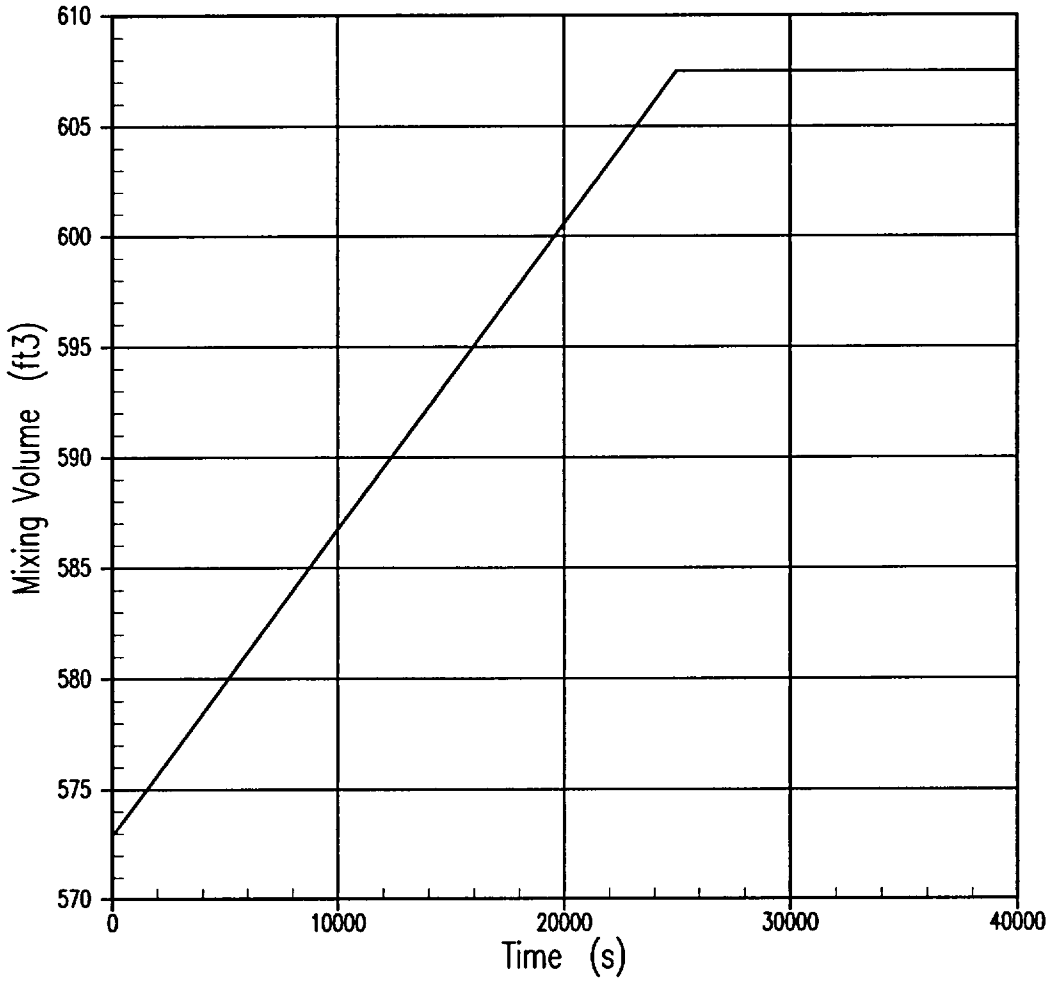


Figure 6 Small Break LOCA Boric Acid Concentration Analysis - Mixing Volume versus Time

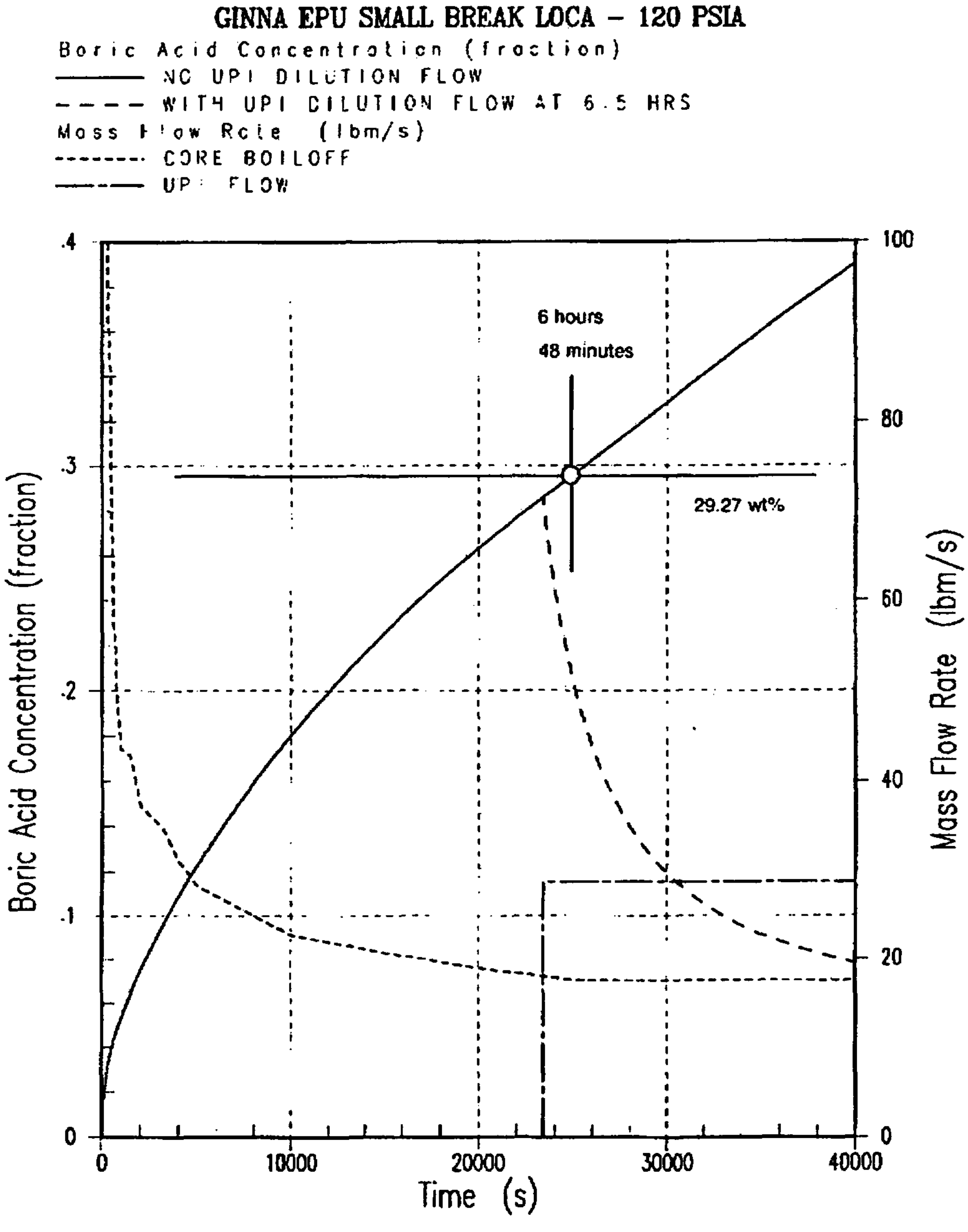


Figure 7 Small Break LOCA Boric Acid Concentration Analysis - Vessel Boric Acid Concentration / Boiloff and Dilution Flow versus Time

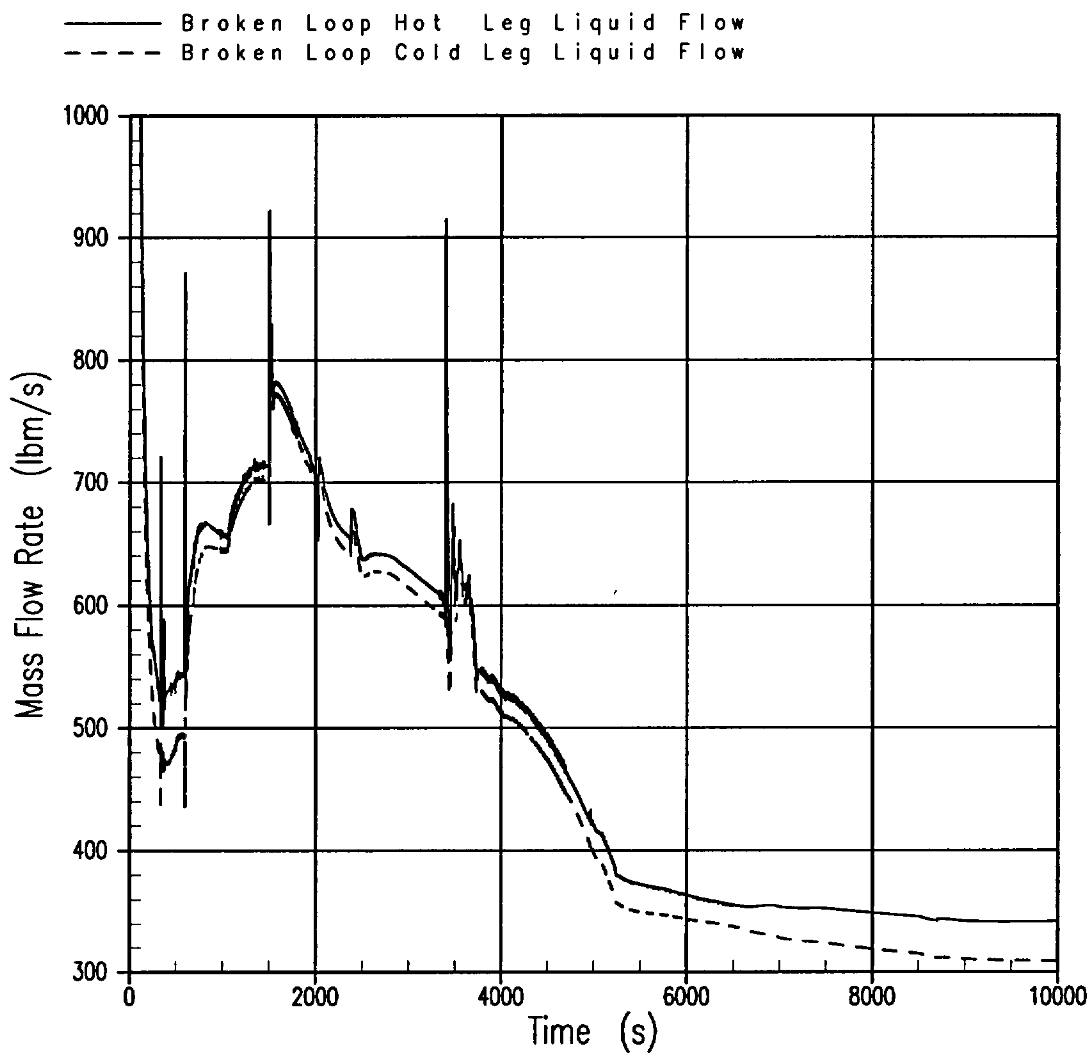


Figure 8 0.8-Inch Break Broken Loop Hot Leg and Cold Leg Liquid Flow

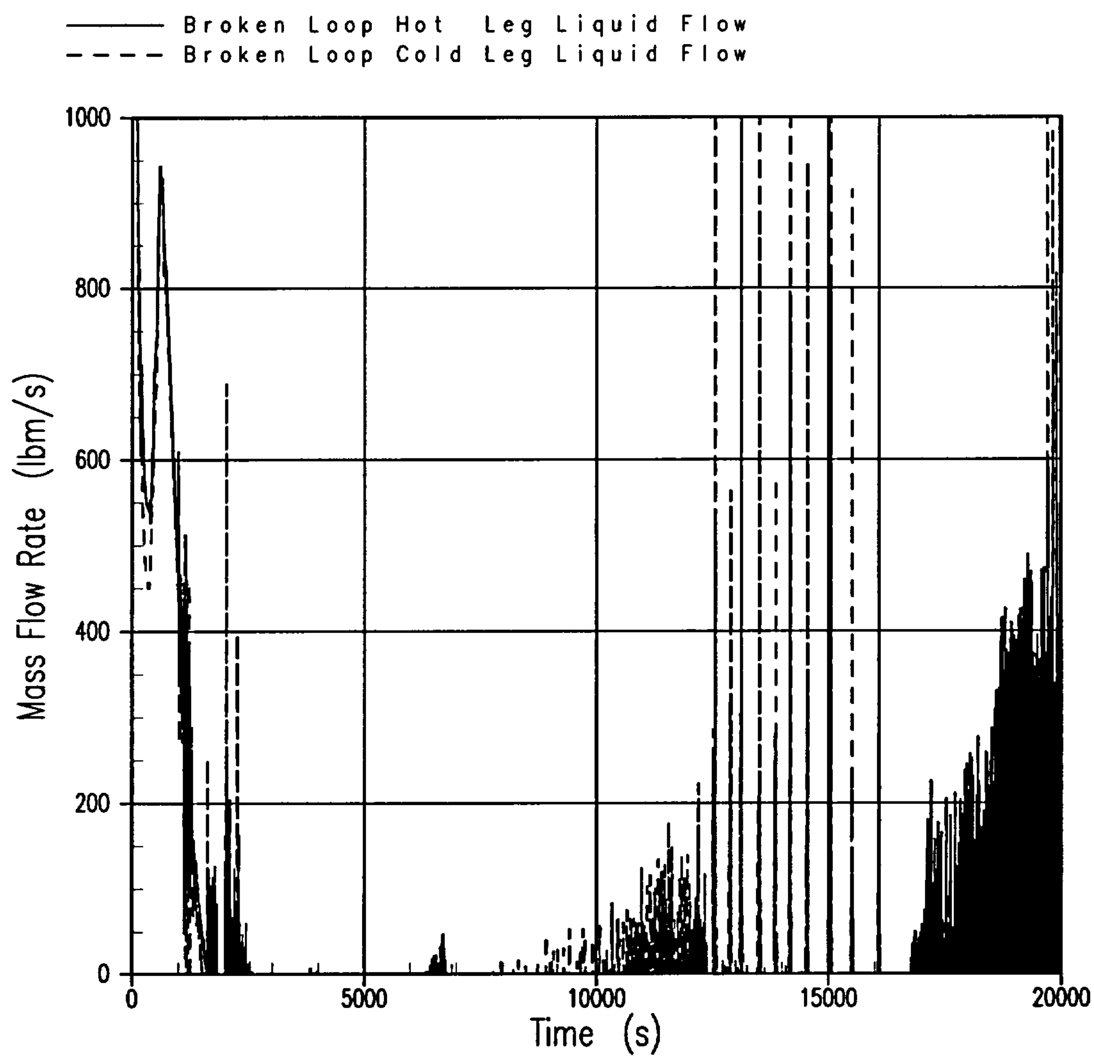


Figure 9 1.1-Inch Break Broken Loop Hot Leg and Cold Leg Liquid Flow

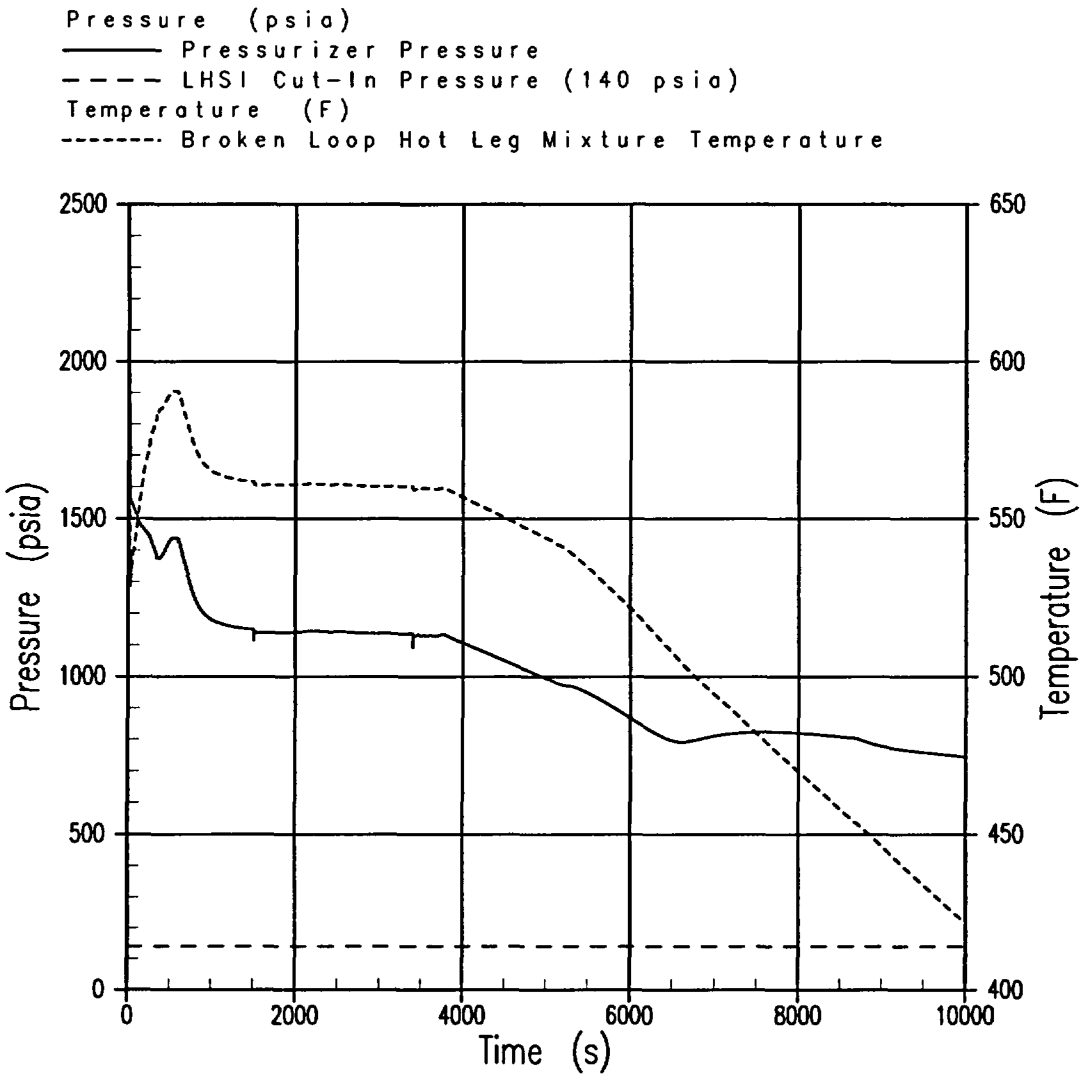


Figure 10 0.8-Inch Break Pressurizer Pressure and Broken Loop Hot Leg Mixture Temperature

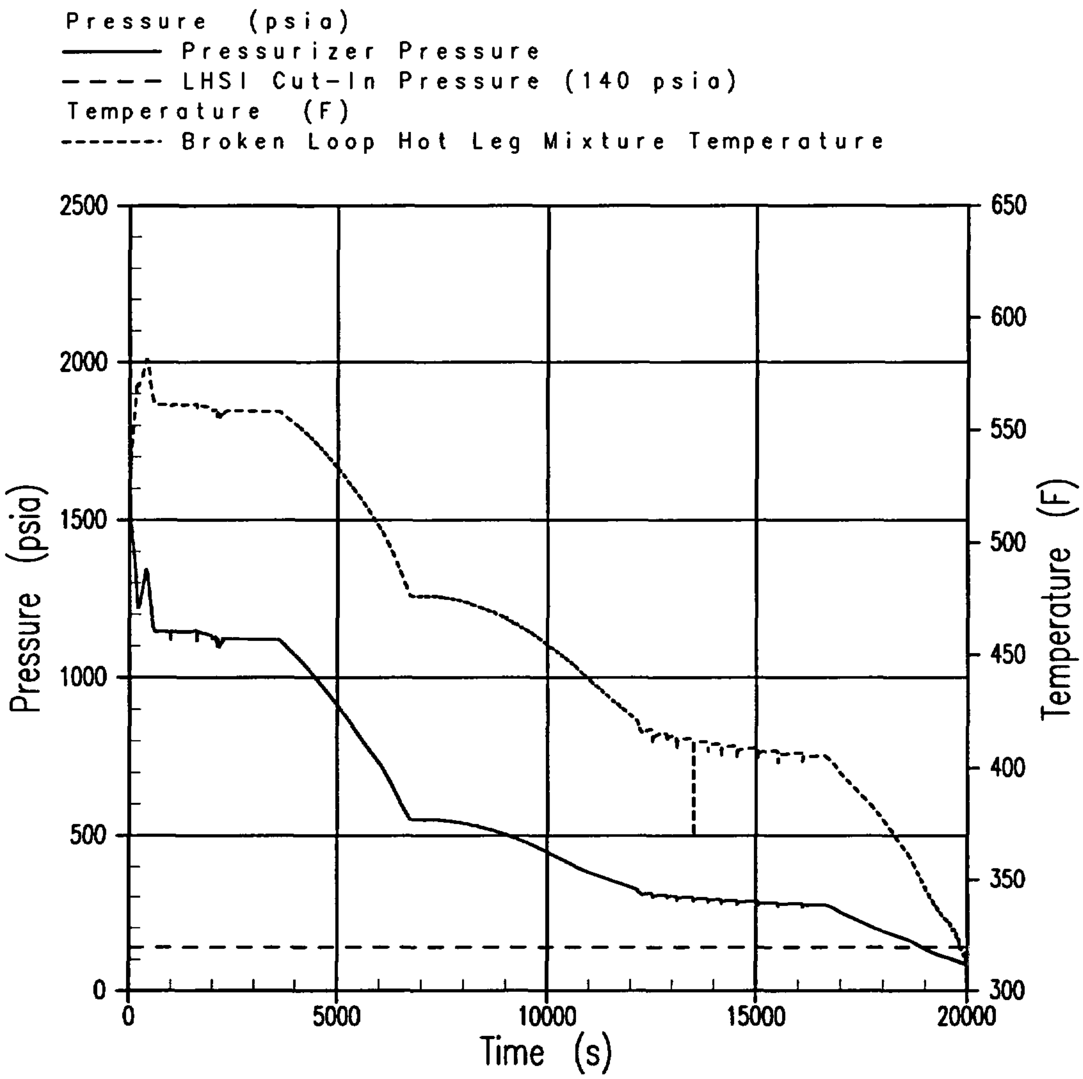


Figure 11 1.1-Inch Break Pressurizer Pressure and Broken Loop Hot Leg Mixture Temperature

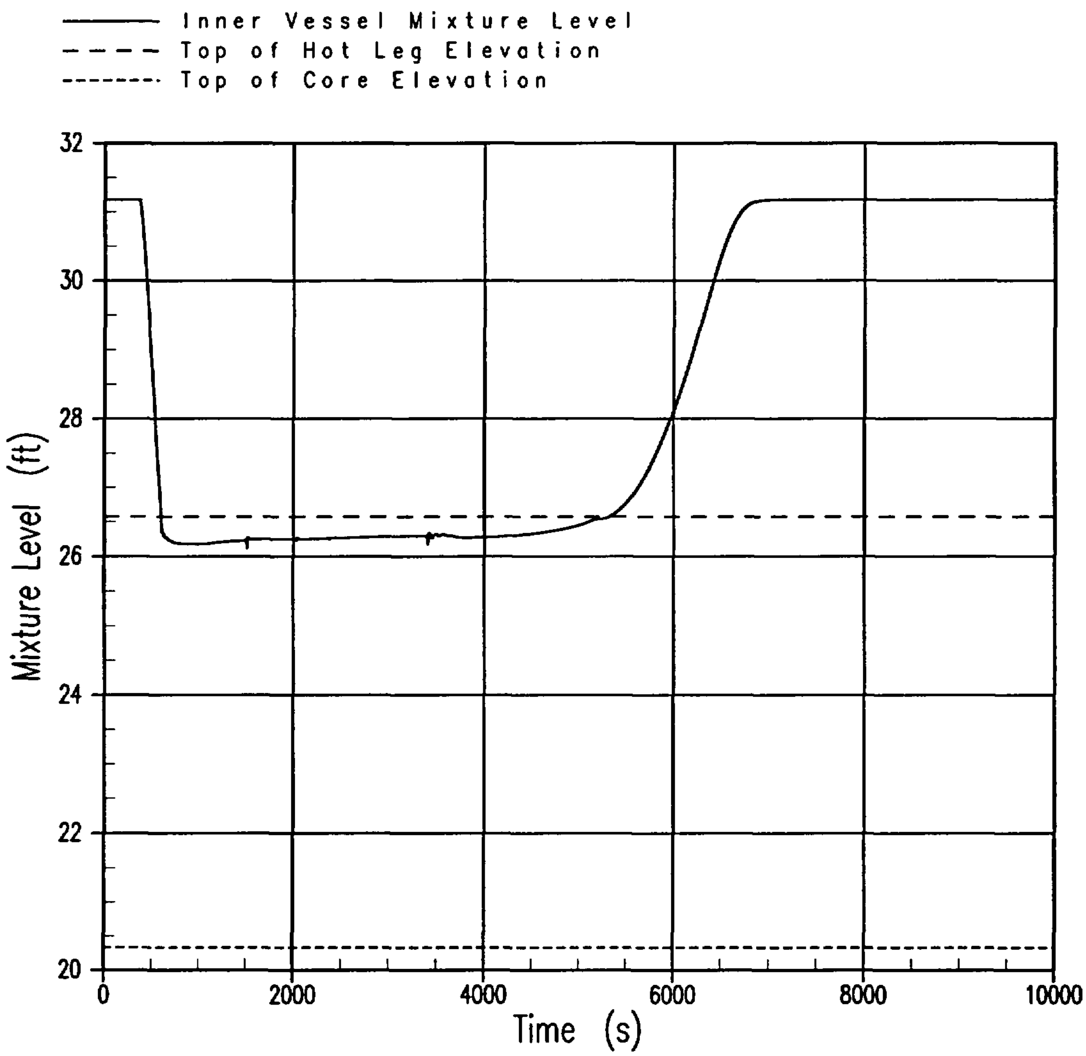


Figure 12 0.8-Inch Break Inner Vessel Mixture Level

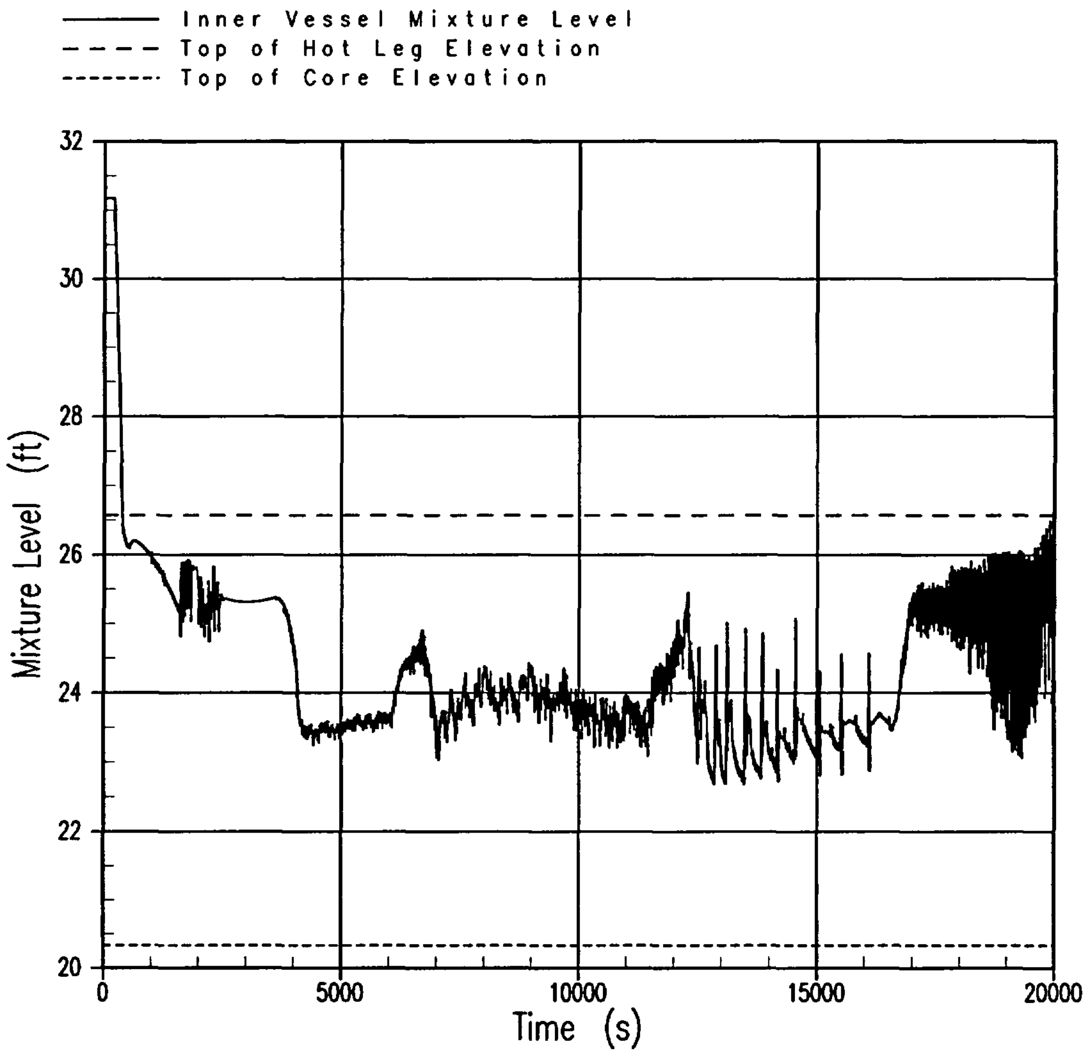


Figure 13 1.1-Inch Break Inner Vessel Mixture Level

LOCA RAI #1

Regarding the small-break LOCA analysis, the licensee evaluated only the 1.5, 2, and 3-inch diameter line breaks, with only limited plots provided for the 2-inch break, in its application. In its August 15, 2005, supplemental letter, the licensee stated that no core uncovery occurred for 4-inch and 6-inch break sizes. However, the licensee did not provide documentation to support its statement. Further, the integer break spectrum approach is too coarse to identify the worse case peak clad temperature (PCT). Also, the analysis of a severed cold-leg injection line was not provided.

Provide: (1) an analysis of break sizes up to and including 1.0 ft^2 in area, including break sizes other than integer break sizes to demonstrate that the worst break has been identified, (2) the major response parameters for the break spectrum, and (3) the NOTRUMP nodalization diagram.

Response

See RAI response to November 3, 2005 letter LOCA Analysis RAI #2, RAI response to October 28, 2005 letter SBLOCA RAI #4 and SBLOCA RAI #5. The NOTRUMP nodalization diagram utilized for the Ginna SBLOCA analysis is the standard Westinghouse NOTRUMP noding diagram and is identical to that provided to the NRC via Reference 1, Enclosure 2, page 125 of 314.

References

(1) FirstEnergy Nuclear Operating Company (FENOC) Letter L-05-112, "Beaver Valley Power Station, Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, Responses to a Request for Additional Information in Support of License Amendment Request Nos. 302 and 173, July 8, 2005.

LOCA RAI #2

There were no quantitative analysis results supplied justifying the operator action time to reinitiate cold-side injection to control boric acid precipitation following a LOCA. No boron concentration vs. time curves were provided for the limiting breaks. No analyses of breaks where the reactor coolant system pressure remains above the residual heat removal pump shut off head were provided nor was the effect of the timing for reinitiating cold-side injection identified to show sufficient time exists to control boric acid concentration for small breaks. The margin in flushing flow was not identified nor was the time needed to turn around the boric acid concentration once flushing begins. The detail of how the boron concentration was calculated was also not provided.

Provide the following information concerning the boron concentration calculation:

a. Does the mixing volume vary with time?

b. Was the loop resistance taken into account in calculating the mixing volume?

c. What constitutes the mixing volume?

The minimum injection temperature and maximum boron concentration in the core was not identified to demonstrate that precipitation is precluded at the time to activate cold-side injection. The 1975 methods cited in the submittal for calculating boric acid concentration contain many unsubstantiated assumptions. See the Westinghouse-CE Topical Report CENPD-254 as an example of the analysis methods and results needed in order to complete the review of long-term cooling performance.

Response

See Attachment 2 to this letter and RAI responses to October 28, 2005 letter Post-LOCA LTC RAIs #1-5, Post-LOCA LTC RAIs, #8, Post-LOCA LTC RAIs, #10, and Post-LOCA LTC RAIs, #14.

LOCA RAI #3

Additional analysis results are also required for the best-estimate large-break LOCA analysis. Only the PCT plot for the hot rod and hot bundle were provided for the limiting break.

Provide the complete analysis results including all of the key major response parameters. Also, did the analysis include downcomer boiling effects and what was the worst single failure if downcomer boiling occurs? What containment pressure was assumed?

Response

Additional plots for the limiting LBLOCA PCT case are provided on the following pages to illustrate the key major response parameters for this transient.

Figure 1.1 is a plot of the pressurizer pressure throughout the transient. Figure 1.2 is a plot of the mass flow rate through the split break, and Figure 1.3 of the void fraction in both the intact and broken loop pumps. Figure 1.4 is a plot of the vapor flow rate at the top of the core for the first 20 transient seconds, and Figure 1.5 a plot of the total flow rate at the bottom of the core for the same time period.

Figure 1.6 is a plot of the accumulator injection flow, Figure 1.7 a plot of the High Head Safety Injection Flow into the intact cold leg, and Figure 1.8 a plot of the Low Head Safety Injection Flow into the upper plenum. Figures 1.9, 1.10, and 1.11 are plots of the lower plenum, downcomer, and core collapsed liquid levels, respectively. The reference point for the lower plenum liquid level is the bottom of the vessel. The reference point for the downcomer liquid level is the point at which the outside of the core barrel, if extended downward, intersects with the vessel wall. The reference point for the core collapsed liquid levels is the bottom of the active fuel.

The vessel fluid inventory throughout the transient is plotted in Figure 1.12. Figure 1.13 is a plot of the Peak Clad Temperature for all 5 rods modeled in WCOBRA/TRAC, and Figure 1.14 a plot of the hot rod PCT elevation versus time. Note, the peak clad temperatures in Figure 1.13 are the WCOBRA/TRAC calculated temperatures, not the HOTSPOT calculated temperatures.

The R. E. Ginna LBLOCA analysis considers downcomer boiling as appropriate. The WCOBRA/TRAC computer code will determine if downcomer boiling occurs for a particular transient. If downcomer boiling is determined to occur in a transient, WCOBRA/TRAC will include the effects of downcomer boiling in the transient calculation. The worst single failure for the LBLOCA analysis is the loss of one train of ECCS injection (consistent with the ASTRUM Topical); however, all containment systems which would reduce containment pressure are modeled for the LBLOCA containment backpressure calculation. The single failure analyzed does not change with regard to the calculation of downcomer boiling or the lack thereof. A comparison of the containment backpressure utilized for the LBLOCA analysis compared to the calculated containment backpressure was previously provided in Section 2.6.6 of the R. E. Ginna Extended Power Uprate License Amendment Request (*Letter from M. Korsnick to USNRC, "License Amendment Request Regarding Extended Power Uprate," July 7, 2005*). This figure has also been provided as Figure 1.15. The Best Estimate LBLOCA analysis and associated model to support the Ginna EPU are both Ginna plant-specific.

Figure 1.1 - Pressurizer Pressure

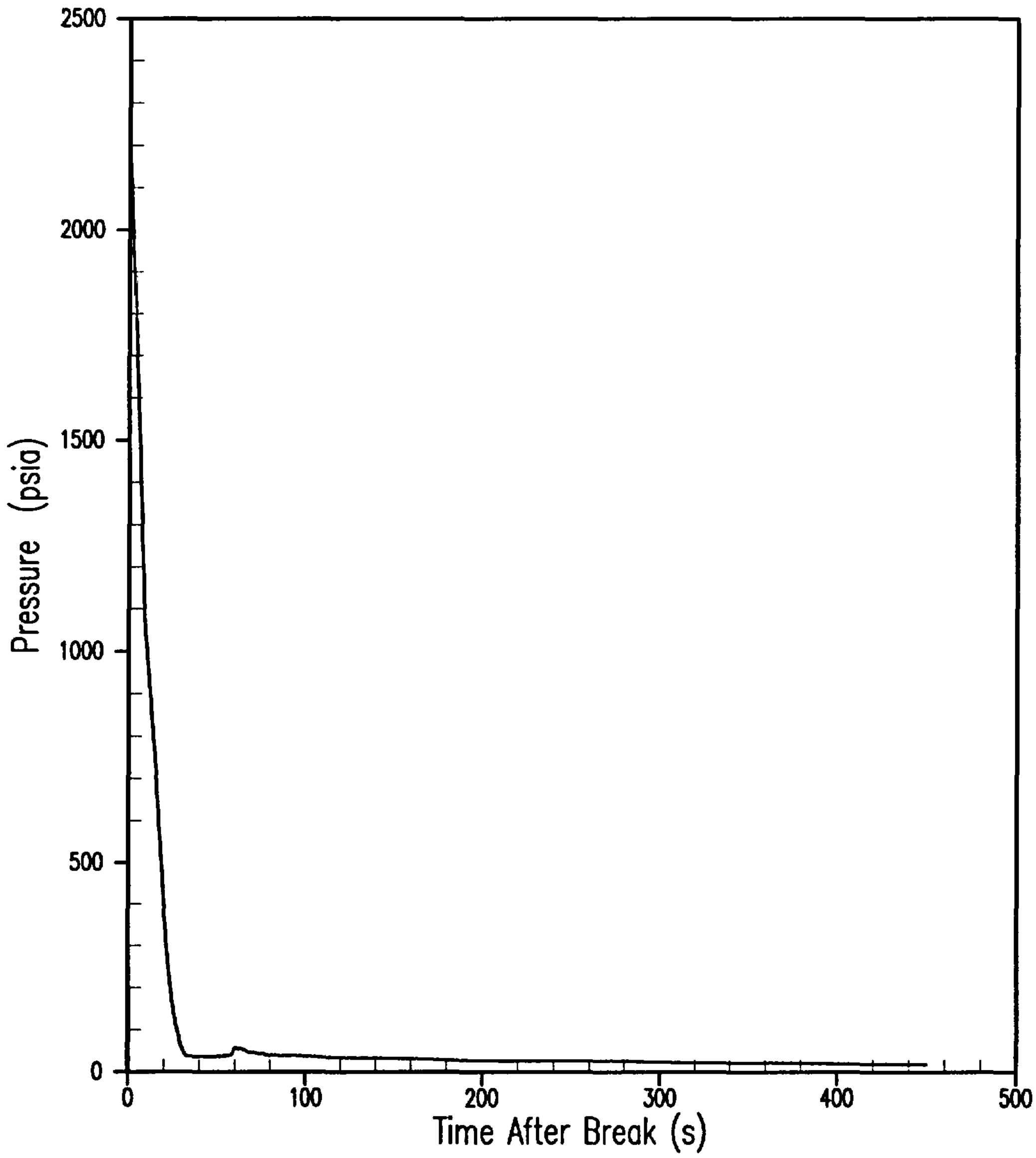


Figure 1.2 - Break Flow

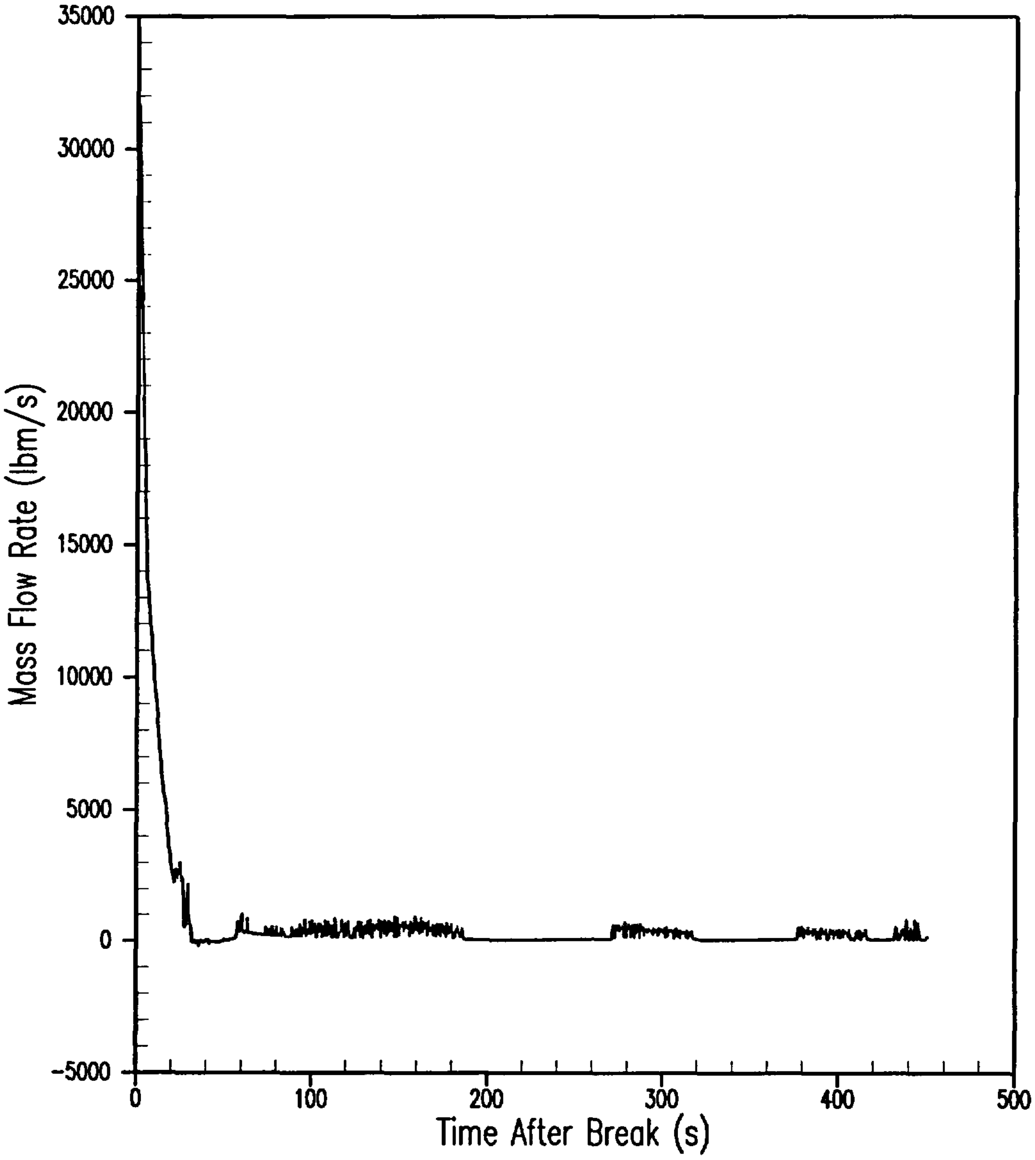


Figure 1.3 - Void Fraction in Pumps

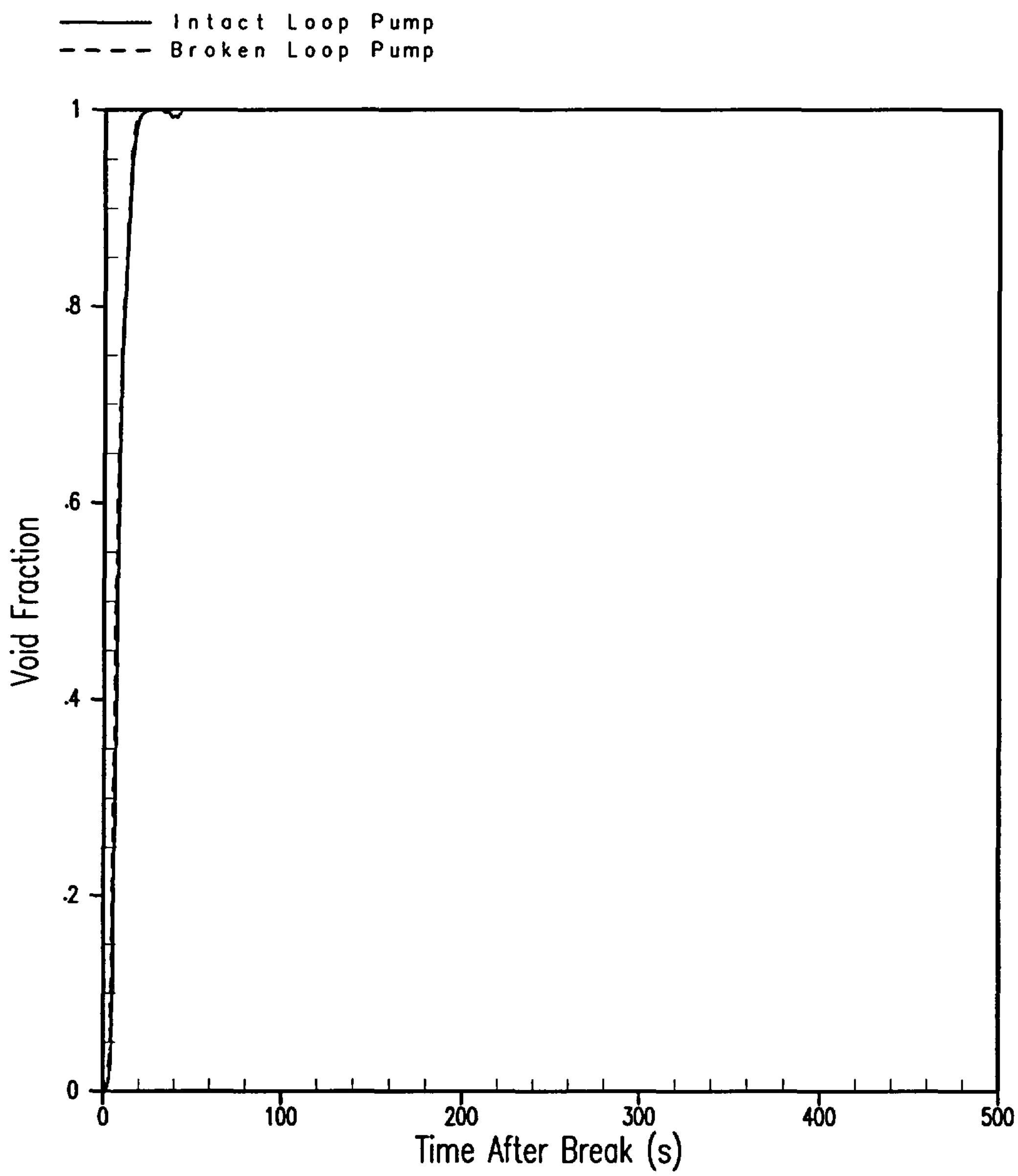


Figure 1.4 - Vapor Flow at Top of Core

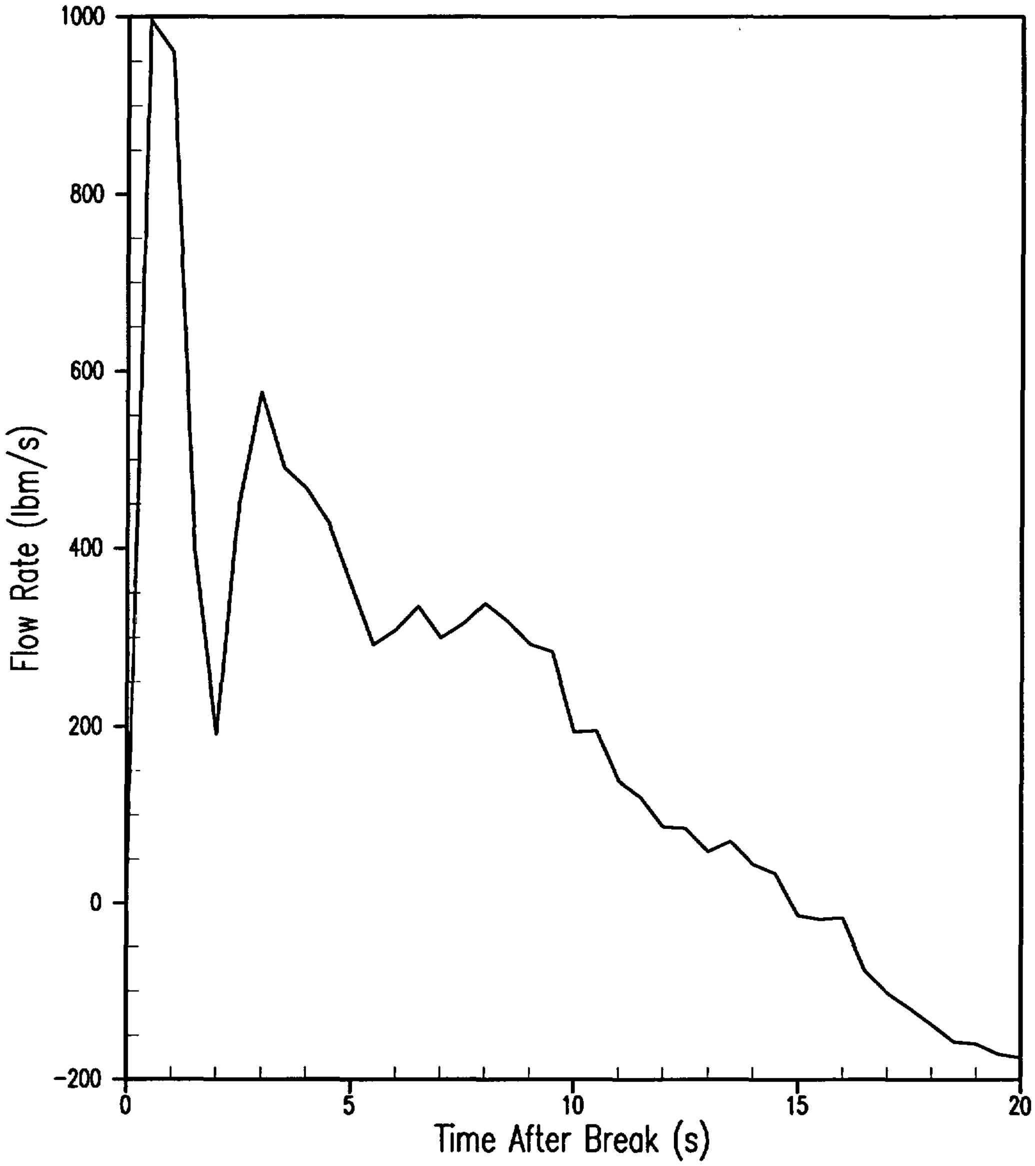


Figure 1.5 - Total Flow at Bottom of Core

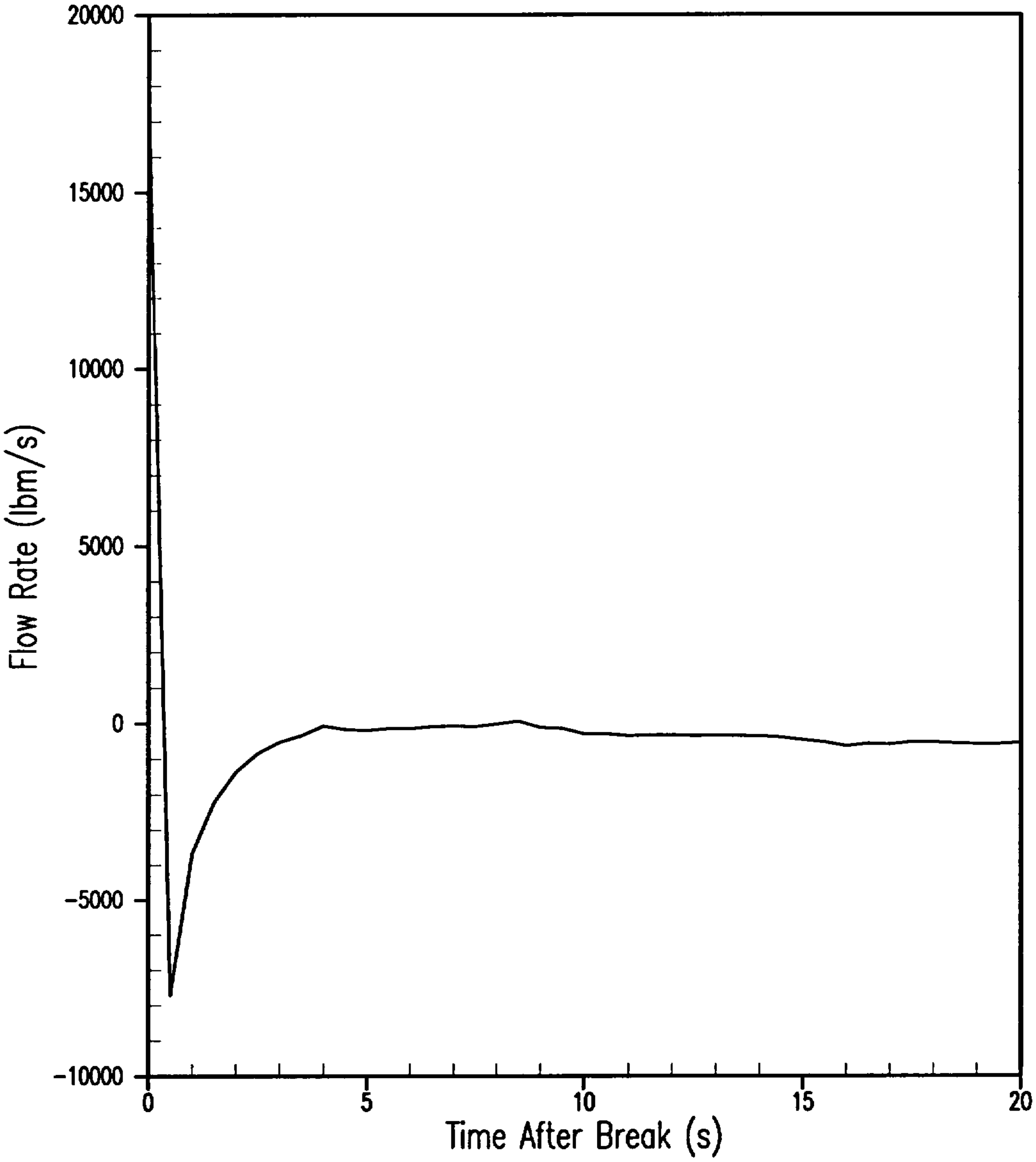


Figure 1.6 - Accumulator Injection Flow

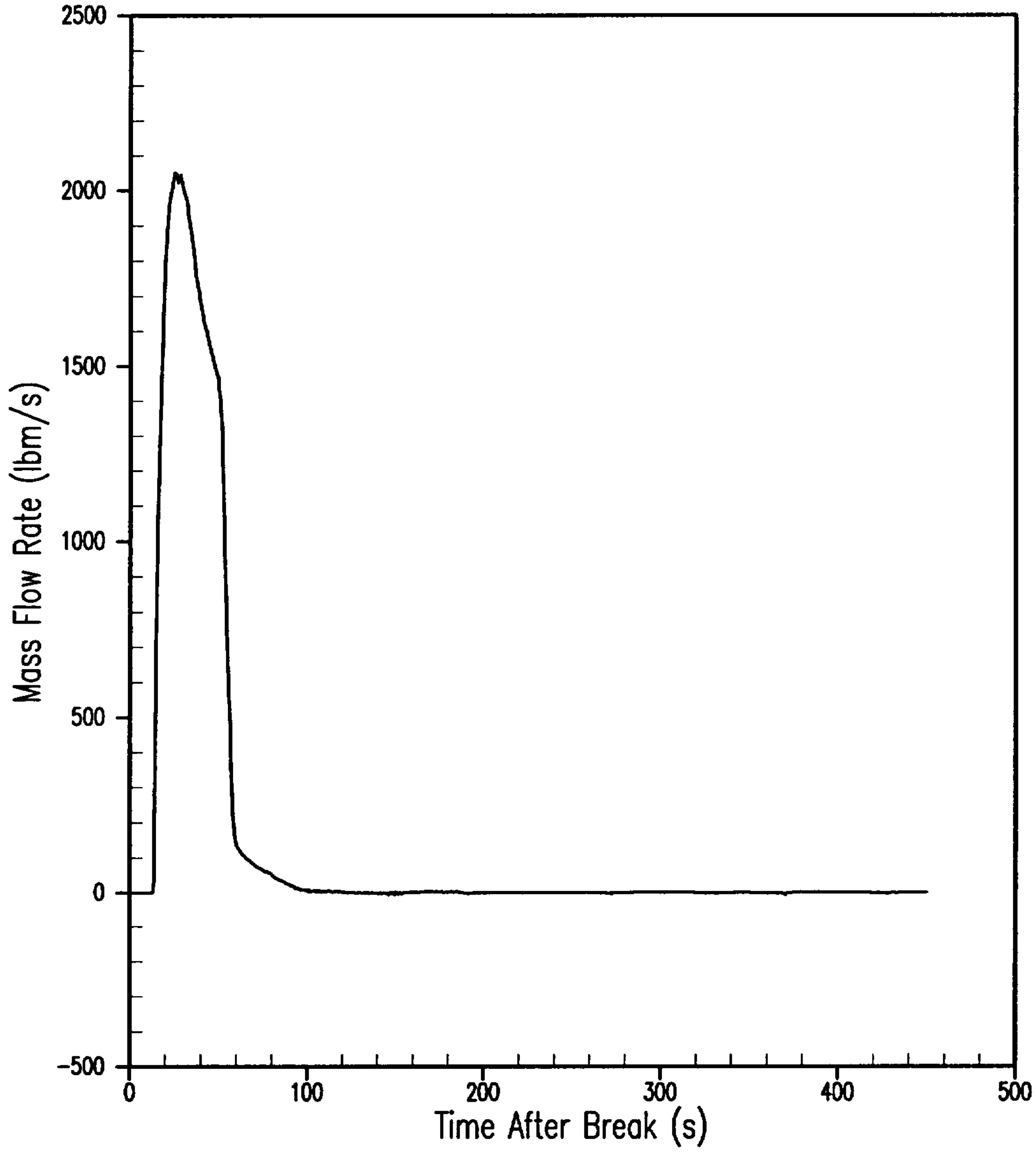


Figure 1.7 - High Head Safety Injection Flow

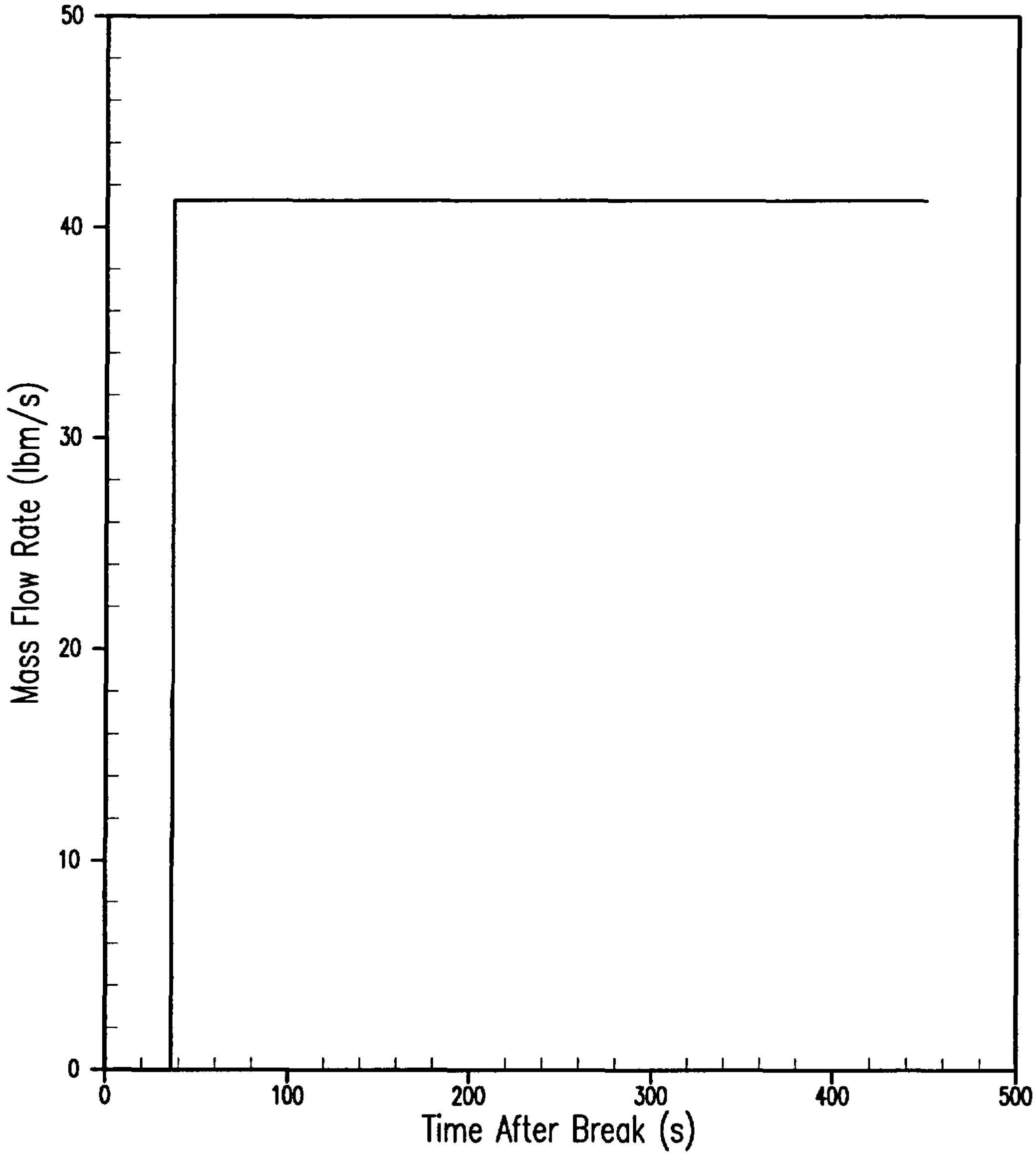


Figure 1.8 - Low Head Safety Injection Flow

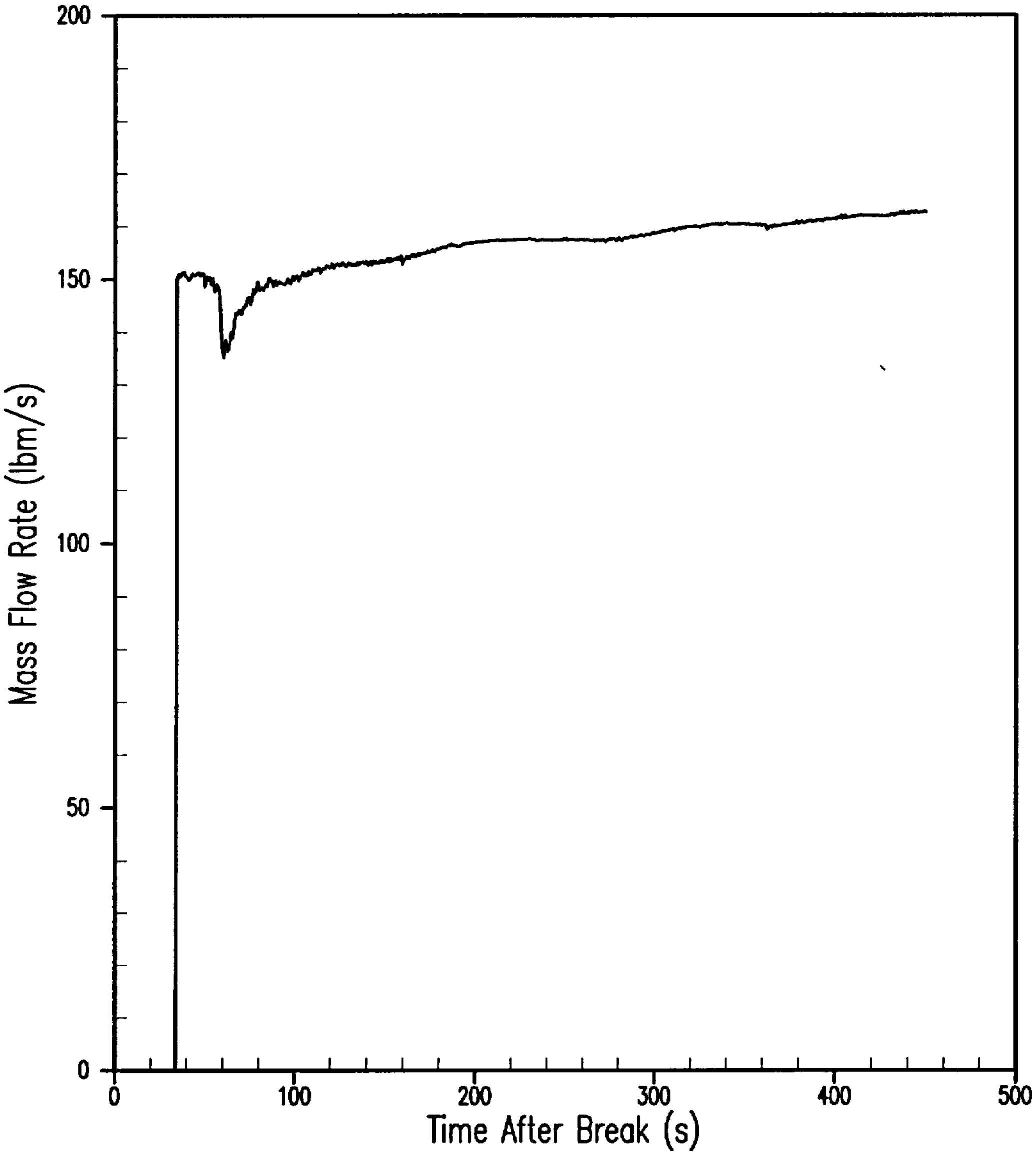


Figure 1.9 - Lower Plenum Collapsed Liquid Level

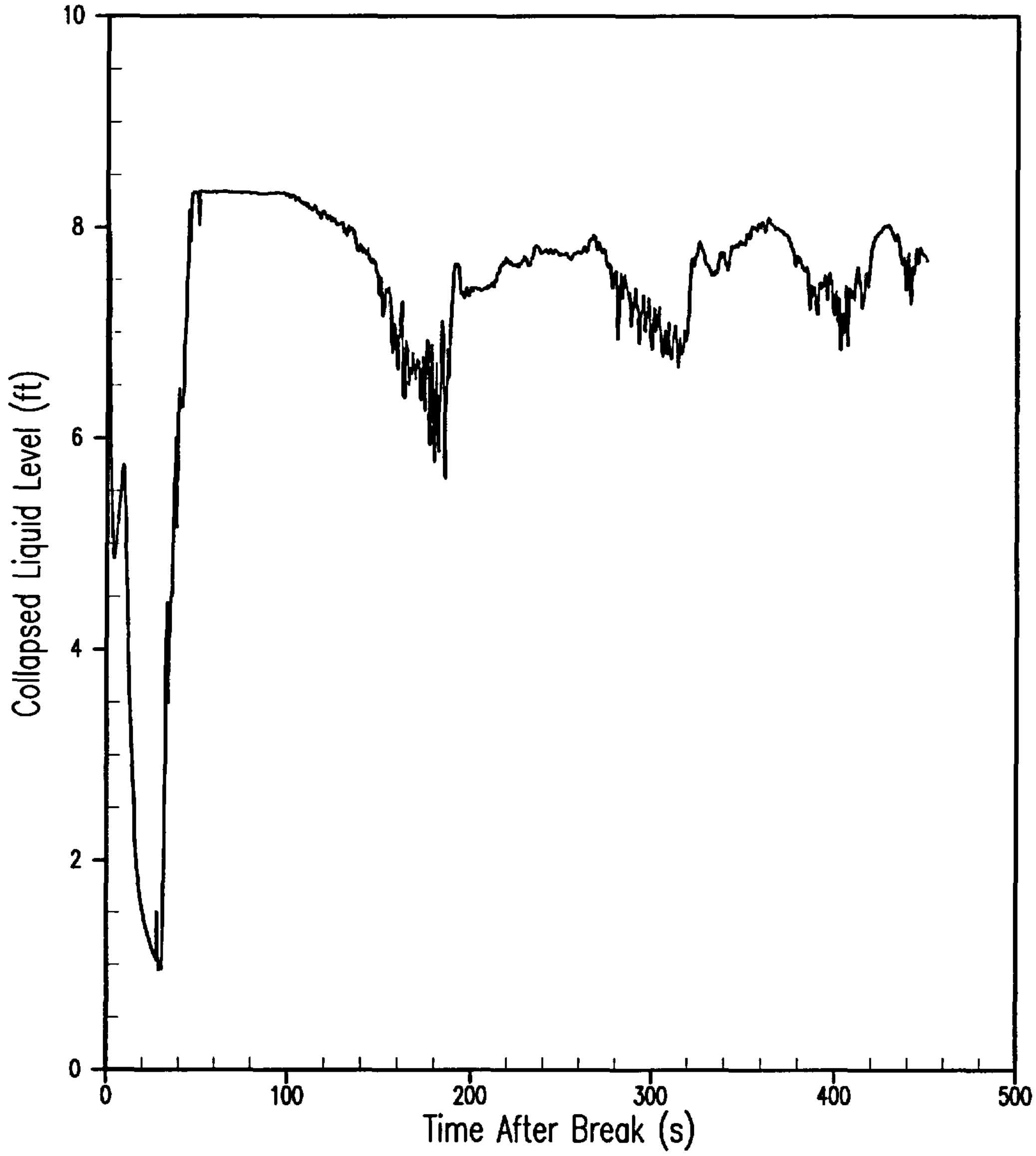


Figure 1.10 - Downcomer Collapsed Liquid Levels

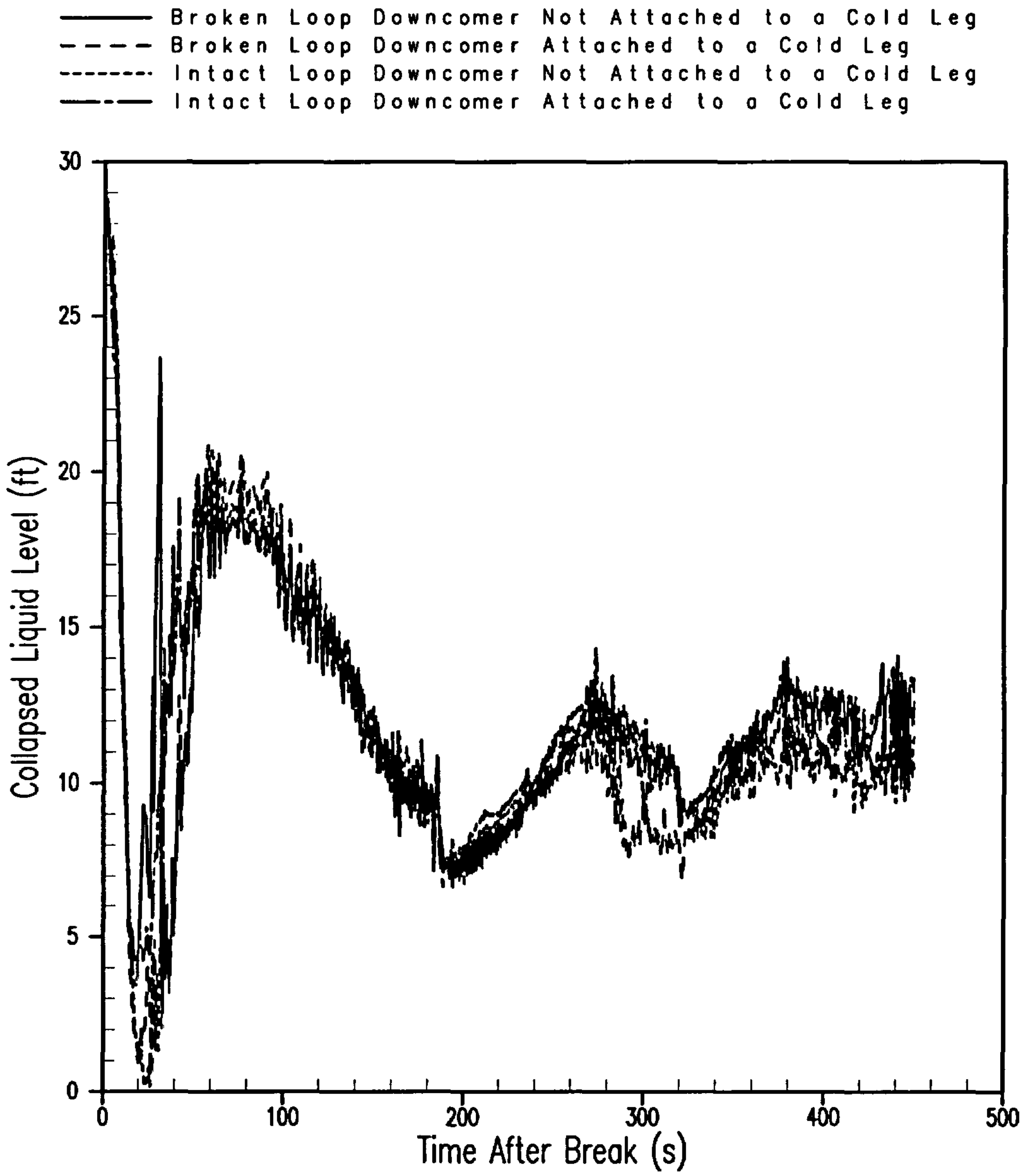


Figure 1.11 - Core Collapsed Liquid Levels

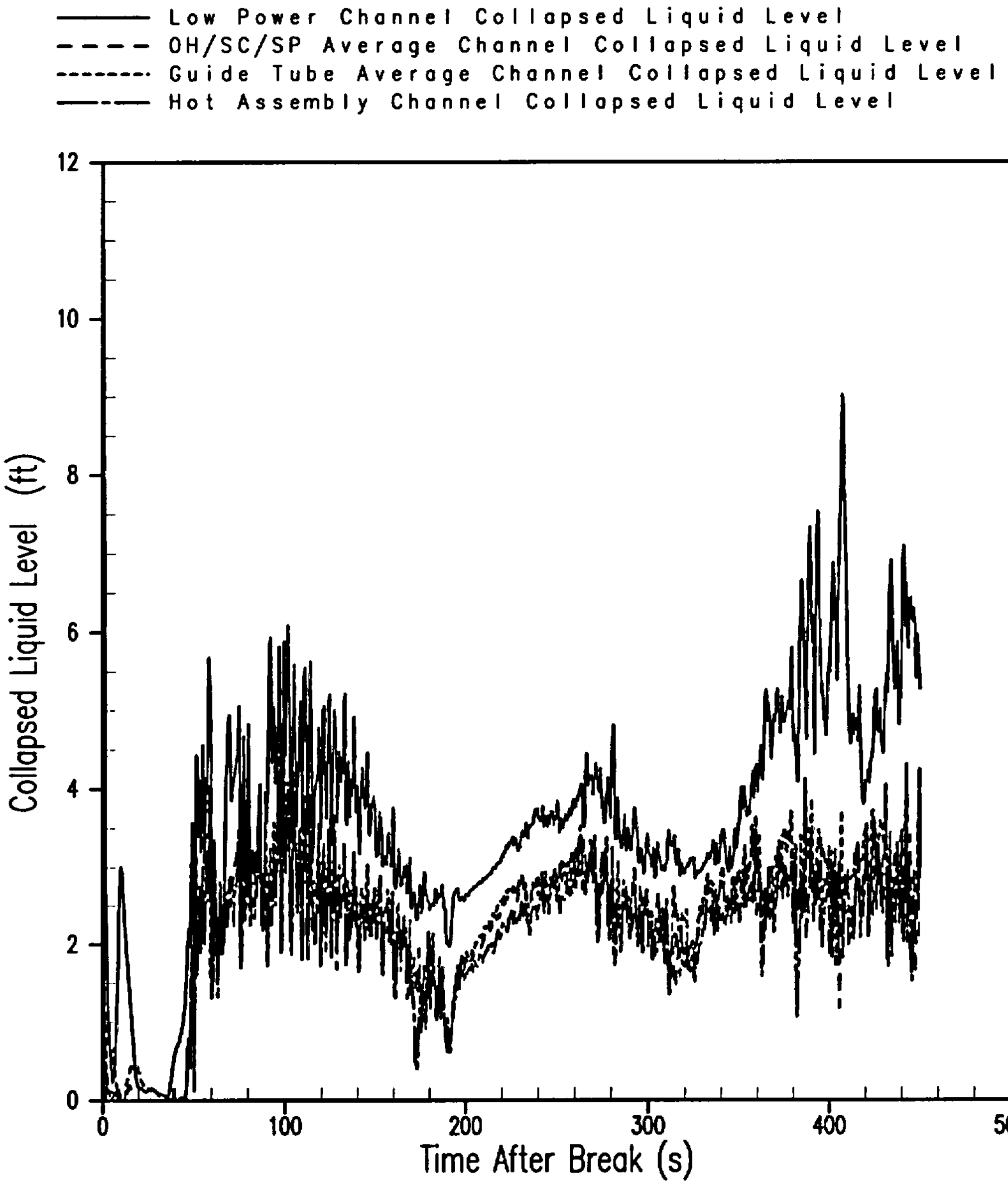


Figure 1.12 - Vessel Fluid Mass

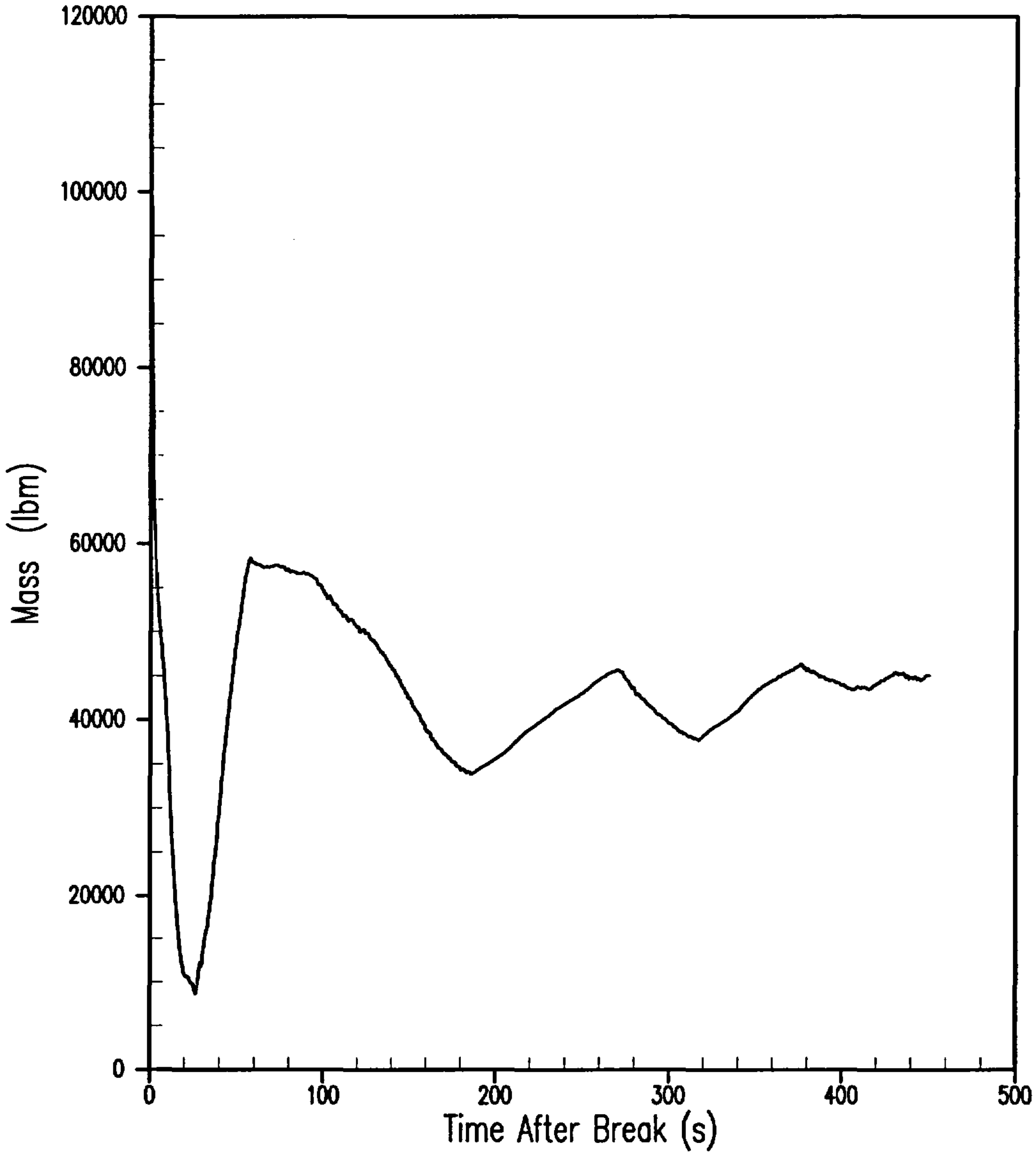


Figure 1.13 - Peak Clad Temperature for all 5 Rods

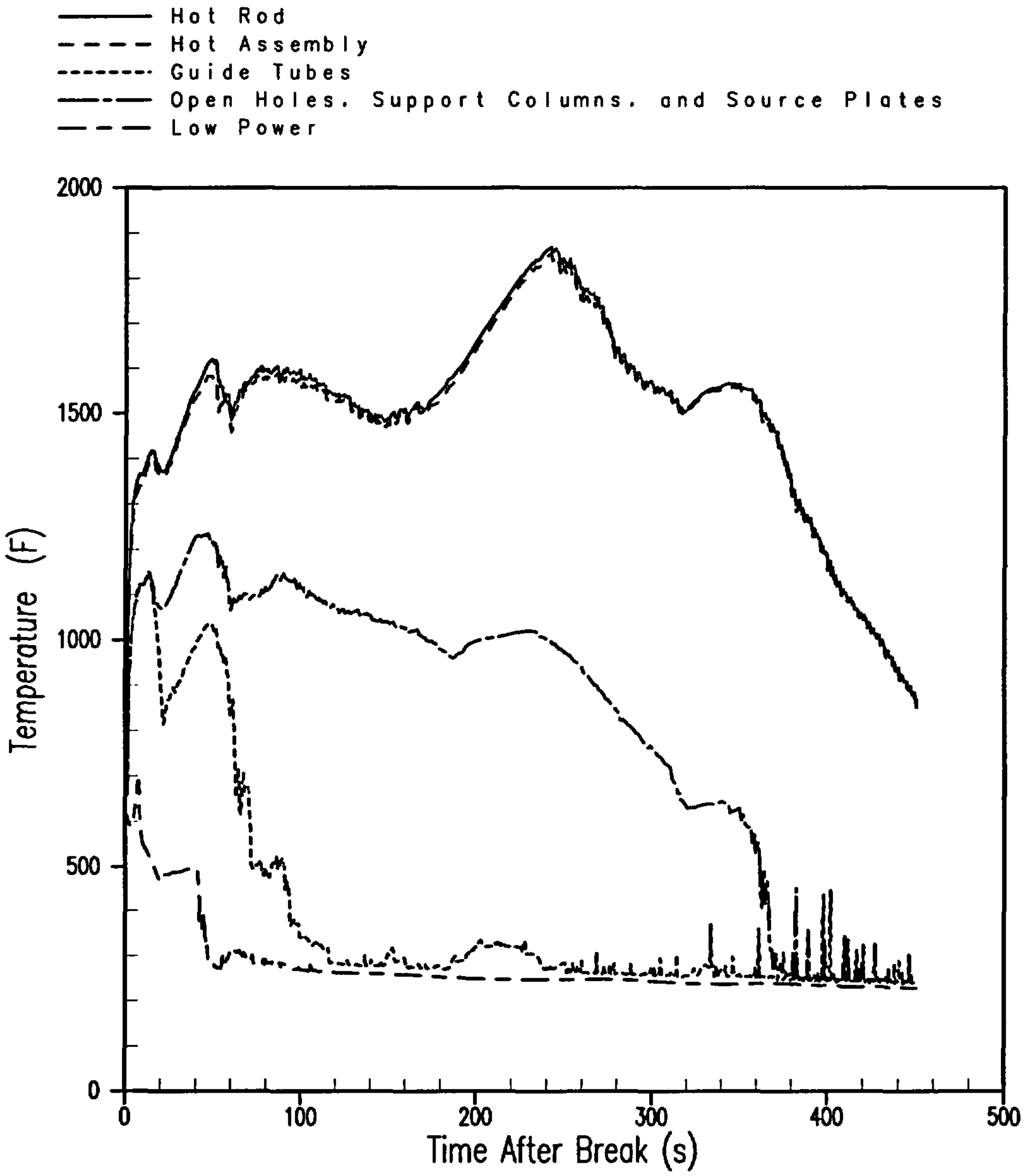


Figure 1.14 - Peak Clad Temperature Elevation for the Hot Rod

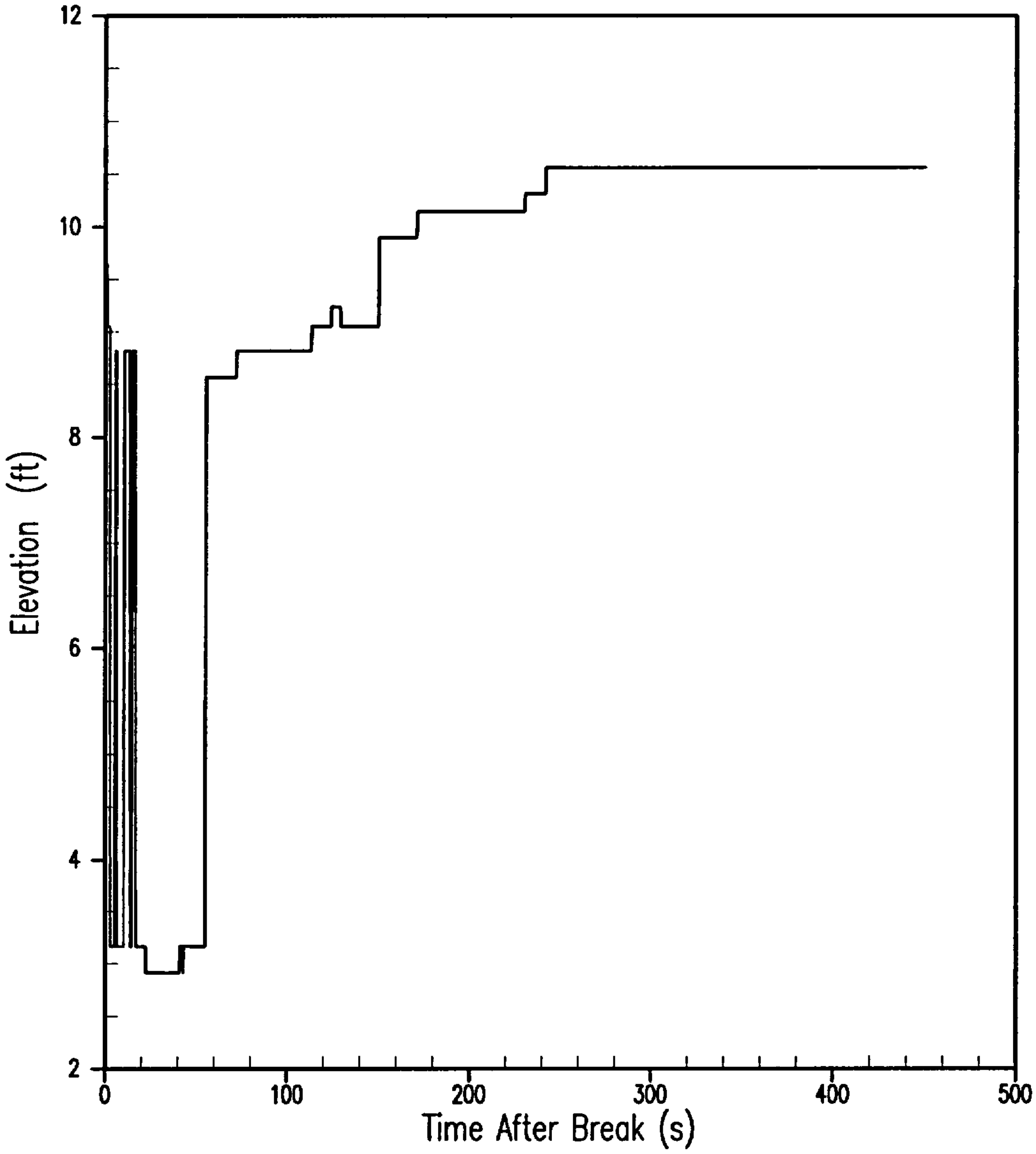
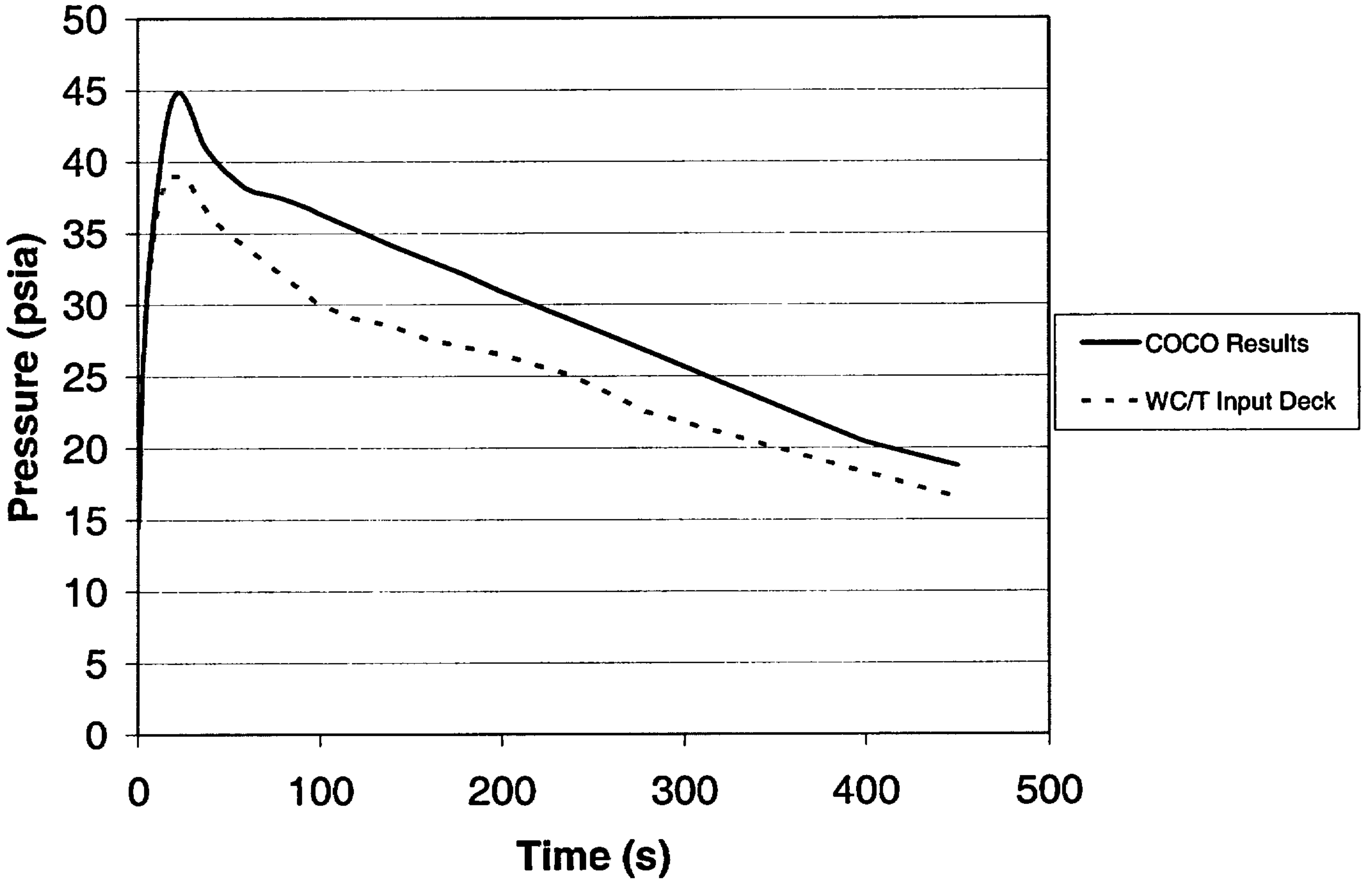


Figure 1.15 – Analysis versus Calculated Containment Backpressure



Core Quench Calculation

In order to demonstrate stable and sustained quench, the WCOBRA/TRAC calculation time for the limiting PCT case was extended. Figure 2.1 shows the peak cladding temperatures for the five rods modeled in WCOBRA/TRAC. This figure indicates that quench occurs at approximately 50 seconds for the low power rod, 100 seconds for the core average rods under guide tubes, 375 seconds for the balance of the core average rods, and 500 seconds for the hot rod and hot assembly average rod. Once quench is predicted to occur, the rod temperatures remain slightly above the fluid saturation temperature for the remainder of the simulation. Figure 2.2 is a plot of the collapsed liquid level in the four downcomer channels and shows steady behavior, with the level in each quadrant remaining near the bottom of the cold leg. Figure 2.3 shows the collapsed liquid level in the four core channels and indicates a gradual increase in the core liquid inventory. This is consistent with the expected result based on the removal of the initial core stored energy and the gradual reduction in decay heat. Figure 2.4 shows the collapsed liquid level in the upper plenum and indicates that there is a pool of water that has accumulated on the upper core plate. Figure 2.5 is a plot of the vessel fluid inventory, which shows a trend of increasing vessel inventory with time after 300 seconds. This indicates that the increase in inventory due to the pumped safety injection is more than offsetting the loss of inventory through the break. Based on these results, it is concluded that stable and sustained quench has been established for the R. E. Ginna Large Break LOCA analysis.

Figure 2.1 – Peak Cladding Temperature for all 5 Rods

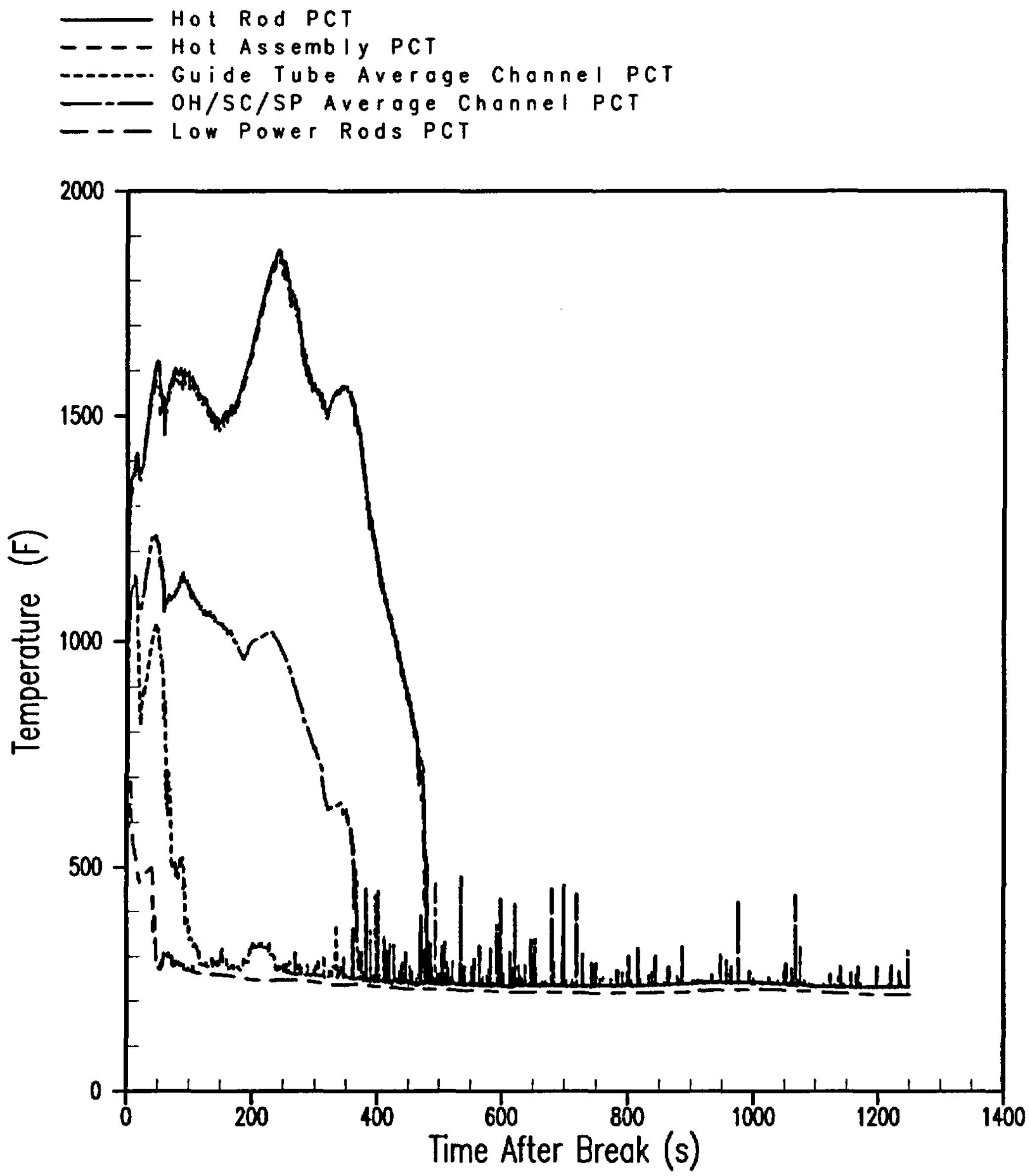


Figure 2.2 – Downcomer Collapsed Liquid Levels

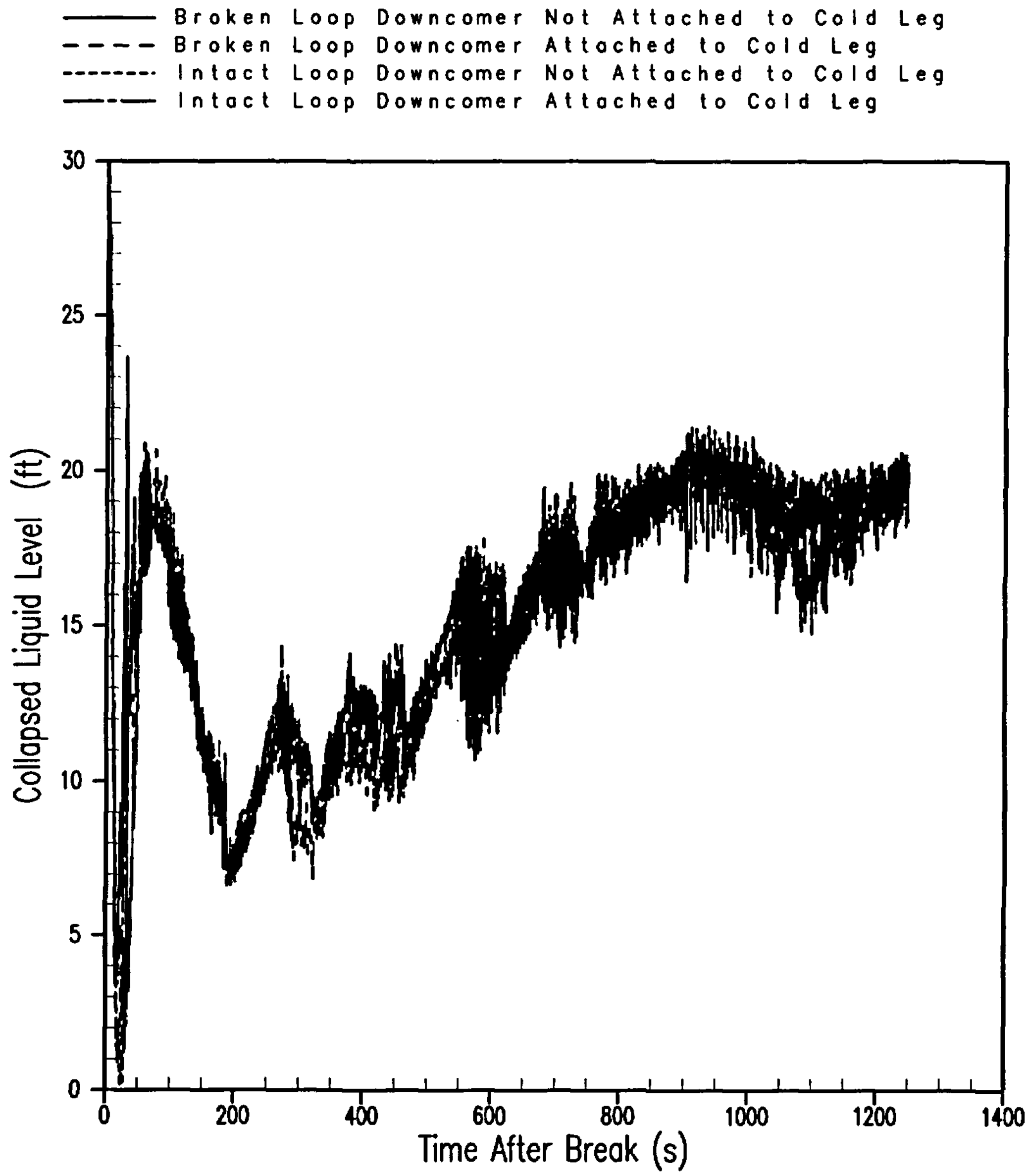


Figure 2.3 – Core Collapsed Liquid Levels

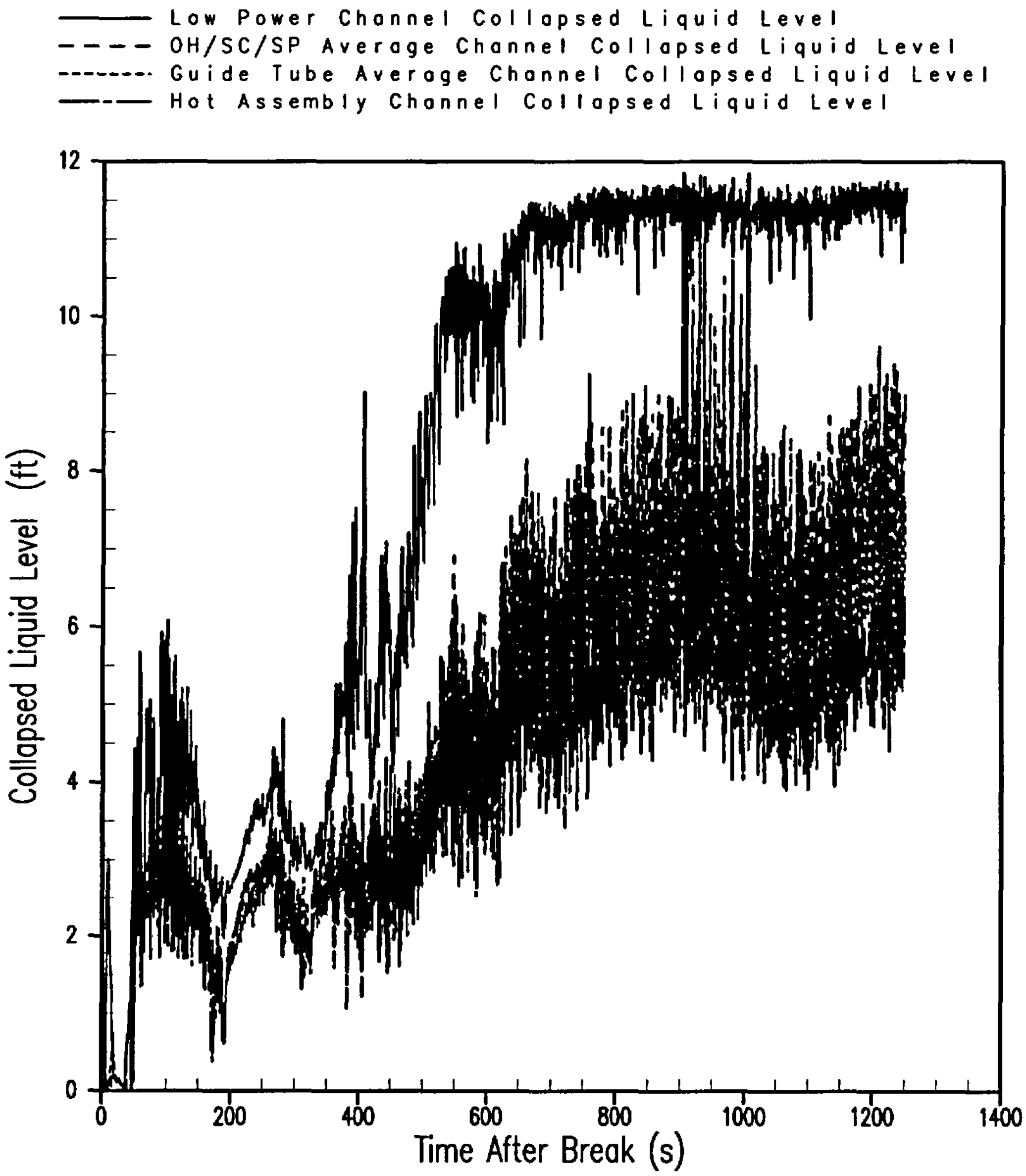


Figure 2.4 – Upper Plenum Collapsed Liquid Level

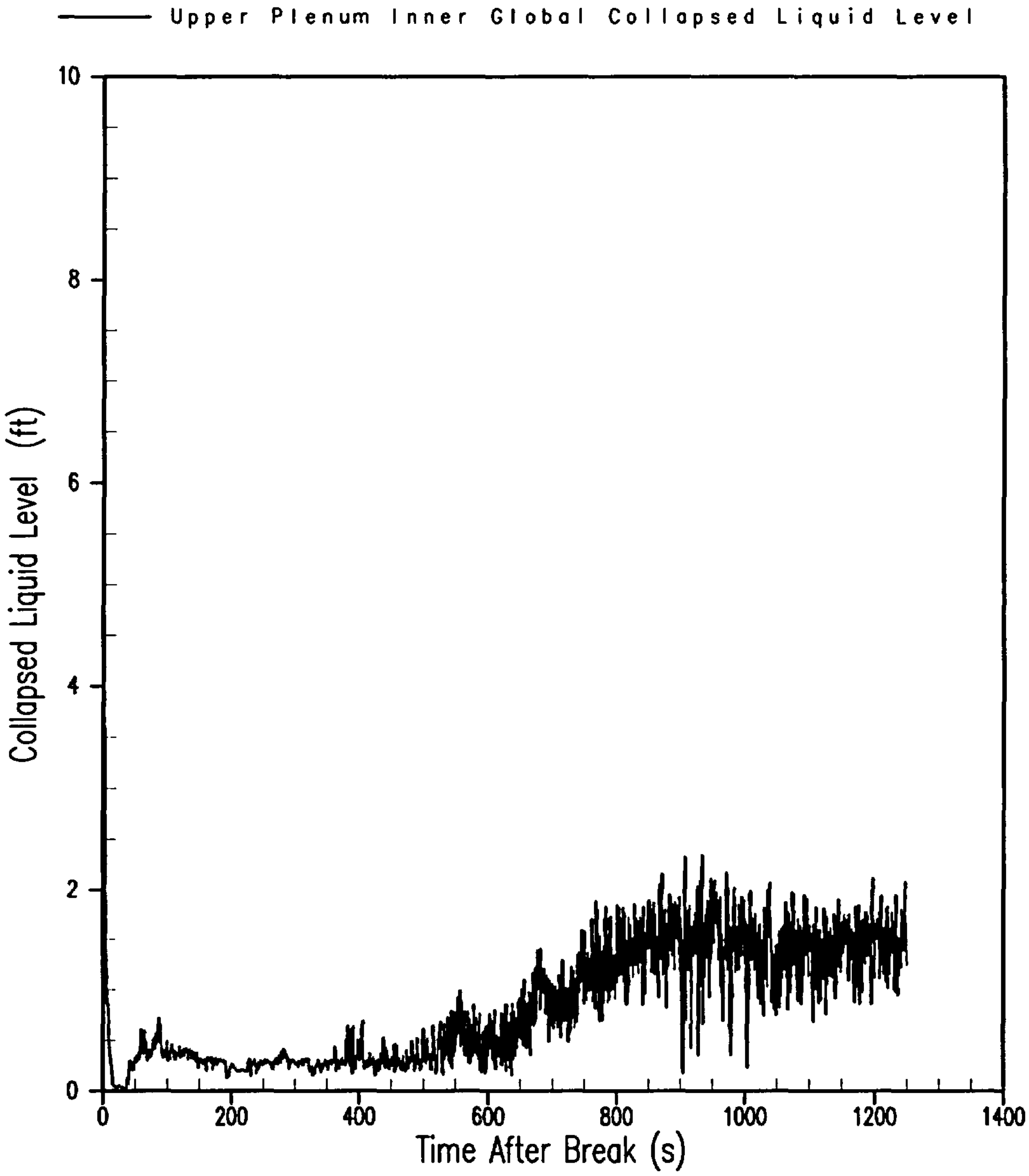


Figure 2.5 – Vessel Fluid Inventory