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Your ref: Docket No. 52-006
Our ref: DCP/NRC1669

January 14, 2004

SUBJECT: Transmittal of Responses to AP1000 DSER Open Items

This letter transmits the Westinghouse responses to Open Items in the AP1000 Design Safety Evaluation Report (DSER). A list of the DSER Open Item responses transmitted with this letter is Attachment 1. The proprietary responses are transmitted as Attachment 2. The non-proprietary responses are provided as Attachment 3 to this letter.

The Westinghouse Electric Company Copyright Notice, Proprietary Information Notice, Application for Withholding, and Affidavit are also enclosed with this submittal letter as Enclosure 1. Attachment 2 contains Westinghouse proprietary information consisting of trade secrets, commercial information or financial information which we consider privileged or confidential pursuant to 10 CFR 2.790. Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosures.

This material is for your internal use only and may be used for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Commission, the Office of Nuclear Reactor Regulation, the Office of Nuclear Regulatory Research and the necessary subcontractors that have signed a proprietary non-disclosure agreement with Westinghouse without the express written approval of Westinghouse.

D063

Correspondence with respect to the application for withholding should reference AW-04-1773, and should be addressed to James A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P.O. Box 355, Pittsburgh, Pennsylvania, 15230-0355.

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

Very truly yours,

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

/Enclosure

1. Westinghouse Electric Company Copyright Notice, Proprietary Information Notice, Application for Withholding, and Affidavit AW-04-1773.

/Attachments

1. List of the AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses transmitted with letter DCP/NRC1669
2. Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated January 14, 2004
3. Non-Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated January 14, 2004

DCP/NRC1669
Docket No. 52-006

January 14, 2004

Enclosure 1

Westinghouse Electric Company
Application for Withholding and Affidavit

Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

January 14, 2004

AW-04-1773

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Mr. John Segala

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: Transmittal of Westinghouse Proprietary Class 2 Documents Related to AP1000 Design Certification Review Draft Safety Evaluation Report (DSER) Open Item Response

Dear Mr. Segala:

The application for withholding is submitted by Westinghouse Electric Company, LLC ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject documents. In conformance with 10 CFR Section 2.790, Affidavit AW-04-1773 accompanies this application for withholding setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-04-1773 and should be addressed to the undersigned.

Very truly yours,

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

/Enclosures

AW-04-1773

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared James W. Winters, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company, LLC ("Westinghouse"), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief.

PATRICIA L. CROWN
COMMONWEALTH OF PENNSYLVANIA
NOTARY PUBLIC

James W. Winters, Manager
Passive Plant Projects & Development
Nuclear Power Plants Business Unit

Sworn to and subscribed
before me this 14th day
of January, 2004

Notarial Seal
Patricia L. Crown, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Feb. 7, 2005
Member, Pennsylvania Association of Notaries

Patricia L Crown
Notary Public

(1) I am Manager, Passive Plant Projects & Development, of the Westinghouse Electric Company LLC ("Westinghouse"), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company, LLC.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company, LLC in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in Attachment 2 as Proprietary Class 2 in the Westinghouse Electric Co., LLC document: (1) "AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Response."

This information is being transmitted by Westinghouse's letter and Application for Withholding Proprietary Information from Public Disclosure, being transmitted by Westinghouse Electric Company letter AW-04-1773 to the Document Control Desk, Attention: John Segala, CIPM/NRLPO, MS O-4D9A.

This information is part of that which will enable Westinghouse to:

(a) Provide documentation supporting determination of APP-GW-GL-700, "AP1000 Design Control Document," analysis on a plant specific basis

(b) Provide the applicable engineering evaluation which establishes the Tier 2 requirements as identified in APP-GW-GL-700.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for Licensing Documentation.

(b) Westinghouse can sell support and defense of AP1000 Design Certification.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar methodologies and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for performing and analyzing tests.

Further the deponent sayeth not.

January 14, 2004

Copyright Notice

The documents transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies for the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.790 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection not withstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond these necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

January 14, 2004

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

January 14, 2004

Attachment 1

List of

Proprietary and Non-Proprietary Responses

Table 1 **"List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1669"**	
15.2.7-1 Item 7 Response Revision 4 *Proprietary	*21.5-2P Item 28 Revision 3 21.5-2 Item 28 Revision 3

DCP/NRC1669
Docket No. 52-006

January 14, 2004

Attachment 3

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: 15.2.7-1 Item 7 Response Revision 4

Original RAI Number(s): None

Summary of Issue:

The revised DCD Section 15.6.5.4C (DSER OI 15.2.7-1P Page 14) states that the LTC phase analysis uses the NOTRUMP DEDVI case at 25 psia containment pressure reported in Section 15.6.5.4B as initial conditions, and the WGOTHIC analysis of this event as boundary conditions.

Please describe the model used to develop the containment backpressure and demonstrate that it represents a bounding and conservative estimate of containment pressure following a small break LOCA. Discuss any differences that may exist between this model and that used in the large break LOCA analyses. Please discuss how water spillage from a broken DVI line is mixed with the containment atmosphere and justify that the treatment is consistent with the Westinghouse ECCS evaluation model. Discuss the conservative treatment of non-safety related containment sprays and containment coolers in reducing containment pressure. Please also clarify if the 25 psia initial condition is consistent with the WGOTHIC analysis of the containment pressure as a function of time.

NRC Comment from 1/8/04 conference call:

2. Please explain why the containment pressure in the NRC case increases after 9000 seconds as shown in Figure A-1, and would containment pressure decrease in the long term.

Westinghouse Response (Revision 4):

Revision 4 of this response provides Westinghouse response to item 2 of NRC comments for this Open Item from the 1/8/04 conference call.

The switchover from IRWST injection to sump injection occurs at ~9000 seconds. This results in lower subcooling of the injection water and correspondingly higher steaming into containment. In the WGOTHIC NRC case this additional steaming is enough to cause a small rise in containment pressure. The pressure will decrease in the long term as decay heat decreases. This pressure rise is not seen in the WGOTHIC base case because the passive containment cooling is more effective at the higher pressure level of the base case.

Westinghouse Response (Revision 3):

Attachment B provides Westinghouse response to three items identified in the 12/17/03 Open Item status meeting.

Westinghouse Response (Revision 2):

As a result of the assessment of the Westinghouse AP1000 small-break WGOTHIC containment model by the NRC Containment and Accident Dose Assessment Section (Ref: "An Assessment of the Westinghouse AP1000 Small-Break LOCA WGOTHIC Containment Model for Minimum Containment Pressure and Lon-Term Cooling," USNRC, November 2003), Revision 2 of this response has been prepared. Attachment A summarizes the NRC assessment and provides the Westinghouse response.

Original and Revision 1 Response:

For AP600 and AP1000, two different WGOTHIC models were used to determine the containment backpressure that would exist following a LOCA event. Assumptions were used in these models to conservatively underpredict the pressure. These two models are discussed below.

Large Break LOCA Model for PCT Calculation

For this case, a simplified WGOTHIC model of the containment was developed to determine the containment pressure response during the blowdown portion of a double-ended cold leg break. This model consists of a single control volume that represents the containment, all the heat sinks inside containment, and a simplified thermal conductor representing the containment shell that is connected from the containment control volume to a control volume that represents the environment. The boundary conditions for this model are specified in Reference 1. The outside temperature of the shell is held at a constant temperature of 0F. The heat transfer coefficient inside containment consists of the Tagami correlation for the blowdown portion of the transient (first 29 seconds), and the Uchida condensation correlation for the time following blowdown. These heat transfer coefficients are applied on all the internal heat sinks as well as the inside of the containment shell. As specified in Reference 1, the Tagami correlation is multiplied by a factor of four, and the Uchida correlation is multiplied by a factor of 1.2.

Small Break LOCA Model to Determine Containment Backpressure

A second WGOTHIC model was used to determine the AP600 and AP1000 containment backpressure after a small break LOCA event. These results were used as the boundary conditions for small break LOCA NOTRUMP analyses and WCOBRA/TRAC long term cooling analyses. The model is the same as the evaluation model used to determine the peak containment pressure for the DCD with assumptions changed to minimize the pressure response. For AP600, this model was used to support the long term cooling analysis, but was not used for the small break LOCA backpressure. For AP1000, this model was used to support the long term cooling analysis as well as the double-ended DVI (DEDVI) break analysis.

This model is described in Reference 2 which was submitted to the NRC and reviewed as part of AP600 Design Certification. As specified in Reference 2, the following changes to the DCD WGOTHIC model were made for this analysis:

a) The DCD model is biased to maximize containment pressure. These assumptions were changed for the backpressure analysis to minimize containment pressure.

- Heat transfer coefficient multipliers which are set to values less than unity for the peak pressure analysis are set to unity for the backpressure analysis
- Heat sinks that are conservatively neglected for the peak pressure analysis are included for the backpressure analysis
- Initial conditions inside containment that are biased to the highest operating pressure and temperature are set to the lowest operating pressure and temperature. Relative humidity is set to 100% to minimize the initial air inventory inside containment. Environmental boundary conditions are biased to maximize heat transfer from the passive containment cooling system and minimize the containment pressure.
- The containment vent system is assumed to be open at the start of the event and closes on an SI signal. This allows an initial decrease in the air inventory which results in a lower containment pressure

b) Mass and energy release rates that are specific for the double-ended DVI break are included in the WGOTHIC model.

- Water spilling from the broken DVI is assumed to enter the PXS compartment containing the break. This water does not interact with the containment atmosphere as it falls from the break.

Non-safety systems such as containment fan coolers and containment sprays are not considered for this analysis. The containment spray system is only used in the event of severe accidents. Its use requires the operator to align the pumps and water sources for operation (requires an operator to open manual valves out in the plant). The chilled water supply to the fan coolers is automatically isolated following an SI signal. The system can be restarted by the operator to assist in long-term recovery following a LOCA, and it is not considered in this shorter-term analysis.

Two sensitivity studies were done to determine the effect of these assumptions.

Cold Water Spill Sensitivity

The DEDVI break consists of two break flow paths; one from the vessel side, and one from the loop side. The vessel side break is a typical high-temperature, high-pressure two-phase blowdown. This two-phase flow is assumed to form droplets that are dispersed into the atmosphere of the break compartment. The recommended drop size is 100 microns. The loop side break flow consists of low-temperature (~80F), high-pressure single phase water. Normally, this water is spilled to the floor of the compartment and is not assumed to interact with the vapor-space region of the compartment. For this sensitivity study, the loop side break flow is assumed to be dispersed into the atmosphere of the break compartment.

Figure 1 shows the containment pressure response for the two cases. By allowing the cold water to interact with the steam and two-phase mixture in the compartment vapor space, the overall pressure is reduced by approximately 2 psi. The pressure remains above 25 psia between the time that the ADS4 flow becomes non-critical and the time of IRWST injection. The interaction between the steam and the water droplets in the compartment causes steam to condense resulting in less steam to pressurize the containment. In addition, the water droplets are heated so that the water accumulating on the compartment floor is saturated.

Heat Transfer Coefficient Sensitivity

The Tagami correlation is not considered appropriate for use in small break LOCA analysis. This correlation was developed to account for significant forced convection heat transfer that takes place during the blowdown period of a large break LOCA. This time period is about 30 seconds. For the DEDVI, the "blowdown" period extends to about 500 seconds during which an equivalent amount of energy is released from the RCS to the containment atmosphere as occurs for the large break LOCA. Since the forced convection in containment depends on a characteristic velocity, the velocities inside containment during the blowdown period can be compared for the two events by comparing the blowdown time. Thus, it is likely that the velocities would be at least a factor of ten lower for the DEDVI than for the DECL during the blowdown, and since the forced convection heat transfer coefficient is roughly proportional to the velocity, use of Tagami during a small break LOCA blowdown would significantly overpredict the forced convection heat transfer. The Uchida correlation is recommended for these analyses.

As a sensitivity, the multiplier on the Uchida correlation was increased to 4.0 during the blowdown period (<500 seconds). Figure 2 shows the containment pressure response with and without this multiplier assuming mixing of the cold water spill as described above. These results show little sensitivity to the increased heat transfer coefficient.

The results of these sensitivity studies show that the containment backpressure boundary condition of 25 psia is valid for use in the DEDVI small break LOCA analysis.

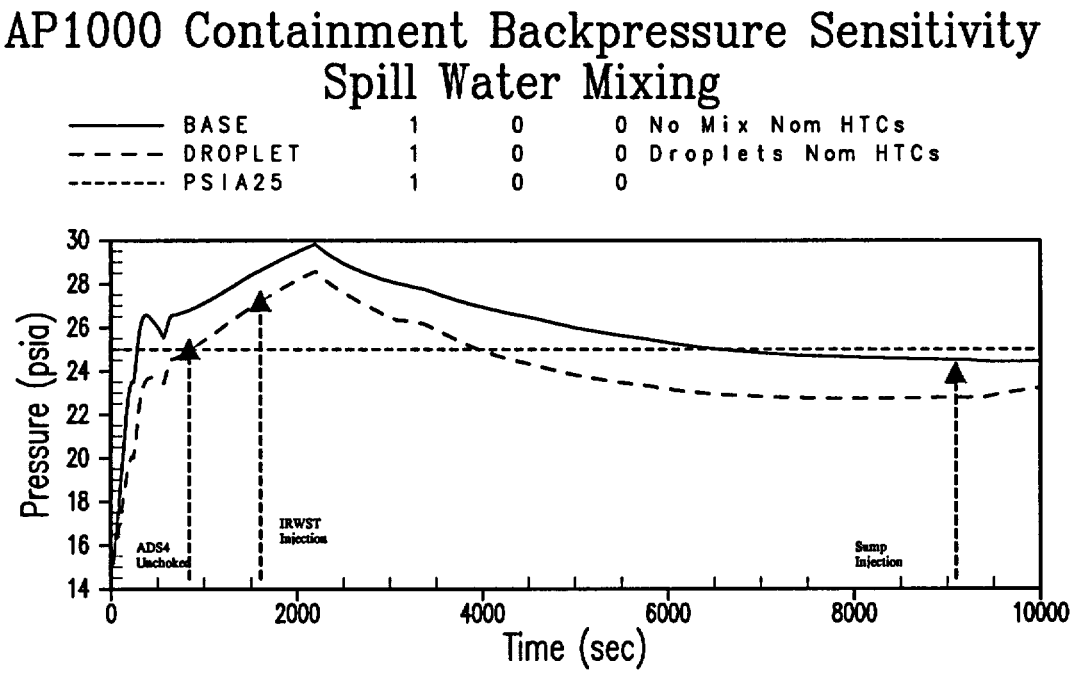


Figure 1: Cold Water Droplet Size Sensitivity

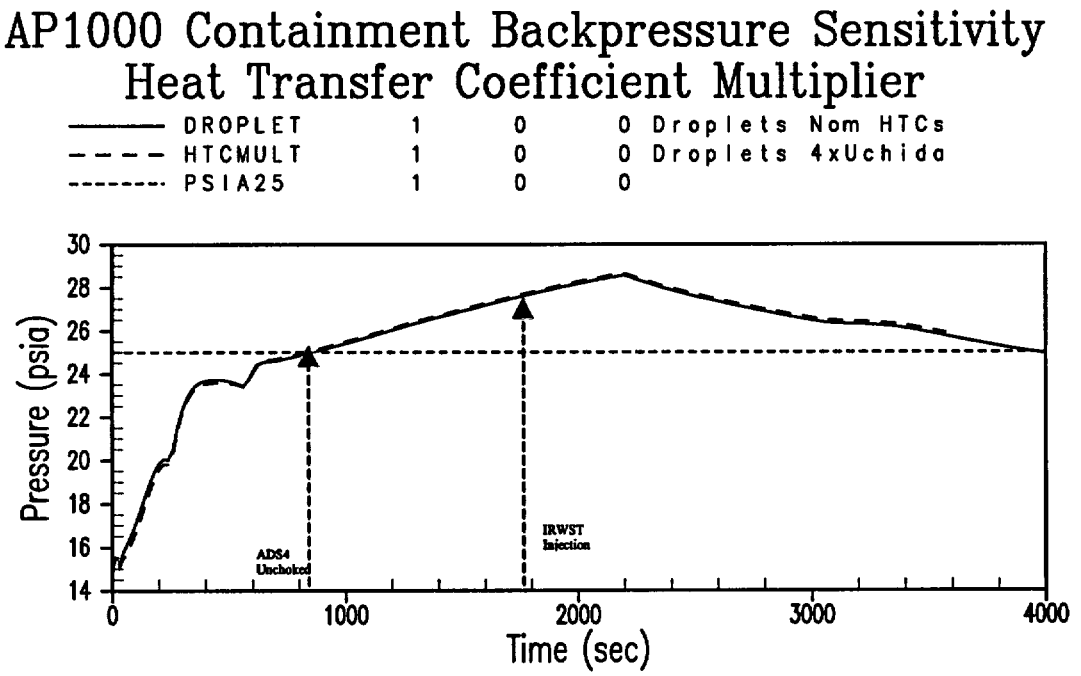


Figure 2: Heat Transfer Multiplier Sensitivity

References

1. WCAP-14171, Rev 2, WCOBRA/TRAC Applicability to AP600 Large Break LOCA March 1998.

2. WCAP-14601, Rev 2, AP600 Accident Analysis Evaluation Models, May 1998.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Attachment A

Summary of NRC Assesment

Bounding Containment Backpressure for AP1000 Long-Term Cooling

The NRC staff asked for a description of the model used to develop the containment backpressure for small-break LOCA and long-term cooling (DSER Open Item 15.2.7-1 Item 7 [Ref 1]). In addition, the staff asked for a discussion of the differences between this model and the model used for minimum pressure following a large-break LOCA. Specifically, the staff asked Westinghouse to discuss how cold water spilled from the broken DVI line interacts with the containment atmosphere, and to discuss the role of non-safety equipment such as fan coolers and containment sprays for these analyses.

The Westinghouse response to this open item is summarized as follows:

1. The WGOTHIC model for small-break LOCA backpressure and long-term cooling is consistent with the methodology in WCAP-14601, "AP600 Accident Analyses – Evaluation Models," Rev 2 (Ref 2).

2. The use of the Tagami correlation is not appropriate for small-break LOCA analyses.

3. Heat sinks that are removed for the peak pressure calculation are included in the small-break LOCA backpressure and long-term cooling calculation

4. Non-safety fan coolers and containment sprays require specific post-accident operator action and would not be available during the time frame prior to sump recirculation switchover.

5. The cold water spill was introduced to the containment atmosphere as a fine mist (100-micron drops) and the resulting containment pressure was reduced by approximately 2 psi.

The Westinghouse response to the Open Item was referred to the Containment and Accident Dose Assessment Section for further review. The NRC staff prepared an assessment of the AP1000 Small-Break LOCA WGOTHIC Containment Model for Minimum Containment Pressure and Long-Term Cooling (Ref. 3). The assessment concluded the following:

1. The AP1000 small-break LOCA and long-term cooling minimum containment pressure methodology is consistent with WCAP-14601, "AP600 Accident Analyses – Evaluation Models," (Ref. 4). Key assumptions for this analysis are summarized below:

   - the containment volume is 1.05 times the best estimate value

- the initial containment temperature is 120F
- the passive heat sink areas are 1.05 times the best estimate values
- the PCS water flow is set to the maximum value and water coverage is set to the maximum value
- no penalties are applied to the PCS heat and mass transfer correlations

2. The AP1000 small-break LOCA and long-term cooling minimum containment pressure methodology differs from the methodology used to determine the minimum pressure for large-break LOCA as described in the AP600 and AP1000 Tier 2 DCD Section 6.2.1.5 (Ref. 5). These differences are summarized below:

   - the containment volume is 1.1 times the reference value
   - the passive heat sink surface areas are 2.1 times their reference values
   - the material properties are biased high
   - the air annulus and containment shell temperatures are assumed to be held at a constant 0F
   - the containment purge is operated at time zero and closes 12 seconds after the pressure setpoint of 8 psig is reached
   - the initial containment pressure and temperature are set to their low values (14.7 psia, 90F) consistent with SRP 6.2.1.5
   - the containment relative humidity is set to 99%
   - the Tagami correlation with a multiplier of 4.0 is used for the blowdown

3. The staff concluded that use of the Tagami correlation was not justified for small-break LOCA. It was recommended that the Uchida correlation with a 1.2 multiplier be used.

4. It is the staff's recommendation that the WGOTHIC small-break LOCA and long-term cooling model be modified to include the most conservative assumptions from the WGOTHIC minimum pressure for large-break LOCA model. Specifically,

   a. The containment net volume should be increased by a factor of 1.1
   b. The containment shell and PCS heat structure area should be increased by a factor of 1.1
   c. The remaining head structure areas should be increased by a factor of 2.1 or a lower value if justified based on an accounting of expected structures in the final as-build plant.
   d. The Uchida correlation with a multiplier of 1.2 should be used for passive heat structures (non PCS structures throughout the accident.
   e. The PCS heat and mass transfer correlation multipliers should be appropriately biased to account for the uncertainty in the experimental data base, and forced convection should be included on the PCS inner surface
   f. Head transfer in dead-ended compartments below the operating deck should not be turned off at the end of blowdown.

g. The air-gap between the steel and the concrete should be reduced from the 20-mill thickness used in the maximum pressure calculation. A zero thickness air-gap would be conservative.
h. The material properties should be biased high for conservatism.
i. Heat transfer credit for the PCS should start earlier than is currently assumed for the maximum pressure calculation.
j. Westinghouse should maintain its treatment of ECCS spillage as implemented in 1979.
k. The containment purge system should be assumed to be operating and isolate on high pressure signal
l. The initial and boundary conditions for the PCS water and environment should be provided with their justification for staff review.

Westinghouse response:

The NRC recommendations listed above were incorporated into the WGOTHIC small-break LOCA and long-term cooling model, and the pressure response to a double-ended DVI break LOCA is shown in Figure A-1 as the NRC case. Also shown as the base case is the pressure using the assumptions from the approved methodology in Reference 2.

The following are Westinghouse comments regarding the recommendations of the staff assessment and discussion of the parameters used in the WGOTHIC analyses for Figure A-1:

a. The main parameters of the volume enclosed by the containment shell are established by an ITAAC that requires the dimension of the shell inside diameter and height above the operating deck. Major structures and components inside containment are also identified in ITAAC. Uncertainties associated with the volume of the structures and equipment inside containment will result in a small uncertainty in the net free volume. The base case uses a multiplier of 1.05 to conservatively account for this uncertainty. The NRC case uses a multiplier of 1.1.

b. The containment shell dimensions (shell inside diameter and height above the operating deck) are established by ITAAC. Also the water film on the external surface of the containment shell is assumed to distribute evenly around the entire circumference of the containment shell to maximize the effectiveness of the PCS heat transfer area. The base case uses a factor of 1.05 on PCS heat transfer area to conservatively account for any residual uncertainty in PCS heat transfer area. The NRC case uses a factor of 1.1 for this uncertainty.

c. The methodology for the WGOTHIC small-break LOCA and long-term cooling containment backpressure was approved for AP600 in Reference 2. The WGOTHIC model for minimum backpressure for large-break LOCA was completed before the passive heat sink information was finalized. Consequently, the passive heat sink area multiplier in the approved methodology, 1.05, was

doubled to account for this uncertainty to 2.1. Since the results were within acceptable margins, there was no need to repeat the analysis as the design matured and the passive heat sinks were better defined. This large overconservatism was noted by the staff during review of AP600. The base case in Figure A-1 uses a 1.05 multiplier on heat sinks. The NRC case uses a 2.1 multiplier on heat sinks.

d. As was noted in Reference 3, the use of the Tagami correlation is not appropriate for small-break LOCA. For the base case analysis the Uchida correlation is used with a 1.2 multiplier during blowdown and 1.0 multiplier after blowdown. For the NRC case the Uchida correlation is used with a 1.2 multiplier throughout the accident simulation.

e. The base case uses multipliers of 1.0 on the PCS heat and mass transfer correlations. For the NRC case these multipliers were 1.19 and 1.37. Since WGOTHIC is being used in the lumped-parameter mode, the gas velocity is not known in the cells adjacent to the shell. Considering that velocities will be small for small-break LOCA events, forced convection is not modeled for either case.

f. For both cases heat transfer in the dead-ended compartments was not turned off at the end of blowdown as recommended.

g. The base case includes the air gap thickness. The air-gap thickness was eliminated for the NRC case.

h. The material properties for steel, concrete and air were set to nominal values in the base case. For the NRC case, the properties were biased to maximize heat absorption.

i. The PCS startup time was accounted for in the base case. The PCS was started at full flow at the start of the transient for the NRC case.

j. The base case treats ECCS spillage as liquid flowing to the containment sump without interaction with containment atmosphere. Consistent with the Revision 1 of this Open Item response, for the NRC case the ECCS spillage is treated as a mist with a droplet size of 100 microns to maximize the heat transfer with the containment atmosphere.

k. For both cases the containment purge system is assumed to open and isolates on a high containment pressure signal.

l. For both cases the initial temperature (120F) and the initial humidity (100%) inside containment are biased high to minimize the amount of non-condensable gas at the start of the transient. For both cases the initial temperature and PCS temperature outside containment are biased low (40F) to maximize heat removal from the containment shell.

The NOTRUMP small-break LOCA response, and the WCOBRA/TRAC long term cooling response will be re-analyzed using the NRC case for the AP1000 DEDVI break. The results will be submitted in another revision to this response.

References

1. DSER Open Item 15.2.7-1 Item 7 Revision 1

2. WCAP-14601, "AP600 Accident Analyses – Evaluation Models," Rev 2

3. Assessment of the AP1000 Small-Break LOCA WGOTHIC Containment Model for Minimum Containment Pressure and Long-Term Cooling, E. Throm, USNRC, December 2003.

4. WCAP-14601, "AP600 Accident Analyses – Evaluation Models"

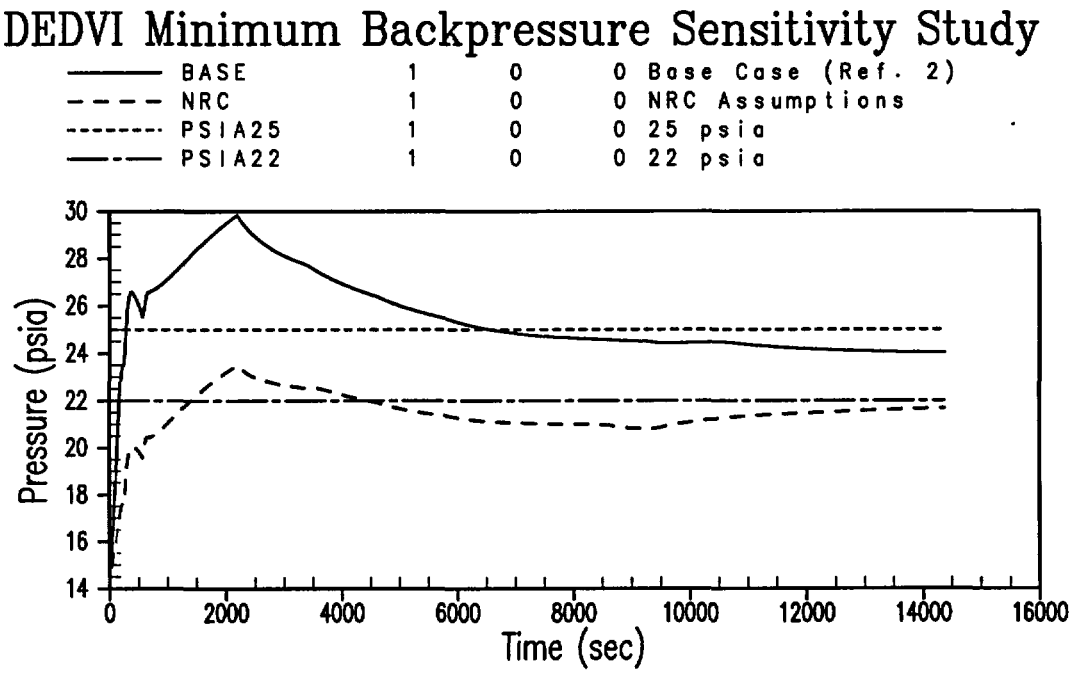


Figure A-1: AP1000 Containment Backpressure Sensitivity

Attachment B

NRC Comments from 12/17/03 Open Item status meeting:

a) Provide complete graphs of minimum containment pressure, minimum containment water level and minimum water temperature as a function of time for 30 days.

The staff calculations show that the ability to cool the core is highly dependant on containment pressure, containment water level, and sump temperature. Westinghouse has provided us with containment pressure only for the first 10000 seconds and then at 14 days and 28.5 days, and the containment water level only at 2.6 hours, 14 days and 28.5 days.

b) Address inadvertent containment spray either from equipment failure or operator error during the 30 day period. Of particular concern is a sufficiently reduced containment pressure that increases the ADS-4 resistance and depresses the two-phase level into the vessel. If the vessel two-phase level is depressed below the top of the hot legs, liquid flow out the ADS-4 valves will decrease causing the boric acid to begin accumulating in the vessel.

c) When the containment pressure issue is settled, Westinghouse needs to redo long term cooling analyzes including those for the PRA using acceptable models.

Westinghouse Response to NRC Comments:

a) An additional bounding WGOTHIC analysis has been performed with NRC assumptions (see Attachment A of this response) and assuming that plant operators re-start the non-safety related containment fan coolers at 10 minutes. The WGOTHIC analysis was extended to 14 and 30 day conditions. The table below provides the resulting containment pressure, sump and PXS compartment water temperatures, and sump level out to thirty days.

Time (days)	Pressure (psia)	Sump Temperature (F)	PXS Compartment Temperature (F)	Sump Level (ft) Grade = 100 ft
0	14.7	N/A	N/A	N/A
0.025 (peak pressure)	22.0	N/A	N/A	N/A
0.104 (beginning of recirculation)	19.0	192	150	108.1
0.5*	17.5	192	158	107.9
1.0*	17.0	193	166	107.7
5.0*	16.1	195	176	105.5
7.0*	16.0	196	178	104.7
14.0	15.7	196	182	103.5
30.0	15.4	196	187	103.5
*Values at these times are estimated by hand calculations.				

b) The containment spray capability in AP1000 is non-safety related and would not be used following an accident unless there were clear indications that a severe accident had occurred, at which point core cooling has already been lost.

The non-safety related containment fan coolers used in normal operation are isolated upon a containment isolation signal. The bounding WGOTHIC analysis reported in item a) above has been performed assuming that fan coolers operate after 10 minutes.

c) A NOTRUMP analysis for the DEDVI case using 22 psia containment pressure has been performed, consistent with the WGOTHIC case in Attachment A with NRC assumptions. Table 1 and Figures 1 to 20 provide the results of this NOTRUMP analysis. The AP1000 DCD will be revised to replace the existing DEDVI 25 psia case with the DEDVI 22 psia case shown here. In AP1000 DCD Revision 3 a NOTRUMP case was presented with a containment pressure of 14.7 psia. This analysis is still a valid analysis for the AP1000 and the AP1000 DCD will be revised to re-insert this case.

A WCOBRA/TRAC long term cooling analysis has been performed assuming a containment pressure of 14.7 psia to show that successful long term core cooling is not dependent on elevated containment pressure. The limiting DCD case of a DEDVI break located in the PXS "B" room has been analyzed in the window mode at the most severe time, the time of switchover to containment recirculation. The results of this analysis are given in Figures WCT-1 to WCT-14. Following the problem restart at 6500 seconds, the initial 700 second portion of the WCOBRA/TRAC window establishes the quasi-steady state cooling condition associated with the 14.7 psia containment pressure. Once the 14.7

psia containment boundary pressure quasi-steady state condition is established at 7200 seconds, the window is executed for 2400 seconds to demonstrate adequate ECCS performance. The AP1000 DCD will be revised to add this WCOBRA/TRAC analysis.

Overall Assessment

Westinghouse has performed a considerable effort to evaluate and defend the analysis of minimum possible containment pressure versus time. While containment backpressure provides a positive impact on SBLOCA, ECCS performance analysis performed at a containment pressure of 14.7 psia with NOTRUMP for the short term performance and with WCOBRA/TRAC for the long term cooling show acceptable performance with the containment at atmospheric pressure.

Table-1 DEDVI 22.0 PSI Containment Pressure

Event	Time
Break opens	0.0
Reactor trip signal	13.1
Steam turbine stop valves close	19.1
"S" signal	18.5
Main feed isolation valves begin to close	20.5
Reactor coolant pumps start to coast down	24.5
ADS Stage 1	182.4
ADS Stage 2	252.4
Intact accumulator injection starts	254
ADS Stage 3	372.4
ADS Stage 4	492.4
Intact accumulator empties	600.0
Intact loop IRWST injection starts*	1440
Intact loop core makeup tank empties	2230

Note:
*Continuous injection period

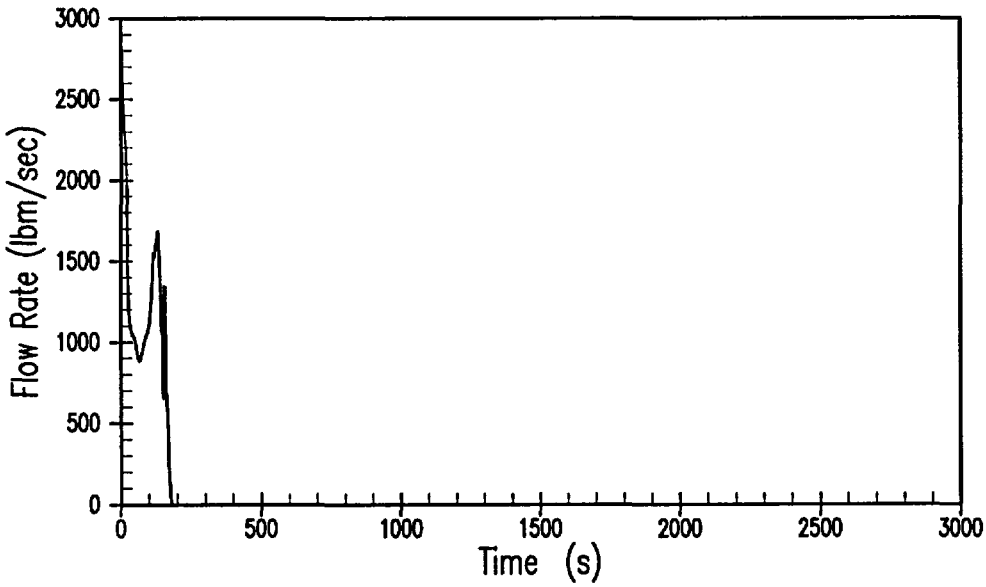


Figure-1 DEDVI 22.0 PSI – Vessel Side Liquid Break Discharge

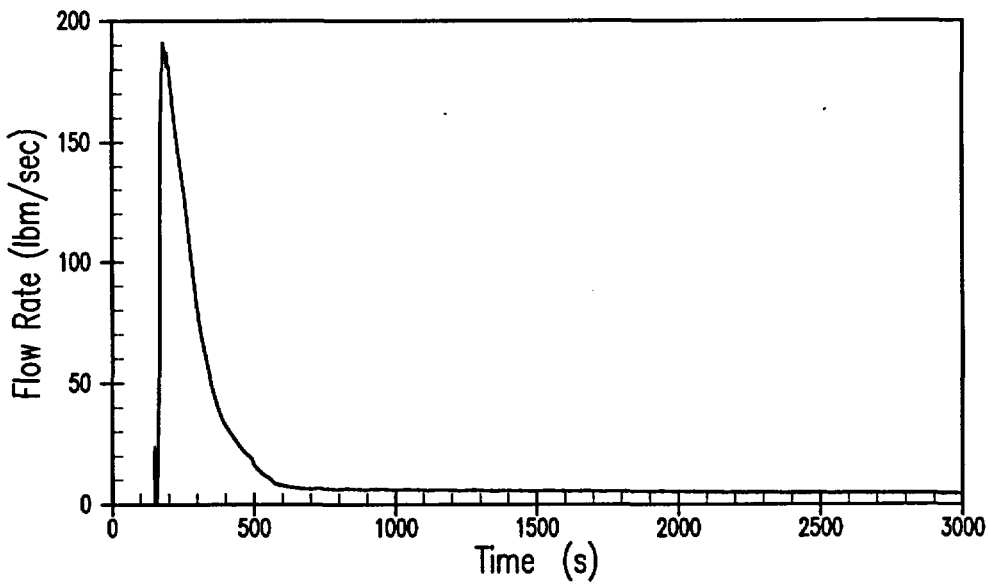


Figure-2 DEDVI 22.0 PSI – Vessel Side Vapor Break Discharge

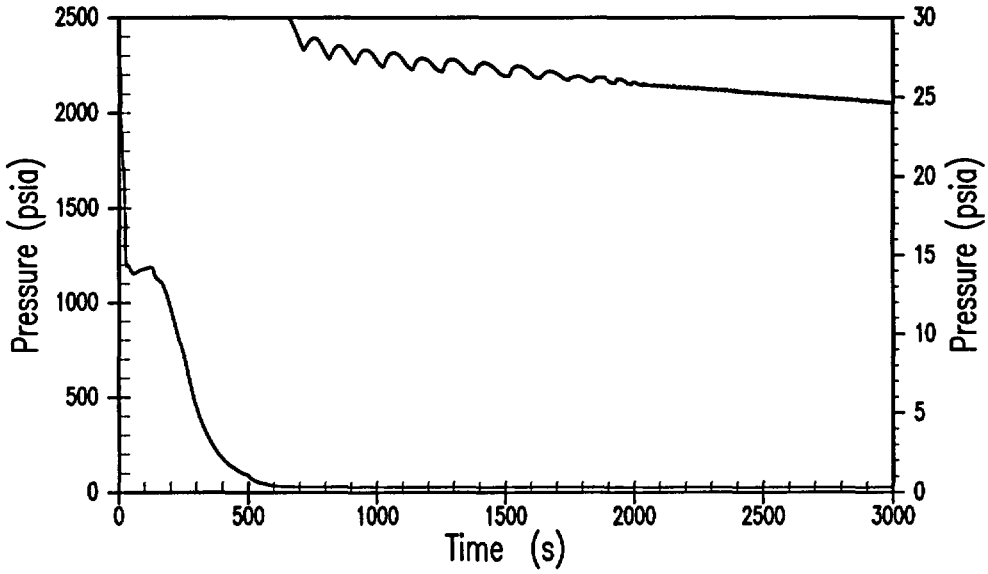


Figure-3 DEDVI 22.0 PSI – RCS Pressure

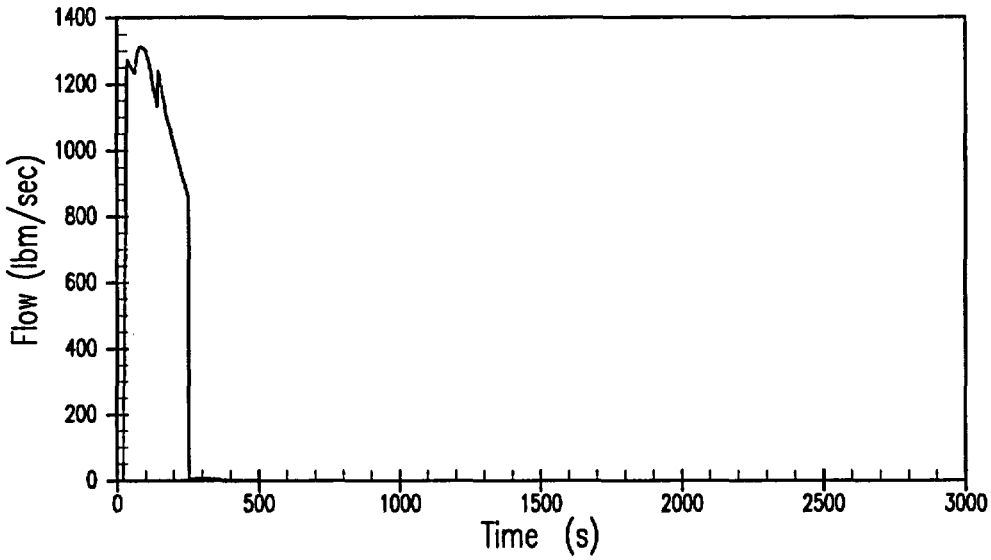


Figure-4 DEDVI 22.0 PSI – Broken CMT Injection Rate

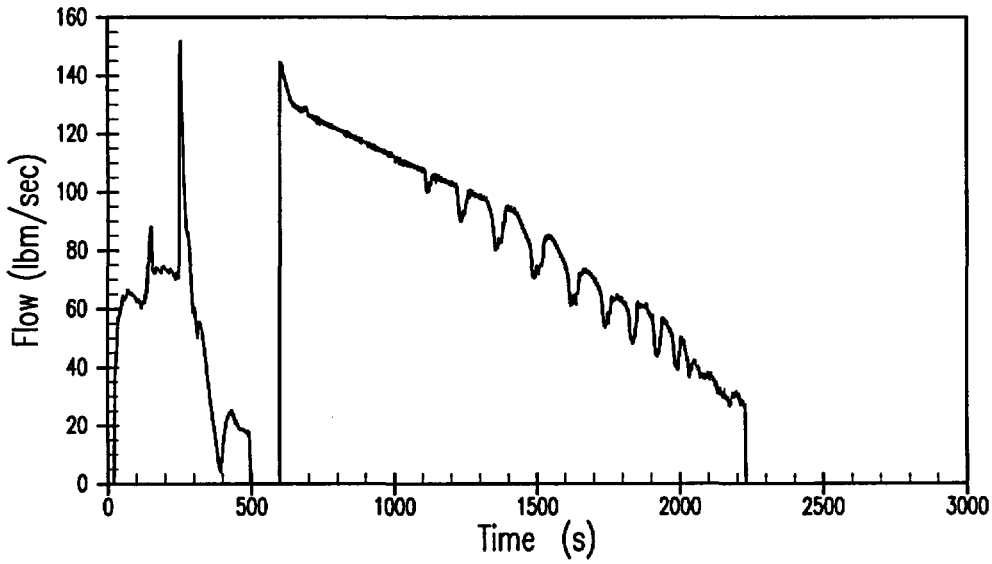


Figure-5 DEDVI 22.0 PSI – Intact CMT Injection Rate

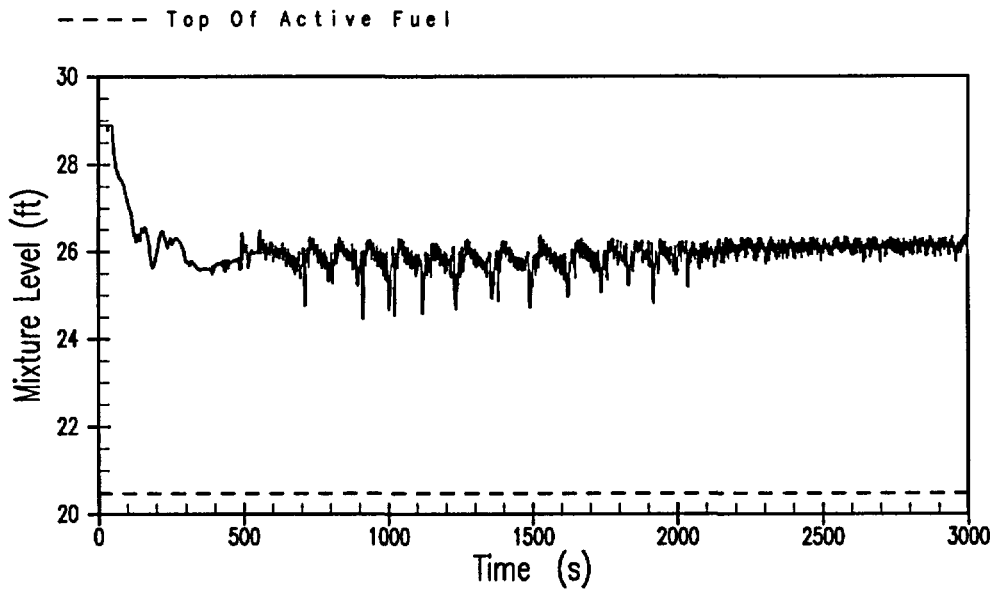


Figure-6 DEDVI 22.0 PSI – Core/Upper Plenum Mixture Level

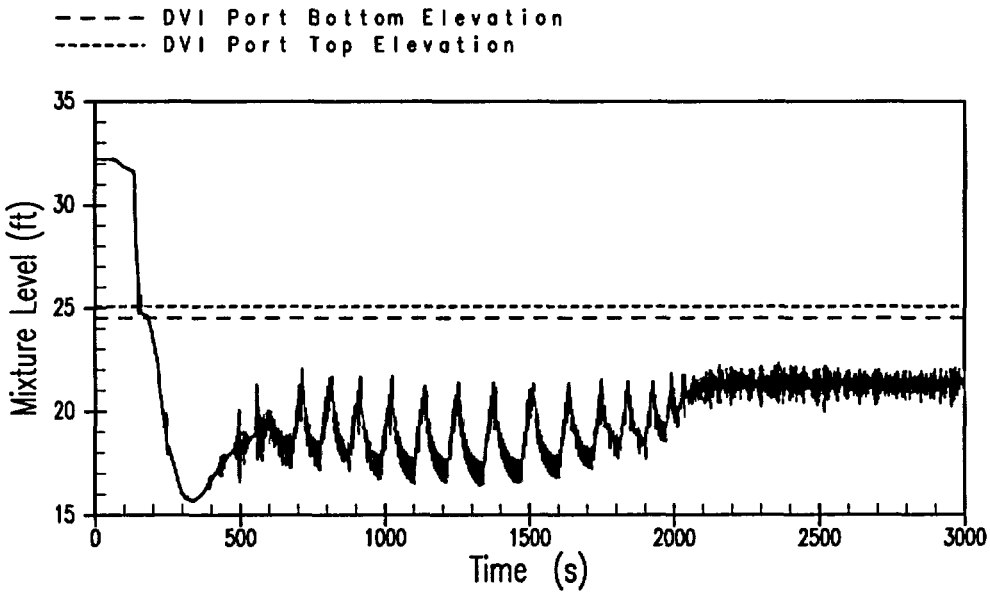


Figure-7 DEDVI 22.0 PSI – Downcomer Mixture Level

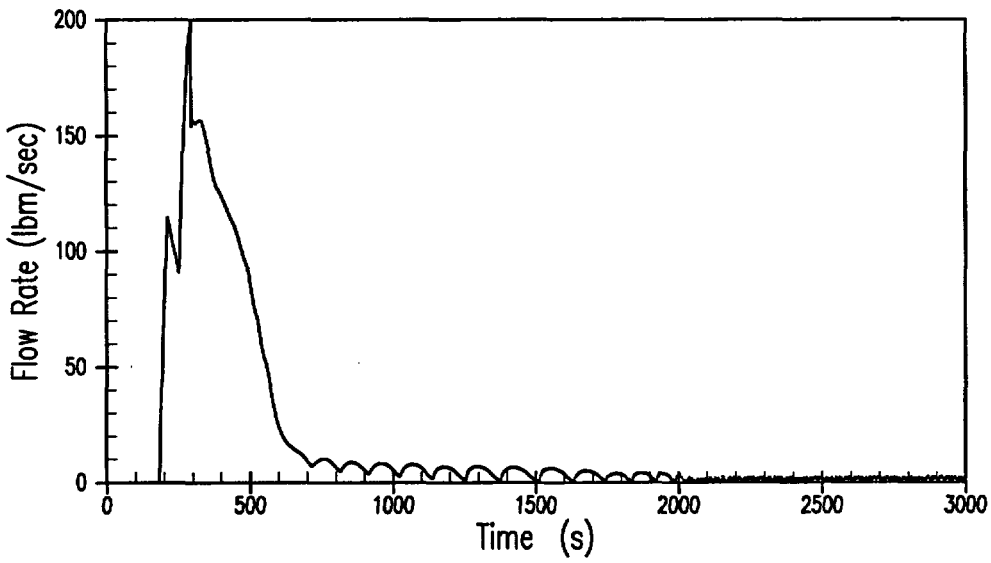


Figure-8 DEDVI 22.0 PSI – ADS 1-3 Vapor Discharge

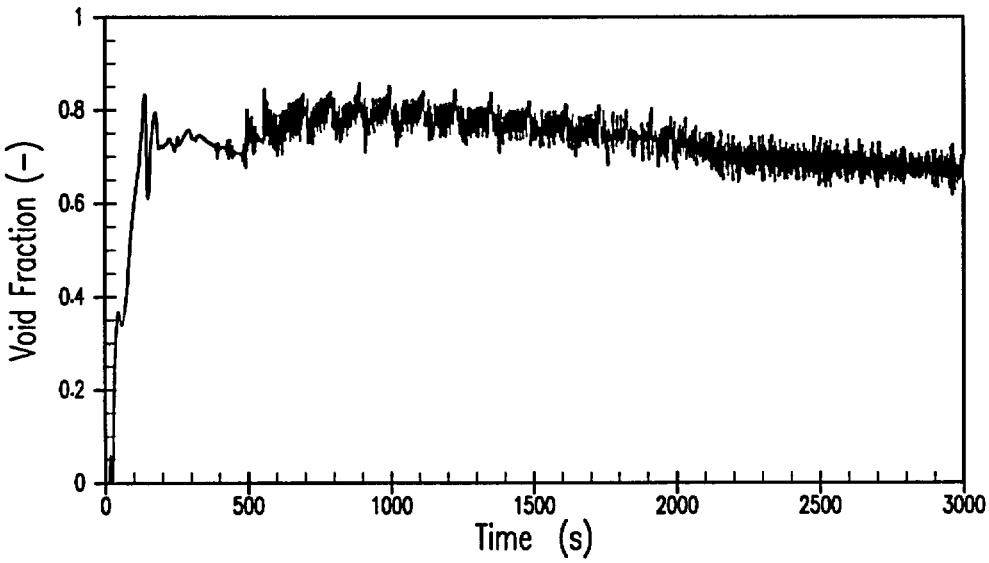


Figure-9 DEDVI 22.0 PSI – Core Exit Void Fraction

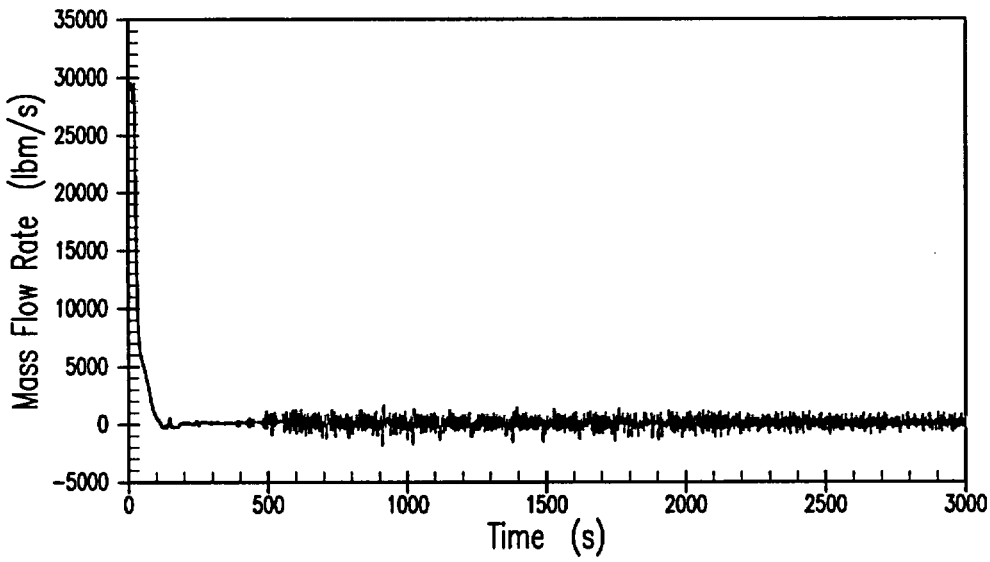


Figure-10 DEDVI 22.0 PSI – Core Exit Liquid Flow Rate

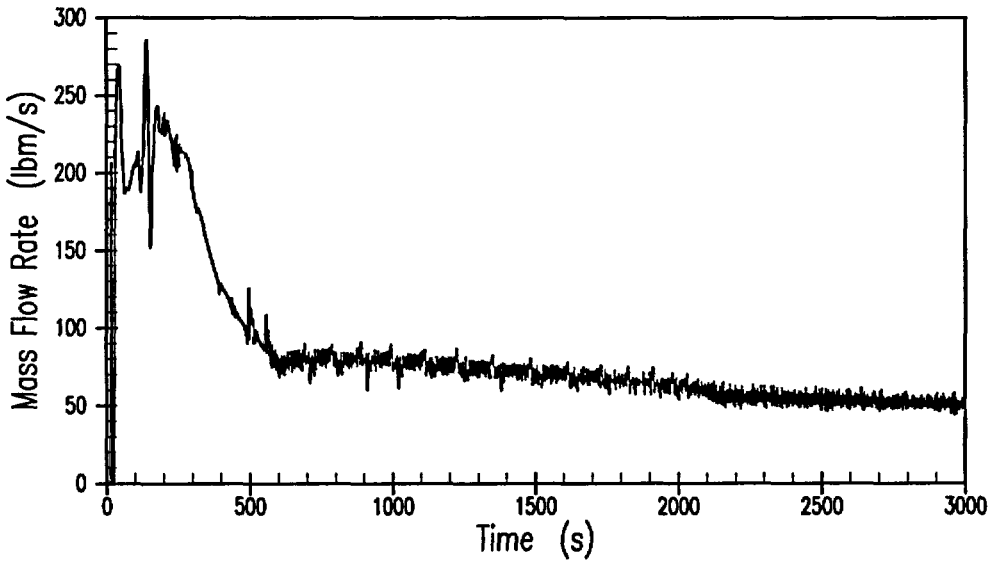


Figure-11 DEDVI 22.0 PSI – Core Exit Vapor Flow Rate

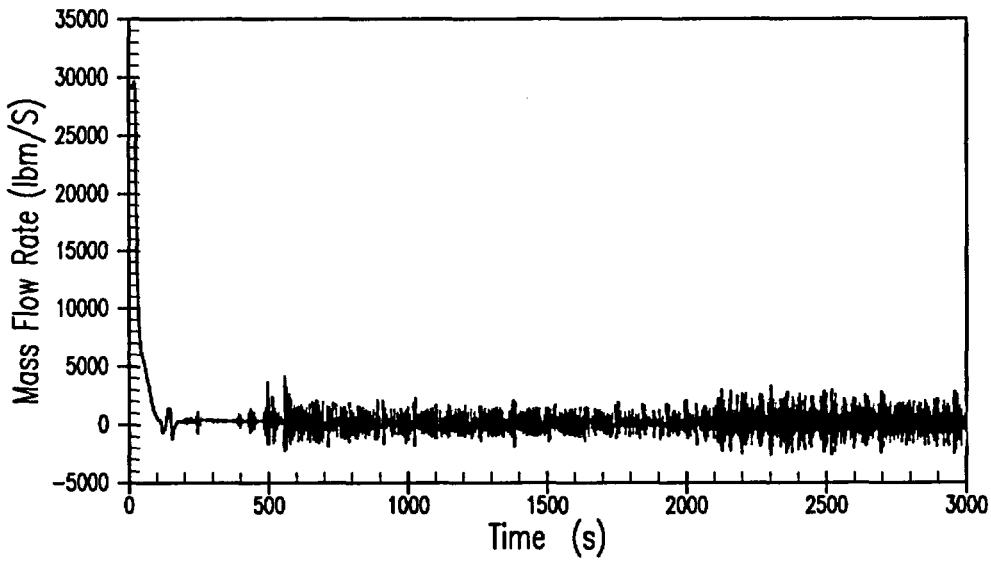


Figure-12 DEDVI 22.0 PSI – Lower Plenum to Core Flow Rate

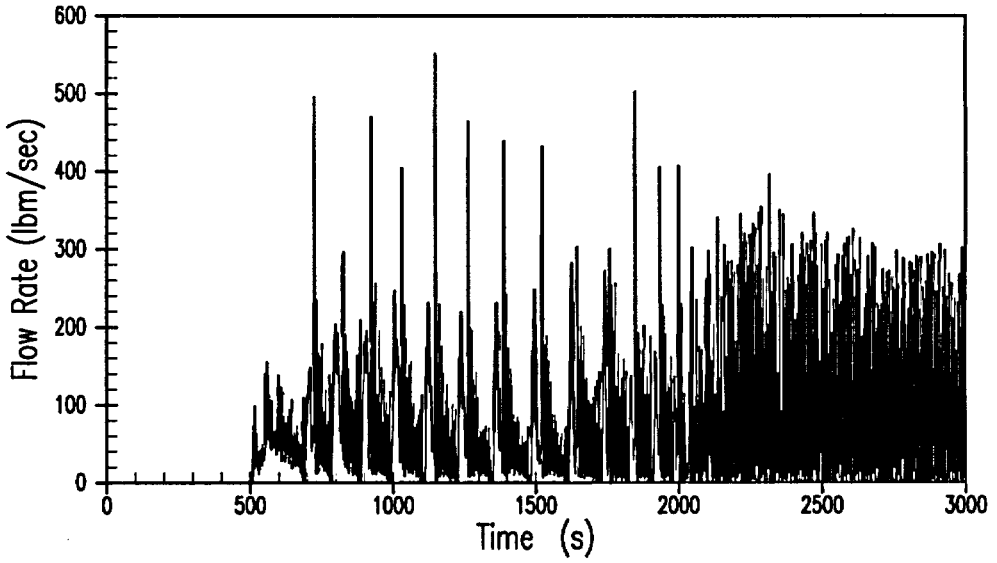


Figure-13 DEDVI 22.0 PSI – ADS-4 Liquid Discharge

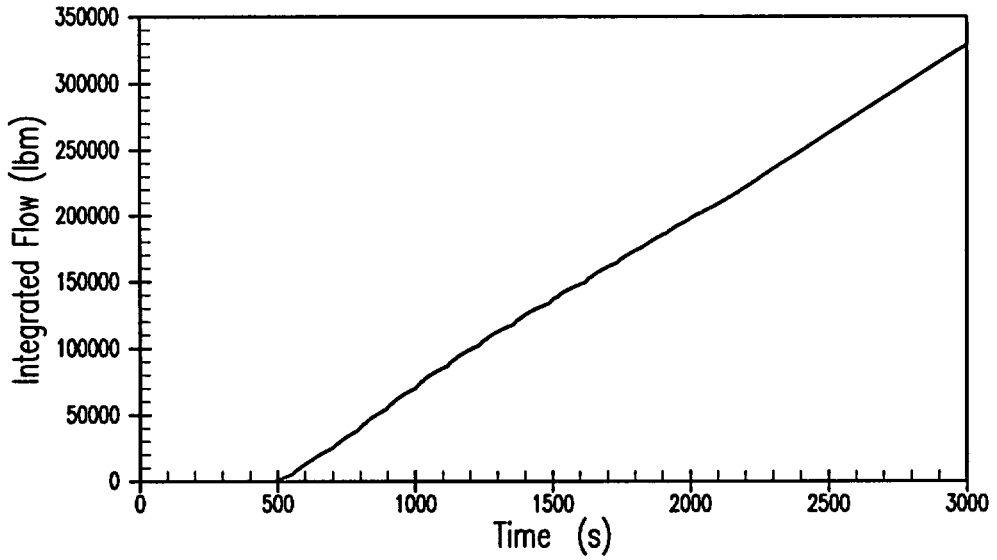


Figure-14 DEDVI 22.0 PSI – ADS-4 Integrated Discharge

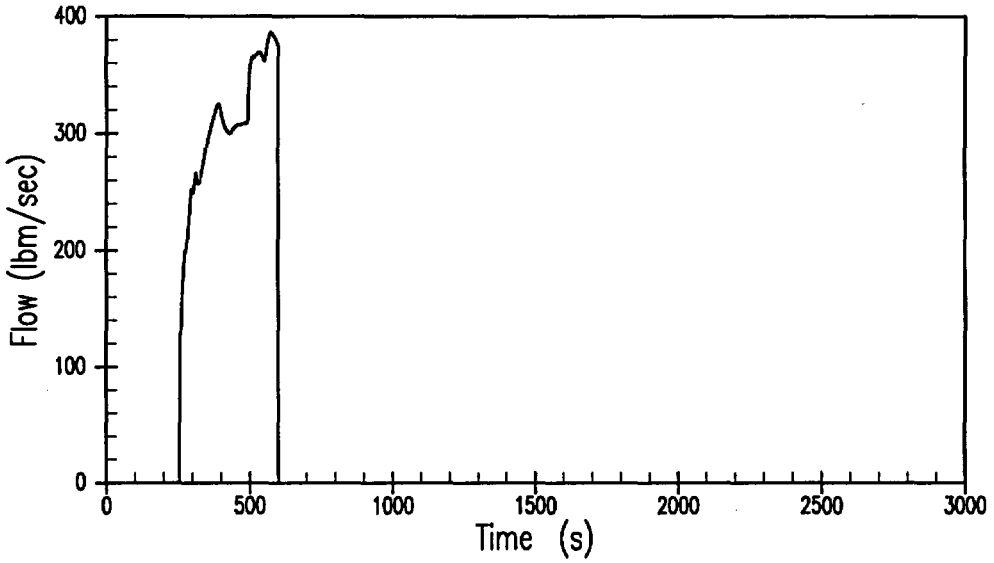


Figure-15 DEDVI 22.0 PSI – Intact Accumulator Flow Rate

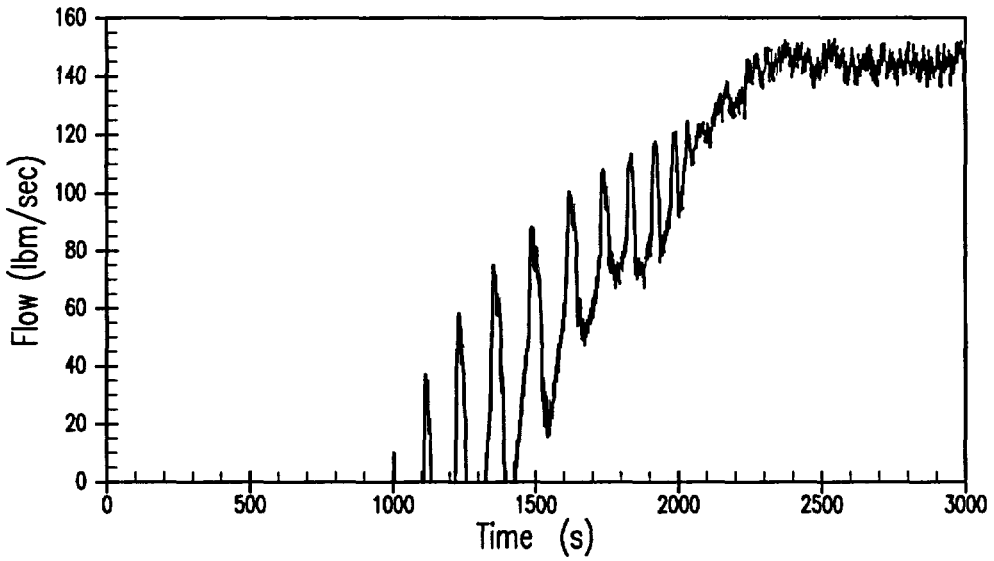


Figure-16 DEDVI 22.0 PSI – Intact IRWST Injection Rate

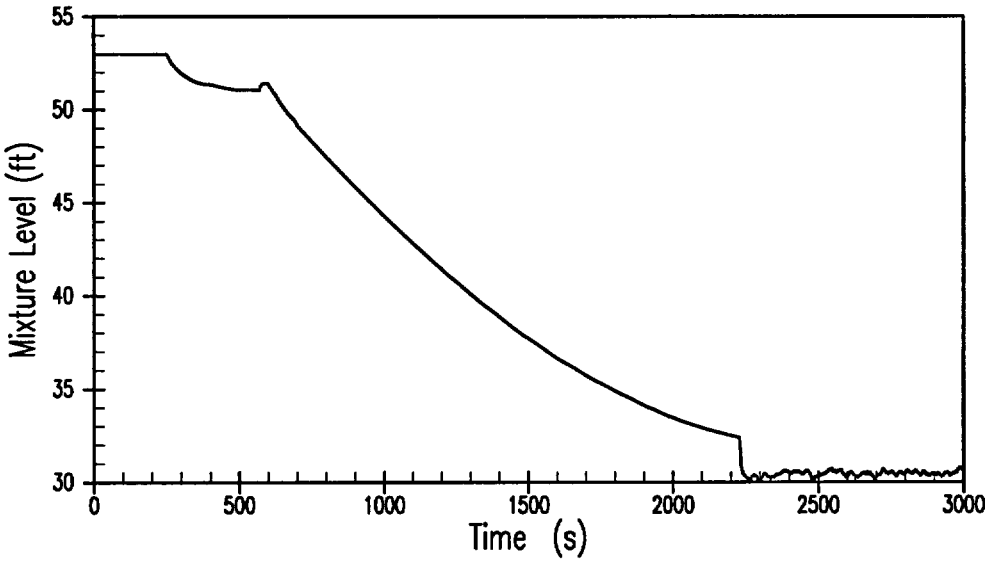


Figure-17 DEDVI 22.0 PSI – Intact CMT Mixture Level

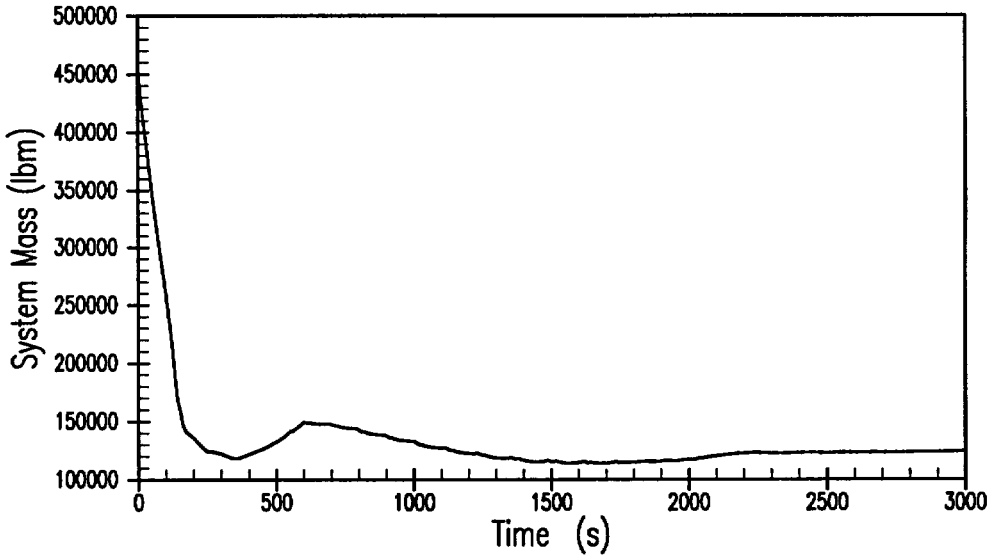


Figure-18 DEDVI 22.0 PSI – RCS System Inventory

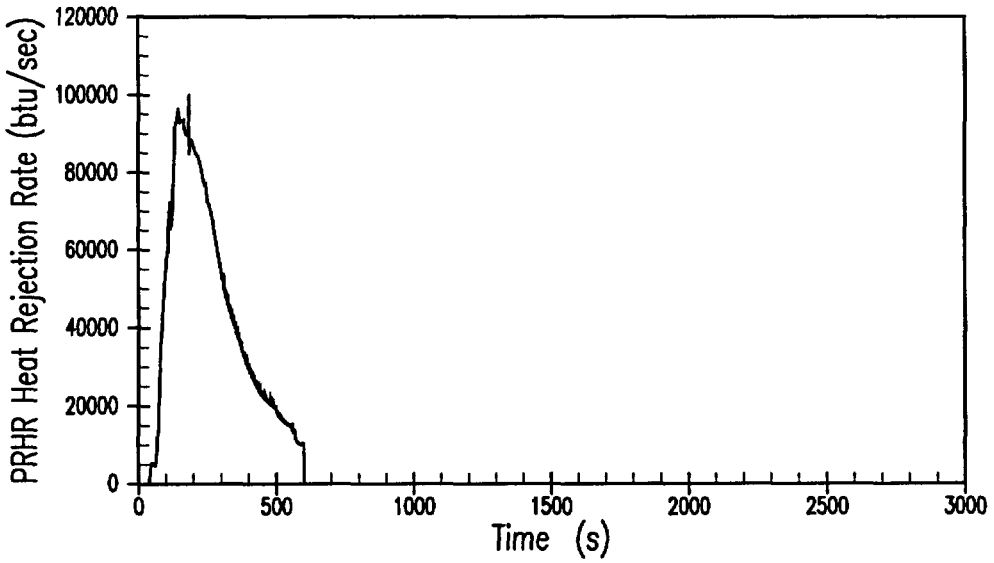


Figure-19 DEDVI 22.0 PSI – PRHR Heat Removal Rate

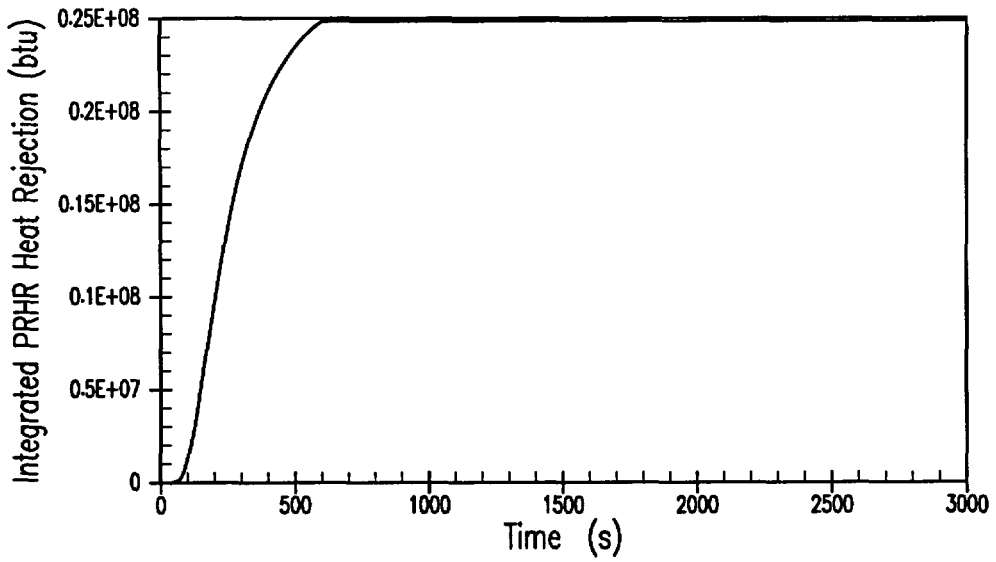
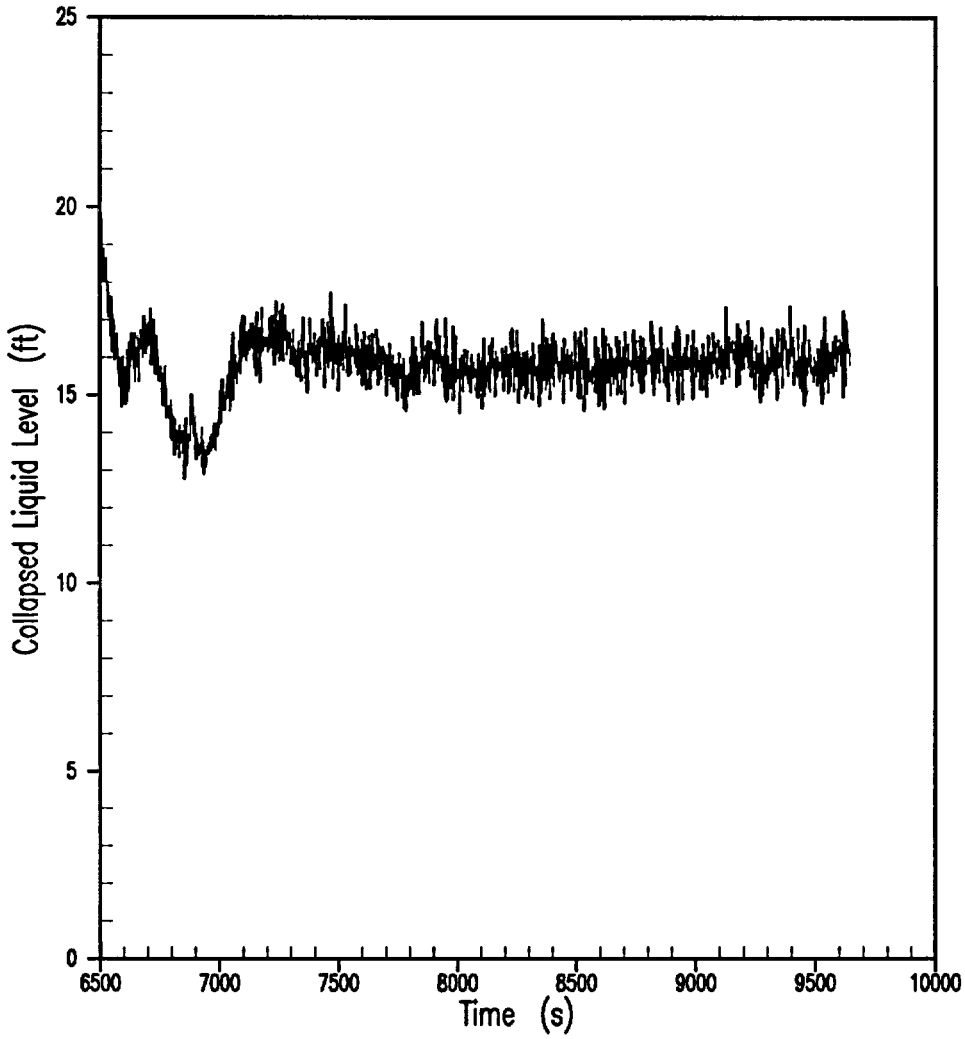


Figure-20 DEDVI 22.0 PSI – Integrated PRHR Heat Removal

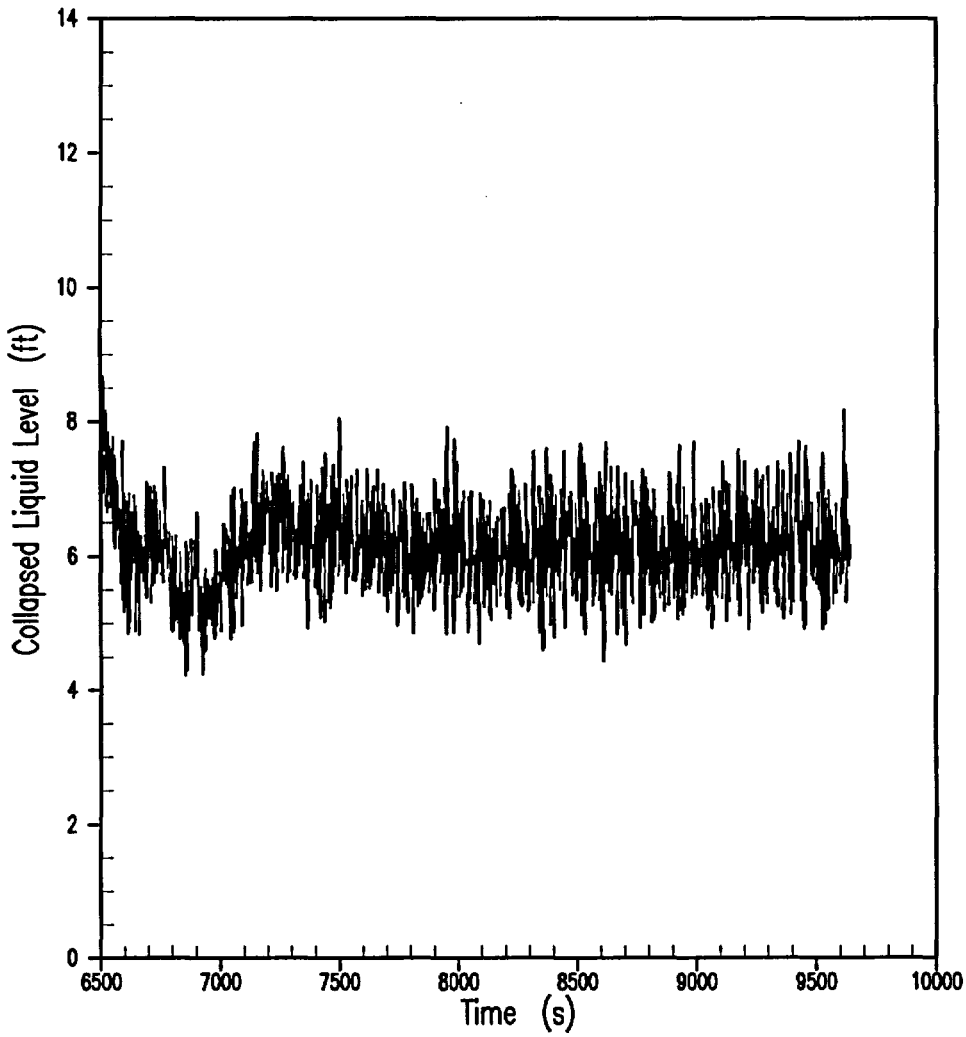
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-1: Downcomer Collapsed Level



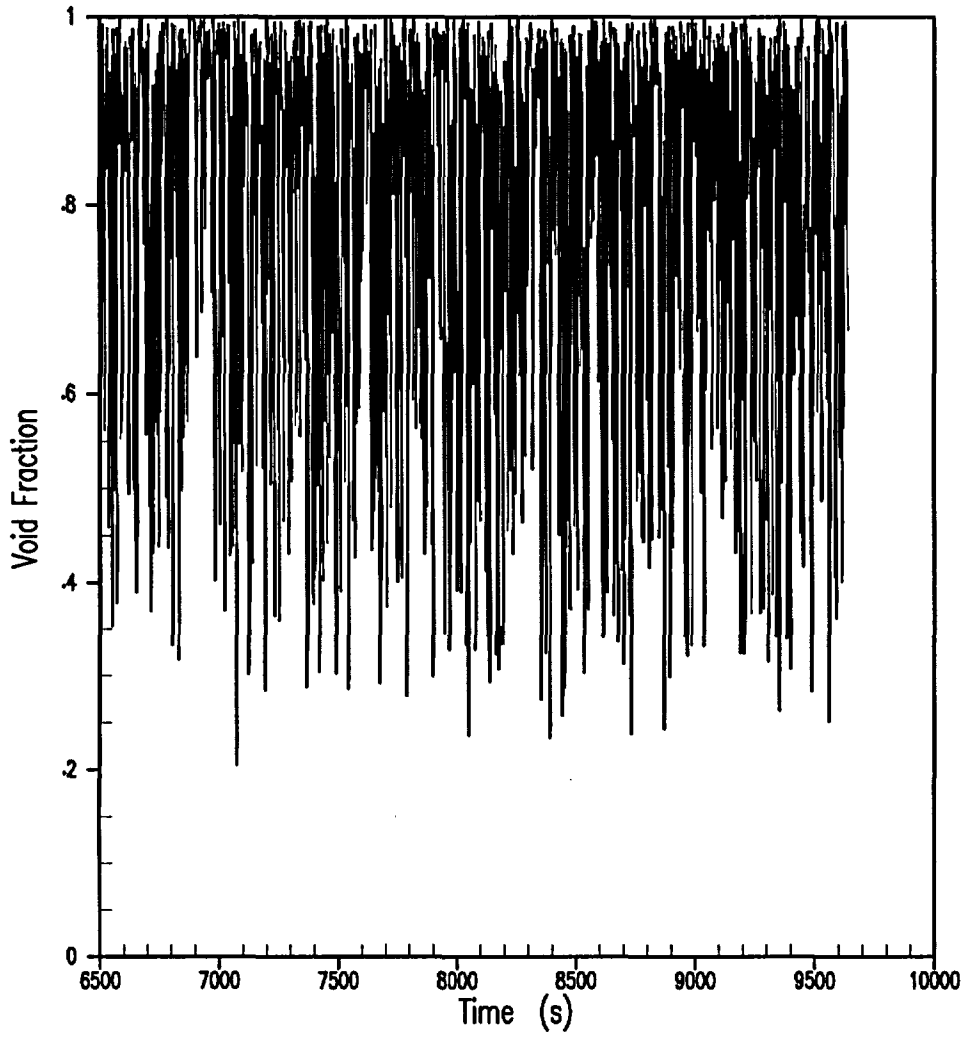
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-2: Core Average Collapsed Level



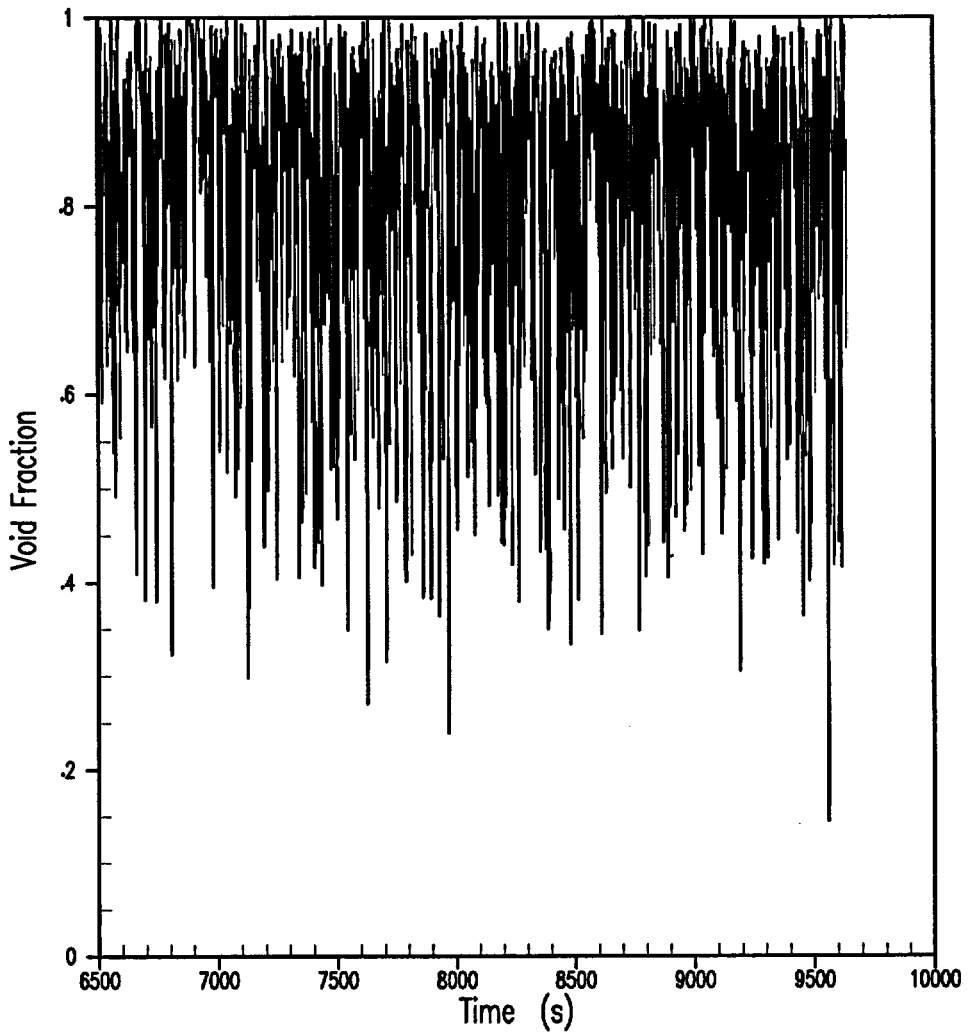
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-3: Hot Assembly Top Cell Void



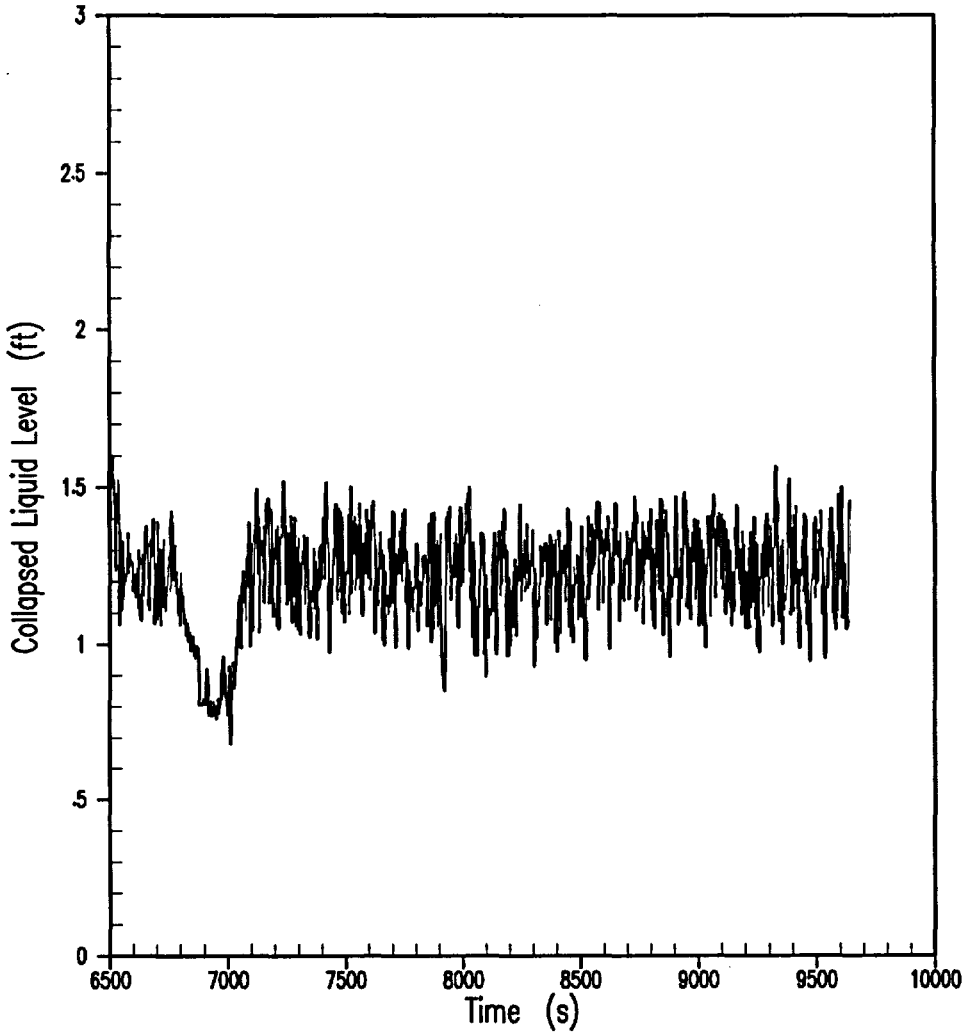
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-4: Hot Assembly Second Cell Void



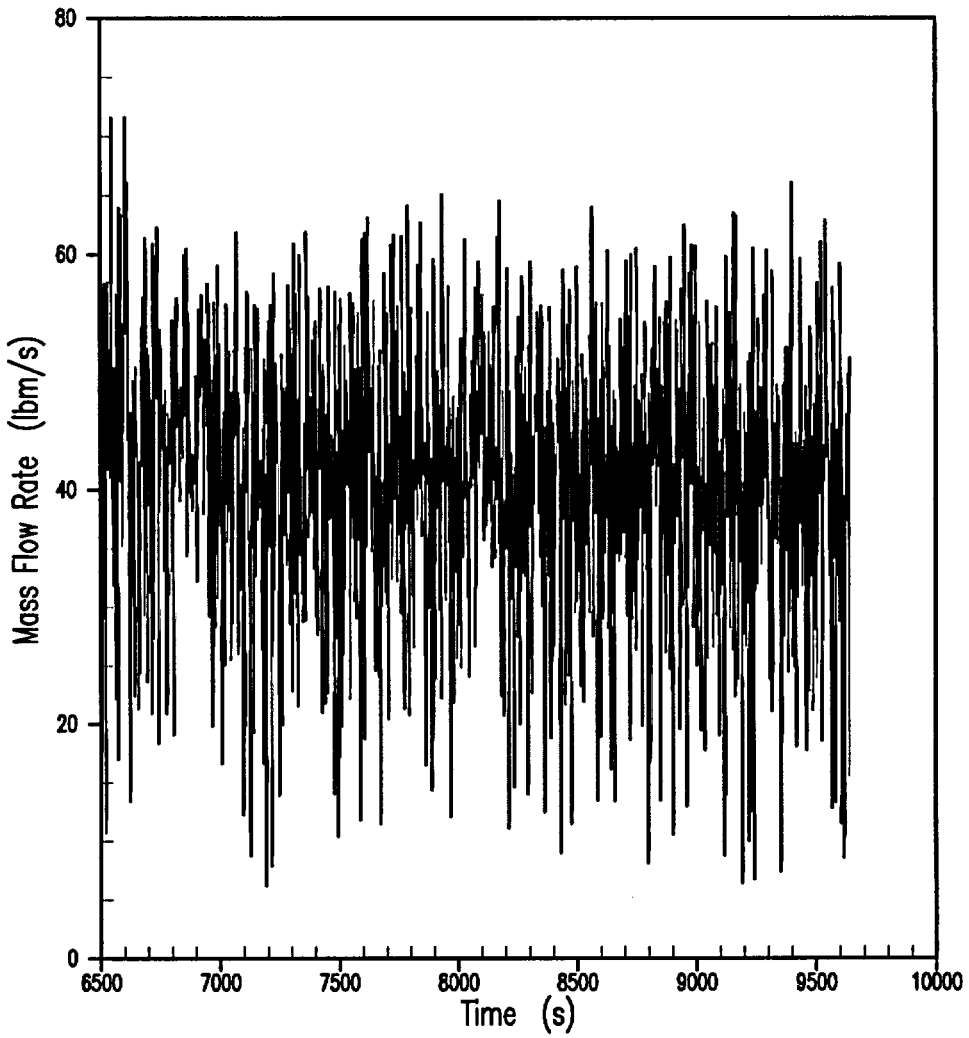
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-5: Hot Leg Level.Pressurizer Loop



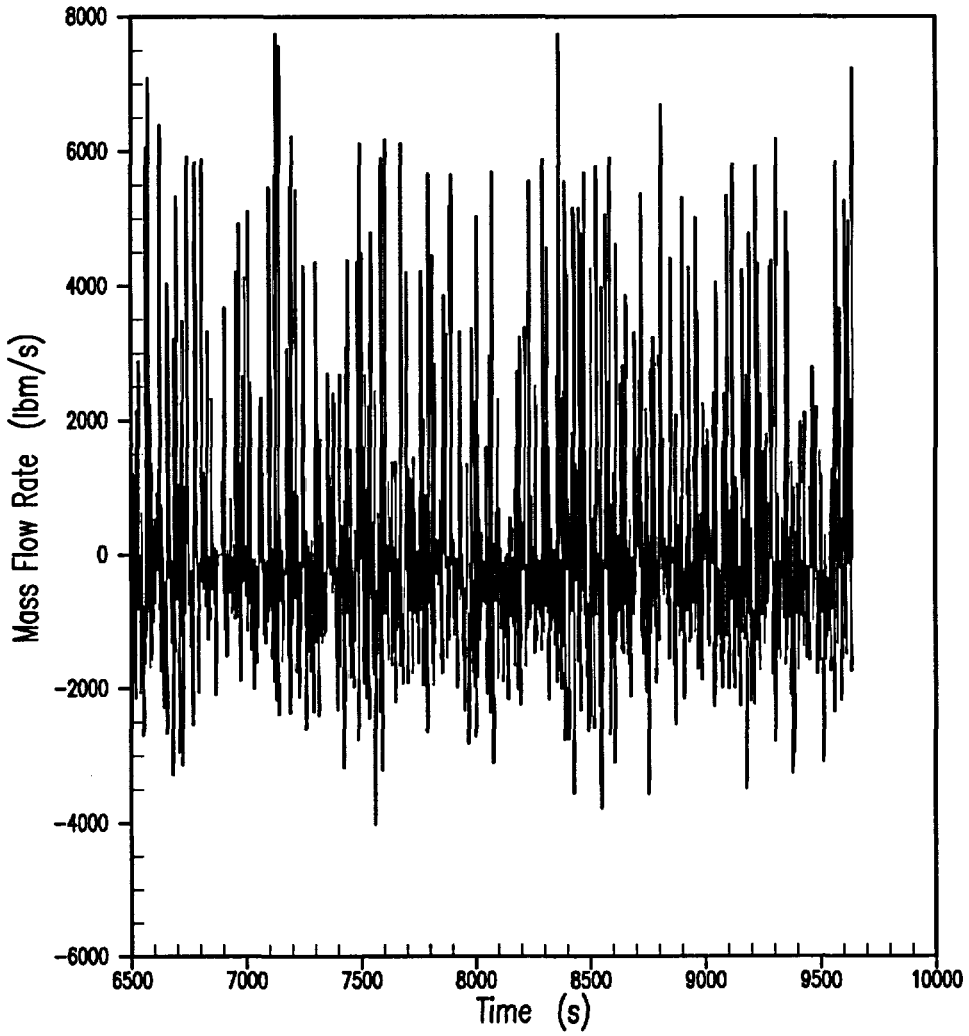
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-6: Core Exit Vapor Flow Rate



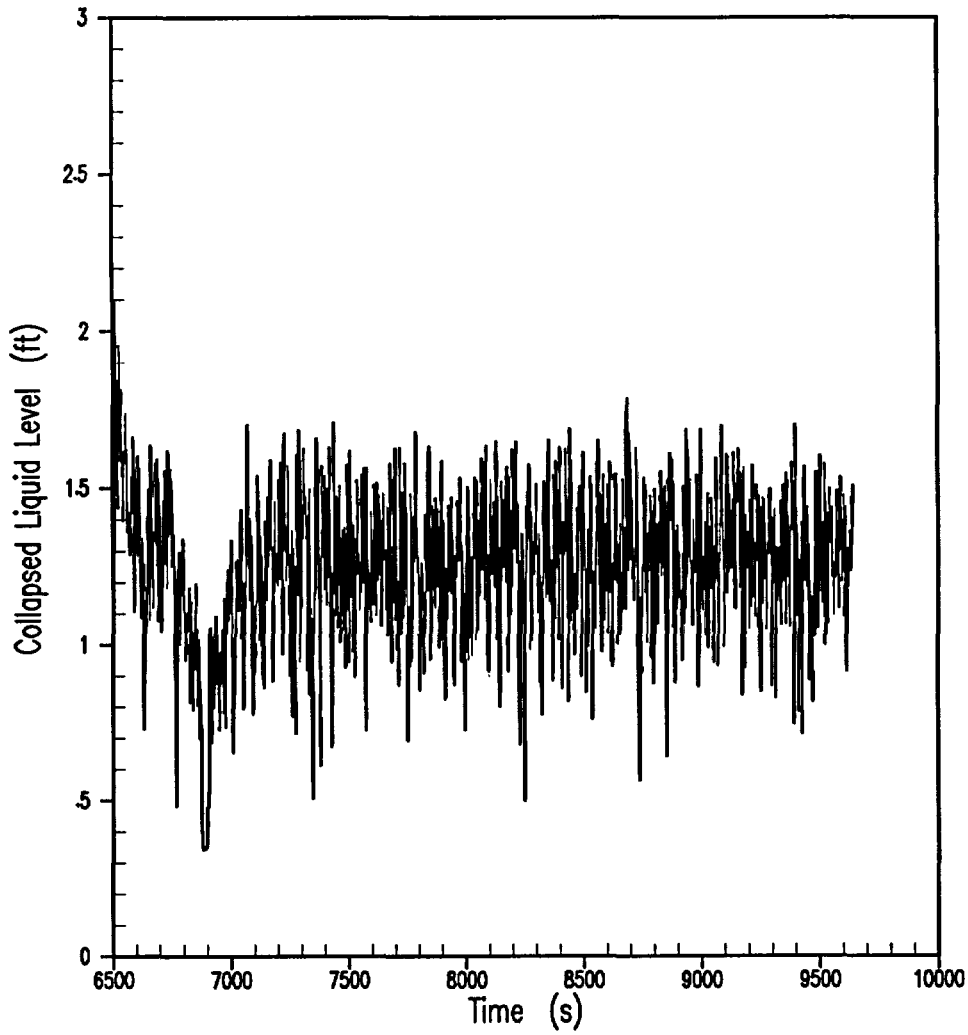
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-7: Core Exit Liquid Flow Rate



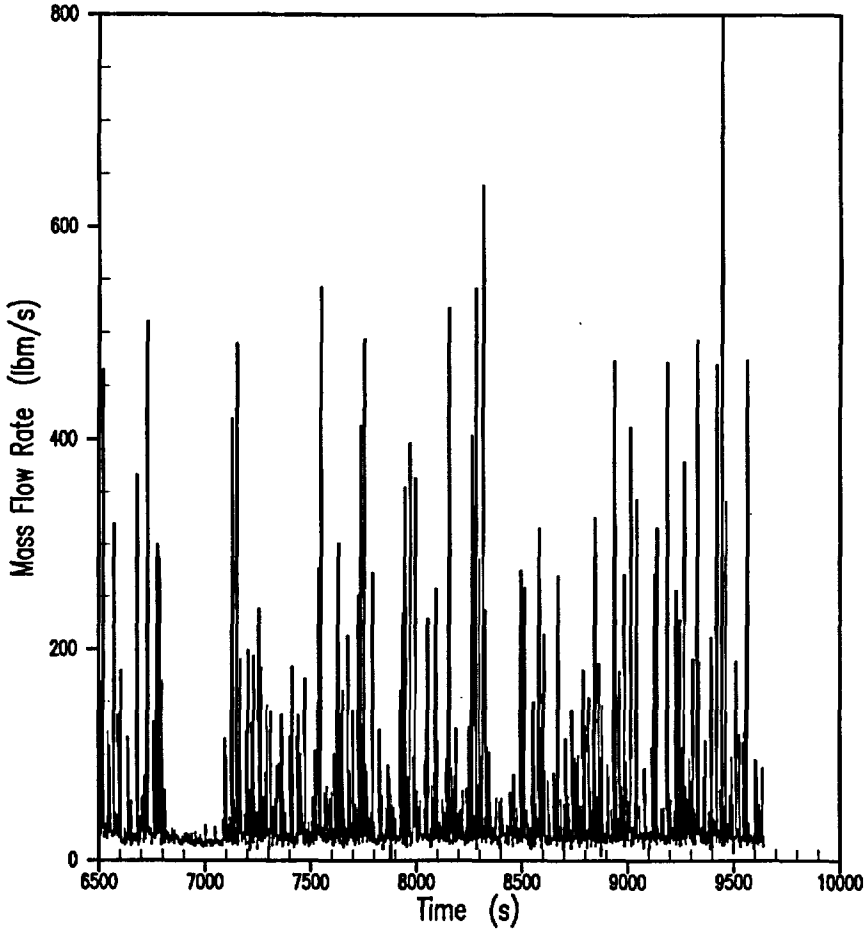
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-8: Upper Plenum Collapsed Level



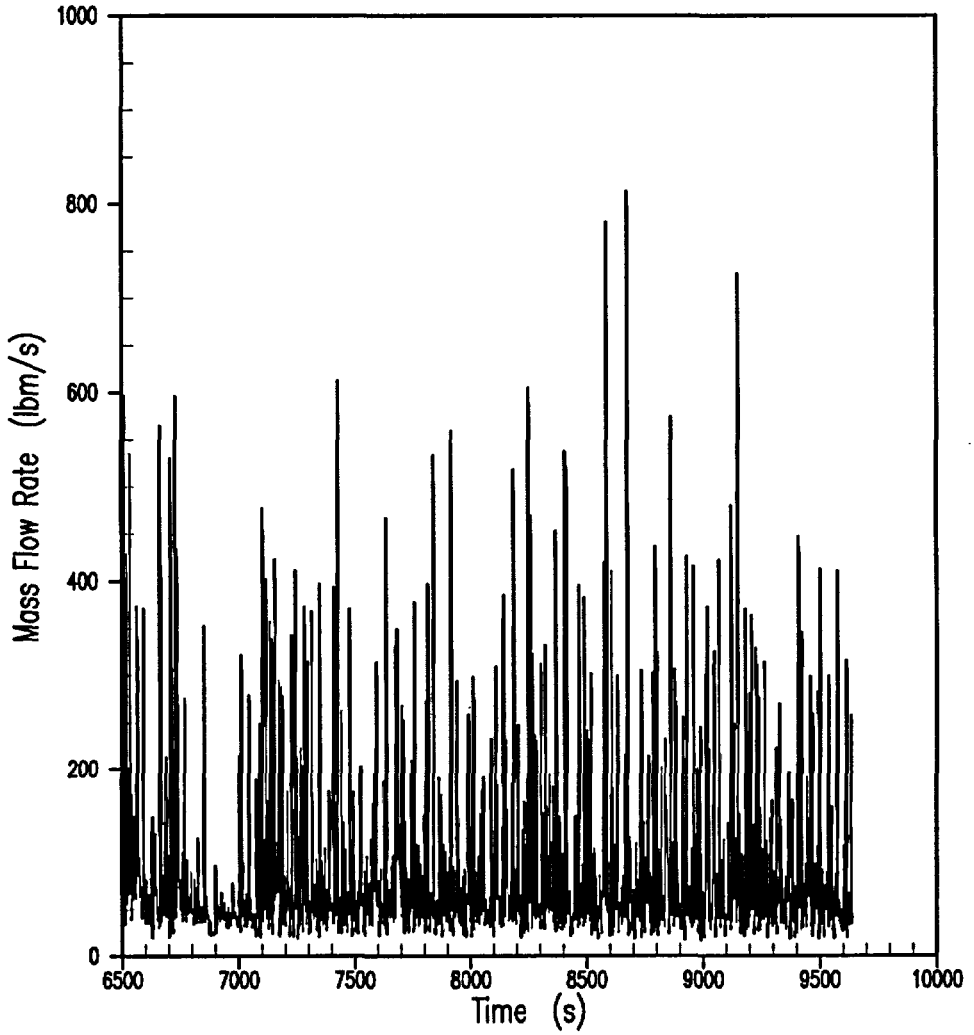
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-9: Mixture Flow Rate,ADS-4A Valves [D [D [D [D [



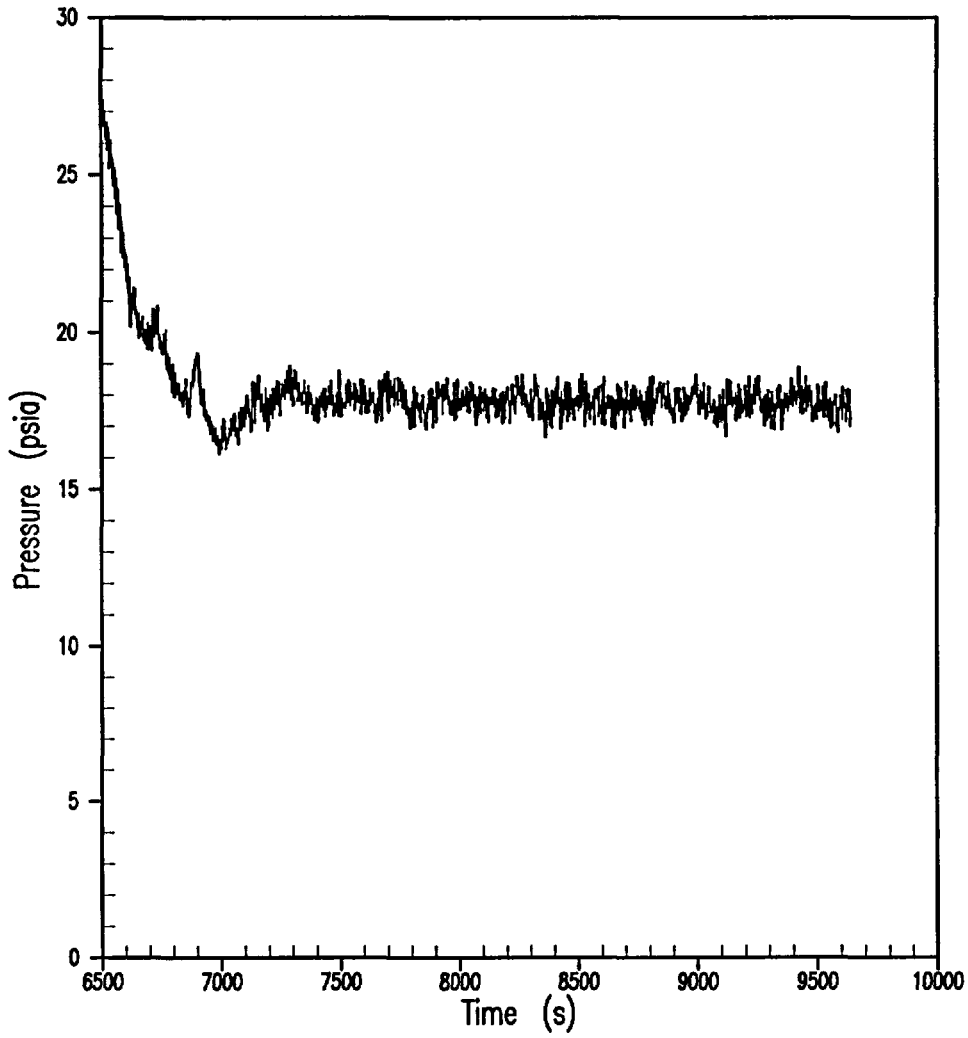
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-10: Mixture Flow Rate.ADS-4B Valves



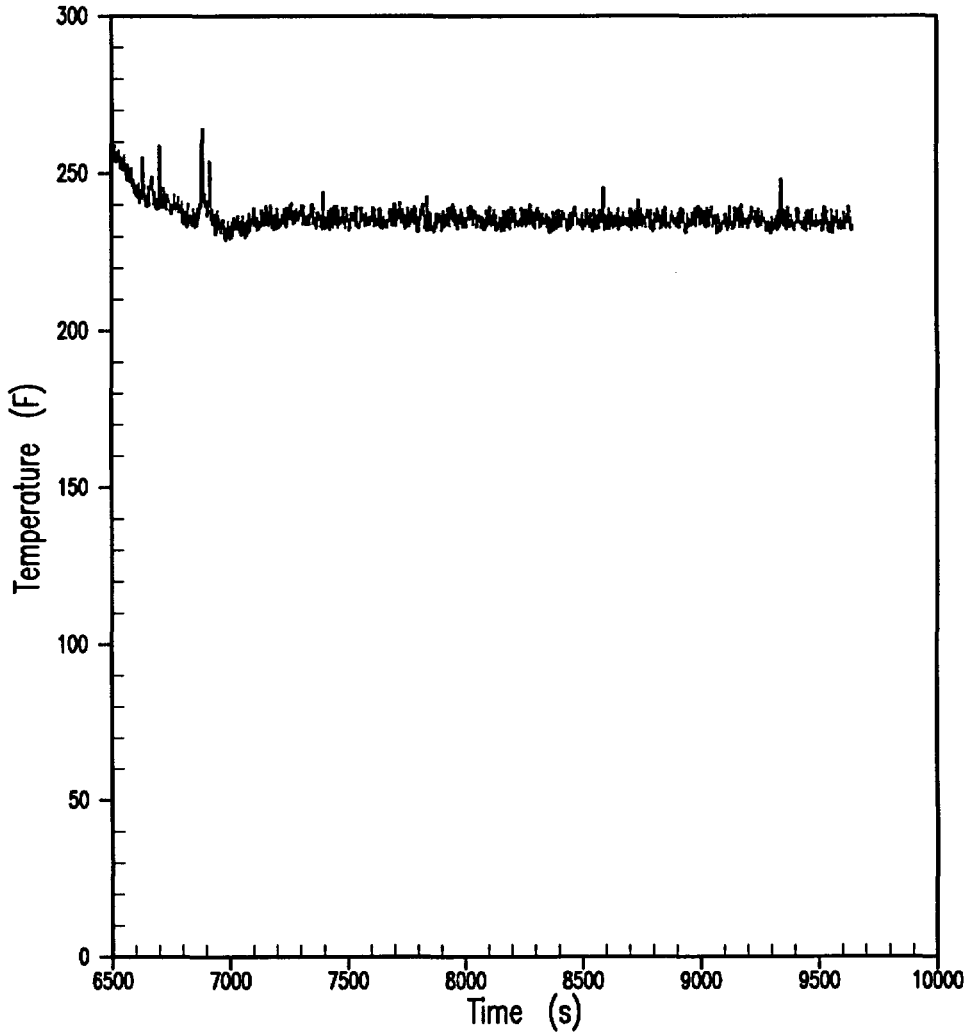
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-11: Upper Plenum Pressure



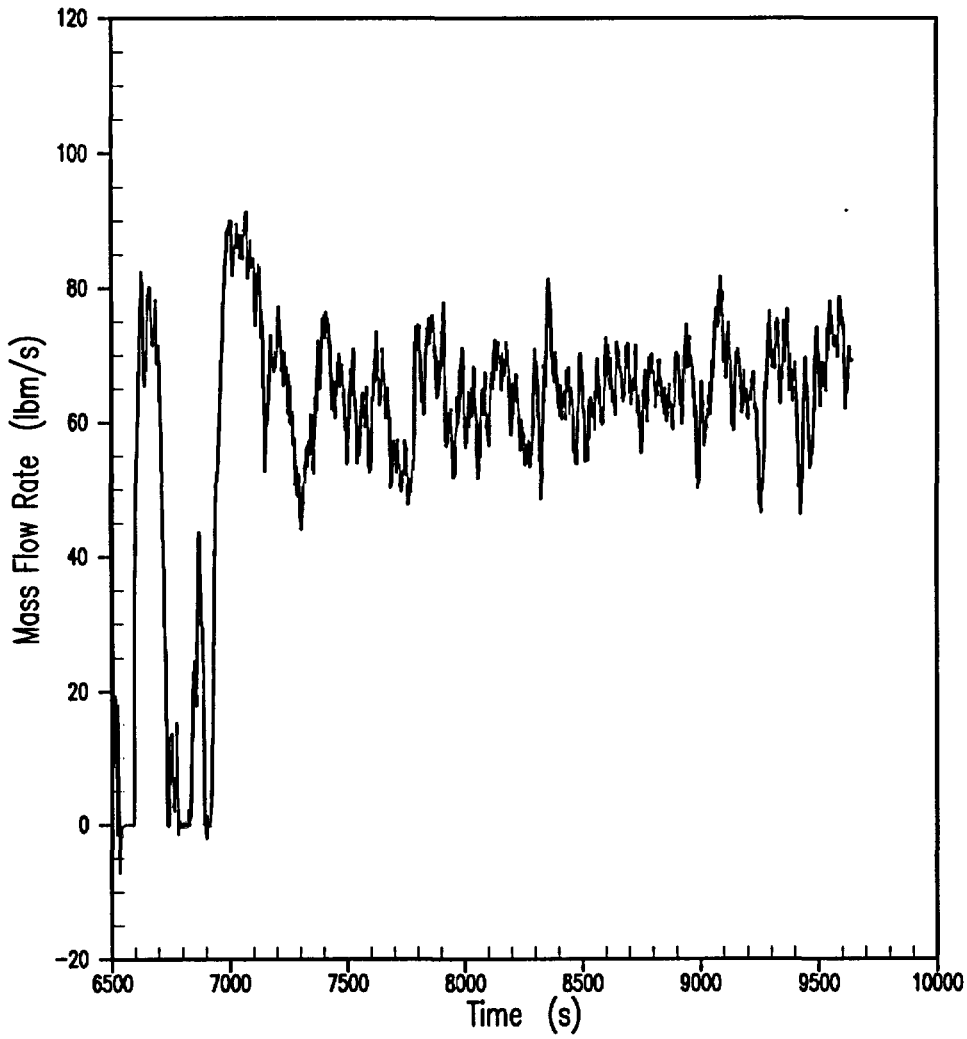
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-12: Hot Rod Peak Clad Temperature



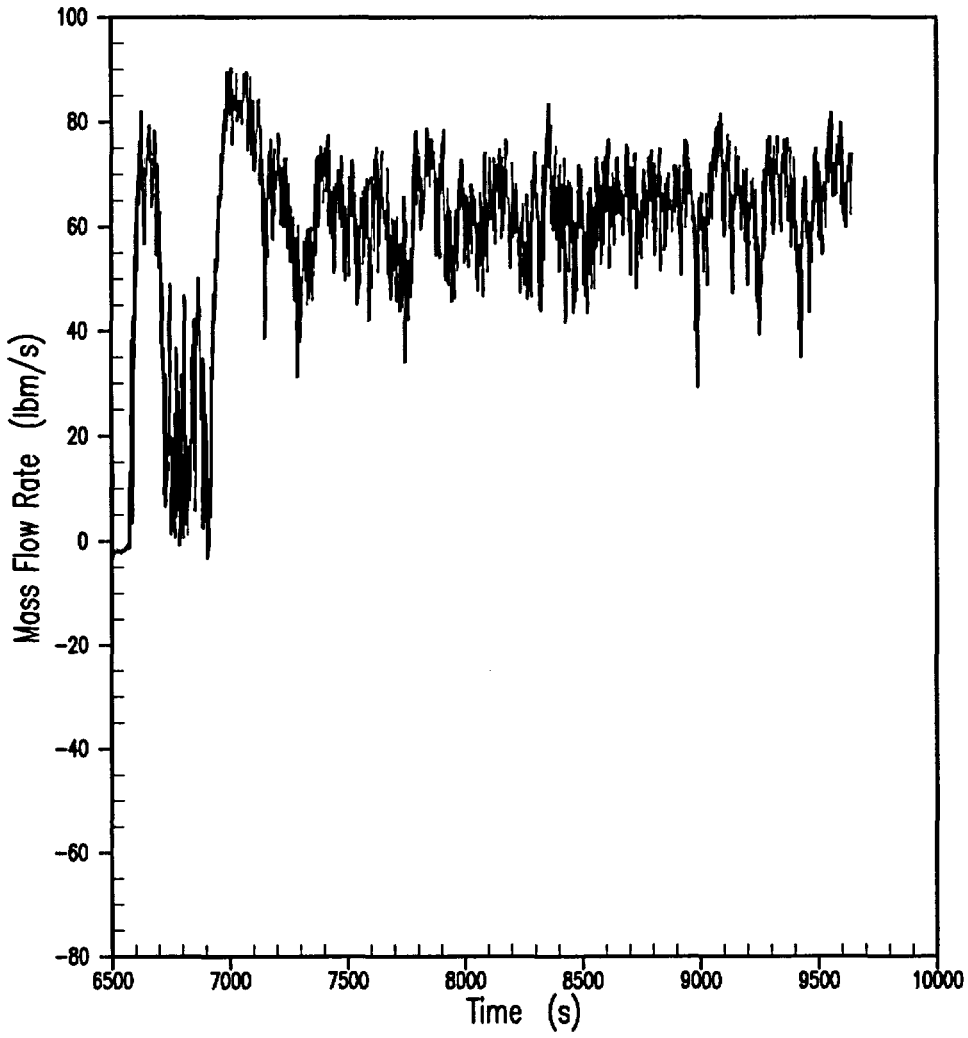
AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-13: Intact DVI Line Injection Rate



AP1000 DEDVI Break Long-Term Cooling Case at 14.7 psia

Figure WCT-14: Broken DVI Line Injection Rate



AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 21.5-2 Item 28 Revision 3

Original RAI Number(s): None

Summary of Issue:

The APEX test matrix contained a subset of tests expected to produce the lowest vessel collapsed liquid levels. The selection of these tests was in part based on results of NOTRUMP simulations. Westinghouse indicated that similar liquid levels were predicted for inadvertent ADS 1-3, 2 inch hot leg break and the DEDVI break. The DEDVI break is considered to be limiting small break LOCA and assessment has focused on this case. Please demonstrate the adequacy of the NOTRUMP simulation of inadvertent ADS 1-3 to ensure that the limiting break has been identified.

Westinghouse Response (Revision 1):

The APEX-600 test matrix included a spectrum of break sizes and locations. The APEX-600 tests have been shown to scale adequately to AP1000 (WCAP 15613, "AP1000 PIRT and Scaling Assessment," February 2001). The NOTRUMP simulations of the APEX-600 tests, including the inadvertent ADS and DEDVI tests, are reported in WCAP-14807-P Revision 5, August 1998, "NOTRUMP Final Validation Report for AP600". Comparison of the NOTRUMP simulation core collapsed liquid level to test data for these two tests is reproduced in Figures 28-1 and 28-2. The APEX-600 DEDVI test exhibited a lower core collapsed liquid level than did the APEX-600 Inadvertent ADS test, although both tests exhibited adequate core cooling throughout. The NOTRUMP simulations for these two tests exhibit this trend of lower core collapsed liquid level for the DEDVI case as compared to the Inadvertent ADS case. The NOTRUMP simulations for APEX-1000 DEDVI tests are reported in WCAP-15644-P Revision 1, submitted by Westinghouse letter DCP/NRC1627 dated September 19, 2003, and show similar comparison to test data as for the APEX-600 DEDVI case. This provides confidence that the NOTRUMP analysis of the AP1000 small break LOCA spectrum, including the Inadvertent ADS case, are adequate.

Figure 28-3 shows the NOTRUMP calculated core exit vapor velocity for the AP1000 DEDVI event at two containment pressures (25 psia and 14.7 psia) and for the Inadvertent ADS 1-3 event at 14.7 psia containment pressure. The vapor velocity is higher for the DEDVI case at 14.7 psia than for the Inadvertent ADS 1-3 at 14.7 psia. Since the 14.7 psia containment pressure applies in the APEX-1000 test facility, this is another indication that the DEDVI tests performed in APEX-1000 are somewhat more limiting from the viewpoint of vapor velocity and its effects on entrainment and ADS4 venting.

NRC Comment from 12/17/03 Status meeting:

Westinghouse's response to the staff's comments ('Item 28') on the selection of the APEX test matrix and NOTRUMP simulations is insufficient. Westinghouse merely provided comparisons of the core collapsed liquid levels of the NOTRUMP simulations of the APEX-600 tests of DEDVI and inadvertent ADS, and the NOTRUMP simulation of APEX-1000 DEDVI tests. Westinghouse concluded that this provides confidence that the NOTRUMP analysis of the AP1000 SBLOCA spectrum, including the inadvertent ADS case, are adequate.

Westinghouse should provide comparisons of the relevant dimensionless groups for the inadvertent ADS case and DEDVI case to demonstrate the NOTRUMP simulation is adequate in identifying the limiting break for AP1000.

Westinghouse Response (Revision 2):

Revision 1 of this response provided the superficial gas velocity at the core exit (Figure 28-3) as predicted by NOTRUMP for the AP1000 DEDVI and Inadvertent ADS cases. This comparison shows that for a given backpressure, the DEDVI case is somewhat more limiting than the Inadvertent ADS case. The APEX-600 test data also confirms that higher core voiding is experienced in the DEDVI case.

NRC Comment from 12/17/03 Status meeting:

In its December 31, 2003, submittal, Westinghouse provided the superficial gas velocity at the core exit as predicted by NOTRUMP for the AP1000 DEDVI break and inadvertent ADS actuation cases, and concluded shows that for a given backpressure, the DEDVI case is somewhat more limiting than the inadvertent ADS case.

The staff finds that showing comparisons for the superficial velocities are not sufficient to conclude which case is more limiting. Westinghouse should include comparison for certain dimensionless group that include superficial velocity and liquid height, etc., which are related to entrainment such as Froude number.

Westinghouse Response (Revision 3):

Identification of Limiting SBLOCA via Downcomer/Reactor Vessel Inventory Test Data

Given adequate core cooling, the next best indicator for identifying limiting SBLOCA transients is Downcomer/Reactor Vessel level or inventory. Figures 28-5 through 28-9 show Downcomer/Reactor Vessel level data for APEX-600 DEDVI (SB11and SB12), 2-inch CL Break (SB01 and SB18), and Inadvertent ADS (SB14) tests. From these figures it can be seen that the minimum reactor vessel liquid level (~40 inches) occurs in the DEDVI tests; minimum reactor vessel liquid levels for the other tests occur at levels ~50 inches. The DEDVI event represents the most challenging DBA SBLOCA as it is a significant size break located very low in the system coupled with the most significant loss of safety injection capability due to a single failure. One half of all safety injection capability is lost in the DEDVI event and this is evidenced

by the coincident low downcomer level (~40 inches). In the other accidents, the downcomer level is 5 to10 inches above the reactor vessel liquid level at the minimum condition. Based upon APEX-600 test experience and results obtained from APEX-1000 test/analysis, the DEDVI event represents the limiting downcomer/reactor vessel inventory for AP1000 SBLOCA DBA events.

Identification of Limiting SBLOCA via Important Entrainment Parameter at Core Exit

Non-dimensional gas velocity is an important parameter found in many entrainment correlations. Figure 28-4 provides non-dimensional gas velocity (j_g^*) at the core exit as predicted by NOTRUMP for the AP1000 DEDVI and Inadvertent ADS cases. The comparison shows that for a given backpressure, the DEDVI case is somewhat more limiting with respect to entrainment-related phenomena at the core exit than the Inadvertent ADS case. Therefore, based upon downcomer/reactor vessel liquid inventory test data/analysis and evaluating an important entrainment parameter, j_g^*, at the core exit the DEDVI event is the most limiting SBLOCA DBA event for AP1000.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

a,b,c

Figure 28-1

a,b,c

[ ]

Figure 28-2

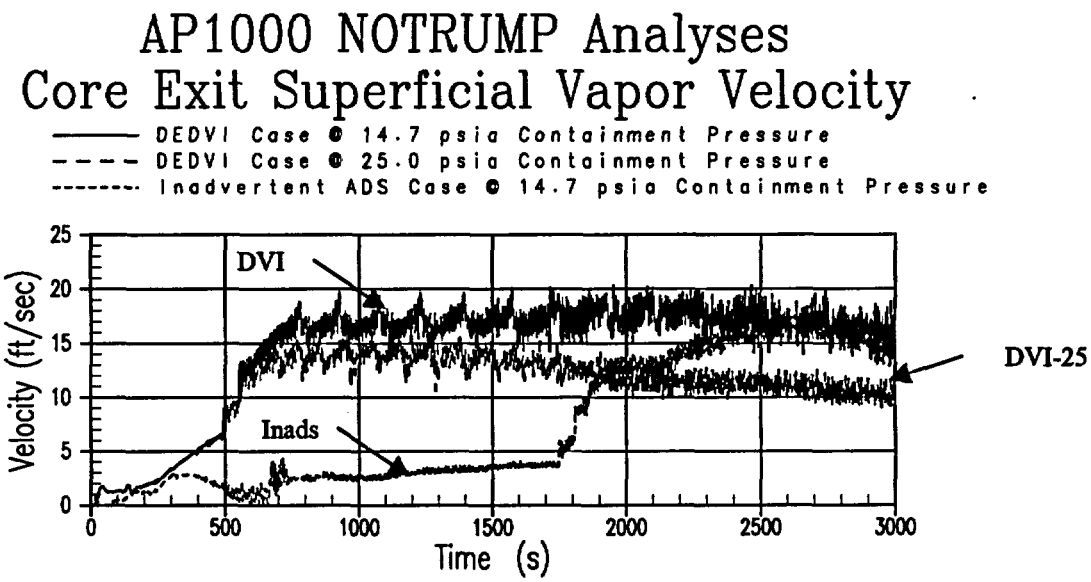

AP1000 NOTRUMP Analyses
Core Exit Superficial Vapor Velocity
DEDVI Case @ 14.7 psia Containment Pressure
DEDVI Case @ 25.0 psia Containment Pressure
Inadvertent ADS Case @ 14.7 psia Containment Pressure
Velocity (ft/sec)
Time (s)
DVI
Inads
DVI-25
0
5
10
15
20
25
0
500
1000
1500
2000
2500
3000

Figure 28-3

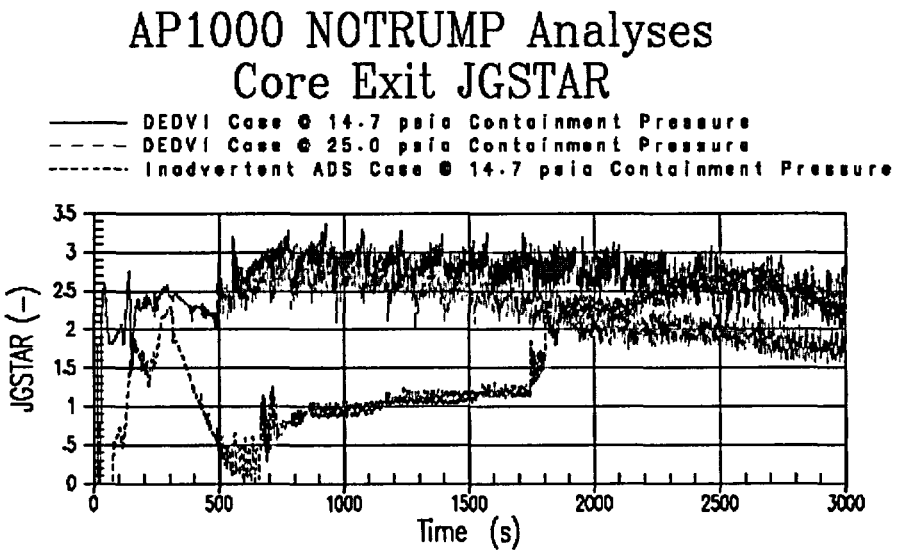

AP1000 NOTRUMP Analyses
Core Exit JGSTAR
DEDVI Case @ 14.7 psia Containment Pressure
DEDVI Case @ 25.0 psia Containment Pressure
Inadvertent ADS Case @ 14.7 psia Containment Pressure
JGSTAR (-)
3.5
3
2.5
2
1.5
1
.5
0
0
500
1000
1500
2000
2500
3000
Time (s)

Figure 28-4

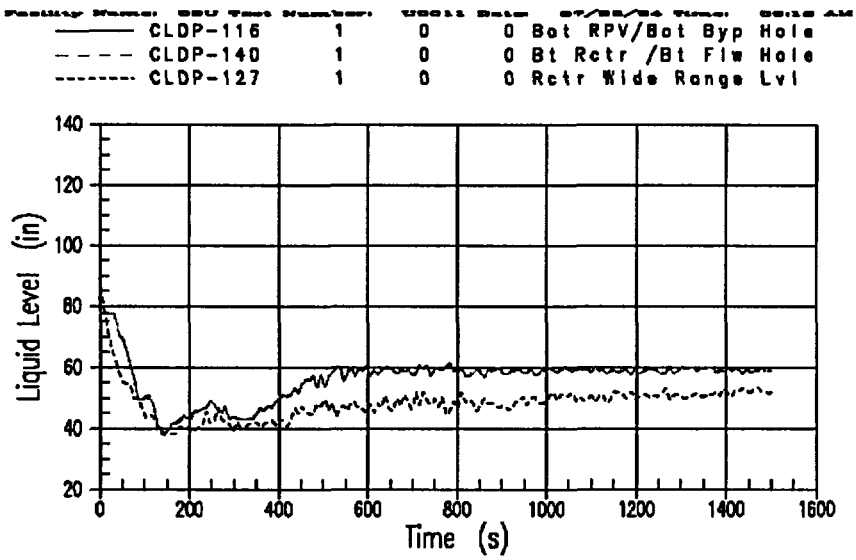


Figure 28-5 APEX-600 DEDVI test SB11

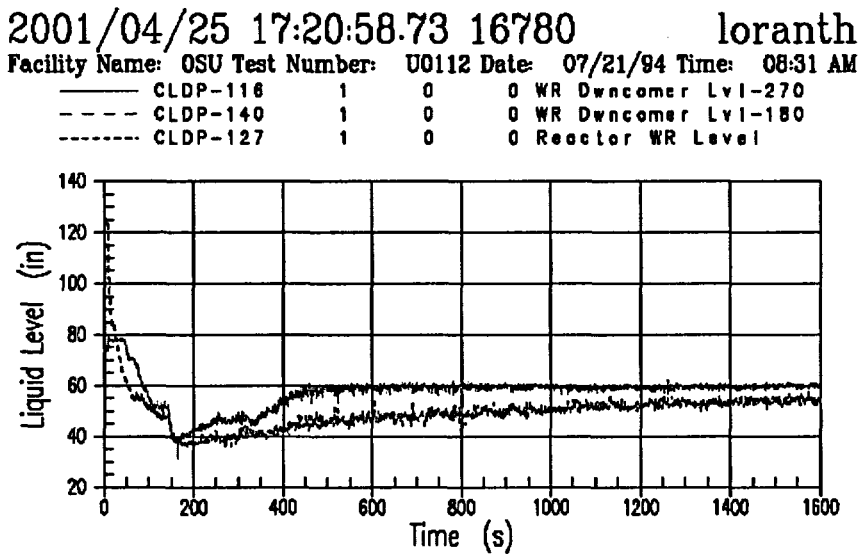


Figure 28-6 APEX-600 DEDVI Test SB12

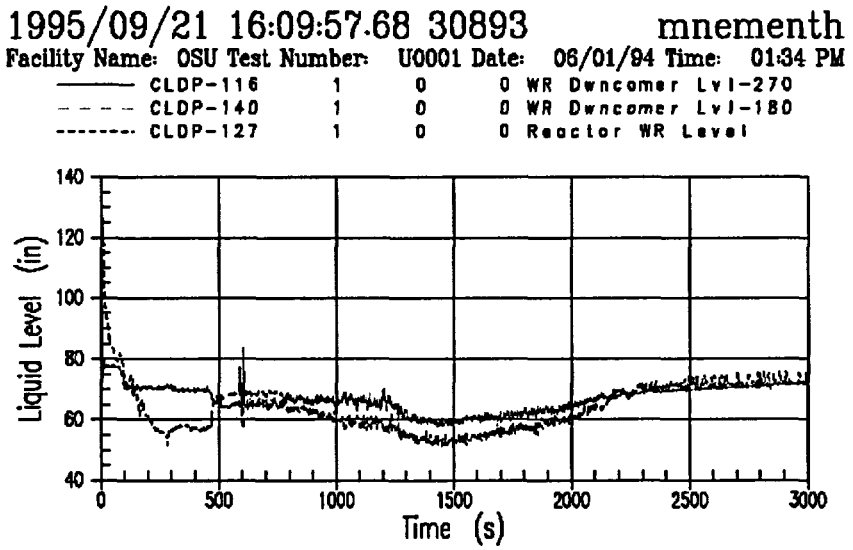


Figure 28-7 APEX-600 2 Inch CL Test SB01

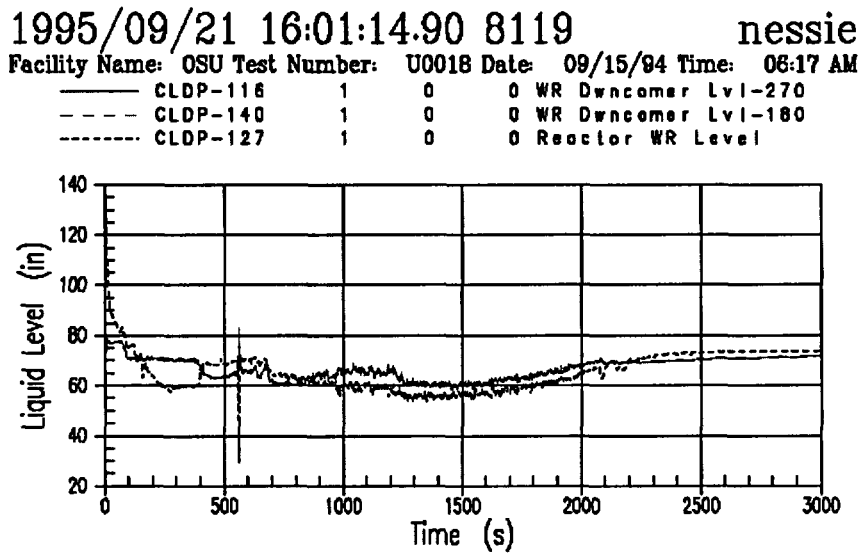


Figure 28-8 APEX-600 2 Inch CL Test SB18

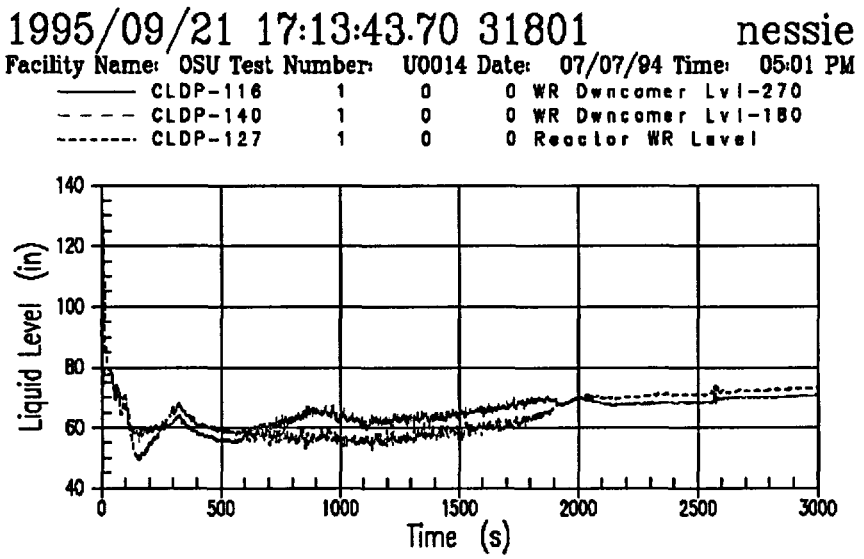


Figure 28-9 APEX-600 Inadv ADS Test SB14