Westinghouse
Electric Corporation

Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-95-908

November 30, 1995

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

ATTENTION: MR. T. R. QUAY

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: WESTINGHOUSE RESPONSES TO NRC REQUESTS FOR ADDITIONAL INFORMATION ON THE AP600

Dear Mr. Quay:

The application for withholding is submitted by Westinghouse Electric Corporation ("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 report. In conformance with 10CFR Section 2.790, Affidavit AW-95-908 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 10CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-95-908 and should be addressed to the undersigned.

Very truly yours,

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

cc: Kevin Bohrer NRC 12H5

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A PDR

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Brian A. McIntyre, 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 Corporation ("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:

Brian A. McIntyre

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

Sworn to and subscribed
before me this 1 day
of December, 1995

Rose Marie Payne

Notary Public

Notarial Seal
Rose Marie Payne, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Nov. 4, 1996
Member, Pennsylvania Association of Notaries

(1) I am Manager, Advanced Plant Safety And Licensing, in the Advanced Technology Business Area, of the Westinghouse Electric Corporation 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 Energy Systems Business Unit.

(2) I am making this Affidavit in conformance with the provisions of 10CFR 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 Energy Systems Business Unit 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 10CFR 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) Enclosed is Letter NTD-NRC-95-4602, November 30, 1995 being transmitted by Westinghouse Electric Corporation (W) letter and Application for Withholding Proprietary Information from Public Disclosure, Brian A. McIntyre (W), to Mr. T. R. Quay, Office of NRR. The proprietary information as submitted for use by Westinghouse Electric Corporation is in response to questions concerning the AP600 plant and the associated design certification application and is expected to be applicable in other licensee submittals in response to certain NRC requirements for justification of licensing advanced nuclear power plant designs.

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

(a) Demonstrate the design and safety of the AP600 Passive Safety Systems.

(b) Establish applicable verification testing methods.

(c) Design Advanced Nuclear Power Plants that meet NRC requirements.

(d) Establish technical and licensing approaches for the AP600 that will ultimately result in a certified design.

(e) Assist customers in obtaining NRC approval for future plants.

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 advanced plant licenses.

(b) Westinghouse can sell support and defense of the technology to its customers in the licensing process.

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 advanced nuclear power designs 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 developing analytical methods and receiving NRC approval for those methods.

Further the deponent sayeth not.

Attachment A to NTD-NRC-95-4602
Enclosed Responses to NRC Requests for Additional Information

Re: AP600 Design
480.216
480.217 (contains proprietary material)
480.220

Re: OSU Test Program
480.275
480.258
480.259 (Revision 1)
440.522
440.523

Re: SPES-2 Test Program
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Re: NOTRUMP Computer Code
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440.492 (contains proprietary material)
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Re: WGOTHIC Computer Code
952.100 (Revision 1)
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Enclosure 2 to NTD-NRC-95-4602

Non-proprietary copy of Enclosure 1

Question 480.216

Re: Questions on AP600 Sump Design:
What is the sump valve actuation level (LO-3) in the IRWST (drawing 1874E376)?

Response:

The IRWST level setpoint "L-5" opens the containment recirculation valves. The IRWST level span is 30 feet. The "L-5" setpoint is 15% of span. The sump recirculation valves would open at a decreasing IRWST level of 4.5 ft or approximately 91,000 gallons.

SSAR Revision: NONE

Question 480.217

Re: Questions on AP600 Sump Design:
Where are the sump-to-direct vessel injection (DVI) valves and check valves located?

Response:

The "A" sump-to-direct vessel injection (DVI) valves are located in Containment at elevation 89' 0" and near coordinates [ ] The "B" sump-to-DVI valves are located in Containment at elevation 90' 4" and near coordinates [ ] The center of Containment is located at coordinates [ ]^{a,c}

Reference: SSAR Figures 1.2-1, 1.2-5 and 1.2-6

SSAR Revision: NONE

Question 480.220

Re: Questions on AP600 Sump Design:
Is the "curb" elevation the same as the 107'2" floor elevation, or is it something else? Explain.

Response:

A curb will be installed on the floor at the 107 foot elevation to assure that water on this floor will not drain into non-flooded compartments.

Overflow to Top of Curb

Top of Curb	108.17 ft
Curb Height	1 ft
Floor Elevation	107.17 ft
Floor Thickness	2 ft
Bottom of Floor Elevation	105.17 ft

SSAR Revision: NONE

Question 480.275

Re: Oscillatory Behavior in OSU/APEX:
The staff has been reviewing data from several of the QLRs for APEX testing, and has noted a variety of oscillatory phenomena that appear in a number of tests. The staff requests that Westinghouse evaluate each of the oscillations described below, and provide, if possible, (i) an explanation of the parameters driving the oscillation in APEX; (ii) an evaluation of the potential for similar oscillatory behavior to occur in the AP600--i.e., applicability of OSU data in these areas to the plant and scaling of facility behavior to the plant; and (iii) an evaluation of the safety significance of each oscillatory mode. It is particularly important to determine if the oscillations may be an artifact of the design of APEX's Break and ADS Measurement System (BAMS). Note: Tests cited as examples below are not intended to denote the only tests in which similar oscillatory phenomena occur, but are mentioned solely for illustrative purposes.

a. Oscillations occurring upon start-up of IRWST injection. This can be seen in tests such as SB5 and SB10, where IRWST discharge flow rate oscillates for several cycles before reaching a peak quasi-steady value (from which it decreases as driving head decreases).

b. Well-defined flow oscillations with a period of about 100-120 seconds, beginning approximately 2 hours after initiation of IRWST injection and continuing for several thousand seconds. These oscillations can also be seen clearly in several of the plots for both SB5 and SB10, including IRWST discharge flow, reactor wide range level, and ADS separator flow.

c. Relatively rapid, large-amplitude flow oscillations occurring shortly after the cessation of the oscillations described in part b, above. These can be seen in the ADS-4 separator flow plots in SB5 beginning at about 14,500 seconds.

d. Oscillations occurring when the CMTs, which often refill during the long-term cooling phase (mentioned in previous questions), drain back into the RCS.

e. Oscillations occurring when the system switches over from IRWST to sump injection, which may be related to opening the valve between the IRWST and the sump.

While the staff requests that Westinghouse evaluate all five types of oscillations, the staff, at this time, considers the two described in (a) and (b) to be the most important from the standpoint of initiation and maintenance of stable long-term core cooling. The first affects start-up of IRWST injection, and has an impact on initiating and establishing long-term core cooling, while the second is a system-wide oscillation that persists for several thousand seconds and has an effect on reactor pressure and level, and for which the phenomena that cause the oscillation to start, continue, and then stop are still in question.

Response:

a. Flow from the IRWST is driven by the difference between the water head in the tank and the pressure in the reactor coolant system. As the flow begins, minor pressure oscillations in the RCS will change the driving force, and thereby change the IRWST flow. As the pressure continues to fall in the RCS, due to flow through the ADS4 and break, the driving force will increase and flow will stabilize. Similar oscillations may be expected in the AP600, however as discussed in Section 6.1.3.4 of Reference 480.275-1, these oscillations will be stable and not affect core coolability.

b. Cyclic flow, pressure, level, and temperature oscillations were observed in about 65 percent of the OSU tests. These oscillations occurred primarily during the latter stage of IRWST injection phase of SBLOCA simulations. Possible causes for the oscillations, evaluation of the test data and the extrapolated effect of the oscillations on the AP600 have been provided in section 6.1.3 of Reference 480.275-1.

c. Large-amplitude flow oscillations occurring at approximately 14,500 seconds in SB5 are a response of the BAMS to the overflow of the primary sump to the secondary sump. This overflow results in slight pressurizations in the BAMS which cause oscillations in BAMS flow indications. These oscillations are a result of the facility configuration and would not be expected in the AP600.

d. Oscillations occur when the CMTs drain back into the RCS following refill. The injection of the CMTs and IRWST are due to the available water head. As the level in the IRWST decreases, a point is reached where the CMT available head and the IRWST available head are equal. At this point, the CMT and the IRWST both feed the RCS and flow oscillations are seen as the two tanks drain. Continuous direct vessel injeciton flow was maintained to the RCS during the entire CMT draindown. Note that CMT refill is not expected for the AP600, therefore, these oscillations relate only to the OSU facility.

e. When the water level in the IRWST reaches the low level setpoint, the sump isolation valves open. The water level in the IRWST changes as it comes into equilibrium with the level in the sump. Flow from sump line 1 directed back through the IRWST and is injected through DVI line 2. Similar flow patterns may occur in the AP600, but uninterrupted injection flow will be maintained.

Reference

480.275-1 WCAP-14292, Revision 1, "AP600 Low-Pressure Integral Systems Test at Oregon State University Test Analysis Report," Proprietary [LTCT-T2R-600], September 1995.

SSAR Revision: NONE

Question 480.258

Re: Test OSU SB3:
The data from a number of instruments, especially many of those associated with the BAMS, appear to be of limited (if any) use. For instance, the ADS 4-1 separator steam flow (Plot 58) has a zero offset, and aside from a few sharp spikes, shows almost no flow at all. Many of these instruments (e.g., FMM-905, FVM-905, FVM-903, FMM-902) are reading values less than 10 percent of their full range (some as low as 1-2 percent), which makes it very difficult to separate the actual data from instrument noise and error. This would appear even more of a problem due to the failure or poor functioning of the ADS-1 and -2 flow measuring devices. Westinghouse should explain how these data are to be used, considering the apparent large potential errors in the readings.

Response:

The vortex flow meters used at the OSU facility for measurement of steam flow from the BAMS were of limited use during post blowdown and long-term cooling due to operation at a steam flow rate which was beneath the instrument dead band. Most of these instruments indicated little or no steam flow out of the BAMS during long term cooling. However, the detailed mass and energy balance performed for Reference 480.258-1 indicated that the core produced a net steam flow during this time, which was not measured leaving the system, due to the underranged vortex meters. Assuming that the mass deficit calculated from the mass balance was steam exhaust that was not measured, and by including that steam energy in the energy balance, the energy balance was near closure. Table 6.2.2-2 of Reference 480.258-1 summarizes the rate of core steam production, together with the inferred rate of steam flow out of the primary system.

The magnetic flow meters used for liquid flow measurements throughout the OSU facility are not designed to accurately measure steam or two-phase flow, nor do they provide an accurate measure of reverse flow. For other conditions, these instruments provide very reliable indication of liquid flow. Operation of the magnetic flow meters used at the facility and the total probable error are described in section 2.4.1.3 and Appendix D of Reference 480.258-2.

Reference

480.258-1 WCAP-14292, Revision 1, "AP600 Low-Pressure Integral Systems Test at Oregon State University Test Analysis Report," Proprietary [LTCT-T2R-600], September 1995.

480.258-2 WCAP-14252, "AP600 Low Pressure Integral System Test at Oregon State University: Final Data Report," Proprietary [LTCT-T2R-100], May 1995.

SSAR Revision: NONE

Question 480.259

Re: Test OSU SB3:
Explain why power is not listed as a specified initial condition. Also, at the end of the test, the power meters go negative. Is this an expected response, or does it raise questions about the accuracy of the power measurements during the test? Finally, the staff notes that the power is increased in a step fashion just before the test begins. Presumably this is a planned event; however, it is not described in the Test Procedure section nor in the list of initial conditions. This type of action needs to be flagged and explained.

Response: (Revision 1)

The AP600 Low Pressure Integral Test at Oregon State University Final Data Report, May 1995, section 2.6.12 describes the control algorithm used to simulate the decay power expected in the AP600 plant scaled to the OSU Test Facility. For all matrix tests except SB21, the control algorithm was:

For $0 < \text{time} \le 140$ seconds; power (KW-101 or KW-102) = 300 kW
For time > 140 seconds; power (KW-101 or KW-102) = $300/[1 + B(t-140)]^C$

The Matrix Test SB21 decay power algorithm was:

For $0 < \text{time} \le 300$ seconds; power (KW-101 or KW-102) = 300 kW
For time > 300 seconds; power (KW-101 or KW-102) = $300/[1 + B(t-140)]^C$

where: $B = 0.01021$ and $C = 0.2848$

Prior to time zero, the test facility was controlled to maintain the hot leg temperature specified and not to a specific power level. At time zero, the power would change to 300 kW. Power is therefore not specified as an initial condition.

At the end of the test, the indicated power is negative. This is an expected response on the DAS to opening of the reactor breakers. It does not raise questions about the accuracy of the power measurements during the test.

SSAR Revision: NONE

Question 440.522

Re: OSU Final Data Report
There are a few typographical errors (see p. 1.3-1) and unclear or apparently misplaced figures. For instance, in the photograph labeled "Reactor Vessel" (figure 2.1-1, p. 2.1-8), it is difficult to discern where the reactor vessel is, since the component in the foreground is the break separator. An arrow or other indicator would be useful. Also, Figure 3.2.2 (p. 3.2-10) is not discussed in Section 3.2; it is first mentioned in Section 3.4 and should appear there. Finally, there is a minor inconsistency in the scaling description (p. 2.2-2); in the first line of Section 2.2.2, the diameter scaling ratio is stated as 1:6.93, while the next-to-last paragraph on the page, it is stated as 1:6.91.

Response:

Typographical errors which are identified in the Final Data Report will be corrected upon re-issuance of the report. Also, where appropriate, indicators or arrows will be added on unclear figures such as the Reactor Vessel (figure 2.1-1, p. 2.1-8). Figure 3.2.2 will be moved to section 3.4 and the figure identification and the text reference will be adjusted.

The detailed rationale for selecting the length and diameter scaling ratios is presented in the Scaling Report (Reference 440.522-1). The length scaling ratio was set to 1:4 and the diameter scaling ratio 1:6.931. This represents the ideal ratio for scaling of system piping. Slight variations from this ideal were taken to permit use of commercially available piping in the facility. The text will be adjusted accordingly.

References

440.522-1 WCAP-14270, Revision 0, "Westinghouse AP600 Long Term Cooling Test Facility Scaling Report", January 1995

SSAR Revision: NONE

Question 440.523

Re: OSU Final Data Report
Facility scaling is described in general, with reference to the detailed scaling report. This is, for the most part, acceptable, but some additional discussion would be useful in specific areas mentioned in the text of the report. In particular:

a. It is stated in section 2.3.1 that the lower plenum region is slightly distorted. The impact of this distortion (if any) is not discussed.

b. Power scaling is described in some detail. However, the effect of not properly scaling the power in the first 70 seconds (approximately) is not discussed. In addition, while two different algorithms are given for the power decay during the tests "depending on the test configuration" (p. 2.3-2), the criteria used to determine which algorithm was used for particular tests are not enumerated. A question about proper scaling of the decay heat has also recently arisen. This issue should be addressed in the FDR and/or TAR, as appropriate.

c. The timing for opening of the ADS valves, as described in Section 2.6.16.1 (pp. 2.6-9 -10) is described, but the way in which the timing was determined (with reference to both the AP600 and scaled time in the facility) is not discussed. In addition, a question arose after completion of the APEX testing about the CMT level setpoints used for ADS actuation. This issue should be addressed, and any potential impact of incorrect setpoints on the test results should be discussed.

d. While initial conditions were established in an attempt to properly scale the facility's state at the beginning of the test, there does not seem to have been any attempt to try to scale the initial derivatives of key scaled parameters, nor is it indicated at what point in the test these derivatives are approximately matched. Since the objectives of the OSU tests were focused primarily on low-pressure, long-term cooling performance, the distortions caused by failing to match initial rates-of-change of facility parameters <u>may</u> be acceptable. However, this issue and the determination of the acceptability of such distortions should be addressed in the FDR or TAR or both.

Response:

a. The lower plenum region is the region below the lower core plate of the reactor core. The net water volume in the AP600 lower region is modeled in the test. In addition, rods located in the OSU vessel simulate the AP600 support columns. Since the reactor vessel inside diameter is determined by proper scaling of the upper plenum volume, core region volume and special downcomer region scaling criteria, the lower plenum region cross sectional area is slightly distorted on the scaling basis. This slightly distorted cross section may have a some impact on the "K" value of the lower vessel. However, for the low flow rates experienced during long term cooling, this should have a negligible effect on pressure drops.

b. The decay power curve used at the OSU facility was structured such that the scaled integrated power was preserved as shown in Figure 5-11 of Reference 440.523-1. Two power curves were formulated, one for SB21, the large break and one for the remainder of the matrix tests. The additional power curve formulated for SB21 maintained the maximum power for a longer period of time before following the facility decay power curve. In effect, this increased the integrated decay power for SB21, providing more conservative test conditions.

c. Section 4.1.2 of the OSU Final Data Report describes the test performed to determine the volume of the core makeup tanks at the OSU facility. Tables 4.1-5 and 4.1-6 provide the test data obtained for CMT-1 and CMT-2 respectively. The setpoint used for ADS-1 operation was 41 inches in either of the CMTs. The setpoint used for ADS-4 operation was 17.1 inches in either CMT. The volume of the CMT at 41-inches is approximately 75% and the volume at 17.1 inches is approximately 26%. These slight deviations from AP600 setpoints (67% for ADS-1 and 70% for ADS-2) should have no impact on facility evaluations because the actual OSU facility setpoints were used to assess facility performance.

The opening times of the ADS valves at the OSU facility were based on ADS actuation signals specified for the opening of the AP600 ADS, plus an assumption of the time required for the valve to lift off its seat and establish flow.

The AP600 first stage ADS actuation signal occurs when the ADS-1 high level setpoint is reached in the either CMT. The first stage control valve receives a signal to open 20 seconds after the first stage actuation. Assuming a 10 second delay before significant flow is established through the valve results in a 30 second delay for the AP600 to establish first stage flow. Because the OSU time scaling was 1/2, a 15 second time delay was used for first stage actuation at the OSU facility.

The AP600 second stage ADS actuation signal occurs 60 seconds after the first stage ADS actuation signal. The second stage control valve receives a signal to open 30 seconds after the second stage actuation signal or 90 seconds after the first stage actuation signal. A 35 second time delay was assumed for establishing flow through the slow opening AP600 second stage control valve. This results in an assumption of second stage flow 125 seconds after ADS first stage actuation. Therefore, a 62 second delay way used for second stage actuation at the OSU facility.

The AP600 third stage ADS actuation signal occurs 120 seconds after the second stage actuation signal or 180 seconds after the first stage ADS actuation signal. The third stage control valve receives a signal to open 30 seconds after the third stage actuation signal. A 35 second time delay was assumed for establishing flow through the slow opening AP600 third stage control valve. This results in an assumption of third stage flow 225 seconds after ADS first stage actuation. Therefore, a 122 second delay way used for third stage actuation at the OSU facility.

The AP600 fourth stage ADS actuation consists of two parts. The AP600 fourth stage A actuation signal occurs 120 seconds after the third stage actuation signal or 300 seconds after the First Stage ADS actuation signal, provided either of the CMTs has reached the fourth stage low level setpoint. The fourth stage A control valve receives a signal to open 30 seconds after the third stage actuation signal or 330 seconds after first stage actuation. The fourth stage B actuation occurs 30 seconds after the fourth stage A actuation. The fourth stage

B control valve receives a signal to open 30 second after the fourth stage B actuation or 360 seconds after first stage actuation. Each of the control valves was assumed to establish flow approximately 15 seconds after receiving its signal to open. This results in an assumption fourth stage A ADS flow 345 seconds after first stage actuation and fourth stage B flow 375 seconds after first stage actuation. Because the OSU facility used single ADS 4 valves on each hot leg, the time delay was averaged and a 180 second delay way used for fourth stage actuation.

Table 440.523-1 summarizes the assumptions used for establishing the OSU Setpoints.

d. The test facility was started from repeatable, water solid initial conditions with the main coolant pump operating. Starting the tests in this manner allowed for the most repeatable boundary conditions and provided a method for checking the facility performance before the tests were initiated. No attempt was made to scale the initial derivatives of scaled parameters because the subcooled depressurization was not scaled. As stated in Section 5.4.2 of the Scaling Report (Reference 440.523-1), subsequent to the rapid depressurization from initially subcooled conditions, the system reached a plateau pressure. For practical purposes, the reference pressure was the pressure at which the initial subcooled blowdown ended. It was defined as the maximum pressure on the secondary side of the steam generators subsequent to initiating the break. This plateau pressure was selected as the reference pressure for scaling. The reference pressure was then used to scale the fluid properties and initial conditions and to establish system setpoints in the bottom-up scaling analysis.

Reference

440.523-1 WCAP-14270, Revision 0, "Westinghouse AP600 Long Term Cooling Test Facility Scaling Report", January 1995

SSAR Revision: NONE

Table 440.523-1 AP600 ADS Actuation Assumed When Establishing OSU Setpoints

Description	Setpoint	Delay	Time assumed to establish flow	Time after ADS-1 Actuation	OSU Setpoints
ADS-1 Actuation	67% CMT volume				
ADS-1 Control Valve	ADS-1 actuation + delay	20 sec	10 sec	20 + 10 = 30 sec	30 / 2 = 15 sec
ADS-2 Actuation	ADS-1 actuation + delay	60 sec			
ADS-2 Control Valve	ADS-2 actuation + delay	30 sec	35 sec	60 + 30 + 35 = 125 sec	125 / 2 = 62.5, rounded to 62 sec
ADS-3 Actuation	ADS-2 actuation + delay	120 sec			
ADS-3 Control Valve	ADS-3 actuation + delay	30 sec	35 sec	60 + 120 + 30 + 35 = 245	245 / 2 = 122.5, rounded to 122 sec
ADS-4A Actuation	ADS-3 actuation + low-2 CMT level + delay	120 sec			
ADS-4A Control Valve	ADS-4A actuation + delay	30 sec	15 sec	60 + 120 + 120 + 30 + 15 = 345	(345 + 375) /2 = 180 sec
ADS-4B Actuation	ADS-1 actuation + delay	30 sec			
ADS-4B Control Valve	ADS-2 actuation + delay	30 sec	15 sec	60 + 120 + 120 + 30 + 30+ 15 = 375	

Question 440.528

Re: SPES-2 Test Analysis Report (Revision 0)
The comments on the data reduction/analysis methodology noted previously for the OSU TAR should be reviewed for applicability to the SPES-2 TAR. In general, there seems to be better explanation of the assumptions made in the SPES data analysis; however, some justification of those assumptions (e.g., homogeneous two-phase flow model) may be need.

Response:

Revision 1 of the SPES-2 Test Analysis Report (Reference 440.528-1) includes revisions to Chapter 2 of the report to provide information requested in this RAI. In particular:

- Information was added on the use of static collapsed liquid levels, and
- A note was added to clarify that all analyses use all data time points except for flow inferred from mass measurements where an average of 70 half second time points on either side of the current time has been included. This supplements an existing statement in the introduction to Chapter 3 of the report.

Reference 440.528-1 was provided to the NRC via Reference 440.528-2.

Reference:

440.528-1 WCAP-14254, Revision 1, "AP600 SPES-2 Test Analysis Report," November 1995

440.528-2 Westinghouse Letter NTD-NRC-95-4601, "AP600 Full Height, Full Pressure Integral Systems Test: SPES-2 Test Analysis Report (Revision 1)," November 30, 1995

SSAR Revision: NONE

Question 440.533

Re: SPES-2 Test Analysis Report (Revision 0)
The description of the analysis methodology presented in Chapter 2 represents a good approach to a "standard" means by which to analyze mass and energy flows during the SPES-2 tests. However, there is no discussion of how instrumentation problems were handled in this methodology. For example, if F_A40E (CMT A drain flow) was unavailable for a particular test, there is no indication of how a substitute instrument might be used, nor how use of alternative data might affect the relevant calculation due to differences in local conditions.

Response:

Revision 1 of the SPES-2 Test Analysis Report (Reference 440.533-1) includes revisions to address this RAI. In particular, a brief discussion of the treatment of inoperable instruments has been added to the introduction to Chapter 2. In the tests where DP instruments on the PRHR inlet were inoperable, a discussion of the assumptions used under these circumstances is provided in the relevant sections of Chapter 3.

Reference 440.533-1 was provided to the NRC via Reference 440.533-2.

Reference:

440.533-1 WCAP-14254, Revision 1, "AP600 SPES-2 Test Analysis Report," November 1995

440.533-2 Westinghouse Letter NTD-NRC-95-4601, "AP600 Full Height, Full Pressure Integral Systems Test: SPES-2 Test Analysis Report (Revision 1)," November 30, 1995

SSAR Revision: NONE

Question 440.534

Re: SPES-2 Test Analysis Report (Revision 0)
This section should be checked carefully for typographical errors. For instance, in Table 2.1.1-3 (p. 2-6), P-B40E is shown as "Top Pressure, CMT-A," when it apparently should be CMT-B. In addition, relevant reference(s) for the SPESAN code should be included, if available.

Response:

Revision 1 of the SPES-2 Test Analysis Report (Reference 440.534-1) includes revisions to address this RAI. As part of the revision, the specific correction noted has been made and a complete review of Revision 0 was undertaken. The methodology used in the SPESAN code is documented in Chapter 2 of the report (Reference 440.534-1).

Reference 440.534-1 was provided to the NRC via Reference 440.534-2.

Reference:

440.534-1 WCAP-14254, Revision 1, "AP600 SPES-2 Test Analysis Report," November 1995

440.534-2 Westinghouse Letter NTD-NRC-95-4601, "AP600 Full Height, Full Pressure Integral Systems Test: SPES-2 Test Analysis Report (Revision 1)," November 30, 1995

SSAR Revision: NONE

Question 440.537

Re: SPES-2 Test Analysis Report (Revision 0)
In Chapter 3, while the written descriptions of the tests appear to be comprehensive and accurately portray the sequence of events occurring in each test, there are relatively few references to the figures included in the TAR, and apparently no references at all to the actual data, which is contained in the FDR. As noted previously, the staff believes that the TAR and FDR together comprise the record of the test program, and the descriptions of the events during the tests would be enhanced significantly if they were tied directly to the test data.

Response:

Revision 1 of the SPES-2 Test Analysis Report (Reference 440.537-1) includes revisions to address this RAI. Table 3.1-1, which cross references related sections in the Test Analysis Report and Final Data Report, has been included in Section 3.1 of Reference 440.528-1.

Reference 440.537-1 was provided to the NRC via Reference 440.537-2.

Reference:

440.537-1 WCAP-14254, Revision 1, "AP600 SPES-2 Test Analysis Report," November 1995

440.537-2 Westinghouse Letter NTD-NRC-95-4601, "AP600 Full Height, Full Pressure Integral Systems Test: SPES-2 Test Analysis Report (Revision 1)," November 30, 1995

SSAR Revision: NONE

Question 480.226

Please provide the characterization data to show the scaled values of various parameters, i.e., flow rates from the CMT, accumulators, IRWST.

Response:

The SPES-2 passive safety injection systems have been designed to reproduce, as accurately as possible, the thermal hydraulic phenomena occurring in the AP600. In the passive safety injection system lines where pressure drops are relevant, the pressure drop in the line at the facility was equal to the pressure drop in the same AP600 line. Therefore, pressure drop characterization data, which has been provided for each of the lines is the important scaled parameter required for these lines. The flow rates through these lines, are therefore appropriately scaled in the SPES-2 facility for the safety injection system interconnecting piping given the test is full height and power scaled.

SSAR Revision: NONE

Question 480.227

Did the ECC injection drain rates account for the presence of the nozzle in the DVI line? If not, how was this factor accounted for?

Response:

For the majority of tests, the presence of the nozzle in the DVI line was accounted for in the overall line pressure drop.

For the double-ended DVI line break, where flow is from the vessel to the DVI break, the nozzle was incorporated into the break spool piece.

SSAR Revision: NONE

Question 480.228

Was any characterization done on the upper head-to-downcomer flow path? If so, please provide the results.

Response:

No characterization tests were performed on the upper head-to-downcomer flow path.

SSAR Revision: NONE

Question 480.229

How is CMT level evaluated? Information comparable to that provided for core and accumulator levels in Section 4.2.3 should be provided.

Response:

Levels at the SPES-2 facility are evaluated from differential pressure indications on the various components. Appendix F of the FDR provides a list of the dP instruments used at SPES-2. It also provides a description of each dP cell configuration, a description of how the engineering unit data should be processed, and the appropriate temperature instrument(s) that should be used in determining the density of the fluid.

SSAR Revision: NONE

Question 480.230

The last line of p. 8 appears to refer to Test C-10, which is never mentioned again. Was such a test run? If so, what were its objectives and results?

Response:

Test C-10 was originally planned to verify the volumes for the pressurizer, the core makeup tanks, the accumulators, and the IRWST at the SPES-2 facility. This data was obtained during performance of other cold pre-operational tests, therefore, a separate volume test was not conducted. Component volume test data is provided in Quick Look Report for the SPES-2 Cold Pre-Operational Tests Results and a summary of the results is provided in Table 2.2-2 of the FDR.

SSAR Revision: NONE

Question 480.231

SPES-2 used a compensation of 150 Kw in additional core power to account for heat losses in the loop. Addition of all of this power in the core (as opposed to distributing it around the loop proportional to the losses) appears to have had an effect on system behavior, compared to other integral test loops. Westinghouse should address, in at least one SPES-2 test report (e.g., Test Analysis Report) how this distortion is accounted for in assessing SPES-2 test data.

Response:

Section 1.6 of the SPES-2 TAR provides a discussion of the SPES-2 atypicalities relative to the AP600 Plant. Included in this discussion are the scaling distortions which result when using the power compensation method, before ADS activation, to account for heat losses in the SPES-2 facility.

SSAR Revision: NONE

Question 480.232

It would be useful to show reference levels in certain liquid level plots, such as showing the top of the active fuel elevation on the power channel level plot.

Response:

Three figures in the SPES-2 TAR provide reference levels for each of the matrix tests. Figure 40 provides two phase liquid levels in the power channel vs. DVI, cold leg and hot leg elevations. Figure 42 provides collapsed liquid level in the downcomer vs. DVI, cold leg and hot leg elevations. Figure 44 provides collapsed liquid level in the tubular downcomer vs. the top and bottom of the active fuel levels. In addition, the Facility Description Report provides the elevations for all of the taps on the power channel. The reference levels vs. liquid levels may be determined using these elevations.

SSAR Revision: NONE

Question 480.234

The behavior of DP-A16P (Plot 28) needs some additional explanation to aid in its interpretation. It starts out negative, then increases to zero, which is interpreted (Section 6.5) as a decreasing level. Later in the transient, the level increases again, which is this time interpreted as an increasing level. Is this a function of the density difference between a reference leg and the power channel, or is there some other explanation for the behavior?

Response:

DP-A16P provides the hot leg A to the top of the upper plenum level. During pump operation, this indication is negative. Once the pumps trip, the indicated differential pressure provides the upper plenum level. For test S00605, the indication starts out negative with the pumps operating, increases to just above zero when the pumps trip, and then falls to zero. The level recovers for about 300 seconds, approximately 1550 seconds into the transient, at the end of accumulator injection. It recovers for the remainder of the transient 300 seconds after IRWST injection starts.

SSAR Revision: NONE

Question 480.235

This test was affected by the necessity of opening the atmospheric dump system (ADS)-4 valves manually about 90 seconds later than the automatic actuation signal. That aspect of the test is barely mentioned in passing in the text, and is only noted at the bottom of the "Sequence of Events" table. Deviations from test procedures of this sort should be clearly stated and discussed in the test reports.

Response:

Section 2.6 of the FDR will be revised by April 31, 1996 to clearly state and discuss deviations from test procedures and/or control algorithms for each of the matrix tests.

SSAR Revision: NONE

Question 480.237

Why does CMT "A" never drain completely?

Response:

The criterion used for test termination during the SPES tests was establishing stable IRWST injection. For test S00706, stable IRWST injection was established and the test was terminated prior to completely draining CMT "A". IRWST injection occurs prior to complete drain-down of CMT "A" since the ADS was activated by the rapid drain-down of CMT "B" DVI line. CMT "A" would have completely drained if the test had continued.

SSAR Revision: NONE

Question 480.238

Flow measurement F-B40E is noted in Table 6-3 as "out of range," but is used as a benchmark (p. 6-2) and is plotted in Plot 32. How can this instrument be used in this situation? If it is considered to be accurate over some period of the test and inaccurate during others, those times should be clearly denoted in the plots and in the discussion of the data.

Response:

Test S00706 is a double-ended guillotine break of a direct vessel injection line. The simulated break occurred on DVI line B. Therefore, injection flow from CMT-B, indicated by F-B40E, is out of range for a short time at the beginning of the blowdown. Alternate instrumentation was used to evaluate flow from the CMT during this time. Appendix D of the FDR will be modified by April 31, 1996 to reflect the out of range condition for this instrument.

SSAR Revision: NONE

Question 480.239

This test used an incorrect (high) core power for about the first 500 seconds. This is noted several places in the discussion, which is commendable, but not in the test procedure section. Presumably, some action had to be taken to reduce the power from its twice-nominal value to its correct value during the power decay, unless the problem was simply a controller programming error, but the reason for the error and the compensating actions are not discussed. The staff expects to see a more detailed explanation of the causes and possible effects of the power error in future reports on the SPES-2 program, especially in light of the fact that this particular transient is generally considered to be the most severe small-break loss-of-coolant accident (LOCA).

Response:

Section 2.6 of the FDR will be revised by April 31, 1996 to clearly state and discuss deviations from test procedures and/or control algorithms for each of the matrix tests.

SSAR Revision: NONE

Question 480.240

A significant number of failed instruments is shown for this (and other) SPES tests. No "critical instrument" list was provided; Westinghouse should be prepared to demonstrate that all tests met instrument operability acceptance criteria.

Response:

A critical instrument list for the SPES-2 matrix tests was provided in Table 3-2 of the FDR. In addition, Appendix D of the FDR provides lists of failed instruments and out-of-range or modified instruments for each of the matrix tests. The SPES-2 facility was equipped with alternate instrumentation which was used to evaluate facility behavior in the event that a critical instrument was unavailable.

SSAR Revision: NONE

Question 480.241

The QLR (Summary, p. iii) states that there was no CMT injection for this transient. This is demonstrably untrue. There may have been little or no draining of the CMTs, but there was clearly recirculation, which is a mode of CMT injection that, in fact, provides a net mass addition to the system due to the difference in CMT and core average coolant densities. This statement should either be modified to reflect recirculatory injection of CMT fluid, or Westinghouse should explain clearly that the term "CMT injection" refers (somewhat inaccurately) to the draining mode only.

Response:

Westinghouse agrees that during this transient, CMT injection by natural circulation did occur. The Quick Look Report has been superseded by a description of the test provided in Section 4.2.12 of the FDR.

SSAR Revision: NONE

Question 480.273

As part of the hot shakedown testing performed in SPES-2, a test was performed simulating inadvertent actuation of the automatic depressurization system in the AP600. The staff had requested that a test of this sort be included in the AP600 matrix, and Westinghouse's response to the staff was that the pre-operational test would be run in the same manner as a matrix test. This information is of considerable interest to the staff, since a similar test (SB14) was performed in the OSU/APEX facility, and can provide a basis for comparison of the behavior of the two test loops. Accordingly, the staff requests that Westinghouse provide a Quick-Look Report (QLR) on this hot shakedown test, including complete transmittal of facility data.

Response:

SPES-2 Hot Preoperational Test H-06 simulated an inadvertant actuation of the ADS Stage 1. A Quick Look Report (Reference) and data tapes were issued for this test in August 1995.

Reference: PXS-T2R-014, SPES-2 Hot Preoperational Test H-06, Inadvertent ADS Stage 1 Actuation (with no ADS Stage 4), July 1995

SSAR Revision: NONE

Question 4~~8~~40.431

The last two lines of Table 2.6.6-1 (page 2.6-29) for Test S00908 refer to break orifices installed in the direct vessel injection (DVI) line. This test was a CMT balance line break, not a DVI line break, and the orifices were in the CMT-B cold leg balance line. Similar discrepancies appear in Table 2.6.4-1, where a "cold leg-B2 break device" is shown for a 2" DVI break test, and in Table 2.6.11-1, where a cold leg break device is again shown for the main steamline break test. Explain or correct these discrepancies and verify that all of the tables for the tests described in Chapter 2 reflect the correct locations for break and other orifices.

Response:

Corrections will be made to Table 2.6.6-1, 2.6.4-1, and 2.6.11-1 as indicated above. In addition, the tables for the other tests have been reviewed to ensure that the correct locations and sizes have been provided for the break and other orifices. The last line of Tables 2.6.9-1 and 2.6.10-1 should read the "SG-B tube break device" rather than "Cold Leg-B2 break device."

SSAR Revision: NONE

Question 440.487

Re: NOTRUMP PVR FOR OSU TESTS, LTCT-GSR-001, JULY 1995
The OSU test data indicate liquid levels in the upper plenum and core regions. Please provide comparisons of the NOTRUMP liquid levels in the core and upper plenum versus the test data. Also, provide a plot of the void fraction in the core and upper plenum for this test along with identification of the subcooled level. Key parameters for judging small break LOCA response are the liquid and two-phase levels in the vessel (i.e. core and upper plenum regions). The ability of the NOTRUMP code to predict AP600 performance is directly related to the code's ability to predict the liquid inventory and location of the two-phase surface in the inner vessel region. To state that the code captures the phenomena of this transient it must be demonstrated that the code can successfully predict the liquid inventory and location of the two-phase surface in the core or upper plenum regions.

Response:

Please see the Westinghouse response to RAI 440.492.

SSAR Revision: NONE

Question 440.492

Re: NOTRUMP PVR FOR OSU TESTS, LTCT-GSR-001, JULY 1995
Please provide the core inlet and bypass mass flow rate predictions for the blind two inch cold leg balance line break of Section 5.2. Also, provide the liquid level plots for the upper plenum and core region and the void distribution in the core region.

Response:

The requested NOTRUMP core inlet and core bypass mass flow rate predictions for this test are provided in the response to RAI 440.491.

The requested data of the upper plenum liquid level, upper plenum void fraction, core liquid level, core void fraction, and the elevation of subcooled liquid for the NOTRUMP analyses and the related tests are provided in Figures 440.492-1 through 440.492-50. The NOTRUMP data is presented on separate figures from the test data because when the information is multiplotted, the plots are not readable. The core and upper plenum liquid levels are collapsed liquid levels for both the NOTRUMP results and the test data. All elevations in the figures are feet above the bottom of the vessel.

The NOTRUMP core void fraction is the arithmetic average over the four core nodes since the calculated mixture level is always above the core nodes. The upper plenum liquid level and void fraction from the test is a weighted average over the four upper plenum regions, as defined in Reference 440.492-1, which are equivalent to the NOTRUMP upper plenum.

The sub-cooled liquid level from the test is a quantity calculated by the data analysis software, based upon the Tsat method described in Section 4.11 of Reference 440.492-1 (pages 4 and 5), which is appropriate for the short term transient. The level from the test data is therefore the elevation at which the fluid and saturation temperatures intersect. For test SB12 the sub-cooled level appears to vary widely for the first 300 seconds. This is an artifact of the Tsat calculational method. The sub-cooled NOTRUMP liquid level is the summed height of those core fluid nodes which do not contain vapor, since only those core fluid nodes which contain pure liquid are sub-cooled. Thus, the resolution of the NOTRUMP level is 0.75 feet (ie. the height of each core fluid node).

Also included as Figures 440.492-51 through 440.492-60 are plots of the void fraction in each of the four core nodes for each test simulated by NOTRUMP.

Reference

440.492-1 WCAP-14292, Revision 1, "AP600 Low-Pressure Integral Systems Test at Oregon State University Test Analysis Report," Proprietary [LTCT-T2R-600], September 1995

SSAR Revision: NONE

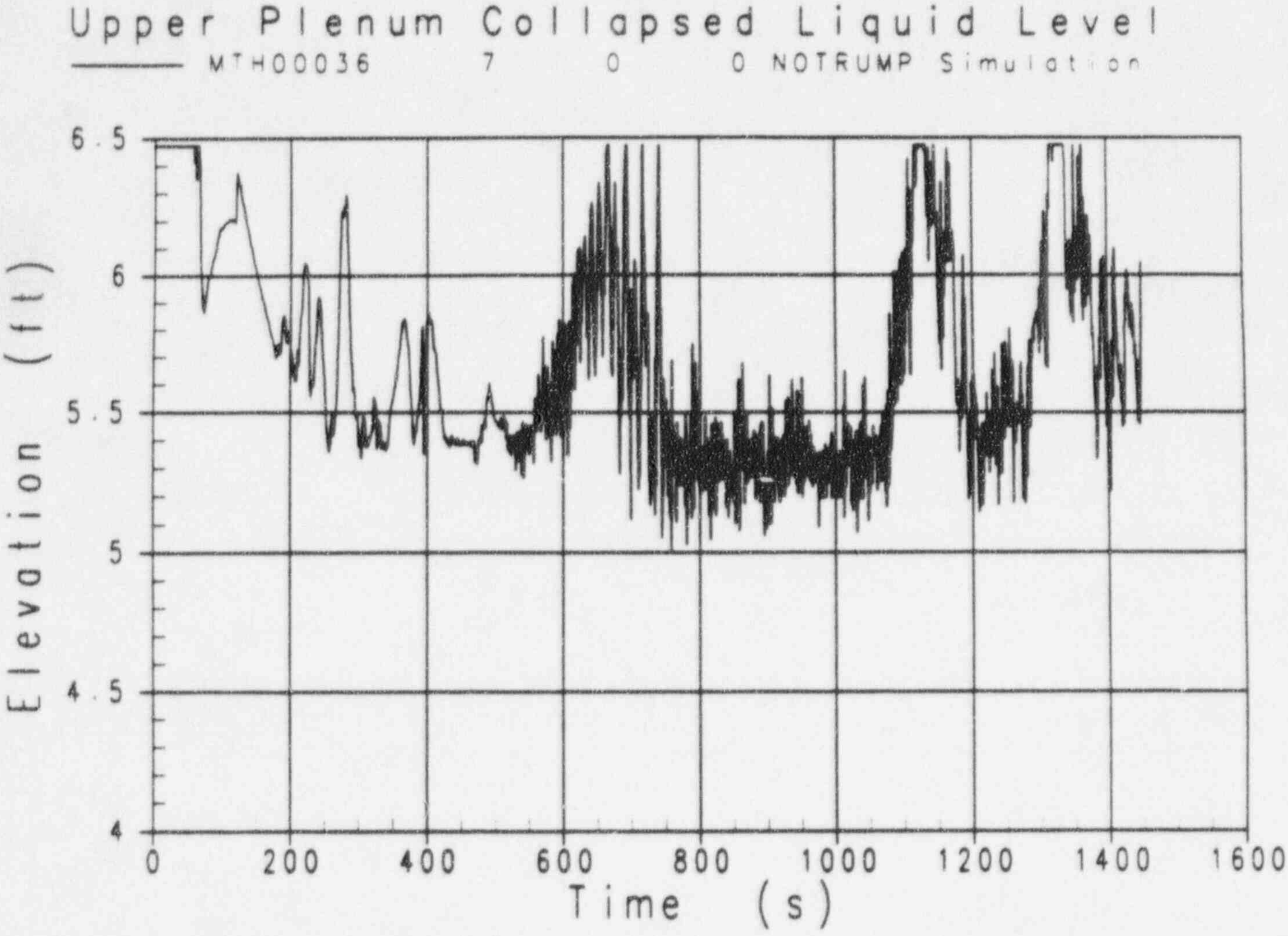


Figure 440.492-1 NOTRUMP - Upper Plenum Collapsed Liquid Level for Test SB01

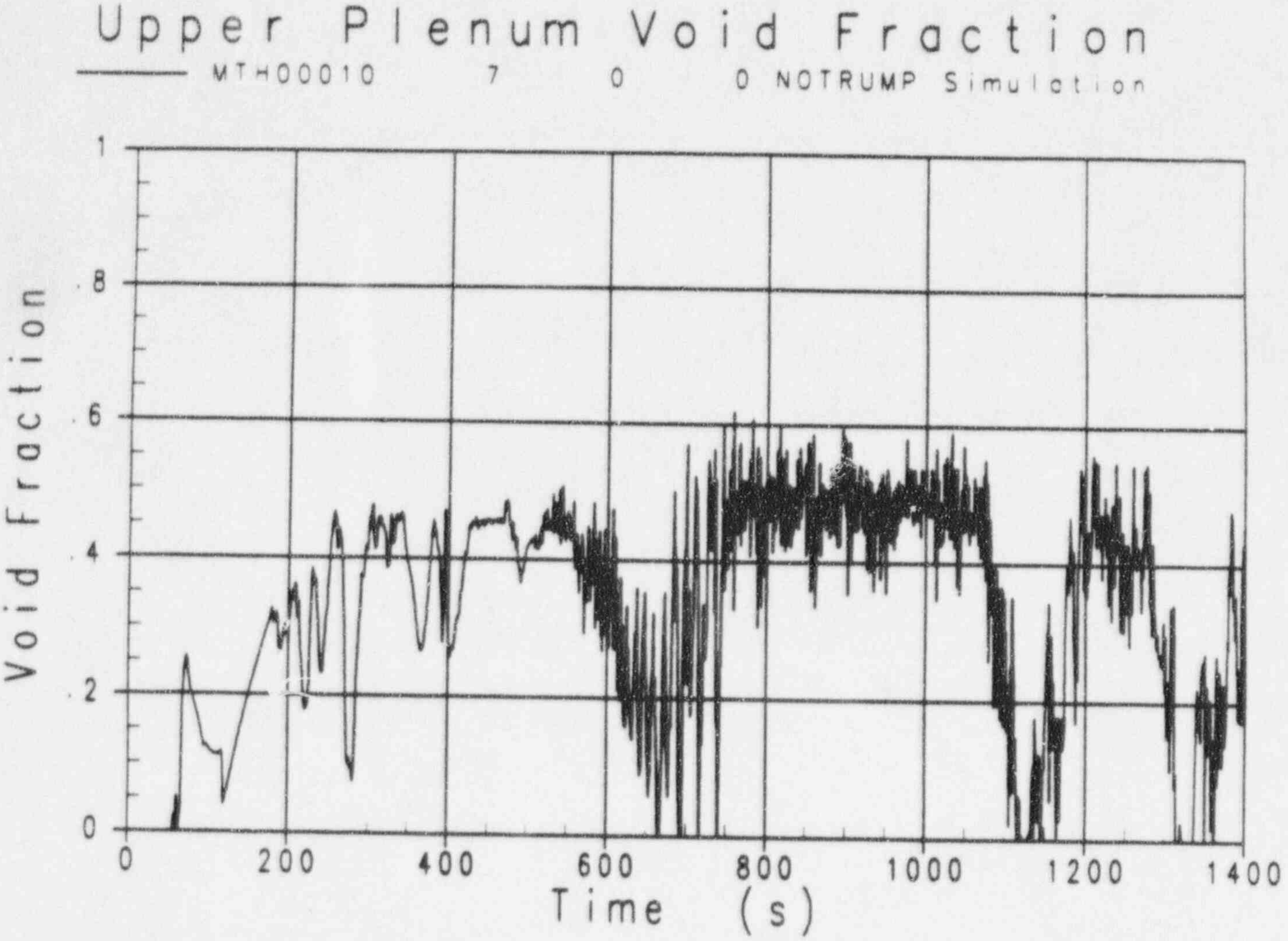


Figure 440.492-2 NOTRUMP - Upper Plenum Void Fraction for Test SB01

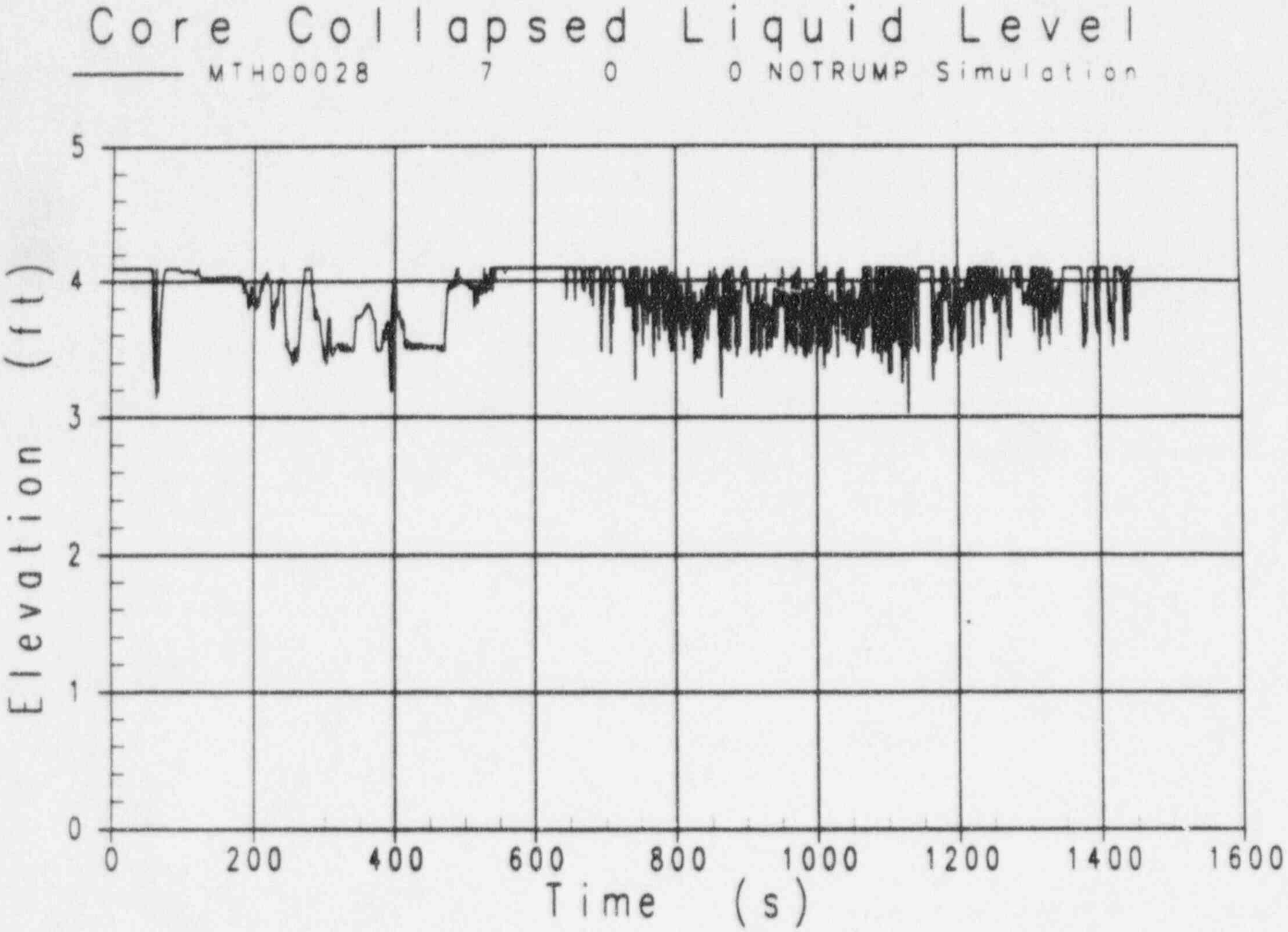


Figure 440.492-3 NOTRUMP - Core Collapsed Liquid Level for Test SB01

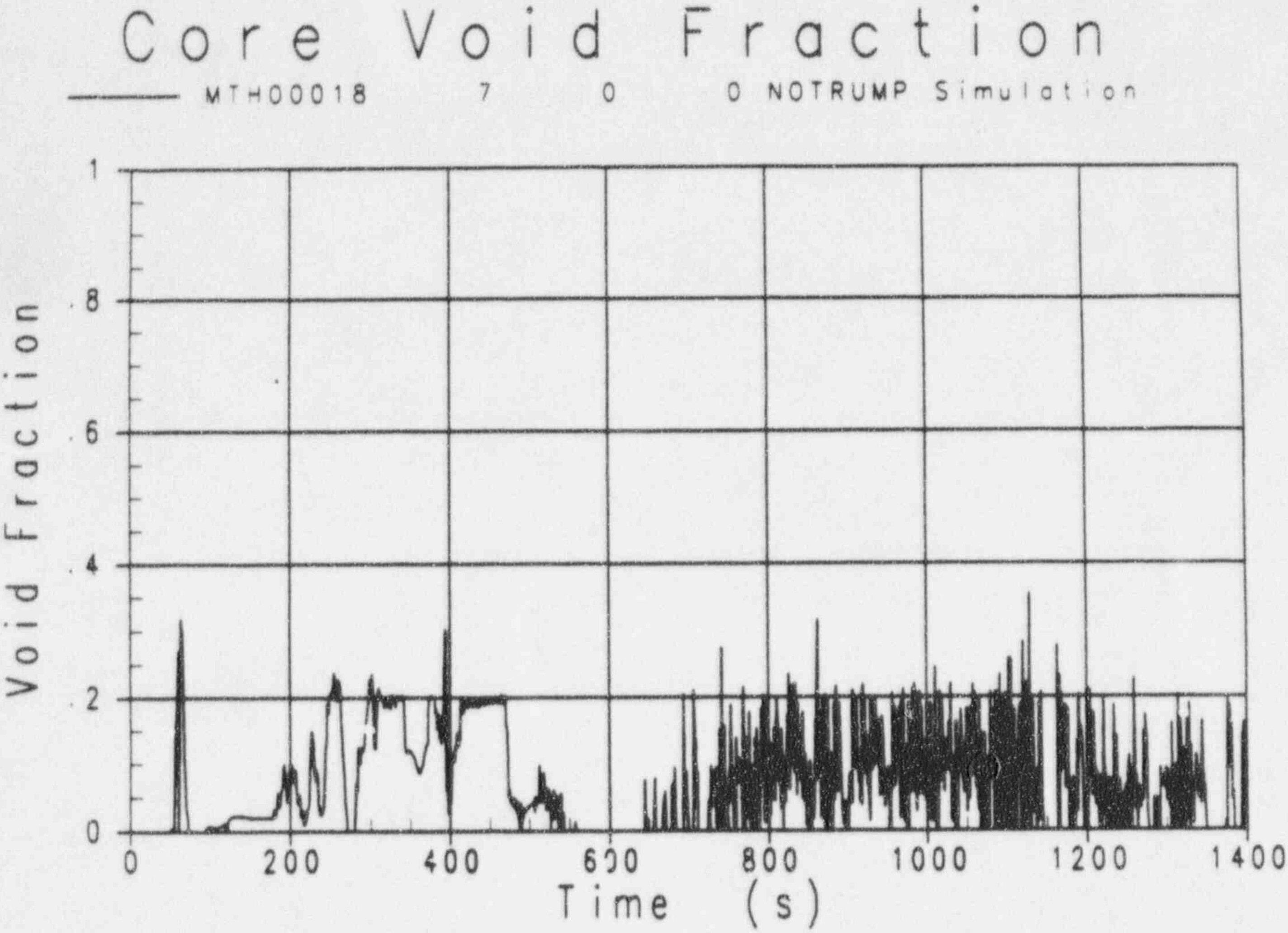


Figure 440.492-4 NOTRUMP - Core Void Fraction for Test SB01

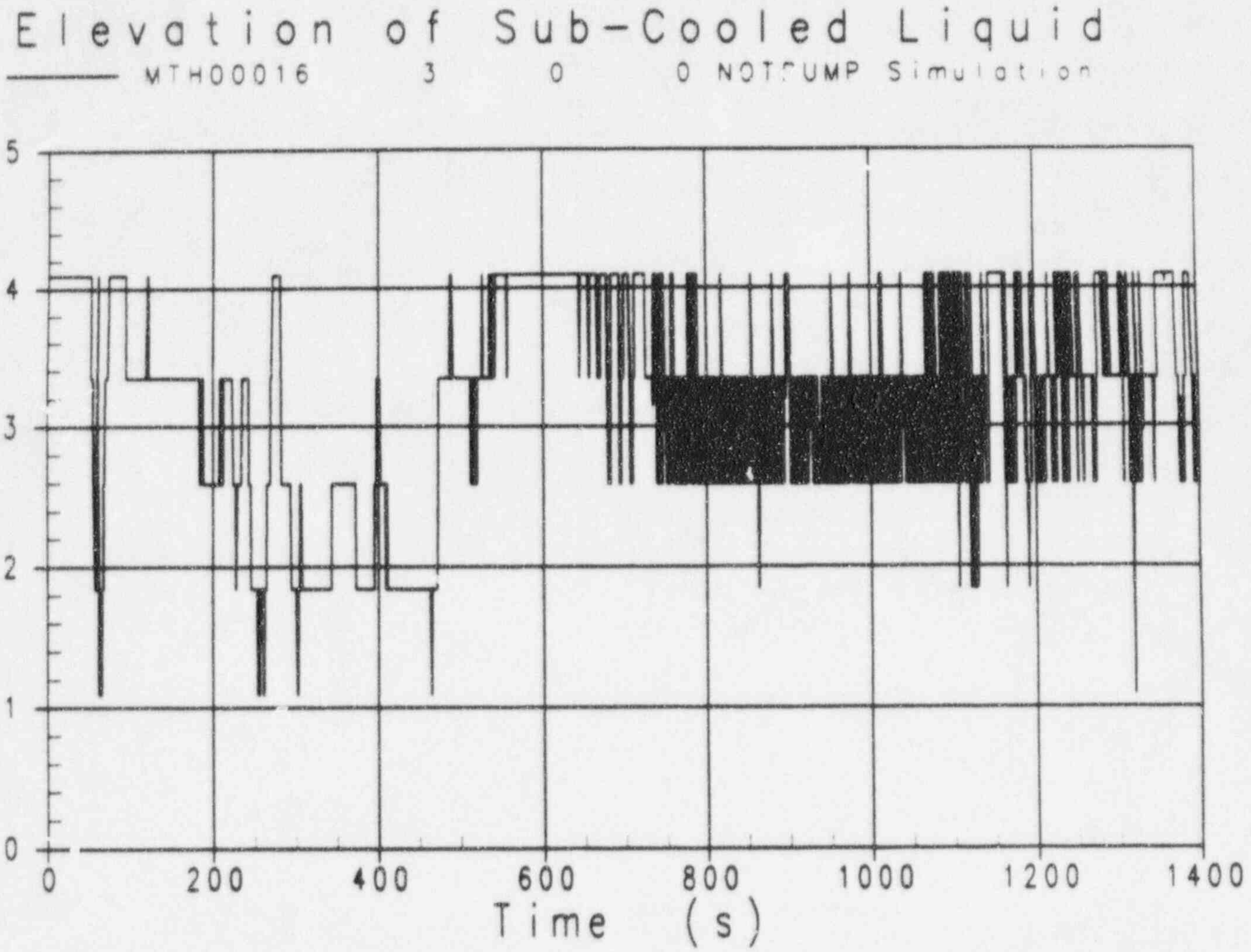


Figure 440.492-5 NOTRUMP - Elevation of Subcooled Liquid for Test SB01

c,D,

Figure 440.492-6 Test - Upper Plenum Collapsed Liquid Level for Test SB01

a,b,c

Figure 440.492-7 Test - Upper Plenum Void Fraction for Test SB01

a,b,c

Figure 440.492-8 Test - Core Collapsed Liquid Level for Test SB01

a,b,C

Figure 440.492-9 Test - Core Void Fraction for Test SB01

a b.c

Figure 440.492-10 Test - Elevation of Subcooled Liquid for Test SB01

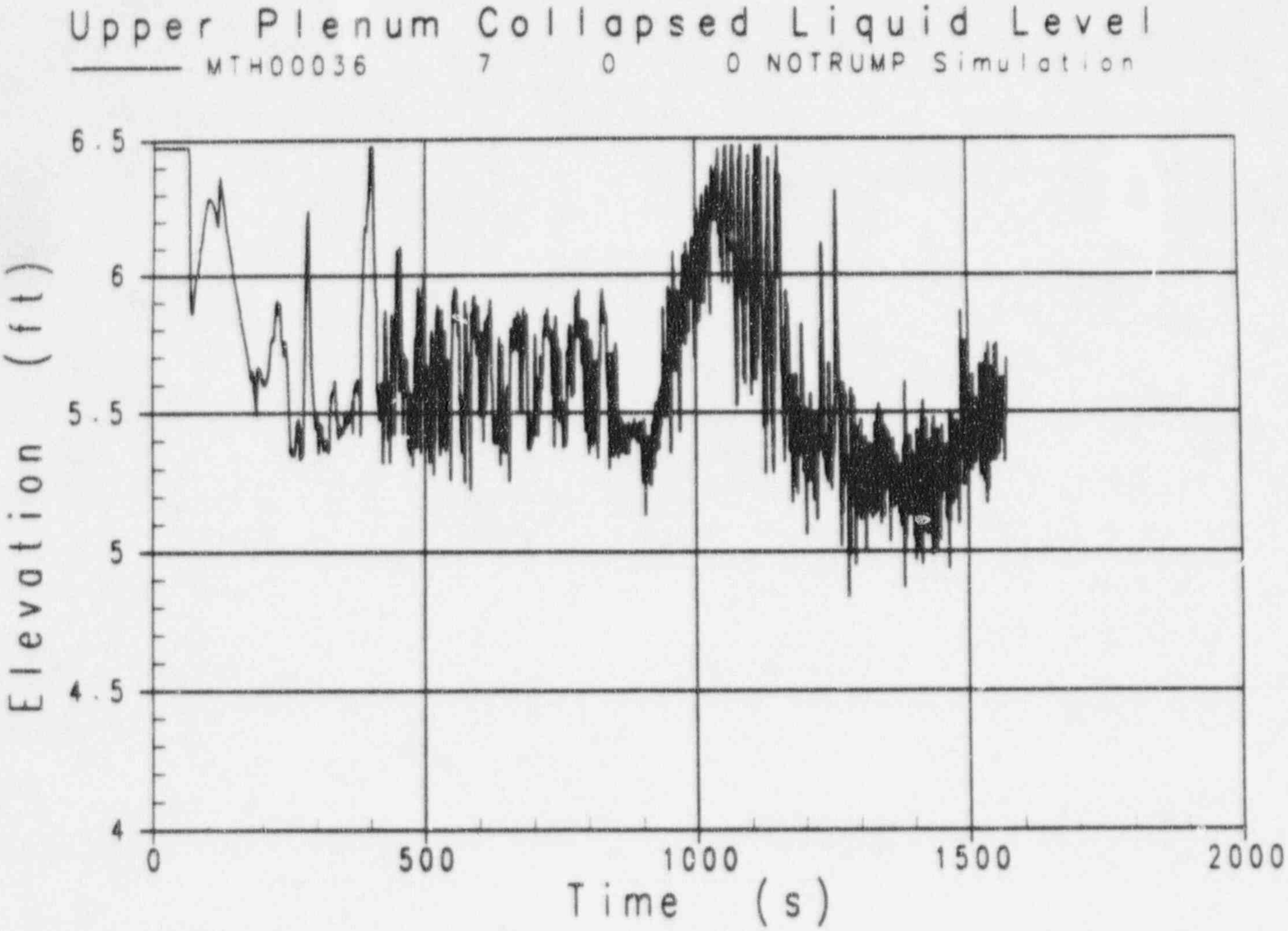


Figure 440.492-11 NOTRUMP - Upper Plenum Collapsed Liquid Level for Test SB09

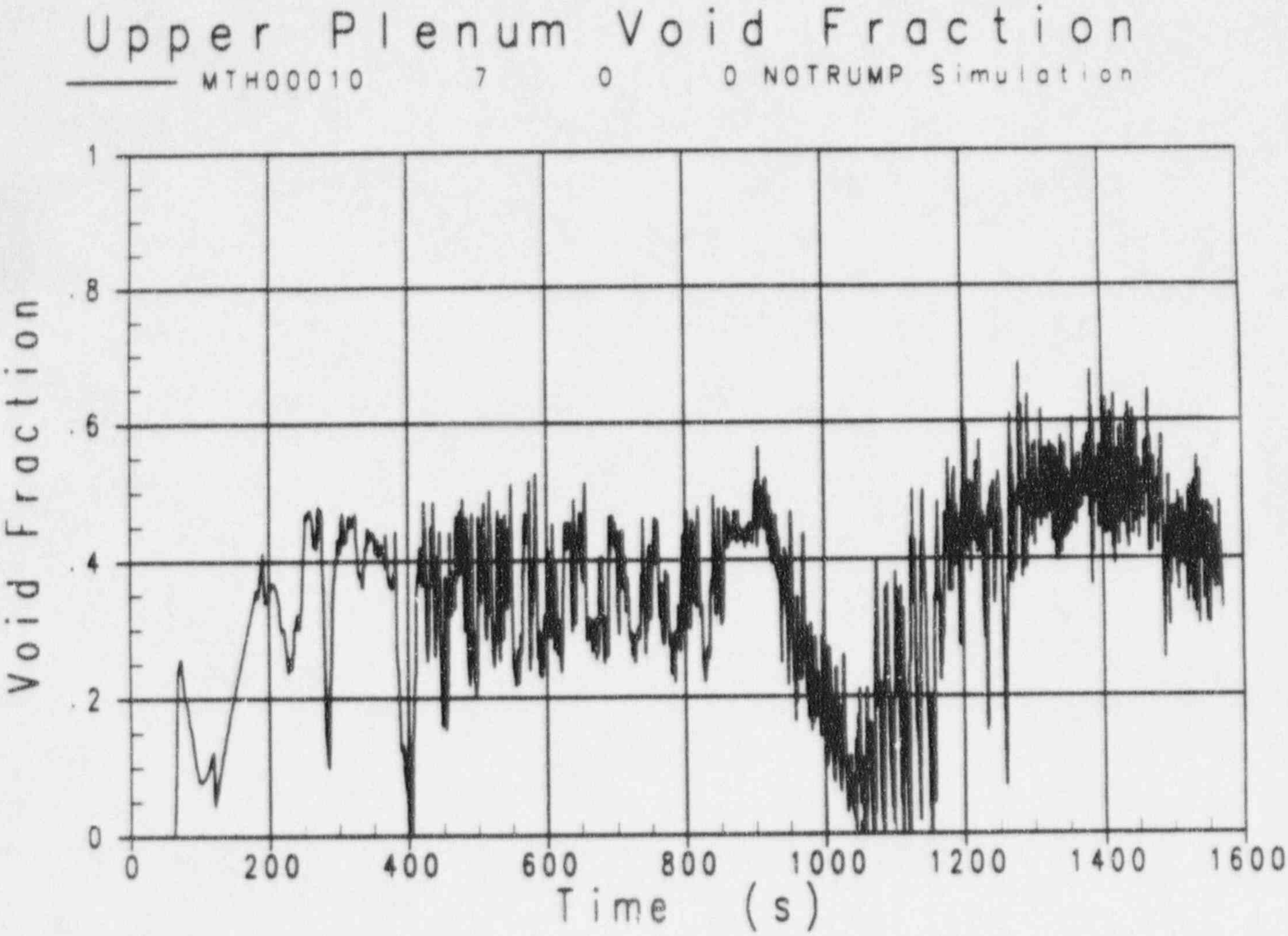


Figure 440.492-12 NOTRUMP - Upper Plenum Void Fraction for Test SB09

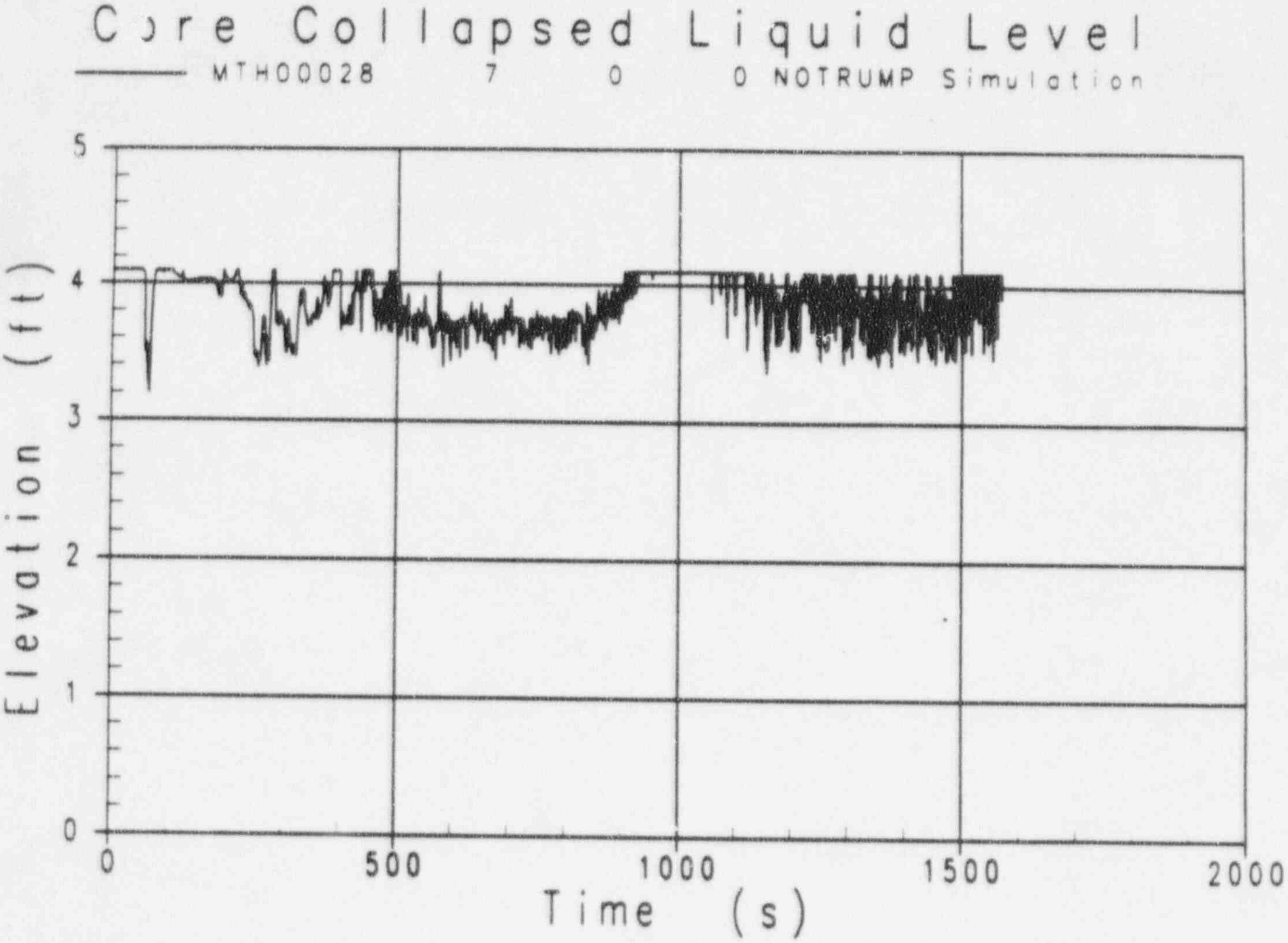


Figure 440.492-13 NOTRUMP - Core Collapsed Liquid Level for Test SB09

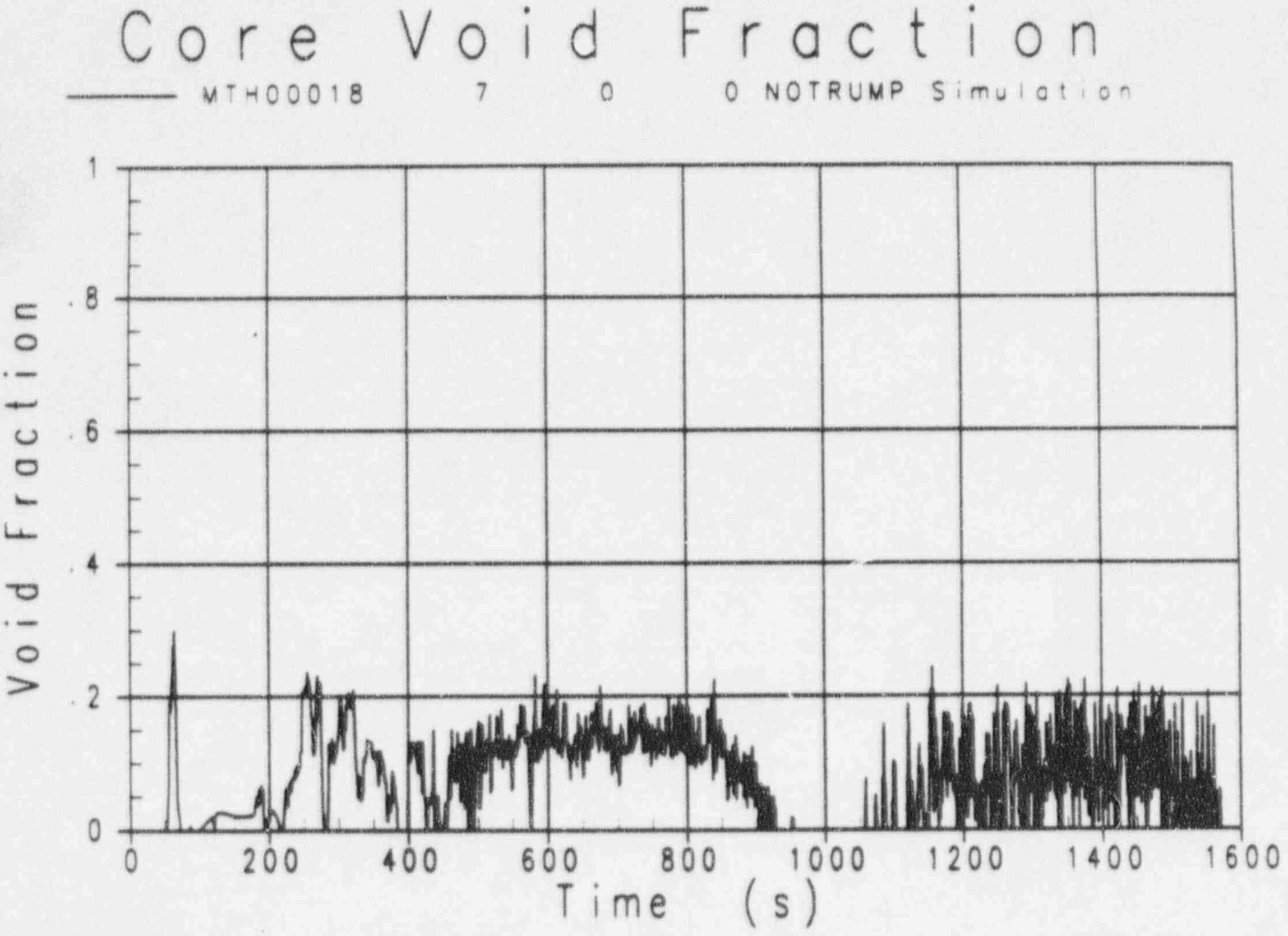


Figure 440.492-14 NOTRUMP - Core Void Fraction for Test SB09

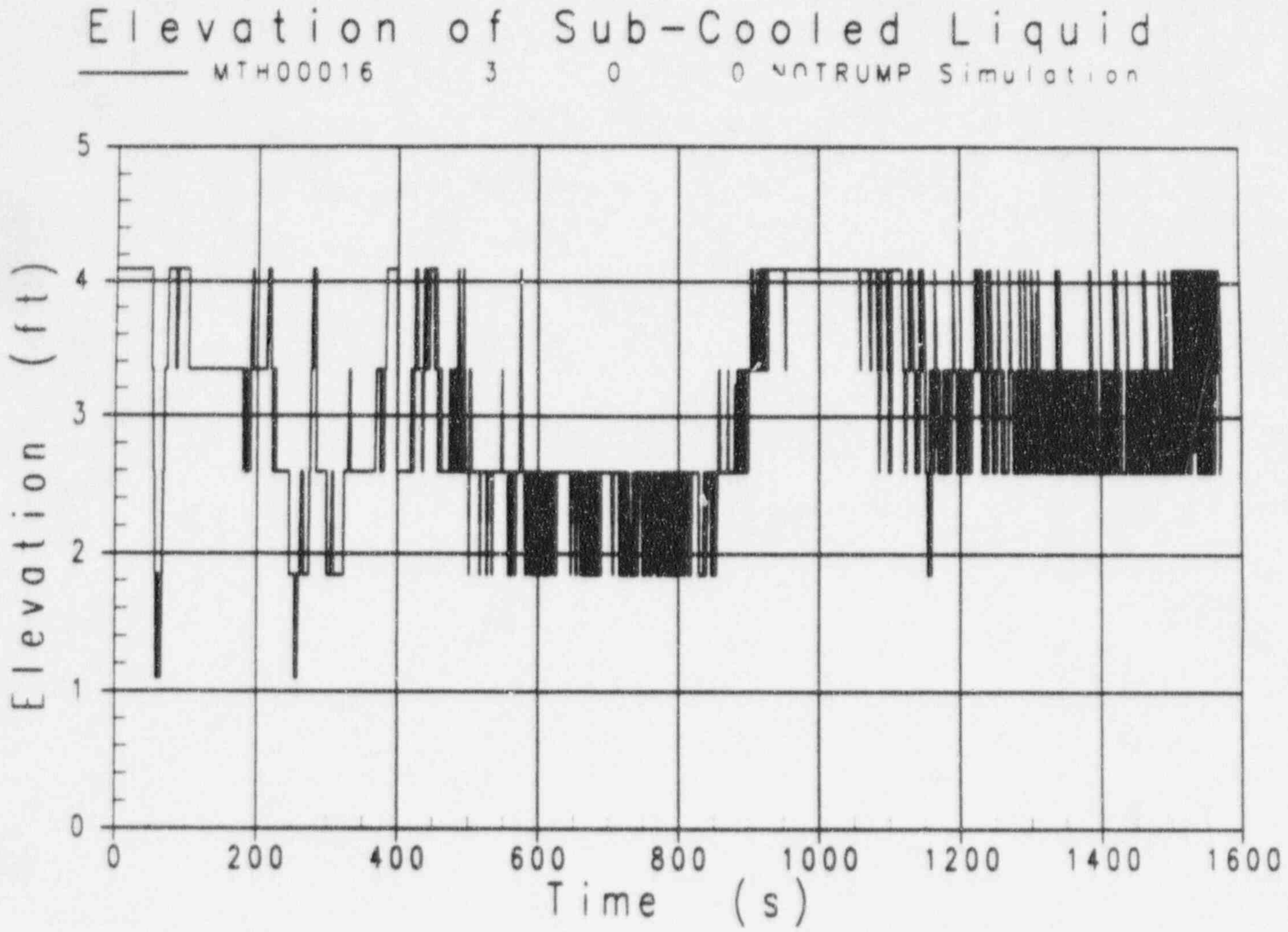


Figure 440.492-15 NOTRUMP - Elevation of Subcooled Liquid for Test SB09

a,b,c

Figure 440.492-16 Test - Upper Plenum Collapsed Liquid Level for Test SB09

a,b,c

Figure 440.492-17 Test - Upper Plenum Void Fraction for Test SB09

a,b,c

Figure 440.492-18 Test - Core Collapsed Liquid Level for Test SB09

a,b,c

Figure 440.492-19 Test - Core Void Fraction for Test SB09

a,b,c

Figure 440.492-20 Test - Elevation of Subcooled Liquid for Test SB09

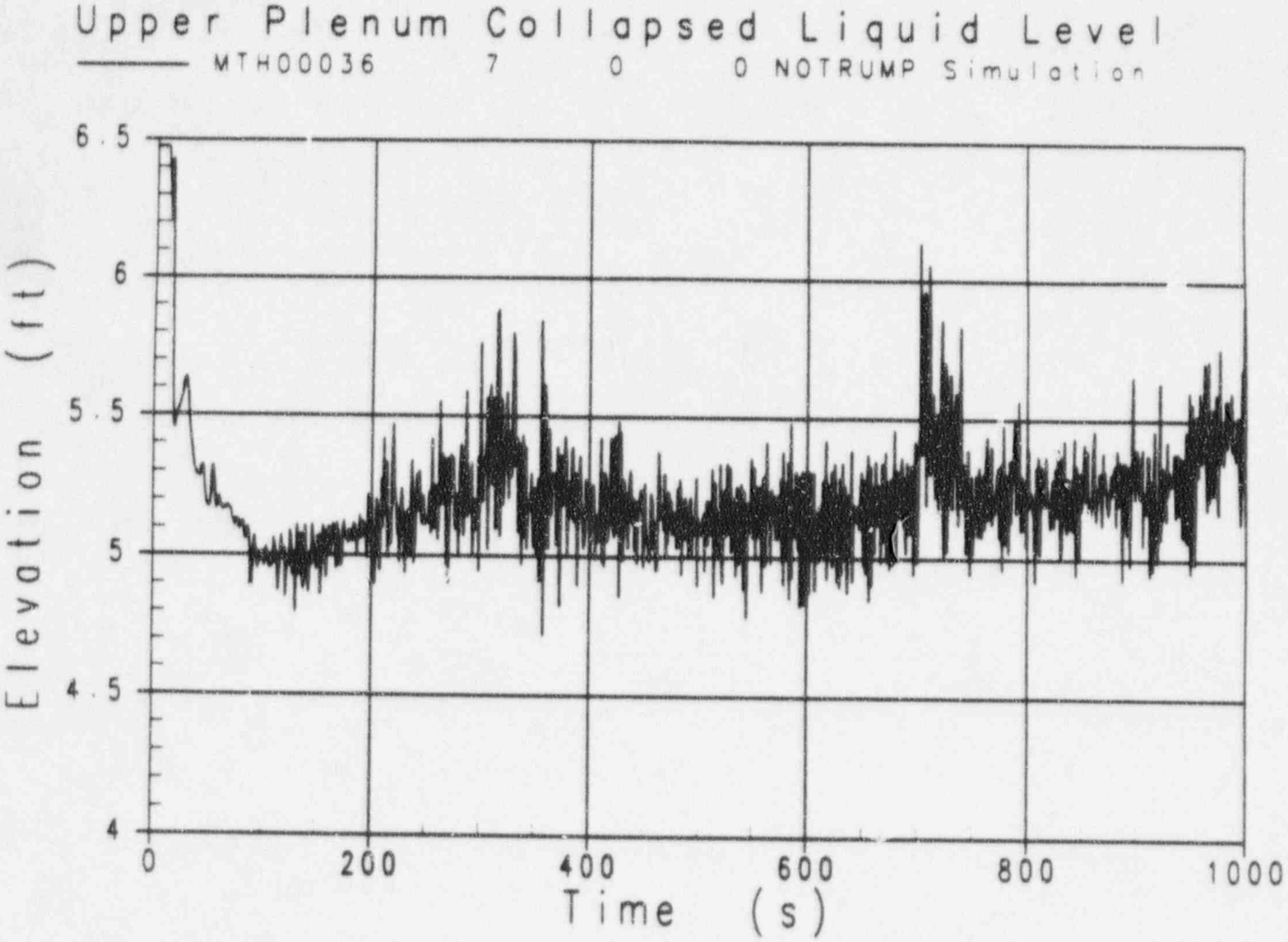


Figure 440.492-21 NOTRUMP - Upper Plenum Collapsed Liquid Level for Test SB10

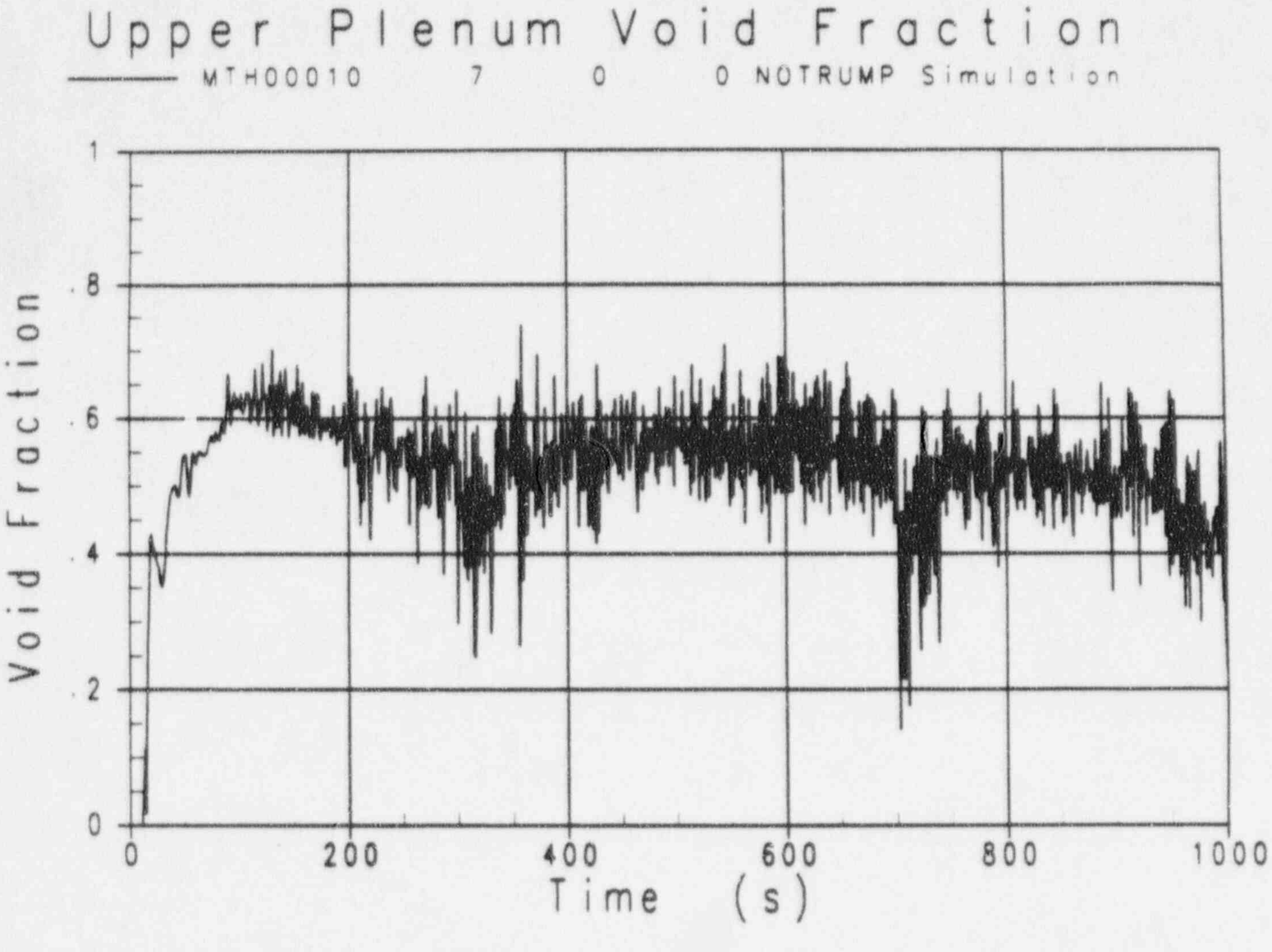


Figure 440.492-22 NOTRUMP - Upper Plenum Void Fraction for Test SB10

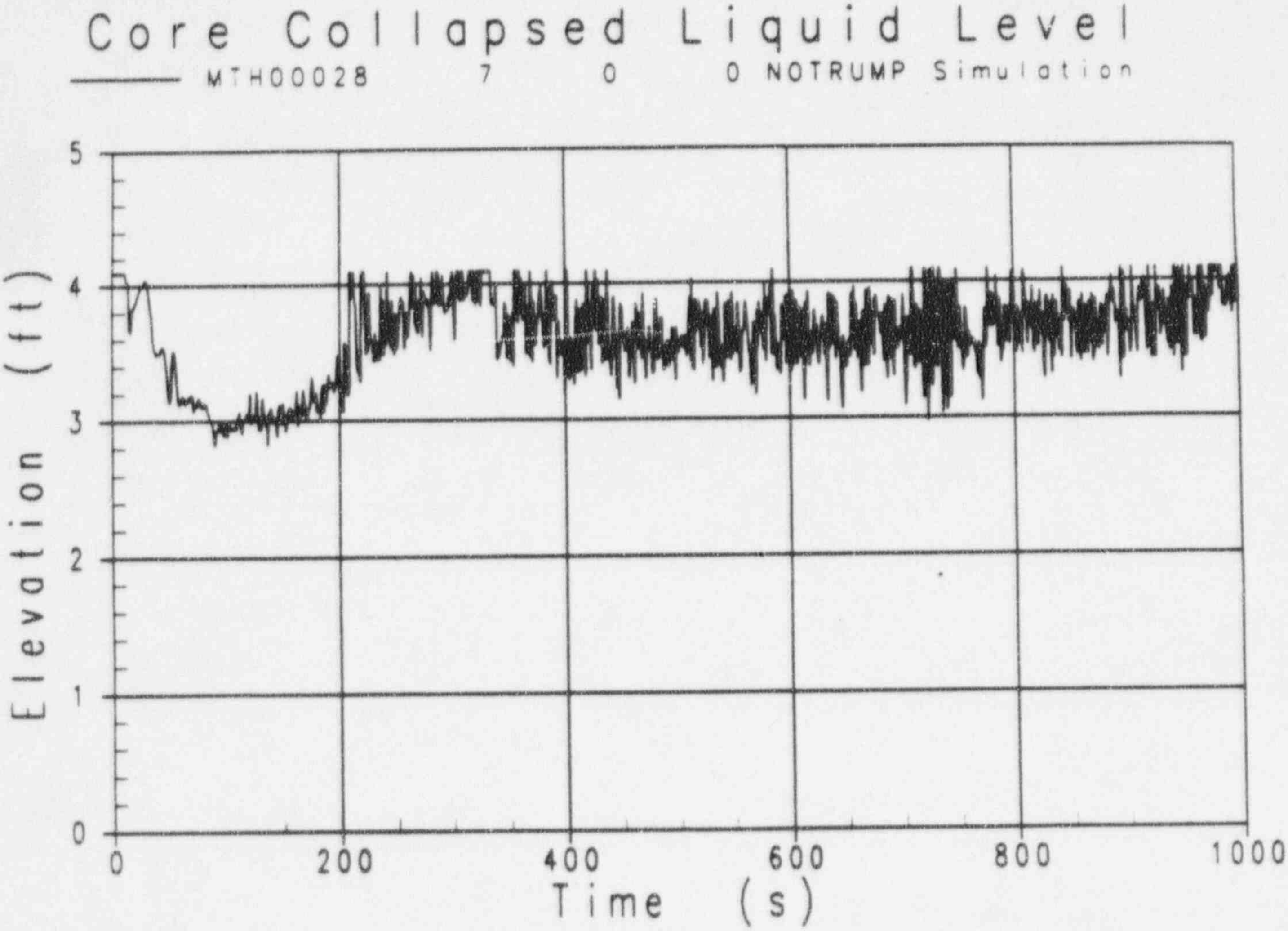


Figure 440.492-23 NOTRUMP - Core Collapsed Liquid Level for Test SB10

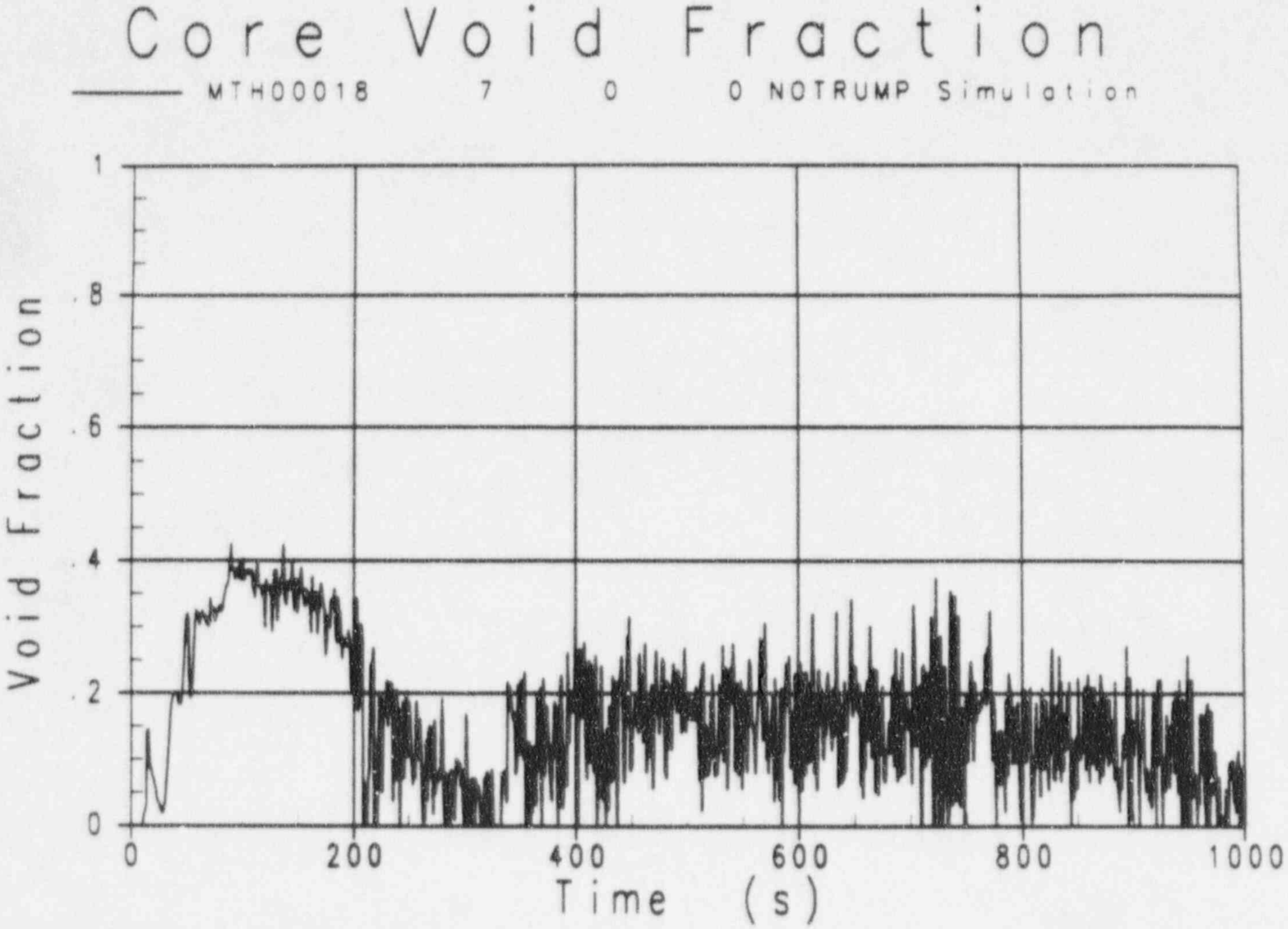


Figure 440.492-24 NOTRUMP - Core Void Fraction for Test SB10

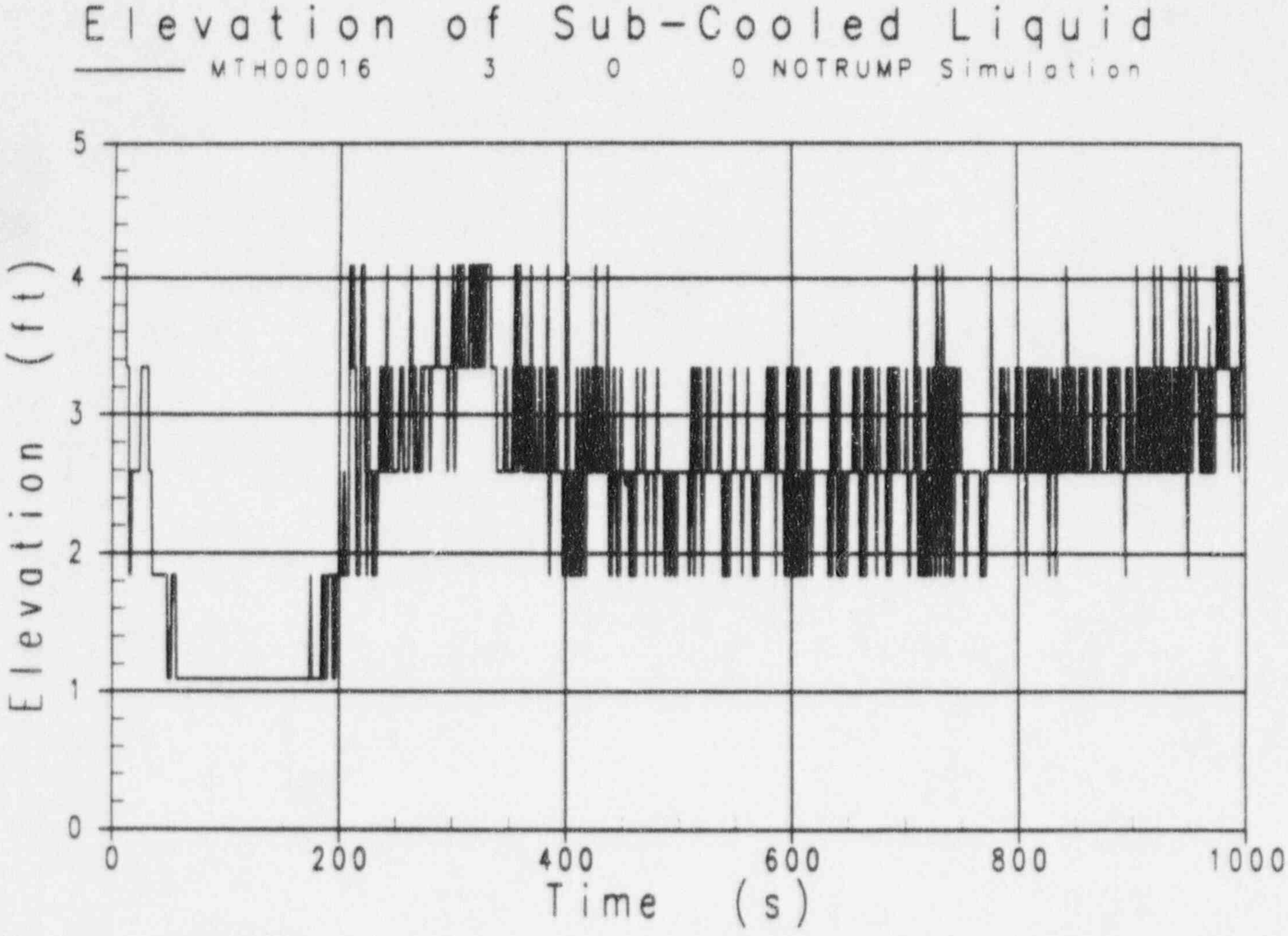


Figure 440.492-25 NOTRUMP - Elevation of Subcooled Liquid for Test SB10

a,b.c

Figure 440.492-26 Test - Upper Plenum Collapsed Liquid Level for Test SB10

a,b,c

Figure 440.492-27 Test - Upper Plenum Void Fraction for Test SB10

a,b,c

Figure 440.492-28 Test - Core Collapsed Liquid Level for Test SB10

a,b,c

Figure 440.492-29 Test - Core Void Fraction for Test SB10

a,b,c

Figure 440.492-30 Test - Elevation of Subcooled Liquid for Test SB10

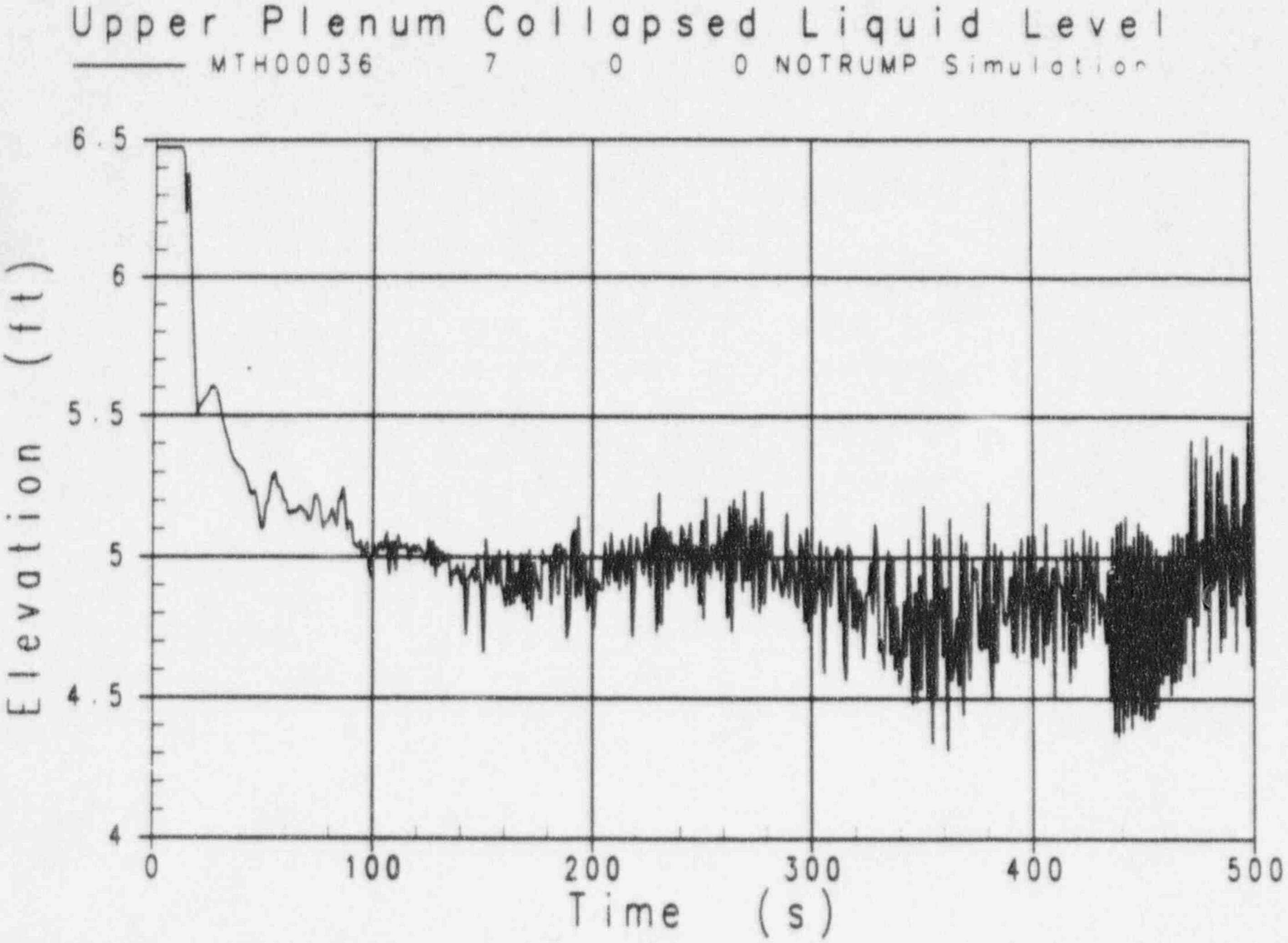


Figure 440.492-31 NOTRUMP - Upper Plenum Collapsed Liquid Level for Test SB12

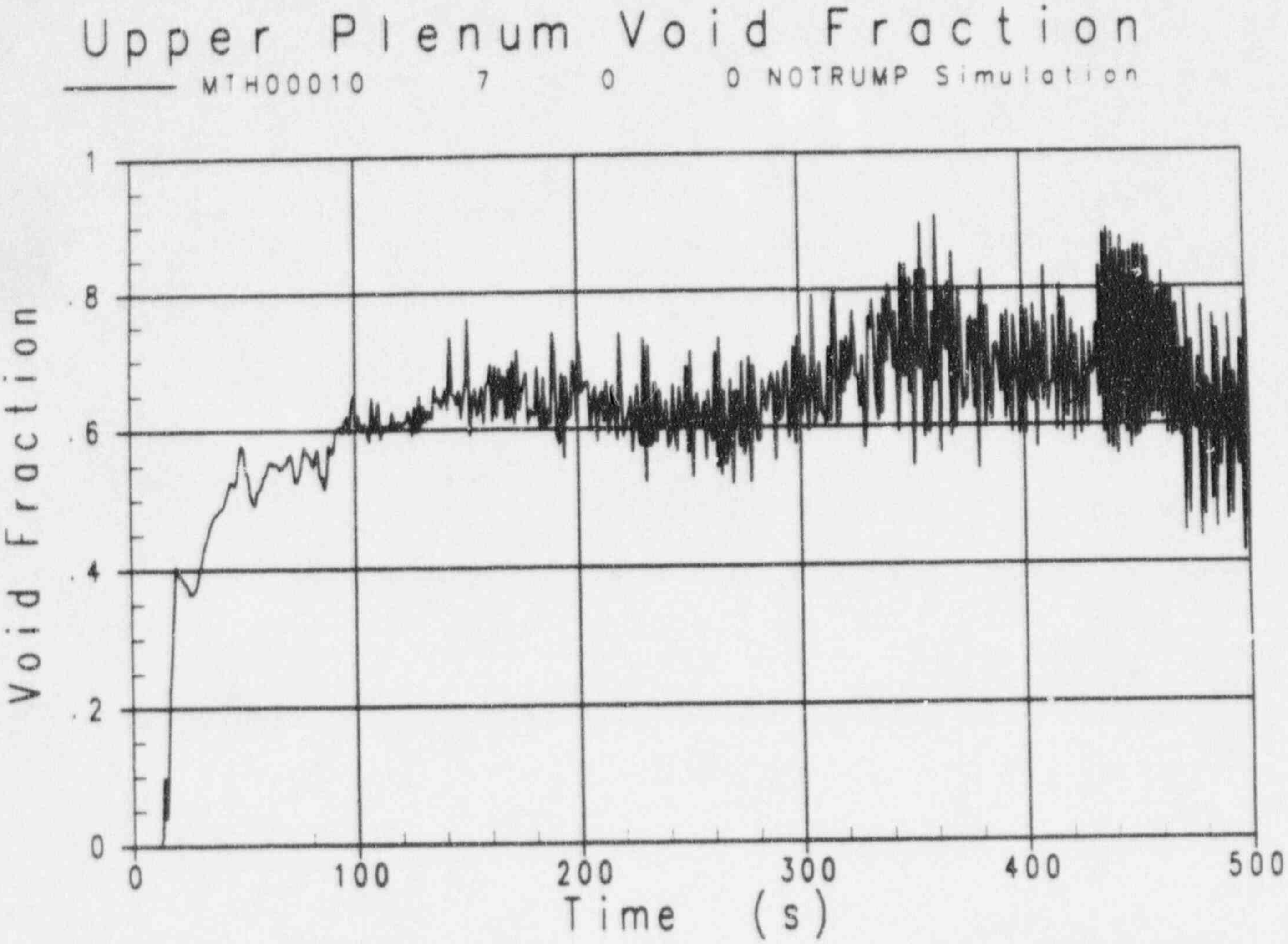


Figure 440.492-32 NOTRUMP - Upper Plenum Void Fraction for Test SB12

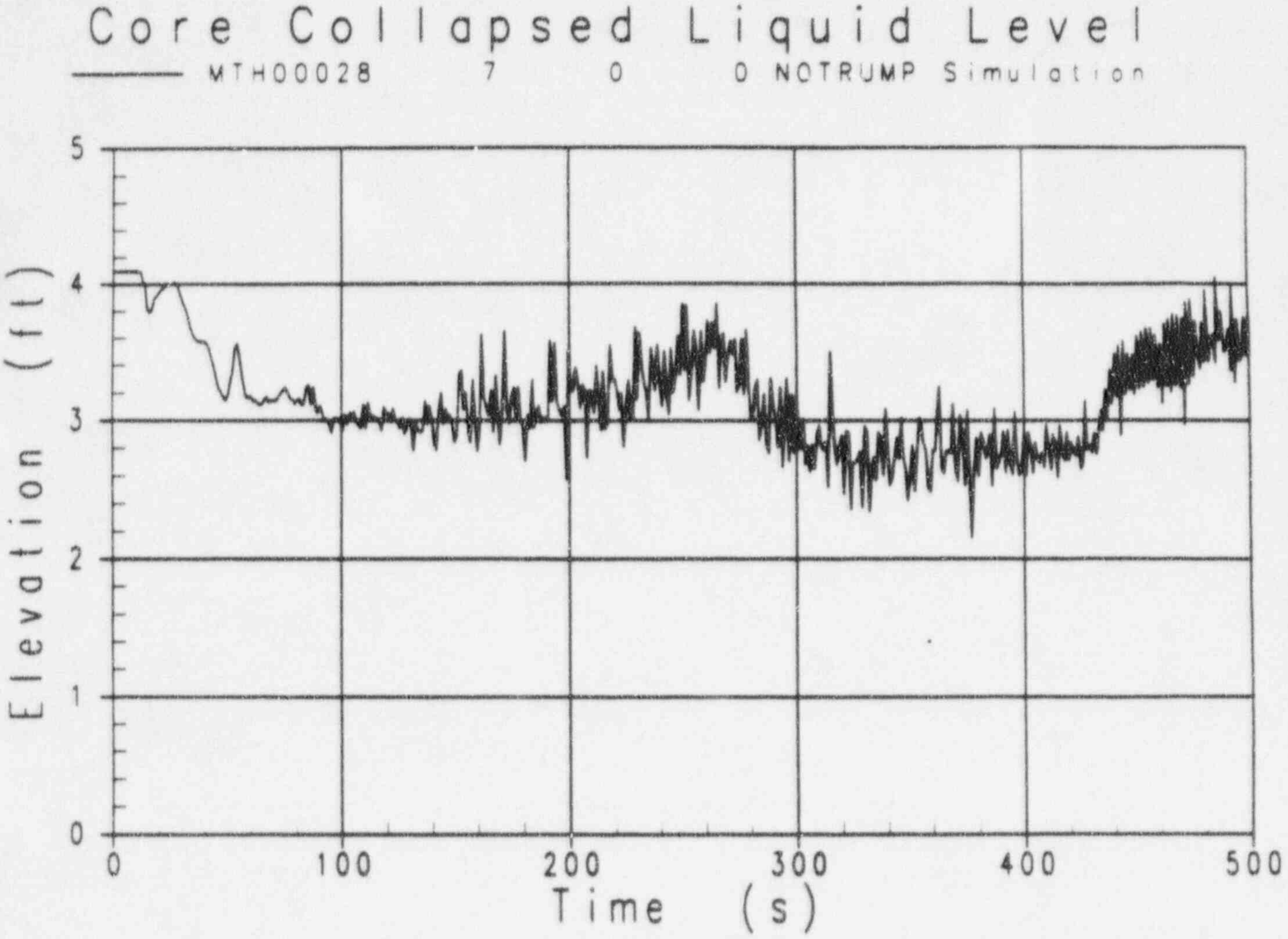


Figure 440.492-33 NOTRUMP - Core Collapsed Liquid Level for Test SB12

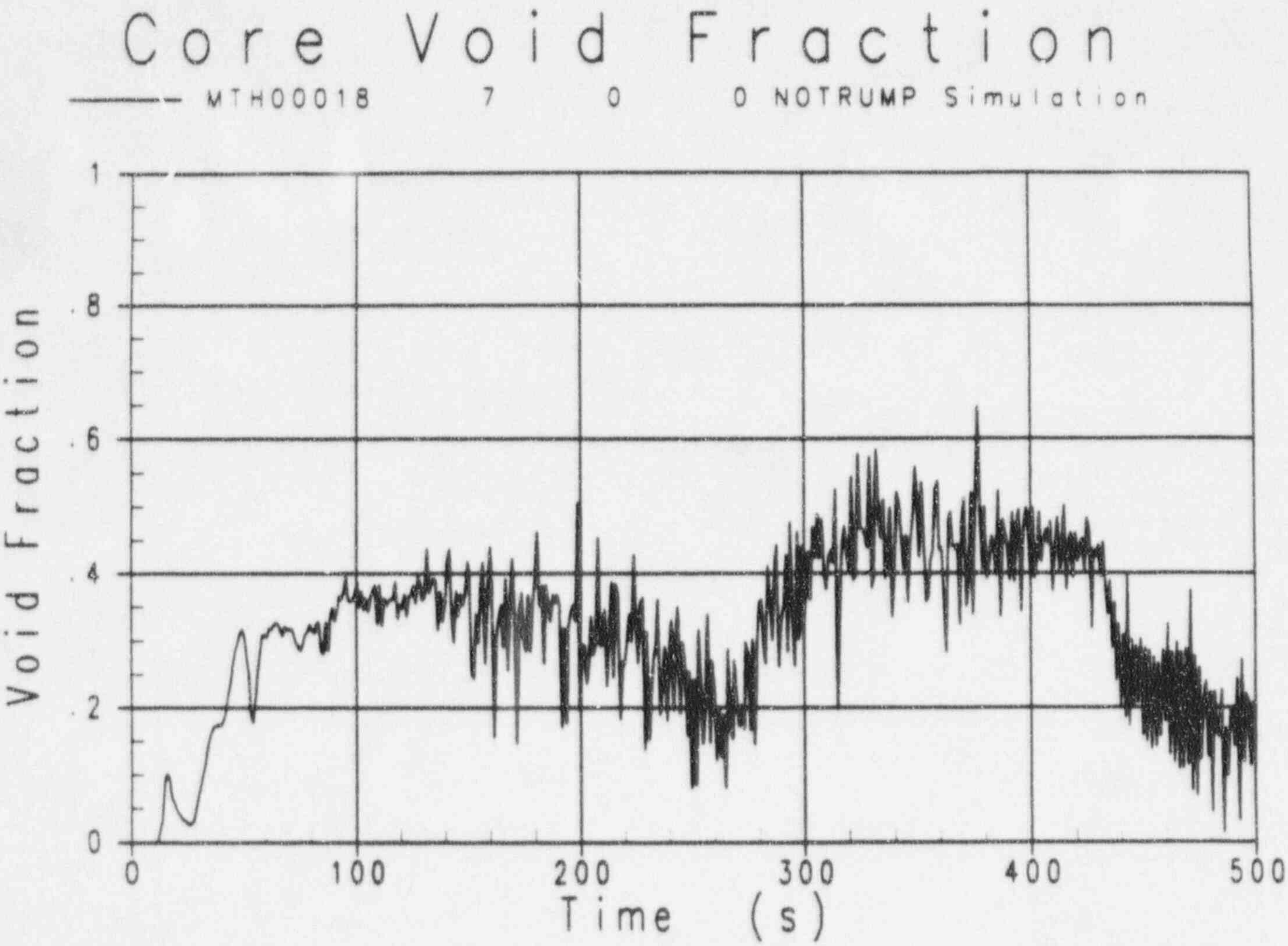


Figure 440.492-34 NOTRUMP - Core Void Fraction for Test SB12

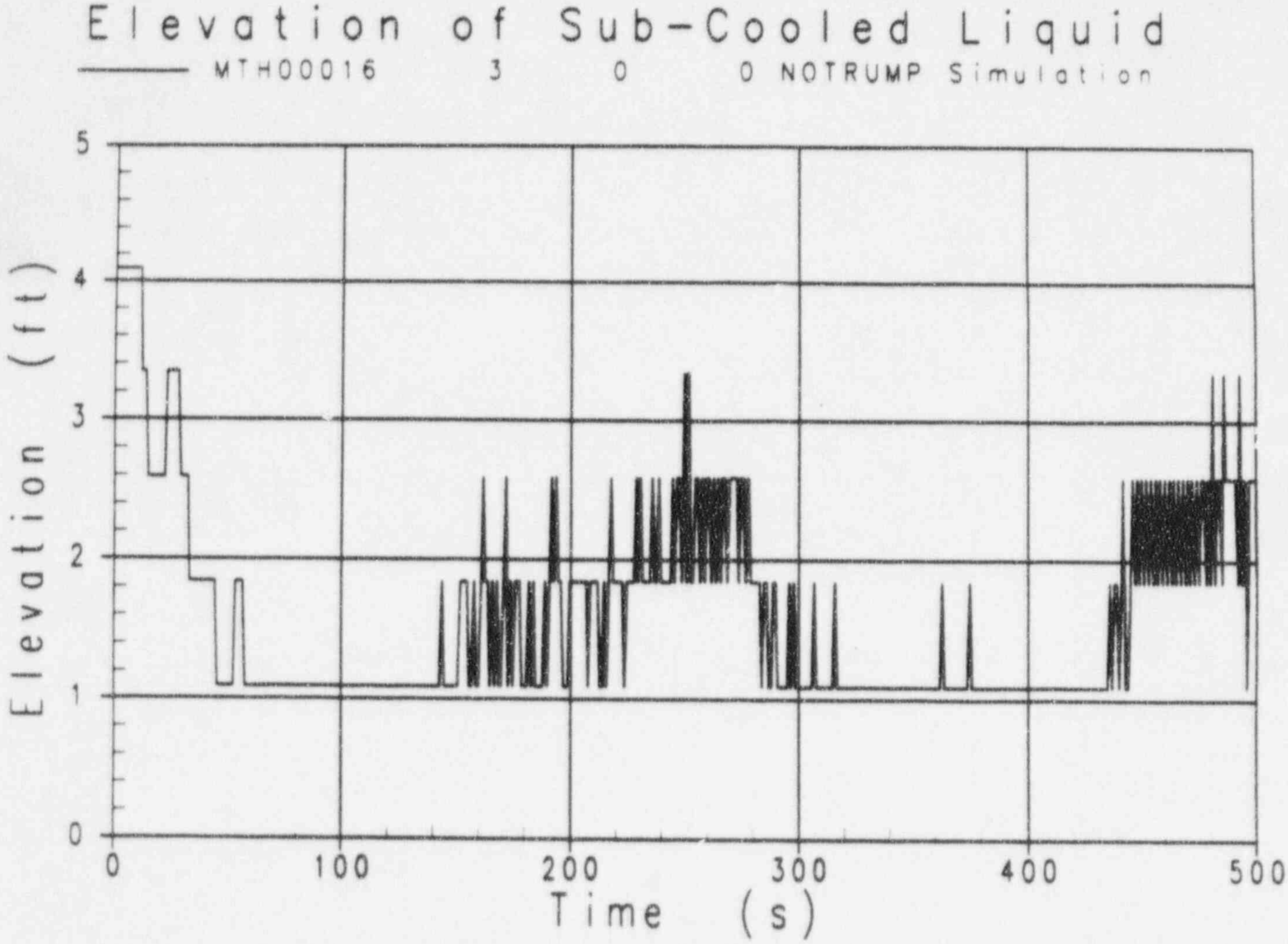


Figure 440.492-35 NOTRUMP - Elevation of Subcooled Liquid for Test SB12

a,b,c

Figure 440.492-36 Test - Upper Plenum Collapsed Liquid Level for Test SB12

a, b, c

Figure 440.492-37 Test - Upper Plenum Void Fraction for Test SB12

a,b,c

Figure 440.492-38 Test - Core Collapsed Liquid Level for Test SB12

a,b,c

Figure 440.492-39 Test - Core Void Fraction for Test SB12

a,b,c

Figure 440.492-40 Test - Elevation of Subcooled Liquid for Test SB12

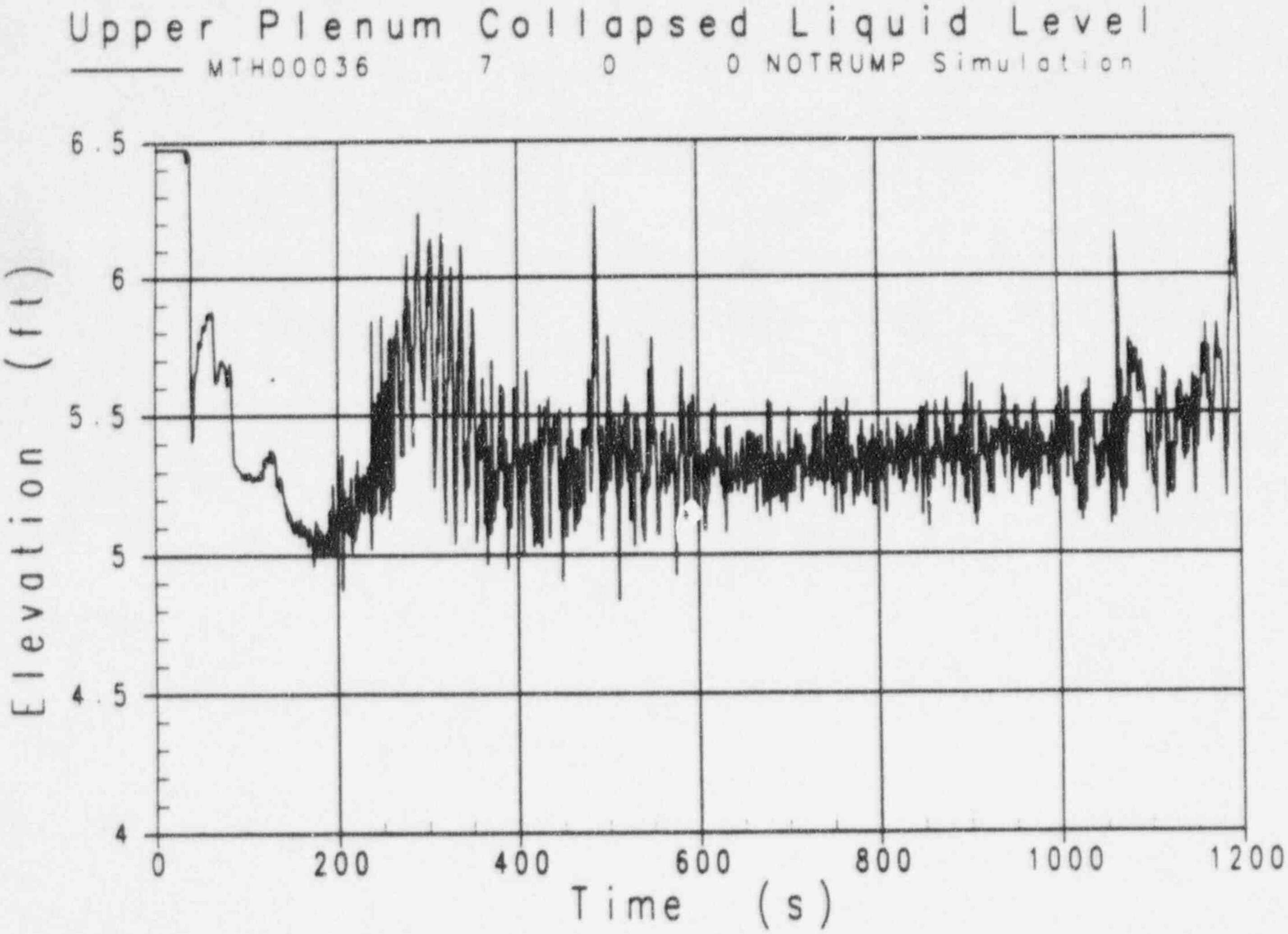


Figure 440.492-41 NOTRUMP - Upper Plenum Collapsed Liquid Level for Test SB14

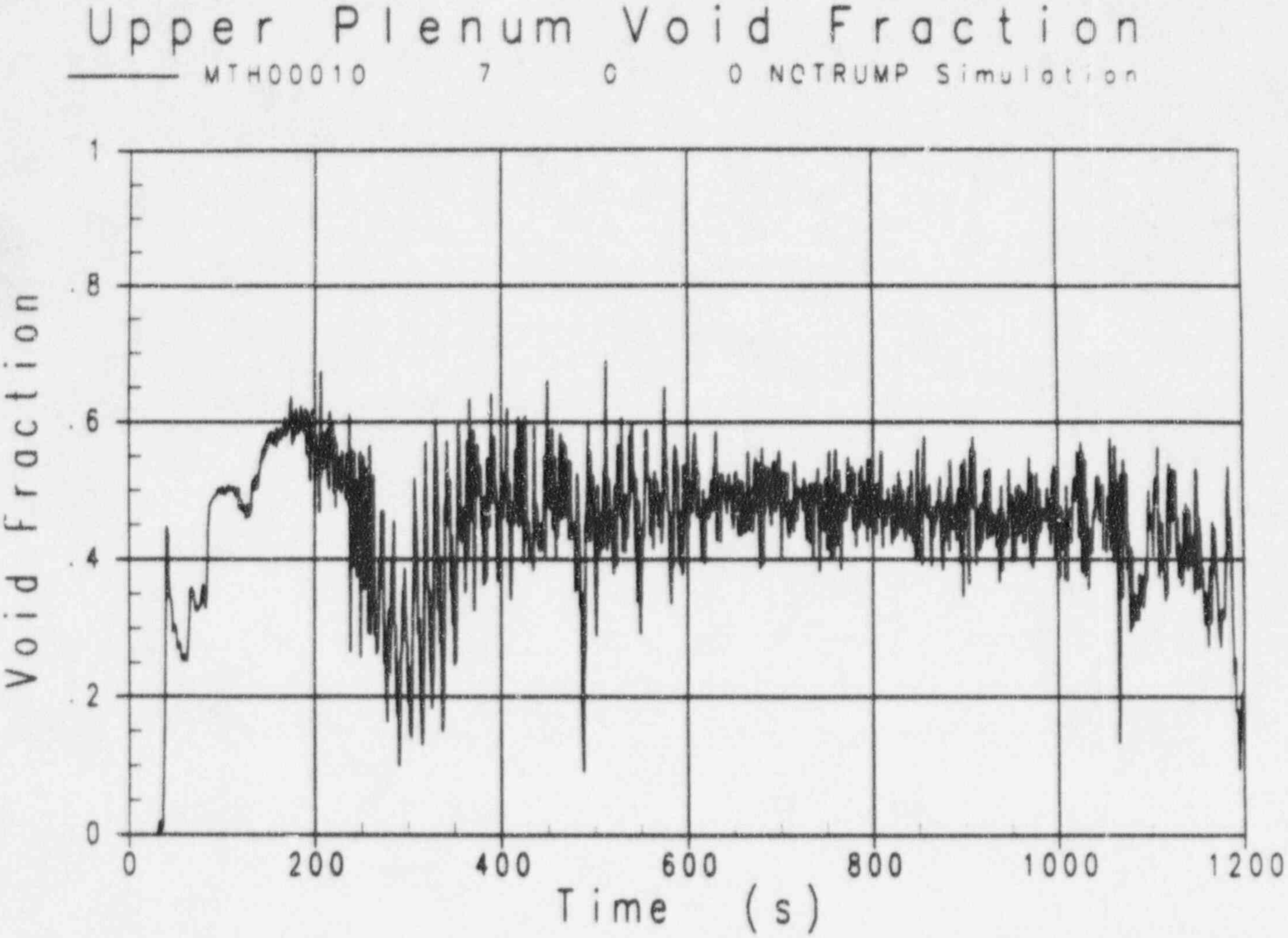


Figure 440.492-42 NOTRUMP - Upper Plenum Void Fraction for Test SB14

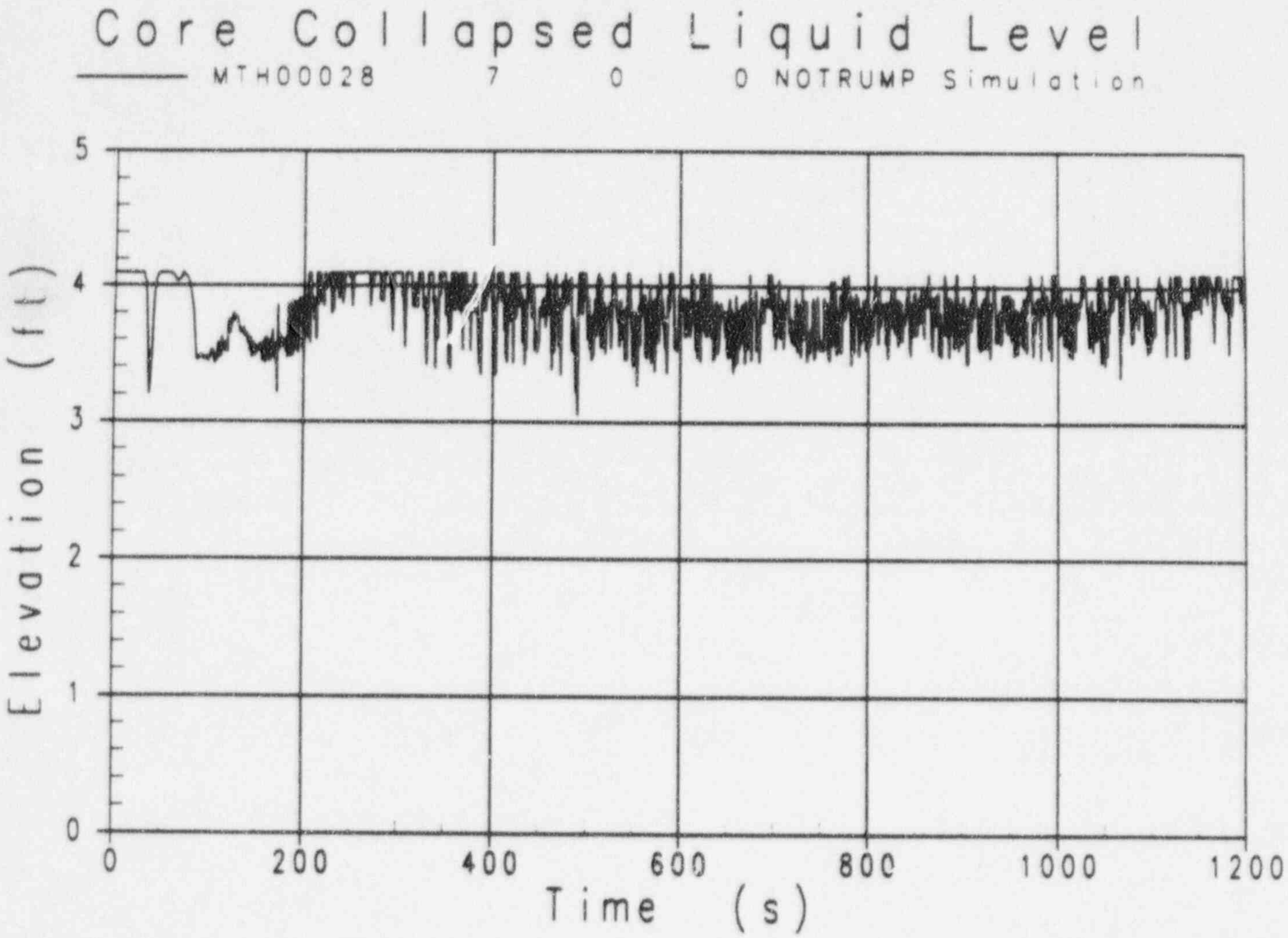


Figure 440.492-43 NOTRUMP - Core Collapsed Liquid Level for Test SB14

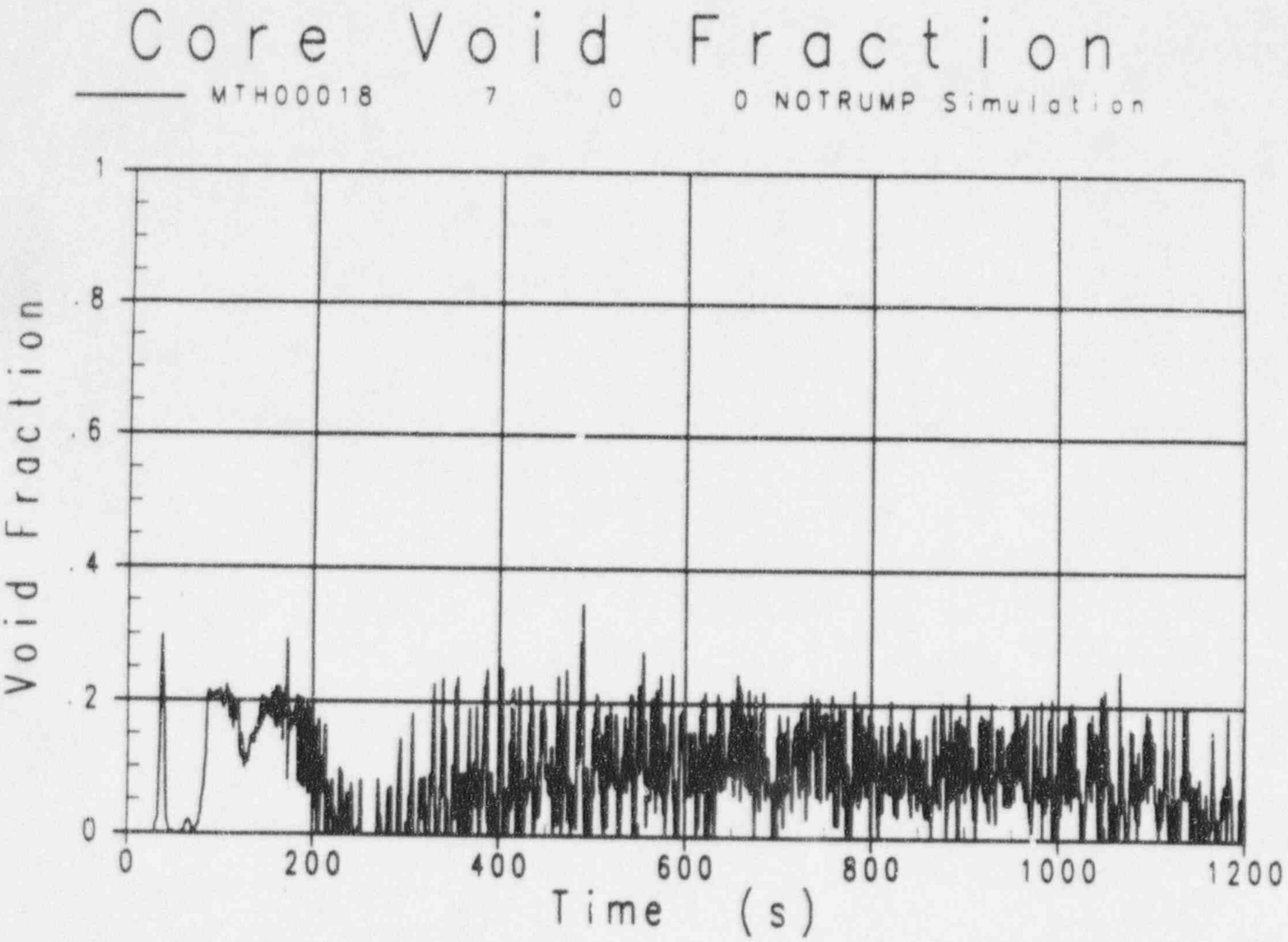


Figure 440.492-44 NOTRUMP - Core Void Fraction for Test SB14

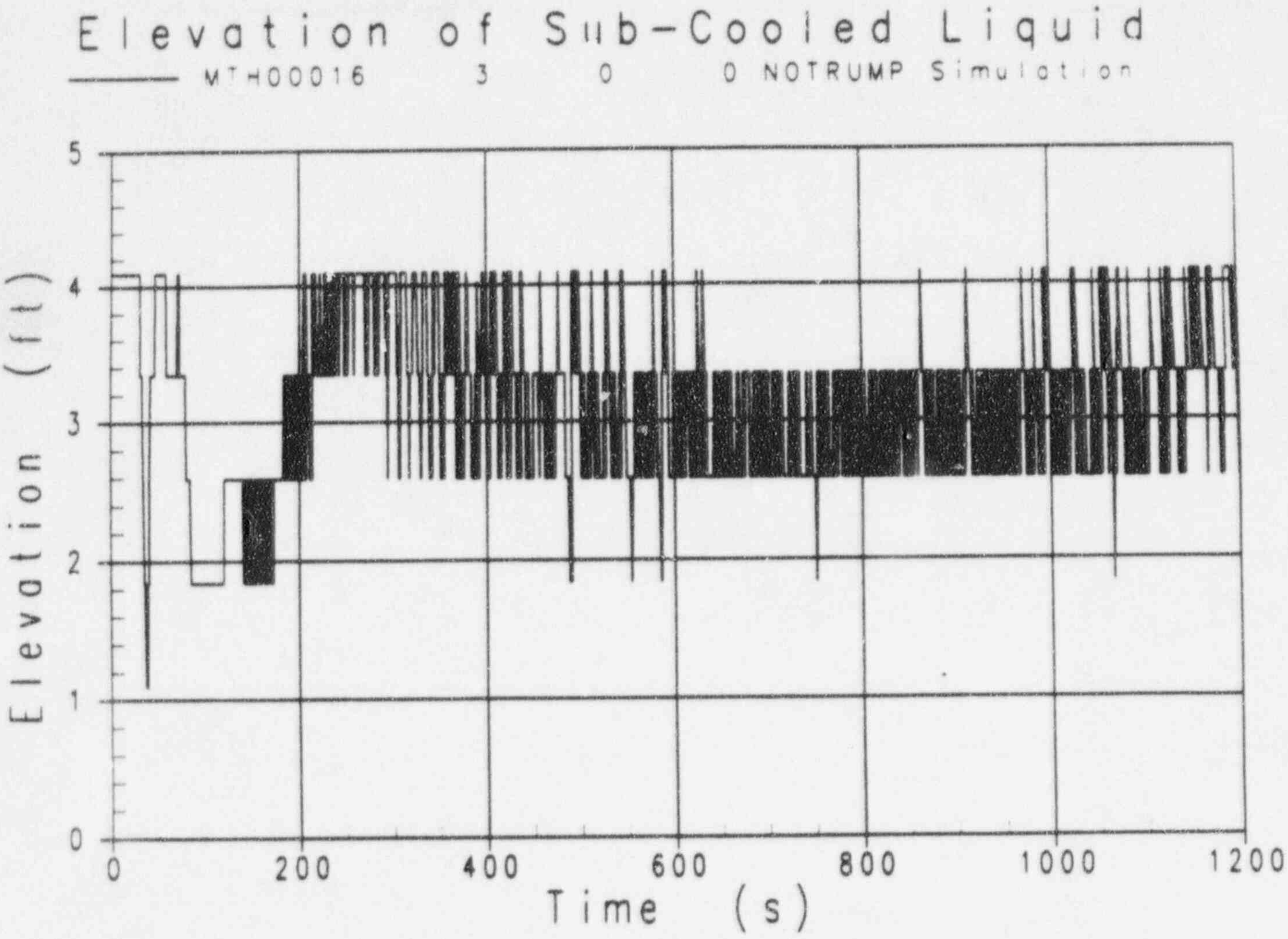


Figure 440.492-45 NOTRUMP - Elevation of Subcooled Liquid for Test SB14

a,b.c

Figure 440.492-46 Test - Upper Plenum Collapsed Liquid Level for Test SB14

a,b,c

Figure 440.492-47 Test - Upper Plenum Void Fraction for Test SB14

a,b,c

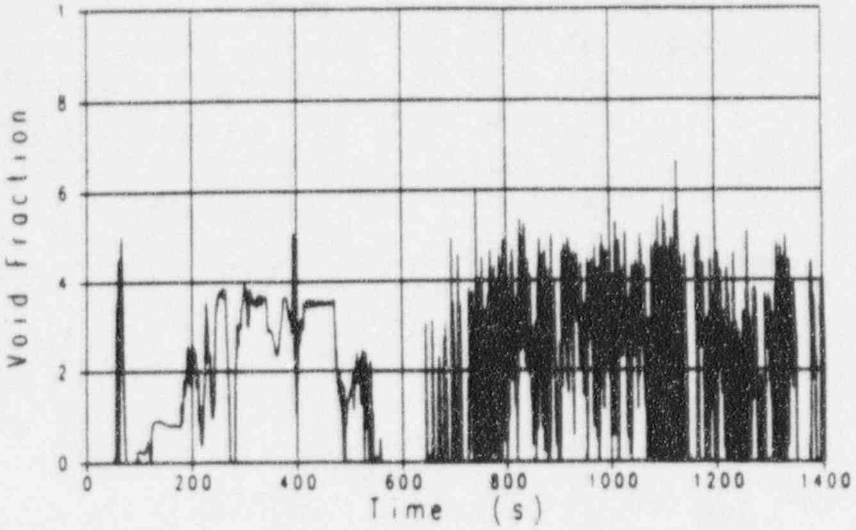
Figure 440.492-48 Test - Core Collapsed Liquid Level for Test SB14

a, b, c

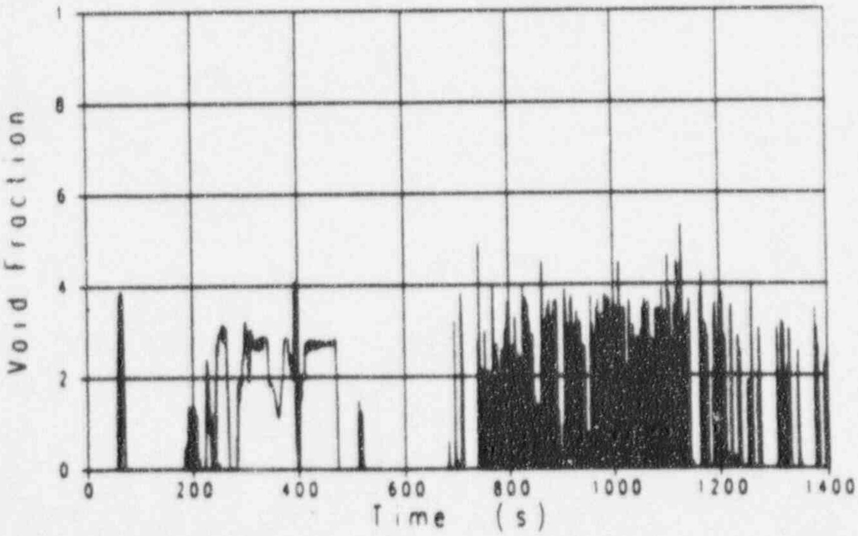
Figure 440.492-49 Test - Core Void Fraction for Test SB14

a,b,c

Figure 440.492-50 Test - Elevation of Subcooled Liquid for Test SB14



Core Void Fraction Distribution in NOTRUMP Simulation (SB01)
Core Level 4 of 4



Core Void Fraction Distribution in NOTRUMP Simulation (SB01)
Core Level 3 of 4

Figure 440.492-51 NOTRUMP - Void Fraction Top Two Core Nodes for Test SB01

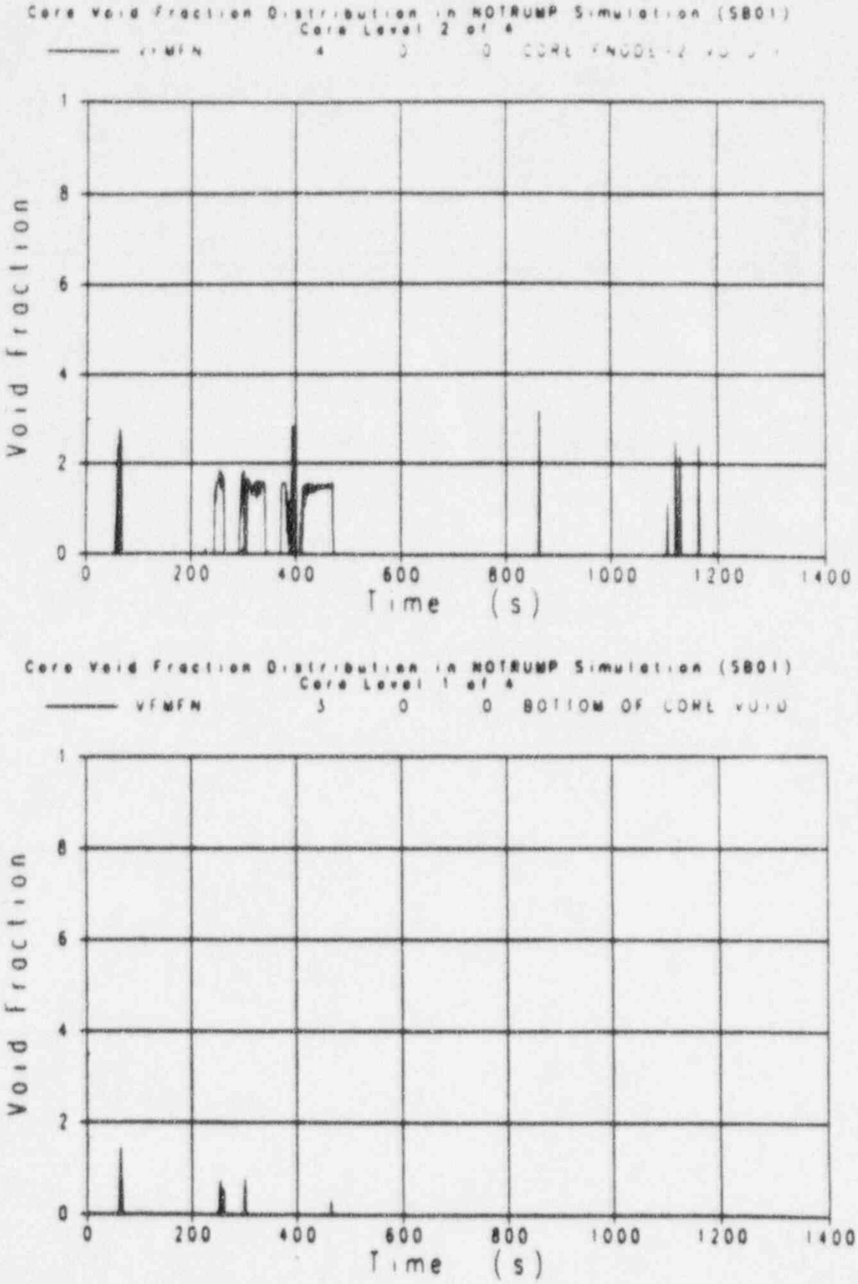


Figure 440.492-52 NOTRUMP - Void Fraction Bottom Two Core Nodes for Test SB01

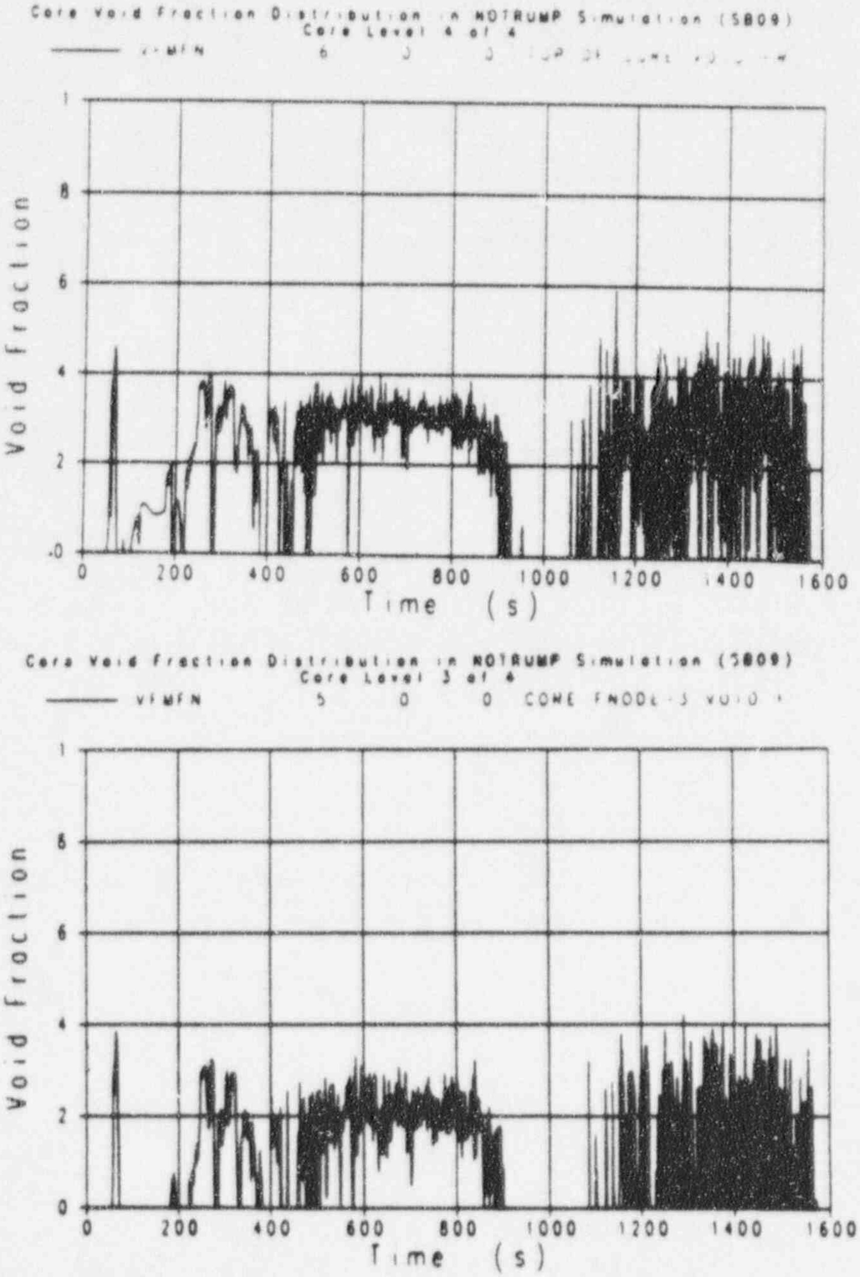


Figure 440.492-53 NOTRUMP - Void Fraction Top Two Core Nodes for Test SB09

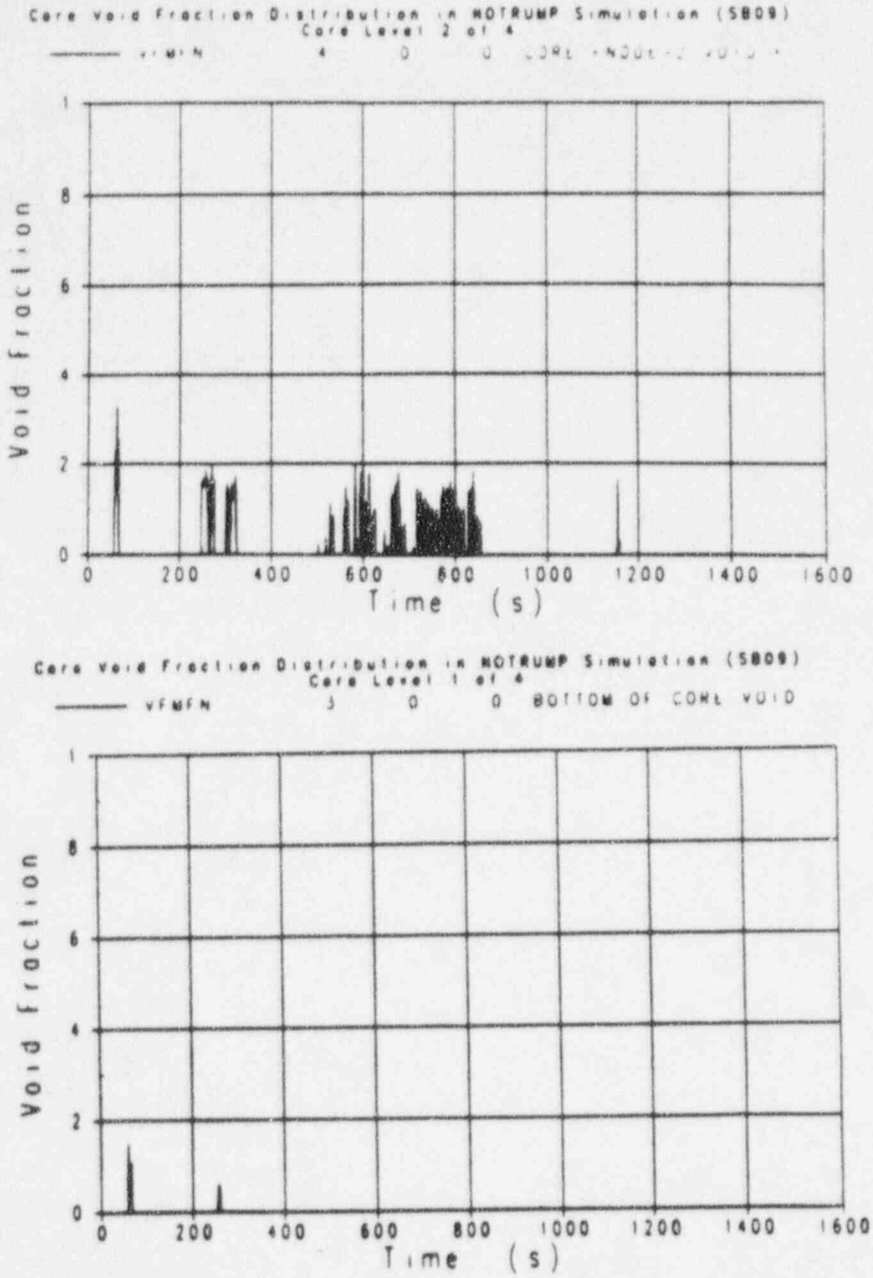


Figure 440.492-54 NOTRUMP - Void Fraction Bottom Two Core Nodes for Test SB09

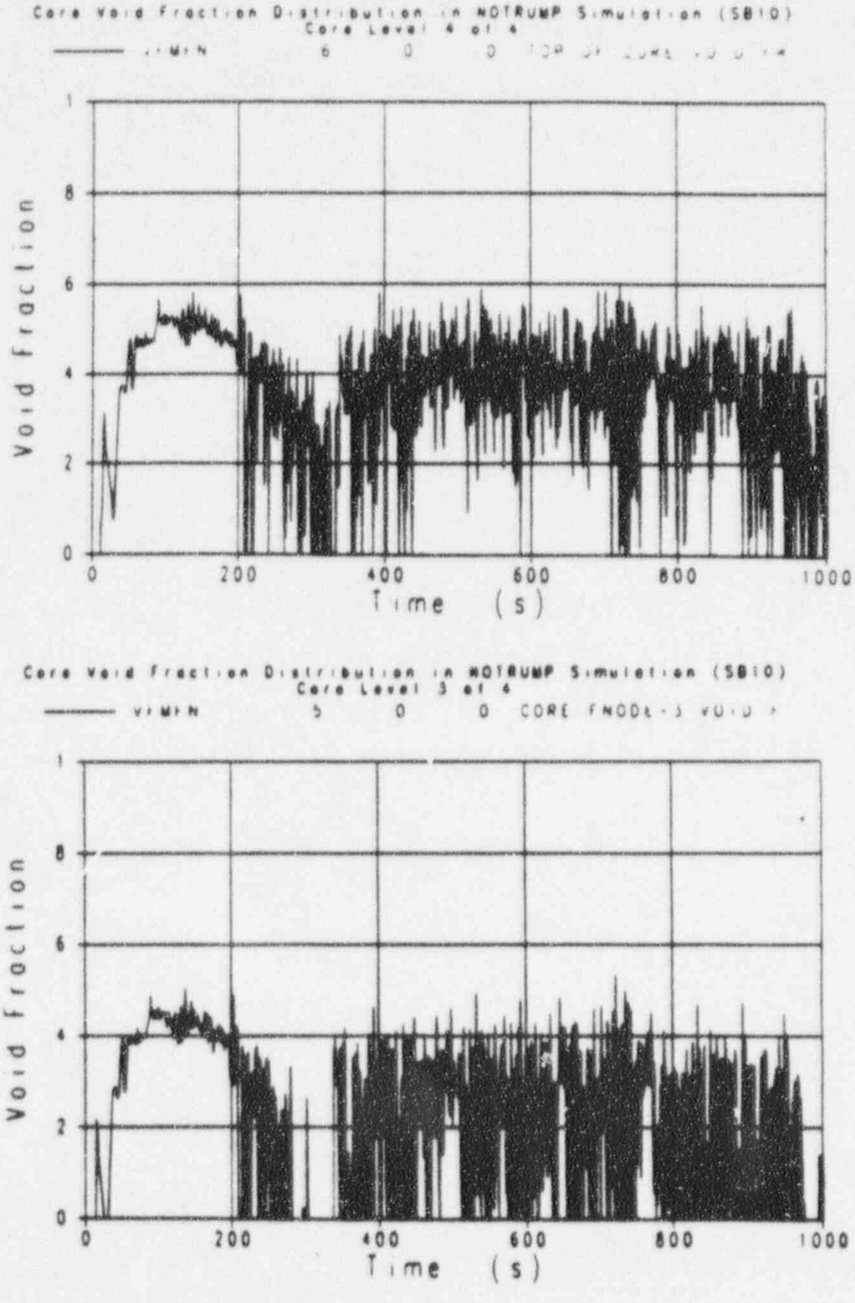


Figure 440.492-55 NOTRUMP - Void Fraction Top Two Core Nodes for Test SB10

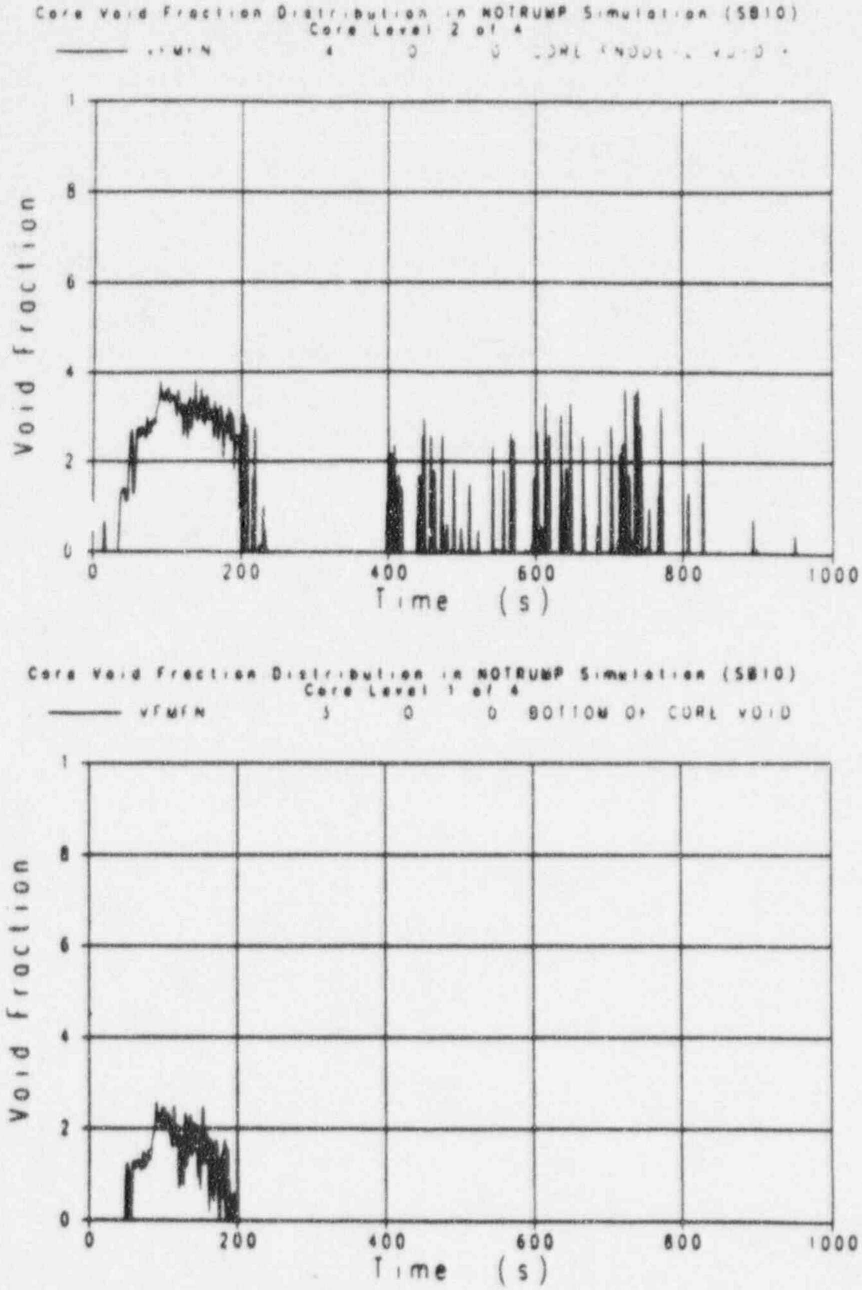


Figure 440.492-56 NOTRUMP - Void Fraction Bottom Two Core Nodes for Test SB10

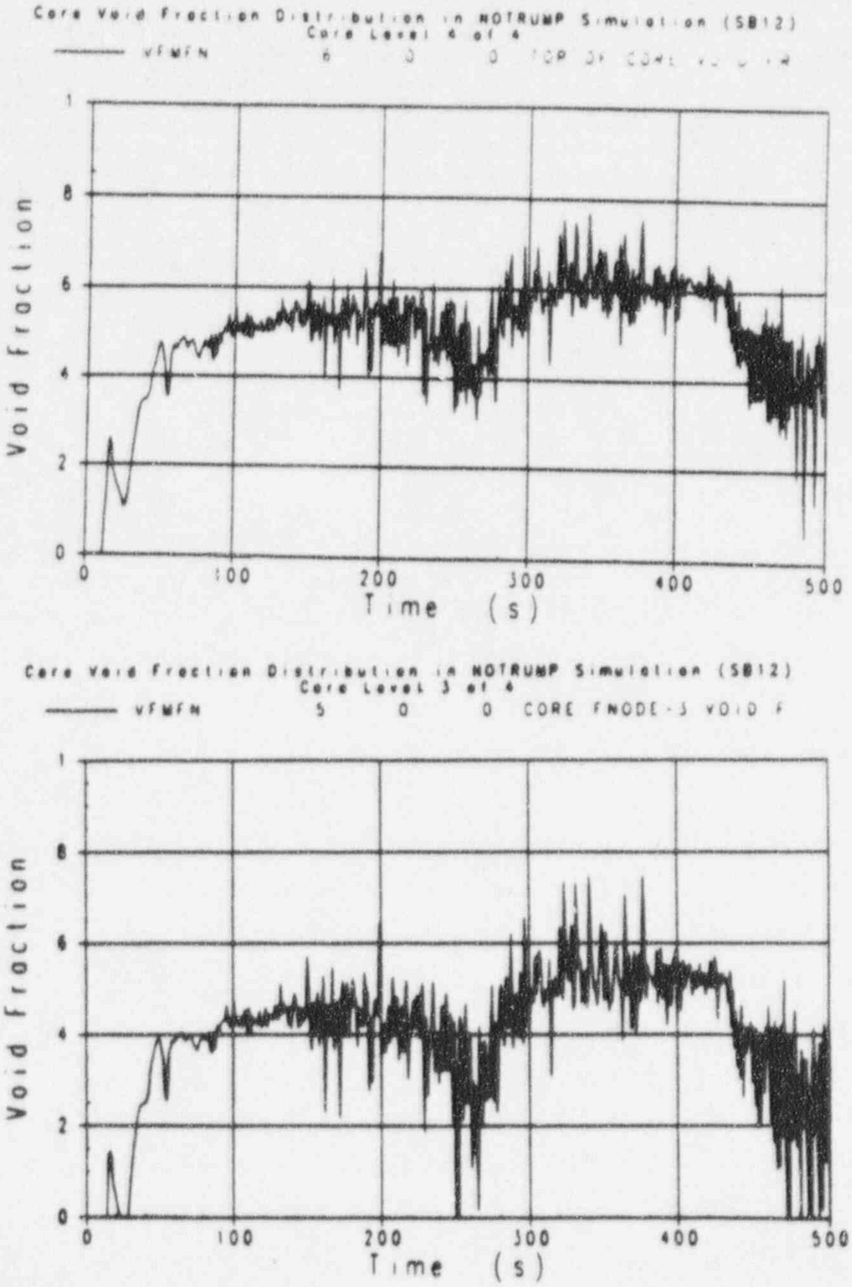


Figure 440.492-57 NOTRUMP - Void Fraction Top Two Core Nodes for Test SB12

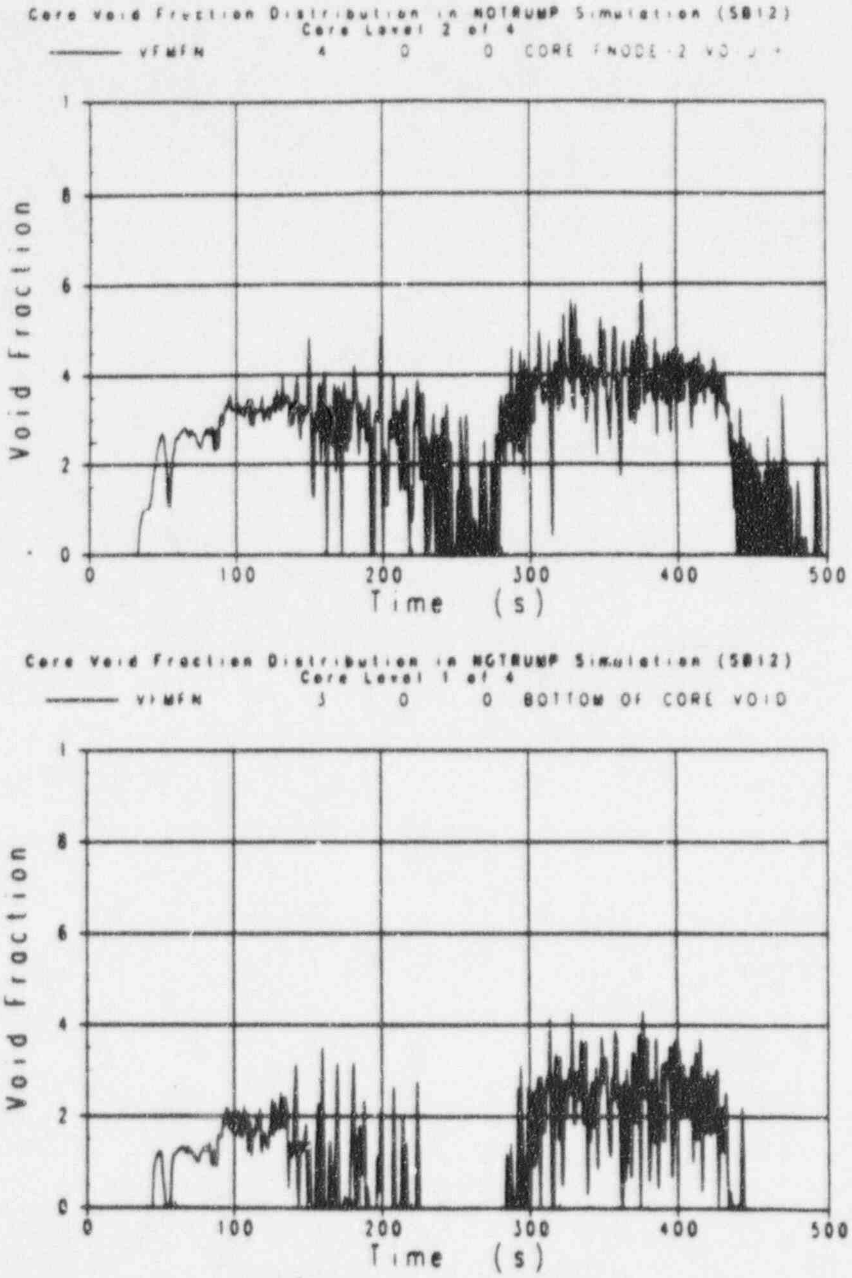


Figure 440.492-58 NOTRUMP - Void Fraction Bottom Two Core Nodes for Test SB12

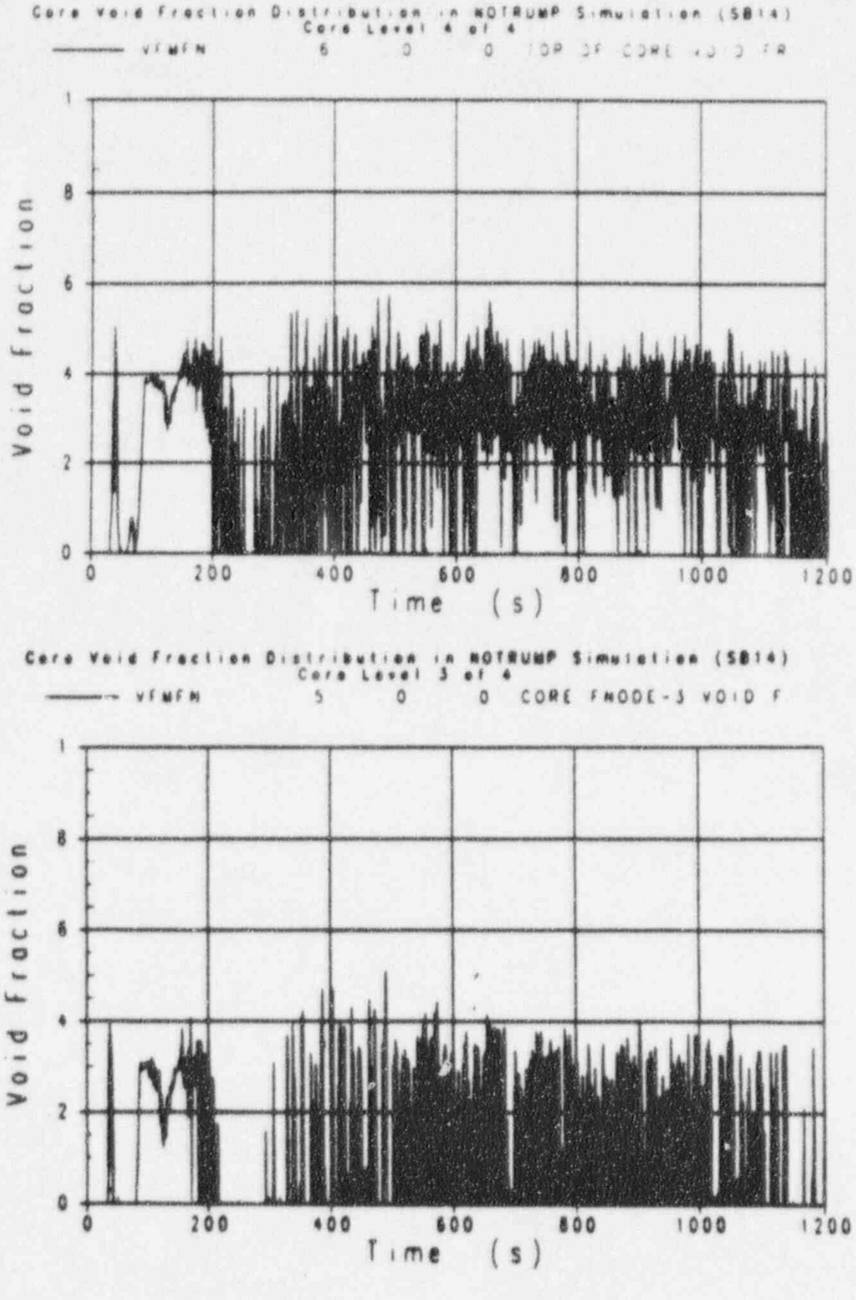


Figure 440.492-59 NOTRUMP - Void Fraction Top Two Core Nodes for Test SB14

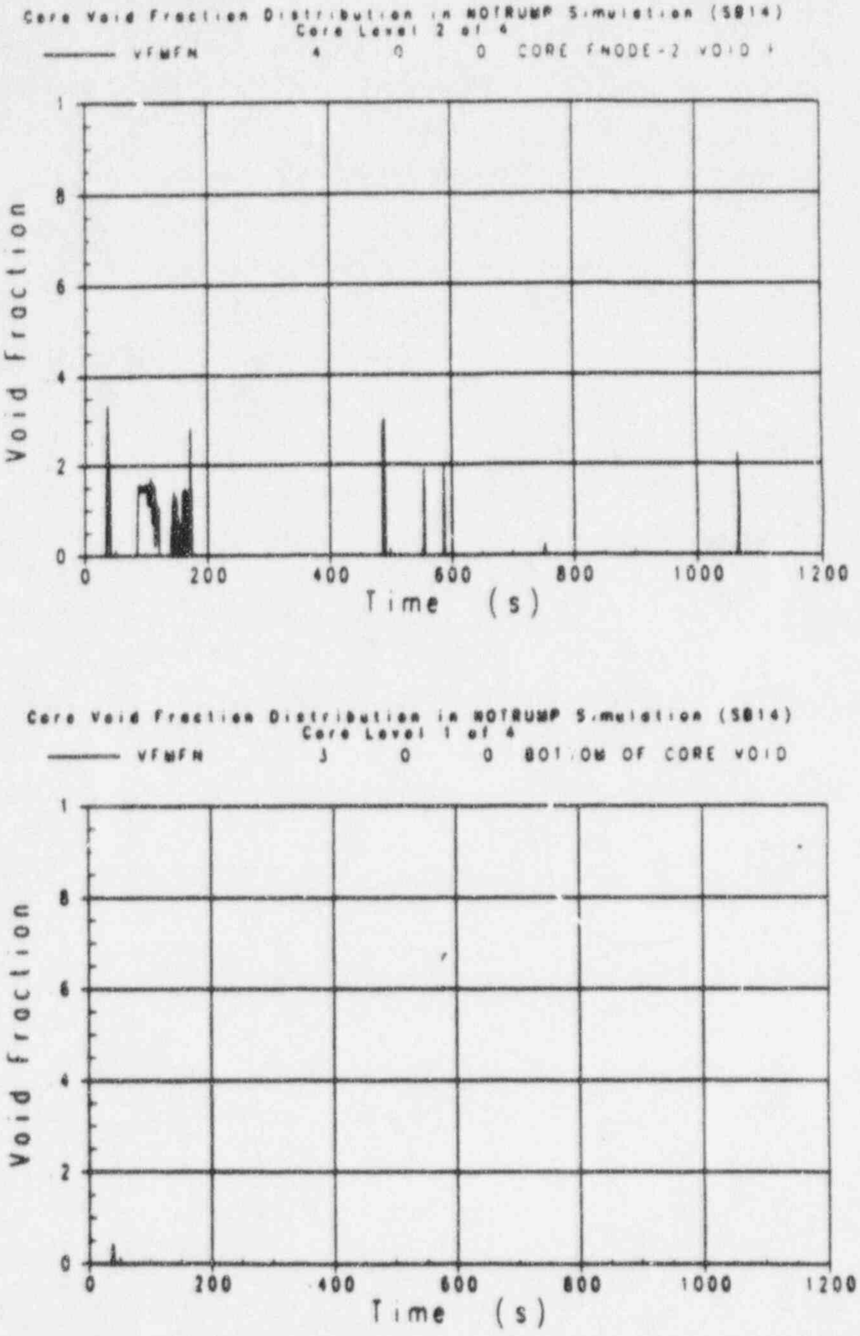


Figure 440.492-60 NOTRUMP - Void Fraction Bottom Two Core Nodes for Test SB14

Question 440.495

Re: NOTRUMP PVR FOR OSU TESTS, LTCT-GSR-001, JULY 1995
Please provide the upper plenum and core liquid level plots. Also provide the void distribution plots in the core for this test.

Response:

Please see the Westinghouse response to RAI 440.492.

SSAR Revision: NONE

Question 440.502

Re: NOTRUMP PVR FOR OSU TESTS, LTCT-GSR-001, JULY 1995
Please provide the core and upper plenum liquid level plots and the core void fraction plots for this event.

Response:

Please see the Westinghouse response to RAI 440.492.

SSAR Revision: NONE

Question 440.507

Re: NOTRUMP PVR FOR OSU TESTS, LTCT-GSR-001, JULY 1995
Please provide the liquid level plots in the upper plenum and core regions. Also provide the NOTRUMP plots of the core void distributions for this test.

Response:

Please see the Westinghouse response to RAI 440.492.

SSAR Revision: NONE

Question 952.100

Provide a commitment to submit a complete PCCS scaling analysis. The report should describe how the scaling analysis will be used in validation of the analysis codes. The scaling report should describe how the large scale tests analysis will translate to the AP600 design. An explanation of how this analysis would be used in the code validation process should be included.

Response: (Revision 1)

A scaling analysis of the AP600 PCS and its relation to the Large Scale PCS Test (LST) has been provided (Reference 952.100-1). A Phenomena Identification and Ranking Table (PIRT) was developed to identify and rank the dominant phenomena governing AP600 containment pressure mitigation. A governing equation for the rate of containment pressure change was developed and pi groups representing the scaled relation of AP600 to the LST were derived. The role of scaling for the PCS Design Basis Analysis has been issued (Reference 952.100-2), providing the use of scaling in validation of WGOTHIC, how the PCS large scale tests are used to develop a bounding evaluation model, and how results are used in the WGOTHIC validation process. All phenomena are either bounded or shown to have a negligible impact on the pressure prediction (Reference 952.100-3).

References

952.100-1 WCAP-14190 (proprietary), WCAP-14191 (non-proprietary), "Scaling Analysis for AP600 Passive ontainment Cooling System," October, 1994.

952.100-2 Westinghouse Letter NTD-NRC-95-4561, "Scaling Role in AP600 PCS DBA Analysis," September 19, 1995.

952.100-3 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995.

SSAR Revision: NONE

Question 480.279

Re: WGOTHIC MODELS AND PHENOMENA
Integral results alone may not constitute an adequate test of model validation; compensating effects can yield reasonable integral result comparisons even when important phenomena are not well represented, and there is no guarantee that compensation occurring in LST analyses will necessarily occur in AP600 analyses. For example, the fact that the mixed correlation gives better agreement with the experimental pressure than the free correlation does not prove that the mixed correlation is more correct; there are many possible reasons why the free-convection calculation may be overpredicting the pressures and the mixed convection calculation may be introducing a compensating error. How is WEC using the LST data to establish the validity of individual models such as the models for heat transfer, evaporation and condensation, and flow velocities? WEC should examine the performance of individual models at a greater level of detail, rather than relying entirely on integral results.

Response:

Westinghouse has used local heat and mass transfer data from the LST and other separate effects tests to validate the heat and mass transfer correlations used in the AP600 evaluation model. The dependence of these correlations on the dominant independent parameters, such as concentration and velocity, have been tested and validated to show that agreement is not due to competing effects.

An overview of the test and analysis program has been provided (Reference 480.279-1, Sections 3 and 4). Individual models for heat and mass transfer, used to predict evaporation and condensation, are validated as follows. Convective heat transfer and evaporation in the annulus is validated in Reference 480.279-2, Sections 3.1 through 3.6, 4.1, and 4.2. The external air annulus has been shown to operate in turbulent, forced convection once the containment shell-to-ambient temperature difference exceeds 2°F (Reference 480.279-2), consistent with the validation database. The LST has been used to validate evaporation predictions by comparing the measured total evaporation rate to WGOTHIC predictions in Reference 480.279-1, Section 8.1 and 8.2.

The condensation correlation is validated in Reference 480.279-2, Section 3.8 using separate effects data. Condensation is also validated using local data inside the integral Large Scale Test vessel in Reference 480.279-3, Section 3.9. To bound the effects of velocity on internal condensation rates in the AP600 PCS evaluation model, condensation is assumed to be by free convection only. This is implemented for the internal PCS surface by setting the forced convection component of the climes to essentially zero, and for the internal structure heat sinks by using the Uchida free convection correlation. Thus, the LST has been used to support the validity of models by examining local data and has also provided input to a bounding evaluation model.

References

480.279-1	WCAP-14382, "WGOTHIC Code Description and Validation"
480.279-2.	WCAP-14326, "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations"
480.279-3	NTD-NRC-95-4397, "Supporting Information for the Use of Forced Convection in the AP600 PCS Annulus," February 16, 1995

SSAR Revision: NONE

Question 480.281

Re: WGOTHIC MODELS AND PHENOMENA
What would be the effect of these velocity differences on the behavior of the heat transfer model and on the predicted pressures? The forced component is important to the calculation, and is dependent on the velocities used in the correlation.

Response:

The forced convection enhancement of in-containment heat and mass transfer due to velocity effects is neglected (see response to RAI 480.279). Consequently heat and mass transfer is bounded and pressure will be overpredicted in the AP600 PCS DBA evaluation model throughout the LOCA and steamline break transients. Therefore, the evaluation model results are not dependent on the predicted flow velocities.

SSAR Revision: NONE

Question 480.282

Re: WGOTHIC MODELS AND PHENOMENA (Lumped Parameter Model)
Why are the pressure results in better agreement with the experiment when WGOTHIC uses a mixed convective correlation with velocities that disagree with experimental measurements?

Response:

The test comparisons under discussion address the lumped parameter model only and were presented in November 1994 and show that velocity is overpredicted and steam concentration is underpredicted in the lumped parameter model (Reference 480.282-1). Velocity and concentration are the two dominant parameters in the mass transfer correlation. Sufficient instrumentation has been used in the LST to identify and quantify the competing effects.

The competing effects in the lumped parameter model results cited in the question have been quantified as follows. The use of measured velocities, rather than the higher, code calculated velocities, in the mixed convection correlation decreases the average predicted shell heat flux by about 15%. The lumped parameter model overmixes non-condensibles from below the steam jet/plume, and the non-condensibles above the operating deck lead to underpredicted steam concentrations which penalize PCS heat removal. Use of the measured steam concentration instead of code calculated concentrations is estimated to increase the average shell heat flux by 18%. It can be concluded that heat flux is overpredicted by 15% due to velocity and underpredicted by 18% due to concentration. It is clear that these are compensating errors of about the same magnitude in the lumped parameter code calculation. In this case the overpredicted velocity used with mixed convection compensated for the underpredicted steam concentration to give nearly correct pressures. When free convection was used in the WGOTHIC calculation, the steam concentration was still underpredicted with no compensation, so the pressure was overpredicted.

These results have been factored into the lumped parameter evaluation model. The use of free convection in the lumped parameter evaluation model eliminates the effects of calculated velocities and results in a conservatively well-mixed containment at 24 hours.

Please also see the response to RAI 480.283 for discussion of free versus mixed convection when measured velocities are considered.

Reference

480.282-1 WCAP-14382, "WGOTHIC Code Description and Validation," May 1995

SSAR Revision: NONE

Question 480.283

Re: WGOTHIC MODELS AND PHENOMENA (Lumped Parameter Model)
Why are the pressure results in better agreement when WGOTHIC uses a mixed convective correlation rather than a free convective correlation, when the experimentally measured velocities indicate that the free convection correlation should have been more nearly correct?

Response:

The question relates to lumped parameter calculations. An explanation of why the lumped parameter model results are in better agreement with vessel pressure when mixed convection is used follows.

Sufficient instrumentation was incorporated in the LST to be able to identify and quantify the potential for competing errors. Therefore, data has been used to show that free convection is the appropriate correlation for the inner shell, independent of WGOTHIC calculations (Reference 480.283-1).

Calculations show that the use of the measured test velocity in the mixed convection correlation would give results the same as using the free convection correlation only, confirming that the internal condensation is dominated by free convection for the velocities measured in the test. The lumped parameter model pressure results are in better agreement with the tests when mixed convection is used because the high predicted velocities used in the correlation offset the underpredicted steam concentration, as discussed in the response to RAI 480.282. These results have been used to develop the lumped parameter evaluation model used to address the 24 hour pressure reduction criterion.

Reference

480.283-1 WCAP-14326, "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," March 1995, Section 3.9

SSAR Revision: NONE

Question 480.284

Re: WGOTHIC MODELS AND PHENOMENA
If the experimentally measured velocities are inaccurate or do not correspond well to the velocities used in the WGOTHIC correlations, how will the velocities calculated by the code and used in its correlations be validated?

Response:

Please see the Westinghouse response to RAI 480.279 for a discussion of how the effects of velocity on heat and mass transfer calculations are bounded. The velocities are not used in determining heat and mass transfer rates internal to containment since free convection is assumed in the evaluation model.

The validity of using a bulk flow velocity average value from the node nearest the wall is shown using the detailed distributed parameter model (Reference 480.284-1) which gave good agreement with measured vessel pressure and velocity instrumentation.

Reference

480.284-1 WCAP-14382, "WGOTHIC Code Description and Validation," May 1995, Appendix A

SSAR Revision: NONE

Question 480.288

Re: WGOTHIC MODELS AND PHENOMENA
In the WGOTHIC approach the forced flow Nusselt number will be higher on the dome than on the walls. However, the effect of subcooling on the dome is much greater for LST than AP600, and a higher heat transfer coefficient for the dome may therefore have different effects for LST analysis than for AP600 analysis. How does this affect code validation for AP600 applications?

Response:

The forced flow Nusselt number is higher on the dome where the plume flow turns and begins to flow down. This is due to the inverse proportionality to the length parameter in the forced convection flat plate correlation. This approach has been shown to predict LST data (Reference 480.288-1, Appendix A) using a detailed distributed parameter model. The model explicitly accounts for the combined effects of forced flow Nusselt number and subcooling on the dome and shows that important phenomena have been identified and modeled.

The Westinghouse response to RAI 480.279 contains a summary of the validation bases for the bounding evaluation model heat and mass transfer calculations. Free convection dominated mass transfer coefficients measured in the LST agree very well with predictions for both the dome and sidewall. Comparisons also have shown that free convection increasingly underpredicts data from LST tests with higher forced convection components. The use of free convection is conservative for all times and for both the dome and sidewall.

References

480.288-1 WCAP-14382, "WGOTHIC Code Description and Validation"

480.288-2 NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.295

Re: WGOTHIC MODELS AND PHENOMENA
It can be argued that the use of a free convective velocity in a forced flow correlation can leads to a significant spurious enhancement of heat transfer on the shell interior. Given this, explain why the WGOTHIC approach and results are valid for a free convection problem?

Response:

The question that has been posed is irrelevant to AP600 DBA because the evaluation model assumes only free convection. The Westinghouse PCS evaluation model bounds the uncertainty in velocity calculations by using only free convection heat and mass transfer on the inner PCS surface for both the LOCA and main steamline break (MSLB) transients. This eliminates any concern regarding "spurious velocities." Internal structures are modelled as heat sinks using the Uchida free convection correlation with revaporization. Limiting heat and mass transfer to that predicted with free convection correlations is conservative. The internal containment heat and mass transfer regime is mixed convection because of the injected steam plume combined with convective cooling at the shell. For times after blowdown in a LOCA, the forced convection contribution to heat and mass transfer is small and heat removal can be approximated using free convection. Results of correlation comparisons to local condensation data from the Large Scale PCS Tests (LSTs) with Froude numbers typical of a LOCA show that the free convection correlation chosen is appropriate for those conditions (Reference 480.295-1).

For an MSLB and for LOCA blowdown, an examination of AP600 Froude numbers shows that the jet has near sonic velocities and therefore is highly kinetic. Thus, it is believed that forced convection strongly contributes to mass transfer in those transients. Large Scale Tests with Froude numbers more typical of an MSLB show that the condensation mass transfer is considerably underpredicted, leading to overpredicting the pressure response, when the free convection correlation is compared to local condensation data.

Therefore, the use of free convection correlations for the AP600 LOCA and MSLB bounds the effects of forced convection.

References

480.295-1 WCAP-14326, "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," March, 1995, Section 3.9.

SSAR Revision: NONE

Question 480.296

Re: WGOTHIC MODELS AND PHENOMENA
Given that the flows in the LST and AP600 are considerably more complex than in a simple free convective problem, can WEC show that any spurious enhancement to heat transfer caused by the use of a free convective velocity in a forced flow correlation is small?

Response:

Please see the Westinghouse response to RAI 480.295 for a discussion of why there is no spurious enhancement of heat transfer using the WGOTHIC mixed convection approach. The use of the free convection correlation on the inner PCS surface for the AP600 LOCA and MSLB eliminates any concern for spurious enhancement to heat transfer which has been postulated to occur when using a free convective velocity in a forced flow correlation.

A quantification of mixed convection correlation values at low velocities shows there is no significant enhancement to heat transfer when bulk flow velocities resulting from forced convection components are used in a free convection dominated regime. In AP600, at 51 psia, h_{free}= 2.2 Btu/hr-ft^2-°F. The ratio h_{mixed}/h_{free} can be used to assess the effect of velocity in the mixed convection correlation relative to the value obtained by the free convection correlation. The effect can be said to be small if $h_{mixed}/h_{free} \leq 1.10$. For a given velocity, the length over which mixed convection would predict heat transfer greater than free convection can be determined. For a velocity of 4 ft/sec or less, the length over which mixed convection effects are greater than 10% is 28 feet, corresponding to only 4.5% of the PCS shell surface. Therefore, mixed convection predicts approximately the same heat transfer as free convection over more than 95% of the inner PCS surface. For lower velocities expected in the postulated "startup flow" scenario, mixed convection approaches free convection values.

SSAR Revision: NONE

Question 480.297

Re: WGOTHIC MODELS AND PHENOMENA
In which LST/AP600 analyses was the forced flow option specified? What option was specified for the WGOTHIC 1.0 calculations cited in the model and margin assessment report (PCS-GSR-001)?

Response:

The final validation report for WGOTHIC (Reference 480.297-1) describes the models used for Large Scale PCS Test (LST) simulations. The distributed parameter LST simulations used the mixed convection correlations described in Section 2.0. In the lumped parameter simulations, the forced convection is set to zero on the inner PCS surface, so that only free convection is used.

The PCS evaluation model for the AP600 assumes only free convection by setting the forced convection component on the inner PCS surface to essentially zero (Reference 480.297-2). The evaluation model also uses free convection on all inner heat sink surfaces. This approach is reflected in the preliminary SSAR 6.2 markups (Reference 480.297-3) for both LOCA and MSLB lumped parameter models. This approach is not currently reflected in the distributed parameter model calculations for the preliminary draft SSAR markup (which used mixed convection).

The WGOTHIC 1.0 results (Reference 480.297-4) used the mixed convection correlation used in the 1992 SSAR calculations which differed from the WGOTHIC 1.2 mixed convection correlation as described in Reference 480.297-5.

References

480.297-1 WCAP-14382, "WGOTHIC Code Description and Validation," May, 1995.

480.297-2 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995.

480.297-3 Westinghouse Letter NTD-NRC-95-4504, "Proposed Draft Markups of SSAR Sections 6.2 and 6.4," July 10, 1995.

480.297-4 Westinghouse Letter NTD-NRC-94-4174, "AP600 Passive Containment Cooling System Design Basis Analysis Model and Margin Assessment," June 30, 1994.

480.297-5 PCS-GSR-001, "PCS Design Basis Analysis Model and Margin Assessment Report," June 1994, page 9

SSAR Revision: NONE

Question 480.298

Re: WGOTHIC MODELS AND PHENOMENA (Sensitivity to Nodalization in the Lumped Parameter Mode)
WEC needs to examine the sensitivity of WGOTHIC results to the nodalization scheme, particularly for the cells adjacent to the shell interior.

Response:

The lumped parameter noding has been established to best represent LST phenomena within the model limitation. No further adjustment of noding will be done for the lumped parameter model. Rather, the lumped parameter results have been used to define a bounding evaluation model approach as follows.

The lumped parameter calculation is used only to assess the 24 hour pressure reduction rate criterion. Since the PCS evaluation models consider only free convection on the inside, the impact on mass transfer of noding in the lumped parameter model is limited to its prediction of noncondensible distributions and their impact on heat sink efficiency. Based on validation with large scale tests, the lumped parameter nodalization is shown to overpredict the rate of mixing in the containment (Reference 480.298-1). Since the internal heat sinks have saturated and in most cases are releasing energy back to containment by 24 hours, the dominant internal pressure mitigation mechanism is condensation on the PCS surfaces above the operating deck. The possible range of noncondensible distributions can range from uniform, resulting from perfect mixing, to steam rich at higher elevations, resulting from plume-induced stratification. For the 24 hour criterion, a well mixed containment provides the limiting assumption and the lumped parameter model predicts a well mixed containment except for dead-ended compartments by about 30,000 seconds and beyond. The lumped parameter model bounds the effects of mixing and stratification at 24 hours by maximizing air concentration above the operating deck.

References

480.298-1 WCAP-14382, "WGOTHIC Code Description and Validation" Section 5.3

SSAR Revision: NONE

Question 480.299

Re: WGOTHIC MODELS AND PHENOMENA (Sensitivity to Nodalization in the Lumped Parameter model) Does WEC intend to adjust the thickness of cells adjacent to the shell interior until the predicted velocities match the experimentally measured velocities?

Response:

The effects of noding used in the lumped parameter PCS evaluation model are understood and have been factored into a bounding evaluation model. Therefore, the thickness of the cells adjacent to the inner surface of the PCS will not be adjusted. See the Westinghouse response to RAI 480.298 for a discussion of the use of the lumped parameter evaluation model with respect to mixing and stratification.

SSAR Revision: NONE

Question 480.300

Re: WGOTHIC MODELS AND PHENOMENA (Sensitivity to Nodalization in the Lumped Parameter model) Will the nodalization scheme used for the WGOTHIC AP600 input deck be similar to a scaled-up version of the LST nodalization scheme?

Response:

Yes. The nodalization of the AP600 model exactly corresponds to the noding used in the LST with respect to the number of nodes and their radial and axial divisions. The only differences are that the AP600 model is a full model while the LST is ½ symmetry and the AP600 model differs slightly where solid boundaries exist and to account for multiple steam generator compartments, pressurizer, and multiple below-deck compartments. The noding is the same to the extent practical given the differences in internal geometry. Explicit noding methodology for both the LST and the AP600 have been provided (Reference 480.300-1).

References

480.300-1 WCAP-14382, "WGOTHIC Code Description and Validation" Section 6

SSAR Revision: NONE

Question 480.301

Re: WGOTHIC MODELS AND PHENOMENA (Sensitivity to nodalization in the Lumped Parameter model)
Can a nodalization scheme developed to generate velocities that match the LST velocities predict the correct velocities in the AP600?

Response:

The effect of the nodalization used in the lumped parameter model have been identified (Reference 480.301-1, Section 8.2) and factored into the bounding evaluation model (Reference 480.301-2). The lumped parameter AP600 evaluation model overpredicts velocities similar to the LST lumped parameter model since the noding is directly scaled as discussed in the response to RAI 480.300. The effects of velocity are bounded in the AP600 PCS evaluation model by assuming only free convection so that the lumped parameter velocities predicted for the AP600 are not used in calculating heat and mass transfer rates.

References

480.301-1 WCAP-14382, "WGOTHIC Code Description and Validation," May 1995

480.301-2 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.303

Re: WGOTHIC MODELS AND PHENOMENA
WEC has stated that a well-mixed containment assumption is conservative. However, some of the effects of stratification may be non-conservative, making it difficult to support a blanket claim that a well-mixed atmosphere will yield conservative results. WEC needs to identify the potentially non-conservative effects of stratification and demonstrate that they do not compromise the case for design certification.

Response:

Sensitivities and first principles calculations have been performed to show that the potentially non-conservative effects of stratification are bounded. The PCS evaluation model bounds the effects of mixing and stratification for each phase of the LOCA and the MSLB (Reference 480.303-1), as follows. During the LOCA blowdown, the high steam release rate pressurizes the steam generator compartment, forcing steam through all openings into the compartments below deck and the open volume above deck. Therefore, stratification is not a concern during blowdown. The primary mode of pressure mitigation during LOCA blowdown is the volume pressurization, with a secondary effect of condensation on internal heat sinks and the containment shell. The AP600 evaluation model has been shown to perform essentially the same as a more traditional "few node style" approach during blowdown (Reference 480.303-2).

In the second LOCA phase, during which the peak pressure is reached, containment pressurization is mitigated primarily by condensation on internal heat sinks. Mixing and stratification affect internal steam distributions and thus affect the heat sink efficiency in various internal regions. The physics of plumes suggest that stratification may reduce the access of steam to lower heat sinks during this phase of the accident. The LST data show that with a plume entering the above-deck region, stratification can lead to a slight positive gradient in the open volume. Because of the large volume change associated with condensation of steam, there are significant driving forces for steam ingress into lower compartments. This driving force is orders of magnitude greater than the forces associated with large scale circulation or plume-induced stratification. Therefore, heat sinks in lower compartments absorb significant amounts of energy well before the second peak occurs. Stratification has only a weak potential to affect the containment pressurization. The distributed parameter model is used to address mixing and stratification for the peak pressure phase by biasing steam distribution to bound the effects of stratification.

During the long term LOCA phase the primary means of pressure mitigation is through condensation on the internal PCS surface, which is located above the operating deck (see also the response to RAI 480.298). Stratification would lead to increased steam concentration above the operating deck and thus would improve PCS performance. A well-mixed containment conservatively bounds the effects of stratification on heat removal through the PCS since mixing moves noncondensibles to the above-deck region next to the PCS and noncondensibles in the above-deck region penalize condensation. Thus, stratification during the long term LOCA would improve PCS performance. The use of the lumped parameter model bounds the effects of stratification as discussed in the response to RAI 480.282. Please also see the response to RAI 480.314 for results of a Large Scale Test calculation that quantifies the effects of increased mixing on PCS heat removal.

References

480.303-1 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps", dated August 31, 1995

480.303-2 Westinghouse Letter NTD-NRC-95-4589, "AP600 Containment Analysis for LOCA Blowdown", dated November 7, 1995

SSAR Revision: NONE

Question 480.305

Re: WGOTHIC MODELS AND PHENOMENA
The effects of stratification in the LST experiments are quite nonprototypic in that the amounts of water applied to the shell substantially exceeded evaporation rates, and the effect of water subcooling was much more important than in the AP600. These issues need to be addressed as to their impact on the AP600 analyses.

Response:

The steam condensation rate is only a few percent of the above-deck steam circulation rate. Therefore, the degree of stratification is only weakly affected by the degree of subcooling. In fact, internal stratification has been observed even with a factor of 10 reduction in external cooling rate associated with no external water application. There could only be a negligible feedback of the somewhat higher LST condensation rates on the degree of stratification in the LST, relative to AP600. The effects of subcooling and stratification in the AP600 PCS evaluation model are addressed as follows.

In both the LST and the AP600, energy removal by sensible heating of the liquid film is a small fraction of the total heat removal. The LST experiments cover a range of fractions of external heat removed by subcooled liquid film (5-20%), with most of the tests at the higher range. The assumption of 120°F for the AP600 PCS water temperature results in only about 5% of the total heat being removed by the subcooled liquid film through most of the DBA transient.

LST data show that there is a small steam concentration gradient within the above-deck volume. The effect on the database of increasing liquid film subcooling is to increase the upper limit of the range of dome heat fluxes. As stated above, the presence in LST tests of higher proportions of subcooling relative to AP600 does not invalidate the LST stratification results.

Liquid film energy removal is addressed by using a convective energy transport model (Reference 480.305-1), and is bounded in the evaluation model by assuming an upper bound PCS water temperature. Data from the LST have been used to confirm the physics of stratification within open volumes. The effects of stratification in the AP600 will also be bounded for each accident/phase (see also response to RAI 480.303).

References

480.305-1 WCAP-14382, "WGOTHIC Code Description and Validation" Section 2.5

SSAR Revision: NONE

Question 480.306

Re: WGOTHIC MODELS AND PHENOMENA
The WEC scaling analysis indicates that internal heat sinks are almost as important in determining the peak pressure as is evaporation, and both processes are more important than any others up to the time of peak pressure. As a result, the effect of stratification in reducing the effectiveness of internal heat sinks is potentially important and needs to be addressed.

Response:

The effect of stratification on peak pressure is bounded in the PCS DBA evaluation model (Reference 480.306-1). Please also see response to RAI 480.303.

References

480.306-1 NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.309

Re: WGOTHIC MODELS AND PHENOMENA
For MSLB, how important are the mixed/forced convection issues discussed previously?

Response:

The high kinetic energy of the releases from a main steamline break result in condensation on internal containment structures, that is strongly dominated by forced convection. An assumption of free convection heat and mass transfer on internal structures has been adopted for the PCS evaluation models, so that the enhancement of mass transfer due to forced convection is conservatively neglected. Therefore, while issues related to code velocity predictions are useful in understanding the nominal performance of the AP600 PCS, uncertainties related to the mixed/forced issues discussed previously are bounded.

SSAR Revision: NONE

Question 480.310

Re: WGOTHIC MODELS AND PHENOMENA
What are the flow velocities assumed at various heat sink locations within the containment for the MSLB analyses?

Response:

Because an assumption of free convection heat and mass transfer on internal structures has been adopted, there will be no velocity used in the calculation of heat and mass transfer to internal structures. Sufficient instrumentation was incorporated into the LST to identify and quantify compensating effects. For LST tests with Froude numbers representative of an MSLB, the internal condensation rates were significantly underpredicted when a free convection correlation was used. This is consistent with the expectation of large enhancements to heat and mass transfer resulting from a large forced convection component. Free convection is assumed for internal containment surfaces to conservatively bound velocity effects.

SSAR Revision: NONE

Question 480.311

Re: WGOTHIC MODELS AND PHENOMENA
For the MSLB, what is the validation basis for the velocities calculated by WGOTHIC for use in the correlations for forced and/or mixed convection?

Response:

The large scale test included elevated small diameter pipes to develop Froude numbers representative of a main steamline break. Comparisons of correlations to data showed that the assumption of free convection significantly underpredicts mass transfer, and would thus overpredict vessel pressures. Please see response to RAI 480.310 for how the evaluation model bounds the effects of velocity on heat and mass transfer.

SSAR Revision: NONE

Question 480.312

Re: WGOTHIC MODELS AND PHENOMENA
What is the potential for stratification to occur in the MSLB?

Response:

The main steamline break releases significant amounts of kinetic energy into containment, thus virtually eliminating the potential for stratification within the volume above the operating deck. It is expected that such high levels of kinetic energy would also promote vigorous mixing within the rest of containment because of the relatively large amount of flow area through the operating deck. A significant reduction in break releases would be required to lower the Froude number enough that stratification within the open volume above deck could occur. The evaluation model bounds the effects of stratification in the AP600 main steamline break (Reference 480.312-1).

References

480.312-1 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.313

Re: WGOTHIC MODELS AND PHENOMENA
If stratification does occur in the MSLB, what are the implications for the maximum containment pressure that results?

Response:

Please see the Westinghouse response to RAI 480.308 for a discussion of how the potential effect of stratification during the main steamline break are bounded.

SSAR Revision: NONE

Question 480.314

Re: WGOTHIC MODELS AND PHENOMENA
In the finite difference WGOTHIC calculation for Test 212.1(A) a flow path is added to connect the steam generator compartment to the dead-ended compartment. Why does the steady-state pressure increase by almost 30% of the base case gauge pressure?

Response:

The effect of the flow path into the AP600 steam generator compartment is expected to be an increase in containment pressure, relative to the hypothetical case of no flow path, due to the additional mixing of noncondensibles from the lower compartments into the above deck region. To quantify the potential effect for the LST, a sensitivity study was performed using the detailed distributed parameter model. The detailed distributed parameter model has been validated with LST data(Reference 480.314-1). A flow path was introduced into the computer model, connecting the dead-ended compartment with the simulated steam generator compartment. The effects are evaluated as follows.

Calculations show that two processes are responsible for the predicted pressure increase in LST 212.2A assuming a flow path between the steam generator and dead-ended compartments. The first is the temperature below deck increases by over 100 °F, or 20% absolute, while the temperature above deck remains approximately the same. The thermal expansion of the below deck volume, at 19% of the total volume, accounts for a total pressure increase of 0.20x0.19 = 0.04. 4% of the 24.9 psia reference pressure is 1 psi. The second is the effect of relocating more of the noncondensibles above deck, by better mixing and by thermal expansion of the below deck noncondensibles. The increased noncondensible concentration degrades the above deck mass transfer and accounts for approximately 2 psi of the pressure increase. Therefore, the thermal expansion and relocation of noncondensibles results in a total increase of about 3 psi, or 12% of 24.9 psia (30% of 10.2 psig) in the code calculation.

References

480.314-1 WCAP-14382, "WGOTHIC Code Description and Validation", Appendix A

SSAR Revision: NONE

Question 480.315

Re: WGOTHIC MODELS AND PHENOMENA
Is the pressure increase noted above an artifact of the finite difference approach? Does the same effect occur with WGOTHIC in the LPM?

Response:

The increase is not an artifact of the finite difference approach. Please see the Westinghouse response to RAI 480.314 for a discussion of the cited results. The detailed LST distributed parameter model predicts all measured data well, and is believed to be a reasonable representation of the effect on mixing and stratification of opening a flow path into the simulated steam generator compartment in the LST.

SSAR Revision: NONE

Question 480.316

Re: WGOTHIC MODELS AND PHENOMENA
What are the implications of this behavior for the AP600 analyses?

Response:

The increase in pressure in the LST simulation with a flow path into the steam generator compartment confirms that increased mixing penalizes pressure during portions of transients when pressure mitigation is dominated by PCS heat removal.

SSAR Revision: NONE

Question 480.317

Re: WGOTHIC MODELS AND PHENOMENA
The WEC scaling analysis is based upon a well-mixed containment and includes only natural convection. As a result, the scaling analysis does not permit inferences from the LST results to be applied to the effects of stratification and/or mixed convection phenomena in the AP600. This issue needs to be addressed.

Response:
The referenced scaling analytical model is used to gain insight into the effects of mixing and stratification, which has been considered in development of the bounding evaluation model. It is not used to directly solve for mixing and stratification in the AP600. The scaling analyses provide insight into internal circulation and mixed convection effects as follows.

For simplicity the Westinghouse scaling analysis model is initially derived based on a single volume inside containment with all relevant processes considered. The model has been extended to include the option to consider multiple internal volumes with specified steam concentrations, to study the effects of mixing and stratification. Reference 480.317-1, Section 6.3 discusses the conclusions regarding mixing and stratification, considering the axial steam concentration gradients as measured from the LST.

The scaling analysis model is not intended to calculate internal velocities. It is used to assess the range of validity of free convection and to examine the effects of assumed velocities parametrically. It is concluded that the free convection model conservatively underpredicts mass transfer under conditions of high kinetic energy releases, such as during a LOCA blowdown or a main steamline break. Reference 480.317-1, section 7.0, provides a discussion of the Froude number and considers the effects of kinetic energy of the break source on mixing, or bulk gas motion, and stratification. The scaling analysis model is validated in Section 8.0 by comparison to LST tests that are representative of several points in time for the AP600. This provides confidence that the model reasonably represents the dominant phenomena and can be used to infer the scaling relations between the AP600 and LST and to draw conclusions regarding appropriate AP600 DBA modelling methods. The effects of mixing and stratification and mixed convection are bounded in the DBA evaluation models (Reference 480.317-2). The evaluation model uses free convection.

References

480.317-1 WCAP-14190, "Scaling Analysis for AP600 Passive Containment Cooling System"

480.317-2 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.318

Re: WGOTHIC MODELS AND PHENOMENA

If LST results concerning the effects of stratification and/or mixed convection phenomena are not applicable to the AP600, WEC needs to assess or bound the uncertainties these effects produce in the WGOTHIC results is needed. How will WEC address these uncertainties for the AP600 analyses?

Response:

LST results are used to provide insight into the potential effects of mixing and stratification in the AP600. Assessment of the effects of mixing and stratification is based on a combination of first principles, hand calculations, LST results, and sensitivity calculations. The effects of mixing and stratification are bounded in the AP600 PCS DBA evaluation model (Reference 480.318-1).

References

480.318-1 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.325

Re: WGOTHIC MODELS AND PHENOMENA
No full-scale wetting tests for a heated surface have been performed; is this limitation of the data base significant?

Response:

Full scale tests have been used to determine wettability effects of full scale geometry with worst case manufacturing tolerances. The lack of full scale heated tests is not significant. Heat flux effects are included in the AP600 water coverage fraction model which has been validated with LST data (Reference 480.325-1, 480.325-2) and used to determine a bounding minimum coverage fraction used in the AP600 PCS DBA. Thus the database is not limited to cold tests and sufficient data exists to validate the water coverage model for relevant effects, including the effects of heat flux.

References

480.325-1 Westinghouse Letter NTD-NRC-94-4247, "Method for Determining Film Flow Coverage for the AP600 Passive Containment Cooling System," July 28, 1994

480.325-2 Westinghouse Letter NTD-NRC-94-4286, "Supplemental Information on AP600 PCS Film Flow Coverage Methodology," August 31, 1994

SSAR Revision: NONE

Question 480.326

Re: WGOTHIC MODELS AND PHENOMENA
How will WEC demonstrate that there will be acceptable wettability of the shell after many years of service?

Response:

Wettability during service will be shown based on periodic In-Service Inspections using simple procedures to sample the surface for wettability. Please see response to RAI 480.327 for cleaning methods which can be used to restore wettability.

SSAR Revision: NONE

Question 480.327

Re: WGOTHIC MODELS AND PHENOMENA

If, after years of service, shell wettability is found to be degraded, are there any means by which acceptable wettability can be recovered?

Response:

Shell wettability can be affected over time by aging of the surface and by deposition of contaminants. Experience indicates that the polarity of the inorganic zinc coating increases as it oxidizes causing wetting to be improved with increasing age. The coating manufacturer has standard cleaning procedures and specially developed detergents which can emulsify contaminants that might degrade wettability so that they can be washed away, thereby improving wettability.

SSAR Revision: NONE

Question 480.328

Re: WGOTHIC MODELS AND PHENOMENA
Have any sensitivity studies been performed to determine the minimum extent of wetting required to turn around the pressure transient? If none are available, they should be performed.

Response:

A specific sensitivity to determine the minimum extent of wetting required to turn around the pressure transient has not been performed. However, the coverage fraction used in the evaluation model is already a lower bound, and sensitivity studies have been documented to the NRC, showing that there is more than a factor of two margin between the bounding, minimum DBA water coverage and the coverage required to not exceed the design pressure for the second peak (Reference 480.328-1). A sensitivity was also provided for a case with no external water. Therefore, the subject sensitivity is not required for determining the margin.

An alternative approach to confirm the margin to minimum required coverage is to examine the coverage fraction required to evaporate all the PCS flow for a given evaporation mass flux. Figure 480.328-1 shows the relationship between the containment pressure and the fraction of the shell required to evaporate 30 lbm/sec (the initial PCS water flow rate). The use of the highest mass flow rate maximizes the required coverage fraction. The calculations are based on a single volume containment, at steady-state, with subcooled, evaporating and dry external surface regions. The AP600 evaluation model free convection heat and mass transfer correlation was used inside, and the forced convection model was used on the outside. Results are shown for the case of perfect mixing, and for a case in which the air concentration above deck is 1/2 that of perfect mixing. At the design pressure, less than 37% of the shell surface is required to evaporate all the water, and hence, achieve the maximum available evaporative containment heat rejection. This conservatively overestimates the required coverage fraction which is still less than the assumed DBA coverage fractions which were established based on testing. Sensitivity studies discussed above also show that a coverage fraction less than this does not significantly impact containment pressure due to the large thermal capacitance available with internal volume and heat sinks (Reference 480.328-1). Therefore, margin in the water coverage assumed in the evaluation model has been quantified.

References

480.328-1 Westinghouse Letter NTD-NRC-94-4286, "Supplemental Information on AP600 PCS Film Flow Coverage Methodology," August 31, 1994

SSAR Revision: NONE

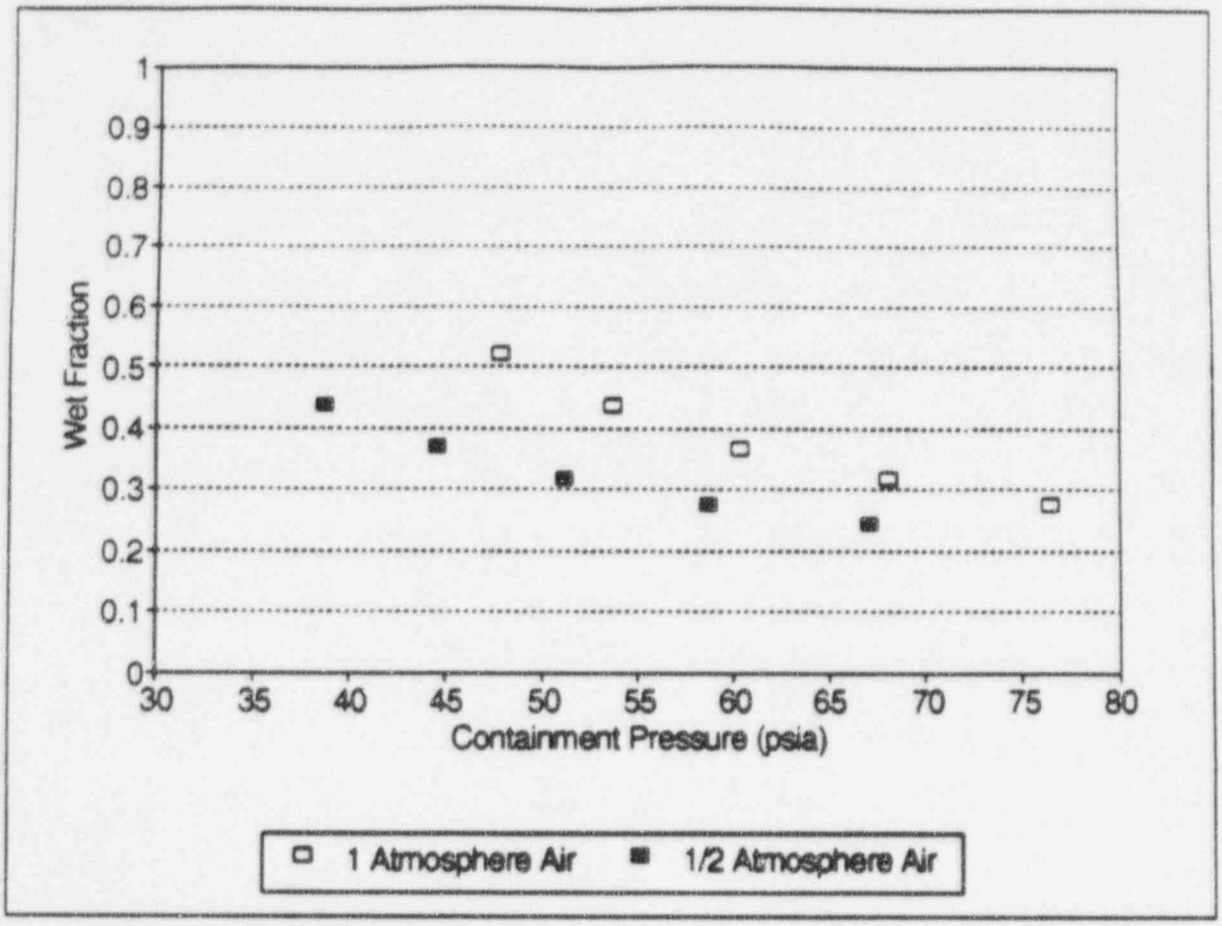


Figure 480.328-1 Fraction of AP600 Shell Surface Area Required to Evaporate 30 lbm/sec of PCS Cooling Water

Question 480.337

Re: WCAP-13246
How will WEC address the documentation errors in WCAP-13246, Appendix A? Appendix A does not adequate describe some of the GOTHIC code features. A schedule needs to be developed for submitted a final, complete code description.

Response:
WCAP-13246 has been superseded by WCAP-14382 (Reference 480.337-1) in which modifications made to create WGOTHIC 1.2 are described. The EPRI-sponsored GOTHIC code has undergone a peer design review (Reference 480.337-2). Design review comments were incorporated into the code and documentation resulting in GOTHIC 4.0 (Reference 480.337-3), bringing the GOTHIC code under 10CFR50 Appendix B quality assurance plan and correcting the errors mentioned in the design review final report. A list of GOTHIC models not used for AP600 has also been provided (Reference 480.337-4).

The following has been provided (Reference 480.337-5):

- a discussion on the applicability of the GOTHIC peer design review package to WGOTHIC,
- a summary of peer design review results,
- a list of design review finding applicable for WGOTHIC, and
- an assessment of the differences between GOTHIC 4.0 and WGOTHIC 1.2.

Therefore, the relevant GOTHIC documentation has been submitted. The evaluation model incorporates the significant differences identified between WGOTHIC 1.2 and GOTHIC 4.0 (Reference 480.337-5).

References

480.337-1 WCAP-14382, "WGOTHIC Code Description and Validation"

480.337-2 Westinghouse Letter NTD-NRC-95-4462, "EPRI Report RA-93-10, GOTHIC Design Review, Final Report," May 15, 1995

480.337-3 Westinghouse Letter NTD-NRC-95-4563, "GOTHIC Version 4.0 Documentation," May 15, 1995

480.337-4 Westinghouse Letter NTD-NRC-95-4577, "Updated GOTHIC Documentation," October 12, 1995

480.337-5 Westinghouse Letter NTD-NRC-95-4595, "AP600 WGOTHIC Comparison to GOTHIC," November 13, 1995

SSAR Revision: NONE

Question 480.338

Re: WCAP-13246
How will WEC address the coding errors in the base version of GOTHIC (version 3.4) that was used to develop WGOTHIC?

Response:
The WGOTHIC code was based on GOTHIC 3.4c and subsequently has been developed in parallel with more recent GOTHIC versions. Westinghouse maintained WGOTHIC consistent with significant GOTHIC changes and enhancements. A peer review was also performed by leading industry experts, which culminated in the issuance of GOTHIC 4.0. An assessment of the differences between the configuration controlled WGOTHIC 1.2 and GOTHIC 4.0 (see also response to RAI 480.337) has been provided, showing that the differences do not invalidate any results using WGOTHIC 1.2 (Reference 480.338-1,480.338-2). Therefore, Westinghouse has addressed coding errors identified in the base GOTHIC code.

References

480.338-1 Westinghouse Letter NTD-NRC-95-4577, "Updated GOTHIC Documentation," October 12, 1995

480.338-2 Westinghouse Letter NTD-NRC-95-4595, "AP600 WGOTHIC Comparison to GOTHIC," November 13, 1995

SSAR Revision: NONE

Question 480.339

Re: WCAP-13246
How will WEC address the validation and verification data base for those experiments that where analyzed with the GOTHIC version found to contain errors? Where there any instances when a fix to the GOTHIC portion of WGOTHIC resulted in different results when compared to the previously performed analyses?

Response:
The impact of changes made to GOTHIC 3.4c to create GOTHIC 4.0, including fixes and enhancements, has been assessed as described in the response to RAI 480.338. Pre-release validation of GOTHIC 4.0 confirmed that none of the validation and verification database in the GOTHIC code qualification report was invalidated. The changes incorporated in GOTHIC to create version 4.0 resulted in no significant differences (Reference 480.339-1) in the results of the WGOTHIC validation base (Reference 480.339-2).

References

480.339-1 Westinghouse Letter NTD-NRC-95-4595, "AP600 WGOTHIC Comparison to GOTHIC," November 13, 1995

480.339-2 WCAP-14382, "WGOTHIC Code Description and Validation"

SSAR Revision: NONE

Question 480.345

Re: WCAP-13246
Where is a description of how subcooling is modeled in the current code?

Response:

Subcooling of the external liquid film is modelled with a liquid film convective energy transport model, described in Reference 480.345-1.

References

480.345-1 WCAP-14382, "WGOTHIC Code Description and Validation", Section 2.5

SSAR Revision: NONE

Question 480.352

Re: PCS-GSR-001
What do the WGOTHIC results for the LST experiments mean in terms of the potential accuracy and/or conservatism of WGOTHIC for the AP600?

Response:

The LST has provided insight into the development of bounding AP600 evaluation models. The accuracy of the LST predictions is not directly applicable to the AP600; rather, comparisons of predicted and measured results have provided insight into the ability of the code to model important phenomena. An objective of the LST experiments was to provide validation of heat and mass transfer predictions in an integral setting. The following summarizes how the LST has been used to develop the PCS evaluation model.

The application of scaling to the LST (Reference 480.352-1) showed that the LST represents the AP600 heat and mass transfer, the dominant transport processes. A model of the LST was developed with the WGOTHIC computer code to make validation comparisons to the LST steady state and transient tests (Reference 480.352-2). The LST model utilized the most accurate and nominal phenomenological models, initial conditions, and boundary conditions available. The computer model represented the transport phenomena identified as important, as well as many others that are of medium and low importance. Comparisons of code predictions to the test data support code validation, and also confirm that the PIRT and scaling analysis have included the important phenomena.

The nominal LST models, both lumped parameter and distributed parameter, served as a starting point for the PCS DBA evaluation model of AP600 and showed a trend towards overpredicting pressure. However, the evaluation model is a bounding model, so it is necessary to input bounding initial and boundary conditions, as well as to bias the phenomenological models of the dominant transport processes to provide bounding results. The means by which the initial and boundary conditions and phenomenological models are bounded have been provided (Reference 480.352-3).

References

480.352-1 WCAP-14190, "Scaling Analysis for AP600 Passive Containment Cooling System"

480.352-2 WCAP-14382, "WGOTHIC Code Description and Validation"

480.352-3 Westinghouse Letter NTD-NRC-95-4545, "AP600 PCS Design Basis Accident Roadmaps," August 31, 1995

SSAR Revision: NONE

Question 480.363

Re: (PCS-GSR-004) EXPERIMENTAL COMPARISONS (GENERAL)
WEC should attempt to apply the results to draw quantitative inferences concerning the conservatism and/or the uncertainties that must be allowed for when applying these correlations to AP600 analysis.

Response:

The uncertainties which must be allowed for when applying the correlations for AP600 analysis are bounded as follows. Separate effects tests and local integral test data has been used to validate the use of the heat and mass transfer correlations selected for use in the AP600 evaluation model (Reference 480.363-1). The bias and other statistics associated with those comparisons are given in Section 4.2 for evaporation and 4.3 for condensation. When the correlations are used in the AP600 PCS evaluation model, conservative biases bounding the data are employed (Reference 480.363-2).

References

480.363-1	WCAP-14326, "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations"
480.363-2	Westinghouse Letter NTD-NRC-95-4570, "Bases for AP600 PCS DBA Mass Transfer Correlation Biases," September 28, 1995

SSAR Revision: NONE

Question 480.364

Re: PCS-GSR-004 - EXPERIMENTAL COMPARISONS (GENERAL)
Based upon the results presented, there is no basis for claiming conservatism in these correlations. Results are consistent with the correlations' being best-estimate (BE) correlations. However, BE analysis is acceptable in this context only if it is accompanied by an assessment of the uncertainties. How will WEC address uncertainties for the AP600 analyses?

Response:

Westinghouse has addressed uncertainties for the AP600 analyses by the use of a bounding approach. The AP600 PCS evaluation model includes multipliers on both the evaporation and condensation correlations that bound the separate effects test data (Reference 480.364-1).

References

480.364-1 Westinghouse Letter NTD-NRC-95-4570, "Bases for AP600 PCS DBA Mass Transfer Correlation Biases," September 28, 1995

SSAR Revision: NONE

Question 480.373

Re: PCS-GSR-006
WEC should attempt to apply the results to draw quantitative inferences concerning the conservatism and/or the uncertainties that must be allowed for when applying these correlations to AP600 analysis.

Response:

Please see the Westinghouse response to RAI 480.363.

SSAR Revision: NONE

Question 480.374

Re: PCS-GSR-006
Based upon the results presented, there is little basis for claiming conservatism in these correlations. Results are consistent with the correlations' being best-estimate (BE) correlations. However, BE analysis is acceptable in this context only if it is accompanied by an assessment of the uncertainties, which has not been provided. How will WEC address uncertainties for the AP600 analyses?

Response:

Please see the Westinghouse response to RAI 480.364.

SSAR Revision: NONE

Question 480.376

Re: PCS-GSR-006
What are the implications of the use of the Uchida correlation for heat sinks inside the containment?

Response:

The Uchida correlation is used to calculate condensation mass transfer on internal structural heat sinks. The Uchida free convection correlation has been established as a conservative bound on total heat transfer for conditions wherein free convection condensation in the presence of noncondensibles is the primary mode of mass transfer. It has been shown to significantly underpredict data from the CVTR tests where significant internal velocities may be inferred. The use of the Uchida correlation for the internal heat sinks is appropriate for use in the AP600 evaluation model.

SSAR Revision: NONE

Question 480.377

Re: PCS-GSR-006
Does WGOTHIC take credit for superheat in applying Uchida?

Response:

WGOTHIC takes credit for superheat in applying Uchida using the revaporization conceptual model. Revaporization is modelled for internal heat sinks where Uchida is used in the AP600 PCS evaluation model. In conditions of superheat in the containment, the heat transfer component becomes a larger fraction of the total heat transferred. Revaporization is the method of accounting for the convective heat transfer which occurs during superheated conditions using the Uchida correlation.

SSAR Revision: NONE