Westinghouse
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Energy Systems

Box 355
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AW-97-1118

June 10, 1997

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: RESPONSES TO OPEN ITEMS ON WCOBRA/TRAC APPLICABILITY TO AP600 LARGE-BREAK LOSS-OF-COOLANT ACCIDENT

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-97-1118 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-97-1118 and should be addressed to the undersigned.

Very truly yours,

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

cc: Kevin Bohrer NRC OWFN - MS 12E20

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PROPRIETARY INFORMATION NOTICE

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

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) contained within parentheses located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Section (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR2.790(b)(1).

AW-97-1118

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, Manager
Advanced Plant Safety and Licensing

Sworn to and subscribed
before me this 11th day
of June, 1997

Notary Public

Notarial Seal
Janet A. Schwab, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires May 22, 2000
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 NSD-NRC-97-5171, June 10, 1997 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 1
TO WESTINGHOUSE LETTER NSD-NRC-97-5171
RESPONSES TO OPEN ITEMS:

4634	4646	4658	4670	4691
4635	4647	4659	4671	4692
4636	4648	4660	4672	4695
4637	4649	4661	4673	4697
4638	4651	4662	4675	4698
4639	4652	4663	4676	4699
4640	4653	4664	4677	4700
4641	4654	4665	4679	4701
4643	4655	4666	4680	
4644	4656	4667	4684	
4645	4657	4669	4685	

COMMENTS ON WESTINGHOUSE'S REPORT
WCAP-14171, REV. 1
WCOBRA/TRAC APPLICABILITY TO AP600 LBLOCA

NOTE: The questions are based on the review of information Westinghouse submitted in Reference 1.

1. The following questions relate to the AP600 Phenomena Identification and Ranking Table (PIRT) presented by Westinghouse in Section 2.1 of Reference 1. They also represent followup questions to Item 8e in the May 17, 1996, NRC letter.

Open Item - 4634

a. In several cases, Westinghouse stated that a lower ranking was given to a certain phenomenon in the AP600 because of the low peak cladding temperatures (PCTs) calculated for the plant. Examples include reflood heat transfer, entrainment/deentrainment in the core, and containment pressure. For these phenomena, and for others if Westinghouse makes similar arguments for them, clarify if (a) calculating these phenomena are important even if PCTs are low or (b) they are important because they contribute to the calculation of the lower PCTs. If Westinghouse answers yes to either a or b above, provide additional information to justify the lower AP600 ranking.

The calculation of these parameters is important to the calculation of the PCT. However, because of the lower kw/ft rating of the AP600, better blowdown cooling, etc., one can have a larger allowable uncertainty in the calculation of these phenomena. Therefore, they are ranked lower than for a 3/4 loop plant in which there is less margin available and for which one can not tolerate a large uncertainty.

Open Item - 4635

b. For containment pressure, reflood heat transfer, and core entrainment/deentrainment, and for other phenomena if Westinghouse makes similar arguments about the lower AP600 PCTs for them, clarify if the INEL understanding is correct regarding the conservatism of the calculations or how the uncertainty is accounted for in the Westinghouse methodology:

(1) containment pressure: Westinghouse uses a lower bound containment pressure consistent with current conservative (Appendix K) analyses.

See Table 4.4-1, a bounded value is used similar to Appendix K.

(2) reflood heat transfer: Uncertainties in this area are included in the uncertainty methodology.

Correct, uncertainties are included in the uncertainty methodology same as 3/4 plants.

(3) core entrainment/deentrainment: WCOBRA/TRAC analyses are conservative in this area as discussed in Section 3.1.6 of the Revised Methodology Report (RMR).[2] In addition, the uncertainty in core entrainment/deentrainment is covered in Westinghouse's overall heat transfer coefficient (HTC) multiplier methodology, which captures differences in local fluid conditions.

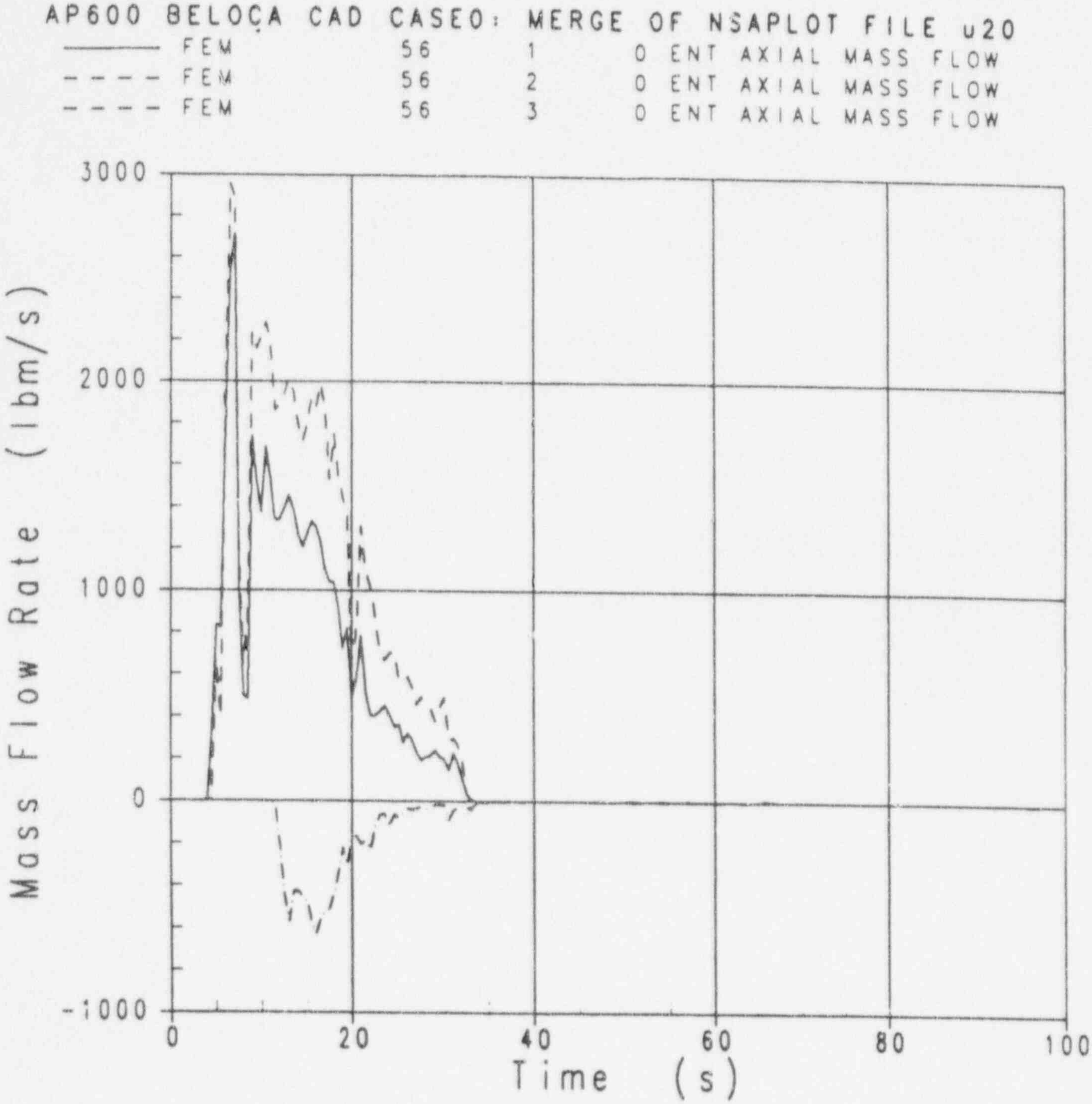
Correct, uncertainties are treated in the same fashion as 3/4 loop plants.

Open Item - 4636

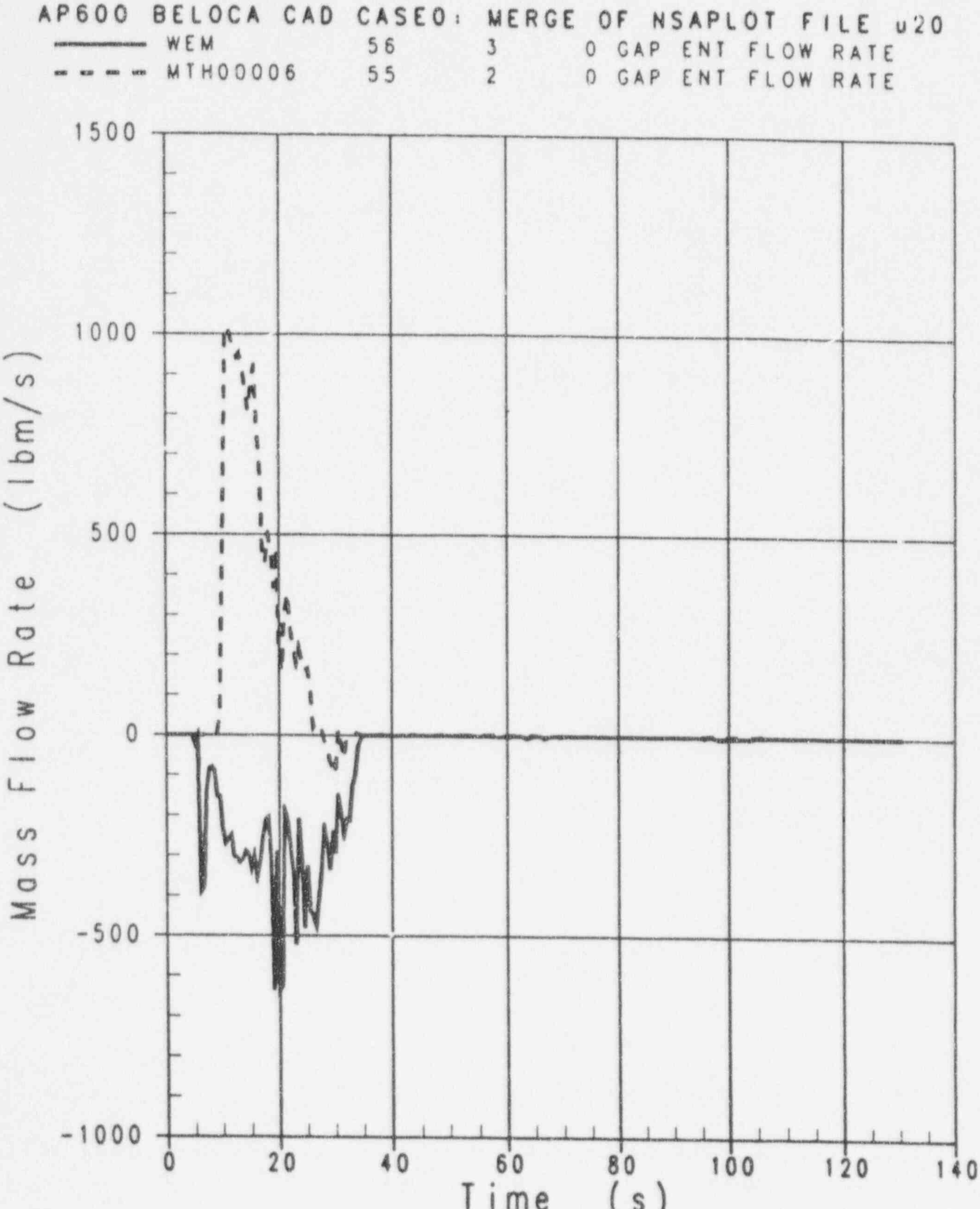
c. Westinghouse ranked downcomer entrainment/deentrainment slightly lower in reflood for the AP600 relative to 3-/4-loop plants but did not discuss why. Clarify the reason for the lower AP600 ranking. If the reason(s) is(are) similar to that discussed in part a, provide the same type of information requested in parts a and b.

The AP600 PIRT shows a lower ranking for downcomer entrainment because it is less important during reflood for AP600 large break LOCA events than it is for 3/4-loop plants. Two phenomena which can lead to liquid entrainment (and deentrainment) in 3/4-loop plants do not apply to AP600. First, the direct vessel injection of accumulator water and the very large accumulators with which the AP600 is equipped mean that no downcomer boiling occurs in AP600 during the time of interest for the calculation of peak cladding temperature. Second, the elevation of the DVI nozzle entrance into the AP600 downcomer is about two feet below the bottom cold leg elevation, and the downcomer is equipped with flow diverters to direct safety injection water downward toward the lower plenum. The safety injection water is not subject to surface entrainment into any high velocity steam which might be progressing from the intact loop cold legs across the downcomer to the break.

The attached Figure 1.c-1 plots the entrained liquid flow predicted between cells in COBRA downcomer channel #56, which is connected to the broken cold leg, in the AP600 WCOBRA/TRAC CD=0.8 DECLG analysis presented in Chapter 2 of WCAP-14171, Revision 1. FEM (56,1) is the entrained droplet flow into the channel's lower cell from the channel below, and FEM(56,3) is the entrained droplet flow out of the channel upper cell, which is connected to the broken cold leg, into the channel above. FEM(56,2) shows the flow between the two cells of channel 56. The figure illustrates that although as much as 3000 lbm/sec of entrained liquid flows into the cell connected to the break during blowdown, there is almost no entrained liquid entering into that downcomer cell from adjacent cells to proceed out the break during reflood. Further, Figure 1.c-2 presents the entrained droplet flowrates in the gaps connecting channel 56 and adjacent channels 55 and 57. The flow direction is into channel 56 in both gaps. Again, after the end of blowdown the droplet flow through these gaps is insignificant. For the reasons specified in the first paragraph, downcomer entrainment during reflood is not as important during reflood for AP600 as it is for 3/4 loop plants.



Response 1(c) - Figure 1



Response 1(c) - Figure 2

d. On page 2-8, Westinghouse discussed flow from the upper plenum to the core during flow reversal in blowdown. During the flow reversal, Westinghouse argued that all the upper head water flows to the upper plenum and then to the core due to the large pressure drop between the upper plenum and the break. However, the flow path to the break through the hot leg is another possible route for upper head water. To clarify the flow split from the upper plenum to the core versus the upper plenum to the hot legs, provide plots of the flows at the intact and broken loop hot leg junctions for comparison to the top of the core flows provided in Reference 1. Clarify how the hot leg flows support Westinghouse's position on the flow to the core or provide additional information to clarify Westinghouse's understanding of the flow split and how any uncertainty in the calculation is accounted for in the AP600 uncertainty analysis. This is a followup to Discussion Item 5b in the May 17, 1996, letter.

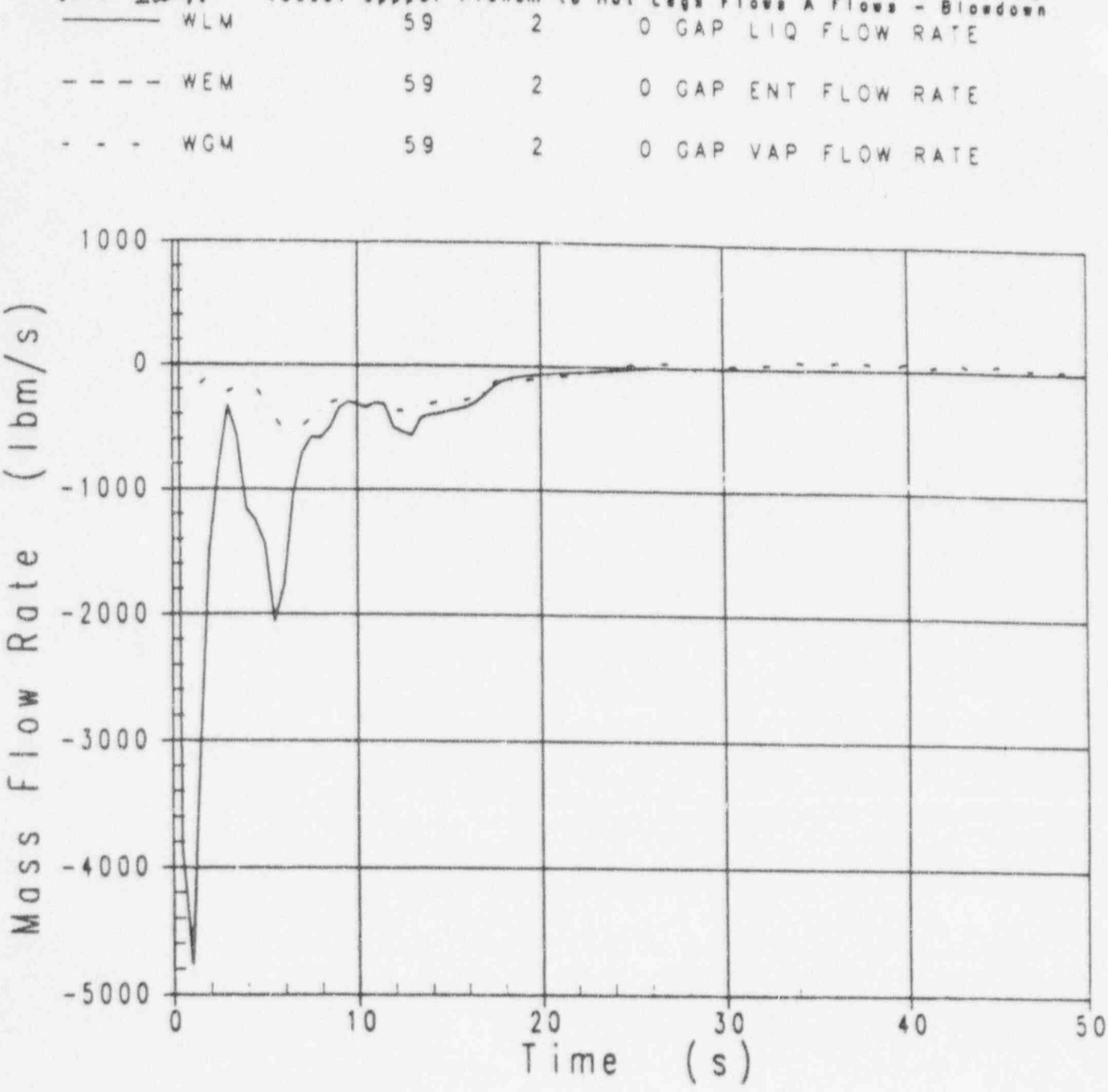
The attached Figures 1.d-1 and 2 depict the flow in the two hot legs at the junction of the vessel outer global channel during the AP600 blowdown. Early on, within the first second following the break, flow in the intact loop hot leg reverses and proceeds into the vessel. During the remainder of the 35 second blowdown, any liquid flowing at the intact loop hot leg/vessel junction flows into the vessel. During the initial seconds of the transient, the influx of liquid from the intact loop hot leg (Figure 1.d-1) into the upper plenum is far less than the flow through the broken loop hot leg (Figure 1.d-2). In the first second, liquid and entrained droplet flow into the outer global channel from the inner global channel through gap 58 contributes most of the rest of the large flow that feeds the break through the broken loop hot leg (Figure 1.d-3). The flow through both levels of gap 58 is from inner to outer global channel during the blowdown.

In the five to six second time frame, a portion of the influx from the intact loop hot leg enters the core as a downflow into the peripheral or guide tube fuel assemblies (WCAP-14171, Revision 1, Figures 2.2-34 and 2.2-36). This is apparent from Figure 1.d-4, the liquid flow at the elevation of the bottom of the hot leg in outer global channel #61. During the first few seconds the mass initially present in this channel drains. The inflection in the channel 61 downflow observed at 5-6 seconds is the net increase of approximately 700 lbm/sec being provided by the intact hot leg. Shortly after six seconds, the broken loop hot leg flow from the vessel once again exceeds the flow into the upper plenum from the broken loop hot leg, and the flow inflection in Figure 1.d-4 ends. Beyond 12 seconds, the liquid flow from the intact loop hot leg is in part predicted to enter the core, and in part proceeds out the broken loop hot leg as liquid and entrained droplets. This pattern continues until the liquid flow in each of the hot legs diminishes to a small value approximately 18 seconds into the transient.

Note the discussion on page 2-8 does not state that ALL the upper head fluid draining into the upper plenum proceeds into the core. Some of this upper head fluid also becomes part of the liquid and entrained droplets passing from inner to outer global channels and leaving the upper plenum out through the broken loop hot leg in the 5-12 second time frame. Overall, approximately one-fourth of the upper head fluid draining into the upper

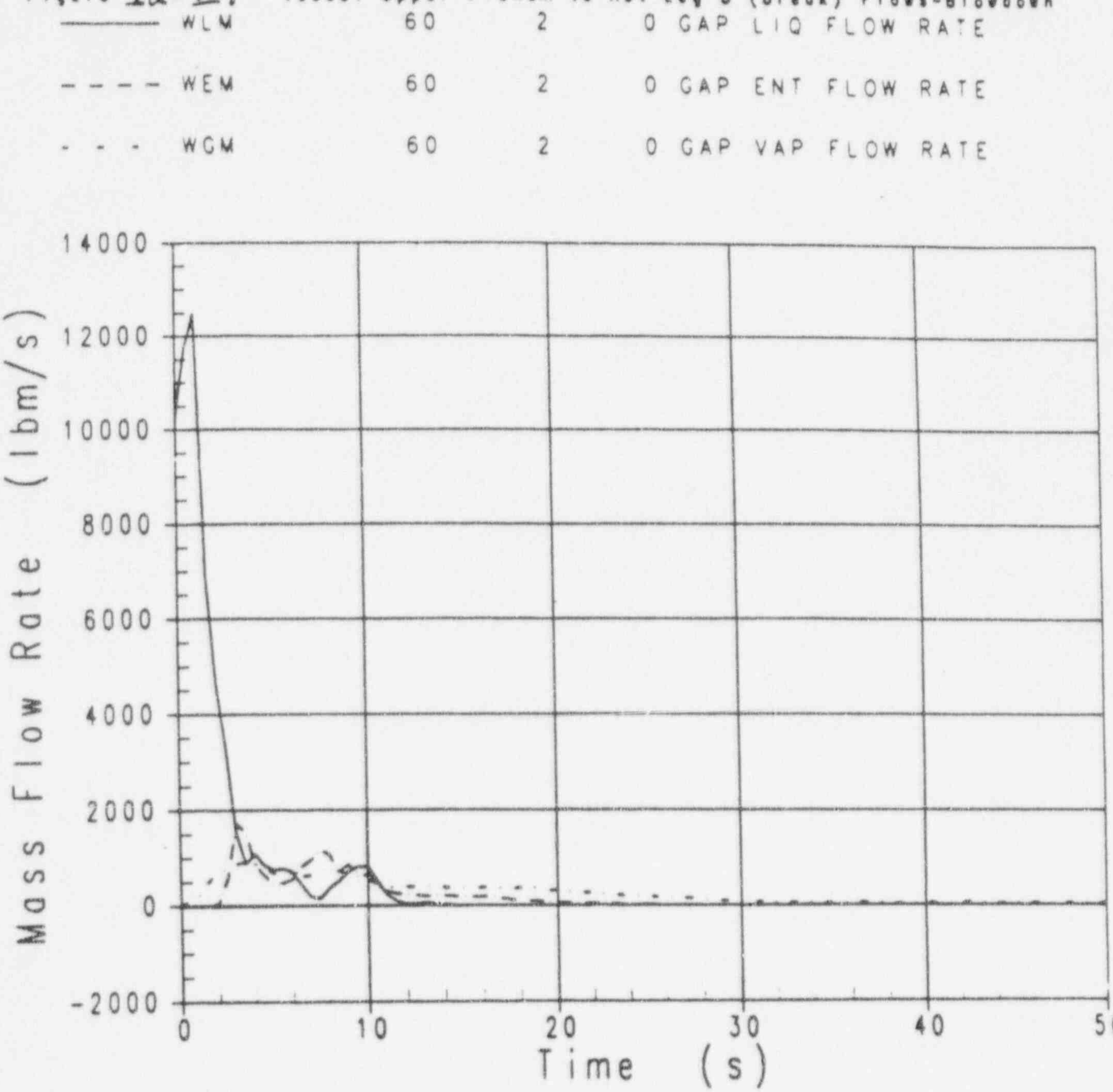
plenum during this time interval exits through the broken loop hot leg. The possible uncertainty associated with upper plenum flow split is addressed in two ways. First, a sensitivity case is performed to identify the worst break location relative to the pressurizer, and the limiting location becomes the basis for the SSAR spectrum. Also, variation of the parameters in the global model matrix performed for the AP600 SSAR will impact the flow split of liquid from the upper plenum. Together, these studies address the uncertainty in the upper plenum flow split by varying the loop parameters which determine the relative flow between the core and the hot legs.

AP600 LBLOCA WC/T CAD CASE 0: DECLG, CD=0.8, Tmin=800F, WITH PXS
Figure 1d-1: Vessel Uppper Plenum to Hot Legs Flows A flows - Blowdown

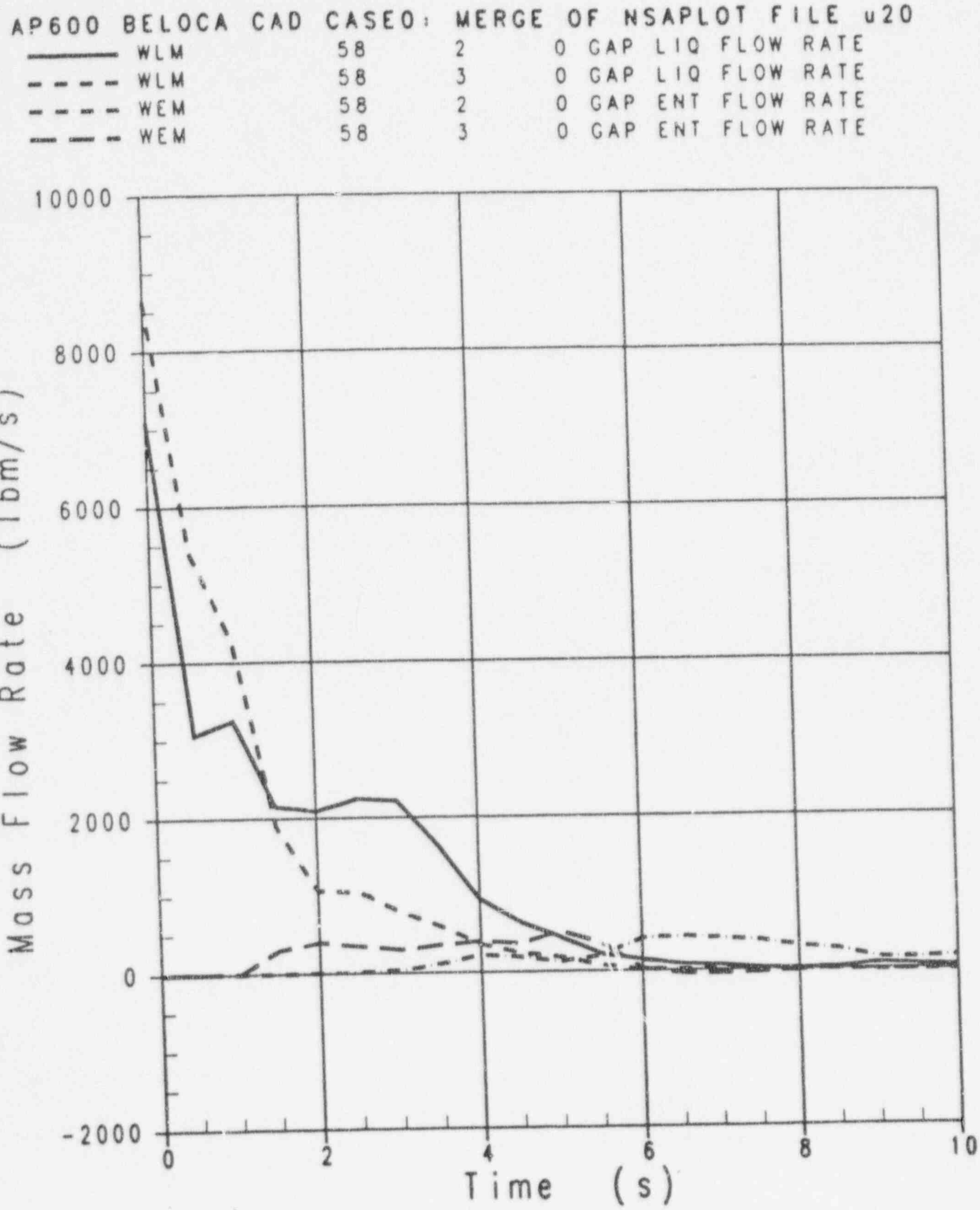


Response 1(d) - Figure 1

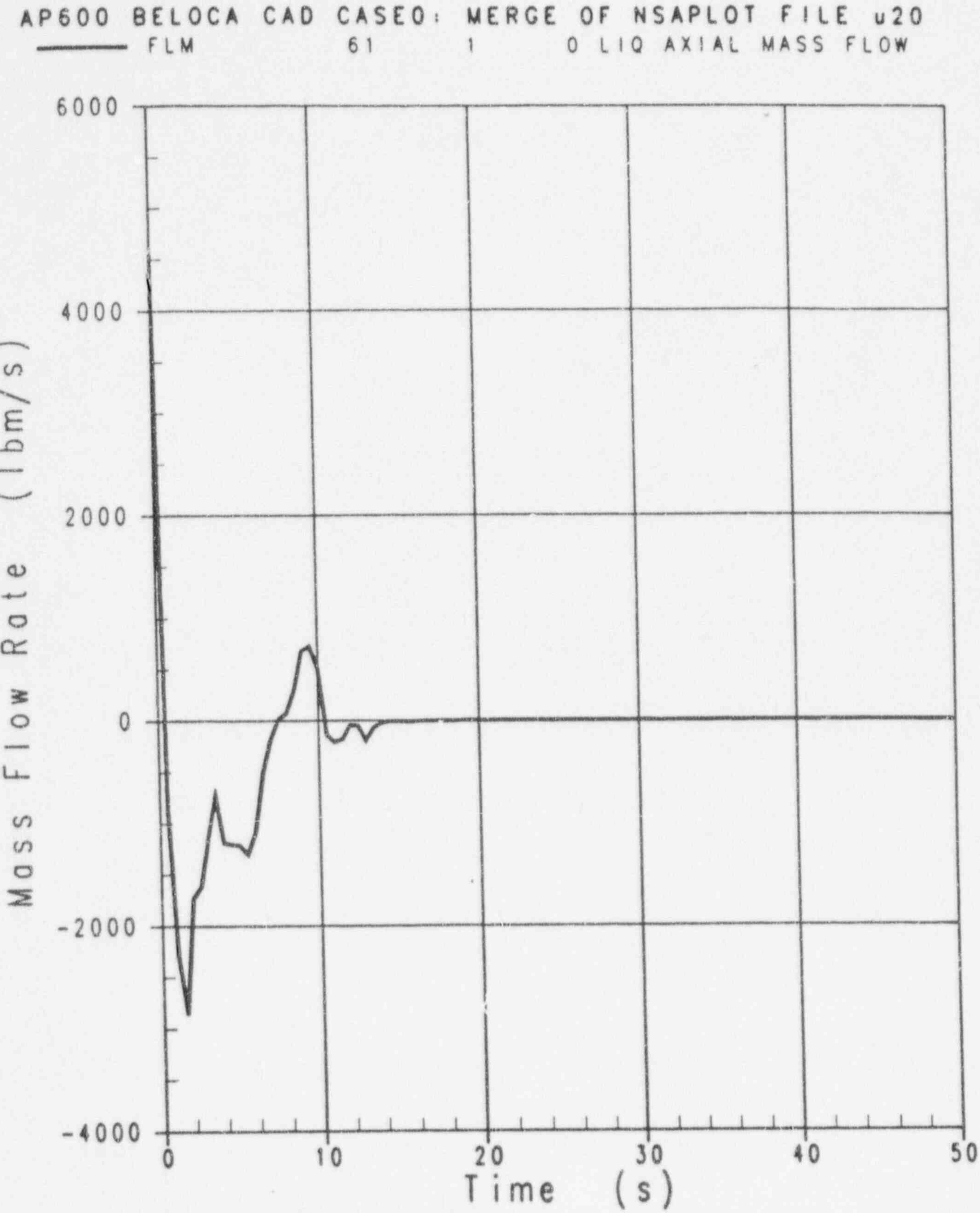
AP600 LBLOCA WC/T CAD CASE 0: DECLG, CD=0.8, Tmin=800F, WITH PXS
Figure 1d-2: Vessel Upper Plenum to Hot Leg B (Break) Flows-Blowdown



Response 1(d) - Figure 2



Response 1(d) - Figure 3



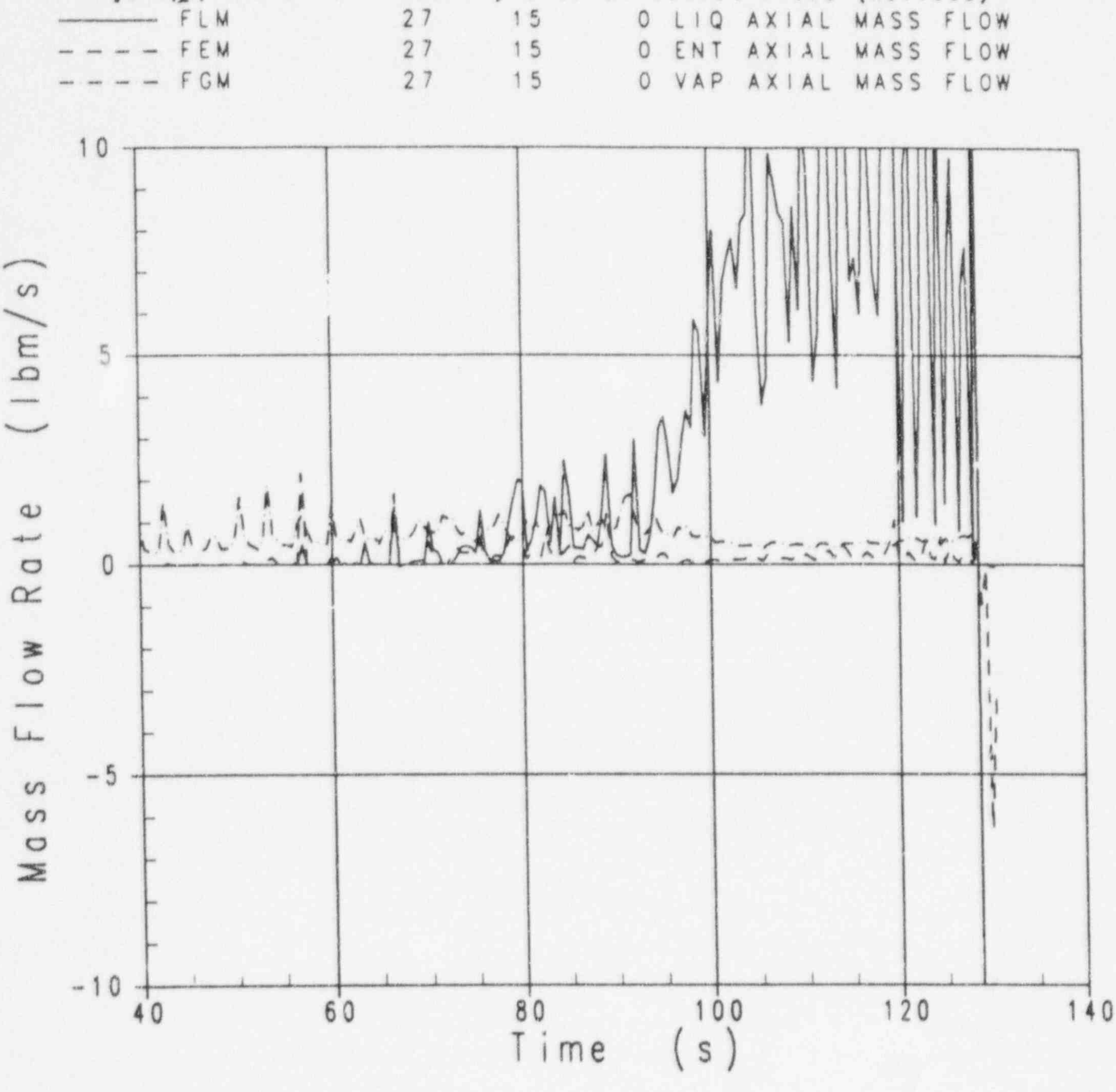
Response 1(d) - Figure 4

e. For core countercurrent flow (CCF) during reflood, provide plots that show the flows calculated at the core outlet to clarify if downward liquid flow is calculated and contributes to core cooling. If yes, justify not ranking this phenomena or provide a ranking and its justification. If liquid flow downflow at the top of the core contributes to core cooling during reflood, clarify how the uncertainty in this phenomenon is accounted for in the AP600 uncertainty analysis.

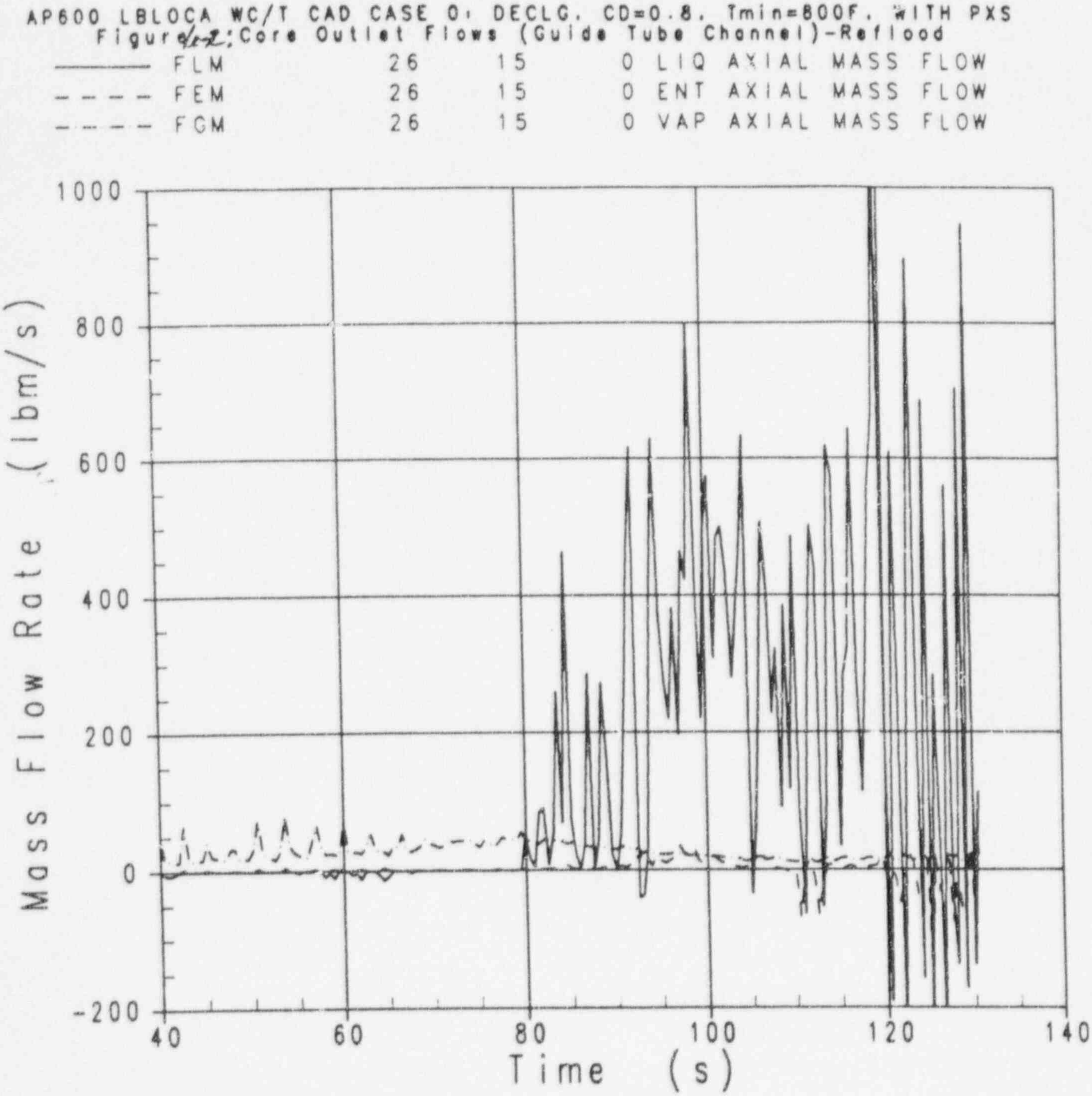
Liquid downflow at the top of the core does not contribute to AP600 core cooling during reflood. Attached are figures which show the liquid, entrained droplet, and vapor flows predicted at the core outlet during the WCAP-14171, Revision 1 Section 2.2 DECLG break case for the hot assembly, guide tube, open hole/support column and peripheral channels. The figures show that during reflood, through the time of core quench, no significant downflow exists in any of the channels, except the peripheral channel. For the low power peripheral fuel channel, the downflow calculated begins almost 90 seconds into the transient, well after the reflood phase PCT has occurred. Therefore, core countercurrent flow during reflood is unimportant and need not be included among the ranked phenomena.

AP600 LBLOCA WC/T CAD CASE 0: DECLG, CD=0.8, Tmin=800F, WITH PXS

Figure/_2-1: Core Hot Assembly Channel Outlet Flows (Reflood)



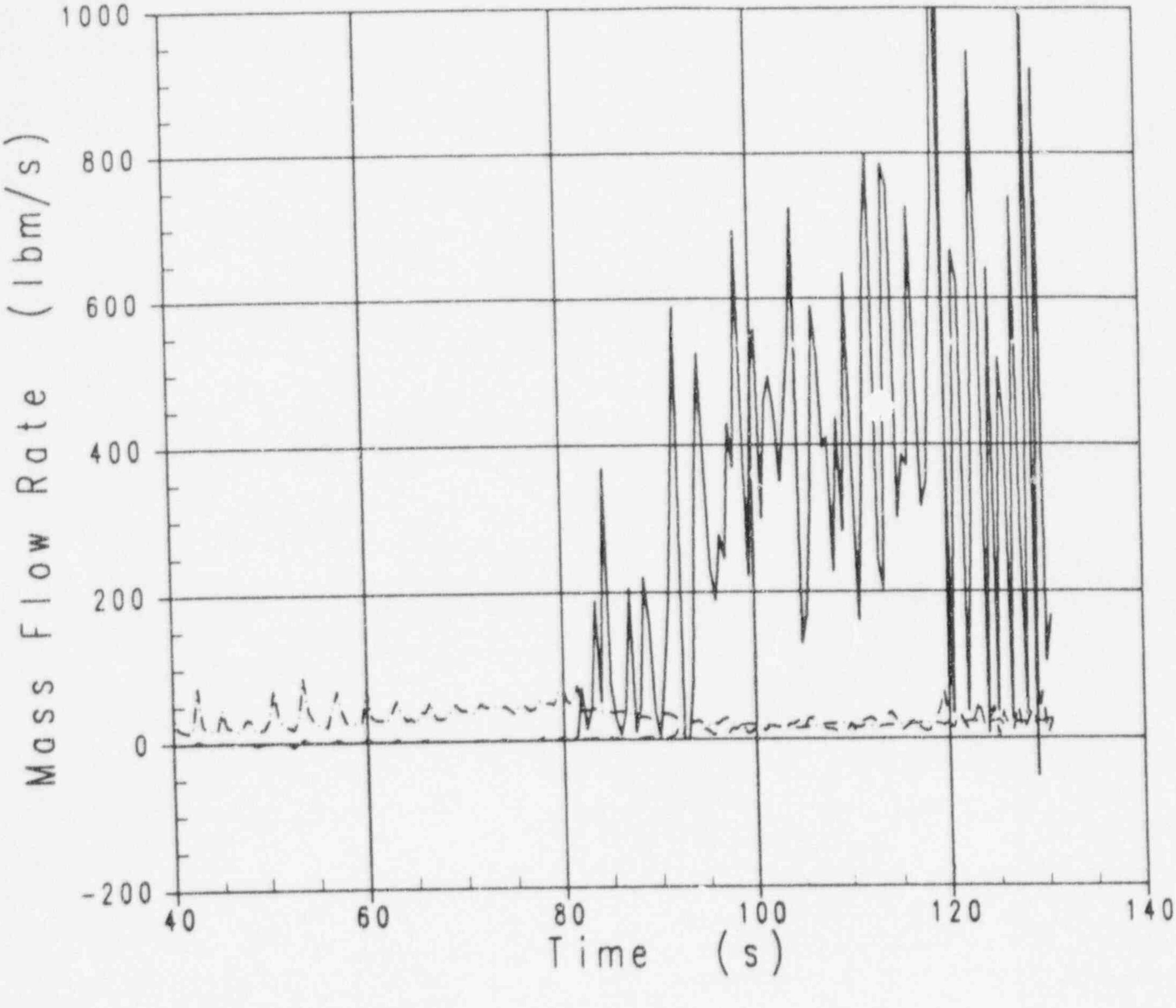
Response 1(e) - Figure 1

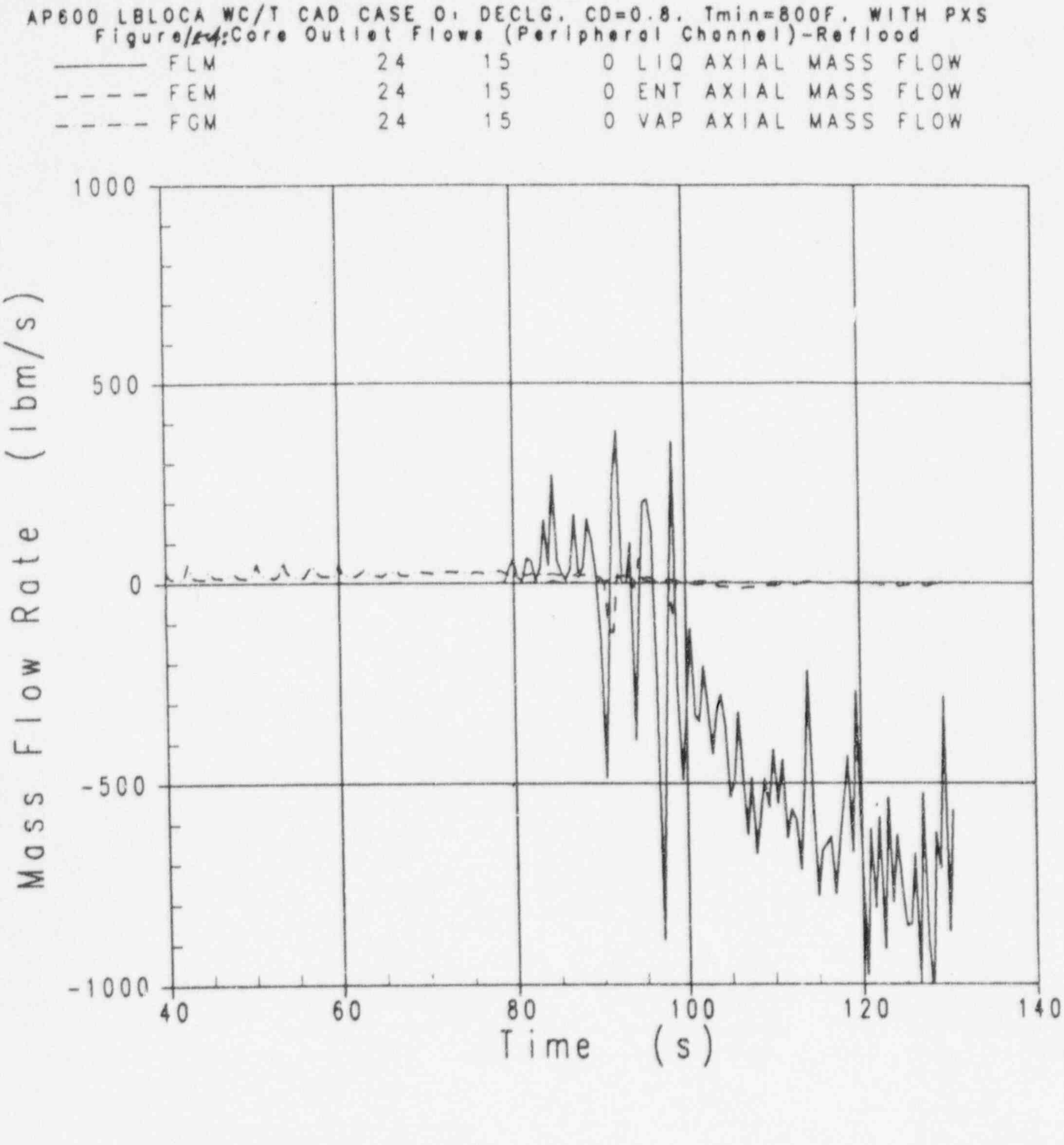


Response 1(e) - Figure 2

AP600 LBLOCA WC/T CAD CASE 0: DECLG, CD=0.8, Tmin=800F, WITH PXS
Figure/a+3 Core Outlet Flows (Open Hole/Support Column Channel)-Reflood

———	FLM	25	15	0 LIQ AXIAL MASS FLOW
- - - -	FEM	25	15	0 ENT AXIAL MASS FLOW
- · - · -	FGM	25	15	0 VAP AXIAL MASS FLOW





Response 1(e) - Figure 4

Open Item - 4639

f. On page 2-2, Westinghouse stated that core top down flow/CCF limit is addressed under the PIRT upper plenum component discussion. However, the PIRT does not rank upper plenum CCF drain/fallback while the upper head blowdown flow is ranked. Clarify if the upper head ranking is what Westinghouse was referring to on page 2-2, or if Westinghouse was referring to the information on page 2-8 discussed in part d.

The discussion of the CCFL is on page 2-8, 4th paragraph. The phenomena is not ranked since its effects only occur momentarily at the end of blowdown as the flow transitions from co-current downflow to co-current upflow during the reflood phase.

Open Item - 4640

g. Given the AP600 results in Section 2.2.3, clarify if the INEL is correct in interpreting that accumulator nitrogen discharge is not an large break loss-of-coolant accident (LBLOCA) issue with AP600 because the core quenches before the accumulators empty. Clarify how much liquid is left in the AP600 accumulators at the end of the analysis discussed in Section 2.2.3 and how long it would take for the accumulators to empty. If there is less than 20% of the accumulator liquid left at the end of the analysis (so that a change in plant design or the analysis could result in the accumulators emptying) or Westinghouse concludes accumulator nitrogen discharge is a LBLOCA issue for AP600, then provide the following information. On page 2-10, Westinghouse stated that the affects of nitrogen discharge after the accumulators empty were addressed in the Code Scaling, Applicability, and Uncertainty (CSAU) report.[3] However, in the CSAU report, only the affects of dissolved non-condensibles were studied, not the large amounts of nitrogen discharged after the accumulators empty. Therefore, clarify this reference to the CSAU report or provide the correct reference. Also, is accumulator nitrogen discharge addressed for AP600 in the same manner as for 3-/4-loop plants?

The PCT occurs before the accumulator is empty. In the SSAR DECLG break analysis, the remaining accumulator inventory when the reflood PCT is reached, is about 60% of the initial. The accumulators empty at 300 seconds which is over 200 seconds after the PCT. Addressing the uncertainty in the accumulator nitrogen discharge is not needed since the accumulators are still injecting well after the PCT and inclusion of the uncertainty would not effect the calculated PCT.

Open Item - 4641

h. In the call on November 25, 1996, Westinghouse stated Discussion Item 8b from the May 17, 1996, letter was discussed in the 4th paragraph of Section 2.1. This paragraph, however, addresses downcomer behavior not upper plenum CCF/fall back. Should Westinghouse have referred INEL to page 2-8, 4th paragraph?

Yes.

Open Item - 4643

2. These items relate to Table 2.1-2 and followup Item 8f (5/17/96 letter).

a. Because of low PCTs, Westinghouse has a low ranking for cladding oxidation in its PIRT and did not discuss cladding oxidation in Table 2.1-2. The INEL agrees that the low cladding temperatures currently calculated by Westinghouse for the AP600 indicate this is not an important phenomenon for the AP600. For 3-/4-loop plants, however, the uncertainty evaluation included the cladding oxidation uncertainty. Clarify if Westinghouse has removed cladding oxidation uncertainty from the AP600 uncertainty evaluation. If yes, will Westinghouse commit to including cladding oxidation uncertainty if plant design or analysis changes result in calculated cladding temperatures that cause oxidation to be important?

The calculated PCTs are significantly below the threshold for significant zirc/water reaction which can influence the PCT. However, the methodology which is used to calculate the AP600 PCT is the same as that used for the three and four loop plants. Therefore, the uncertainty of the zirc/water reaction and its effects will be calculated in the "hot spot" calculations; however, since the PCTs computed for the AP600 are low, the impact of the uncertainties and the zirc/water reaction are expected to be negligible.

Open Item - 4644

b. Gap conductance was not listed in Table 2.1-2. Based on the discussion on page 2-4, is the INEL correct in interpreting that this highly ranked phenomenon is covered under stored energy?

Yes

Open Item - 4645

c. Westinghouse stated decay heat uncertainty is addressed in the same manner as 3-/4-loop plants. However, the portion of the 3-/4-loop plant methodology that addressed decay heat was changed for application to AP600. Therefore, provide additional information to justify how the decay heat uncertainty is addressed for the AP600 plant.

Table 2.1-2 is incorrect. As described in Section 4.4, the use of tech spec/COLR peaking factors and 102% core power results in equivalent or higher linear heat rates than if the full best-estimate methodology were used. The response toquestion 12c will give further information.

Open Item - 4646

d. For rewet, Westinghouse stated the same approach for 3-/4-loop plants would be used to address the uncertainty. Clarify if Table 2.1-2 should also state that this approach is supplemented by the information in Section 4.1

Yes, the reviewer is correct. A more conservative approach will be used for the AP600, as discussed in Section 4.1.

Open Item - 4647

e. Westinghouse did not discuss the following highly ranked PIRT items in Table 2.1-2: core 3D flow and void generation/distribution, core flow reversal/stagnation, upper head blowdown flow and flow area, downcomer condensation, and direct vessel injection (DVI).

Discussion of the individual items cited in the question follow below:

Core 3-D Flow/Void Generation and Distribution: To account for uncertainty in the 3-D flow/void generation and distribution, the limiting hot assembly location is identified and then used in the bounding plant calculations (Reference SSAR subsection 15.6.5.4A). Multi-dimensional effects are also captured by the four separate assembly groupings modeled in the core nodalization scheme. The response to question 1i(3) provides additional commentary on 3-D effects during reflood.

Core flow reversal/stagnation: The core voids very quickly during a large break LOCA, and DNB occurs quickly for DECLG breaks. The impact of differing blowdown core flow patterns is investigated in the break flow parameter variations in the global model series of runs specified in Table 4.5-1.

Upper head blowdown flow/flow area: The discharge of fluid from the upper head into the upper plenum during blowdown due to flashing is an important factor in core cooling. For AP600, minimal uncertainty exists in the upper fluid head volume and in the area of the flow paths from the upper head. As discussed in the response to question 12.e, the upper head fluid temperature is bounded in the SSAR analyses by applying the "maximum mean" upper head fluid temperature associated with the Tavg value assumed. Together with the design values for upper head geometry, the use of this temperature enables WCOBRA/TRAC to provide a suitable calculation of upper head flow behavior during the blowdown phase of a large LOCA.

Downcomer condensation: The impact of downcomer condensation is investigated in the global model series of runs specified in Table 4.5-1.

Direct Vessel Injection: The ability of WCOBRA/TRAC to predict DVI-related phenomena is confirmed by the CCTF and UPTF DVI test simulations presented in Chapter 3.

Open Item - 4648

f. Westinghouse stated that downcomer liquid level oscillations were covered by the a conservative emergency core coolant (ECC) bypass calculation. Clarify this approach because these oscillations are a reflood phenomenon that occurs after ECC bypass is over. In a similar way, Westinghouse stated core flow oscillation are covered by the core level calculation (see page 2-2). In Table 2.1-2, Westinghouse stated the core level uncertainty is addressed by a conservative core level calculation. Clarify and justify how this accounts for core flow oscillations and the uncertainty in calculating that phenomenon.

The liquid level oscillations observed in the WCAP-14171 and AP600 SSAR WCOBRA/TRAC analyses in the core and downcomer regions are those associated with the introduction of water into a hot fuel bundle. As cold water quenches the fuel rods, steam generation pressurizes the core region, the core level drops and the downcomer level rises for a short period; then, water flows in again from the downcomer, and the cycle repeats. This predicted behavior is the same as that observed in FLECHT and other reflood heat transfer tests.

In the AP600 SSAR bounding parameters to minimize accumulator flow delivery and therefore downcomer level at any point in time are modeled: minimum gas pressure, maximum water volume, maximum flow resistance in the injection flow path. This approach penalizes the downcomer filling rate and level relative to a best estimate value at any point in time during the large break LOCA transient. This follows the conservatism in the ECC bypass calculation, which initially penalizes the downcomer level. As a result, the possible level oscillations which could be calculated are suppressed and exert less of an effect on the cooling of the upper regions of the core. Another possible effect of core level oscillations would be large changes in core heat transfer during the reflood transient. The AP600 cladding temperature transients during the reflood phase of the SSAR cases are smooth. Because flow oscillations predicted by WCOBRA/TRAC correspond to those expected for gravity reflood, and the liquid present in the reactor downcomer is calculated in a bounding, conservative manner, and the calculated PCT transients are well-behaved in the SSAR cases, the uncertainty associated with the calculation of core flow oscillations is covered for the AP600 SSAR large break LOCA analysis.

Open Item - 4649

g. For hot wall effects in the downcomer and lower plenum, Westinghouse provided information different from that supplied for 3-/4-loop plants in Reference 5. Clarify the reasons for the differences.

Hot wall effects are ranked the same for 3/4-loop plants and the AP600. Nevertheless, some differences in phenomena exist. In the 3/4-loop plants, heating of water in the downcomer during reflood can eventually cause boiling, which results in level swell and the spilling of water through the broken cold leg. AP600 is equipped with large accumulators that provide injection of highly subcooled water until after quench of the fuel rods is

calculated. No downcomer boiling is predicted. Further, because no boiling occurs and because the AP600 accumulators inject through the DVI nozzles, little liquid is lost through the break after the end of ECC bypass in AP600.

Open Item - 4651

4. Westinghouse discussed pressurizer location in AP600 LBLOCA analyses on page 2-32. The reference given to support the chosen location does not seem correct; therefore, provide the correct reference. Also, have any AP600 specific studies been performed to support the pressurizer location relative to the break? If yes, provide them for review. If not, justify why they are not needed.

The impact of pressurizer location relative to the break has been investigated in a sensitivity case. The location that is indicated in WCAP-14171, Revision 1 has been shown limiting. The reference provided is incorrect; it should be Reference 5.

Open Item - 4652

5. On page 2-33, Westinghouse stated that after 10 s vapor flows out of the core in the guide tube locations. Clarify this statement because Figure 2.2-34 shows vapor downflow after 10 s.

The last sentence on page 2-33 should read "During this time interval, vapor flows down into the core at the guide tube locations" rather than "up out of the core."

Open Item - 4653

6. Westinghouse's discussion on the response of the low power rod in Figures 2.2-31 to 2.2-33 on page 2-34 is confusing. First, Westinghouse indicates that the low power rod undergoes a small temperature excursion but later states that no initial temperature excursion in blowdown. Based on Figures 2.2-31 to 2.2-33, the later statement appears to be correct. Therefore, clarify the apparent inconsistency or correct the report.

The text should read that the peripheral rod exhibits "no significant initial temperature excursion" during blowdown. Review of Figures 2.2-31 and 32 indicates that at the 6.0 and 8.5 foot elevations a small temperature increase, on the order of 10 degrees F, is predicted at the inception of blowdown.

7. The following questions relate to the CCTF analysis in Section 3.1.

Open Item - 4654

a. Clarify the statement on page 3-8 that in the calculation the low power rods quench early at the lower elevations. Figures 3.1-16 to 20 show an early quench calculated at all elevations.

Figures 3.1-16 through 3.1-30 indicate that WCOBRA/TRAC predicts an early quench of all fuel rods modeled in the simulation of CCTF Test 58 at all elevations. The lower elevations are emphasized because the exceedingly delayed quenching of the upper elevations in this CCTF test is not important relative to the AP600 large break LOCA event, in which the quenching of all rods occurs within 100 seconds.

Open Item - 4655

b. Clarify the statement on page 3-9 that Figures 3.1-31 to 33 show the calculated quench front is 80 s too early. This is true for the high power rods, but the quench fronts on the medium and low power rods are early by approximately 120 s.

The fact that WCOBRA/TRAC predicts early quenching of the uppermost elevations of the medium and low power rods in CCTF Test 58 is unimportant. As shown in Figure 2.2-26 of the report, all fuel in the AP600 core quenches during the first 100 seconds of the large break LOCA transient. Therefore, the most significant comparison of quenching is for elevations between the bottom core elevation and the elevation for which WCOBRA/TRAC predicts the maximum quench time. Within this elevation envelope, the code-predicted quenching occurs within 80 seconds of the times observed in the CCTF Test 58 for rods at each power level.

Open Item - 4656

c. Clarify if the first paragraph on page 3-10 should be deleted because it refers to the WCOBRA/TRAC analysis in Rev. 0 of Reference 1.

The first two sentences of the first paragraph on page 3-10 are artifacts of WCAP-14171, Revision 0 and should be deleted.

Open Item - 4657

d. Clarify if the references to Figures 3.1-41 and 3.1-41A, Rev. 0 and Rev. 1, respectively, in the fourth paragraph on page 3-10 should have been to Figures 3.1-45 and 3.1-45A.

The fourth paragraph on page 3-10 contains a typographical error; references made to Figures 3.1-41 and 3.1-41A should instead refer to Figures 3.1-45 and 3.1-45A, respectively.

Open Item - 4658

e. Is the basis for the better comparison of the BLHL liquid flow in the Rev. 1 CCTF analysis the improved BL modeling in the revised calculation? This will clarify the response to Discussion Item 1b, in the May 17, 1996, NRC letter.

Improved modeling of the broken loop in the simulation of CCTF Test 58 presented in WCAP-14171, Revision 1 produces the better comparison of WCOBRA/TRAC to data.

Open Item 4659

f. WCOBRA/TRAC analysis no oscillations vs test data with oscillations. Westinghouse did not clarify the reasons for differences between the code results and the data for the core and downcomer differential pressure differences or the steam flows in the cold legs or the liquid flows in the hot and cold legs. (Discussion Item 6c, May 17, 1996, letter).

For further discussion of WCOBRA/TRAC not predicting the oscillations in CCTF Test 58, refer to the response to 2/26 set Question 8. The core and downcomer differential pressure differences in Test 58 are predicted well by the code, as shown in WCAP-14171, Revision 1 Figures 3.1-35B and 3.1-36B. The steam flows in the cold legs and the liquid flows in the hot and cold legs are also predicted well in the respective WCAP-14171, Revision 1 figures, during the 500 second time period of interest until fuel rod quench occurs; the sole exception to this is the Loop 1 cold leg steam mass flow, which is overpredicted by the code.

8. The following questions relate to the UPTF analysis in Section 3.2.

Open Item - 4660

a. On page 3-72, Westinghouse noted the test results showed increased flow to the lower plenum when liquid was discharged from the cold leg to the downcomer. WCOBRA/TRAC does not calculate liquid slug discharge for UPTF Test 21 because it underpredicted cold leg filling. As noted on page 3-75, this is one reason for the conservative WCOBRA/TRAC calculation. However, cold leg filling is not expected in AP600 because of steam flow in the cold leg that was not represented in the UPTF test. How does Westinghouse factor this test to AP600 difference into the interpretation of the code/data comparisons for this test?

Consideration of the draining of cold legs filled during the UPTF tests does not alter the conclusion that WCOBRA/TRAC provides a conservative calculation of ECC bypass. The lower plenum mass inventory comparison of UPTF Test 21 vs. the WCOBRA/TRAC simulation and the comparison of cold leg inventories between the two are reviewed for each case at the end of the WCOBRA/TRAC simulation.

For UPTF Test 21 Phase A, WCOBRA/TRAC predicts only 6000 lbm to be in the lower plenum at 98 seconds, whereas in the test 43000 lbm were measured (Figure 3.2-16). Comparing the cold leg mass inventories of Figure 3.2-23, the sum of the cold leg masses in the test equals 22000 lbm, whereas WCOBRA/TRAC predicts only 8000 lbm to be present. Thus, the WCOBRA/TRAC result could be skewed low relative to the Test 21 , Phase A result by 14000 lbm. Even if this is presumed to be the case, the WCOBRA/TRAC underprediction of lower plenum inventory remains greater than 20000 lbm.

For UPTF Test 21 Phase BI, WCOBRA/TRAC predicts only 8000 lbm to be in the lower plenum at 120 seconds, whereas in the test 27000 lbm were measured (Figure 3.2-24). Comparing the cold leg mass inventories of Figure 3.2-31, the sum of the cold leg masses in the test equals 9500 lbm,

whereas WCOBRA/TRAC predicts only 6500 lbm to be present. Thus, the WCOBRA/TRAC result could be skewed low relative to the Test 21 , Phase BI result by 3000 lbm. Even if this is presumed to be the case, the WCOBRA/TRAC underprediction of lower plenum inventory remains greater than 15000 lbm.

For UPTF Test 21 Phase BII & BIII, WCOBRA/TRAC predicts only 36000 lbm to be in the lower plenum at 395 seconds, whereas in the test 53000 lbm were measured (Figure 3.2-32). Comparing the cold leg mass inventories of Figure 3.2-39, the sum of the cold leg masses in the test equals 14500 lbm, whereas WCOBRA/TRAC predicts only 9500 lbm to be present. Thus, the WCOBRA/TRAC result could be skewed low relative to the Test 21 , Phase BII & BIII result by 5000 lbm. Even if this is presumed to be the case, the WCOBRA/TRAC underprediction of lower plenum inventory remains greater than 10000 lbm.

Open Item - 4661

b. Does the discussion in part a of this question impact the information provided and conclusions drawn by Westinghouse on page 3-80 as it relates to the DVI location difference between UPTF and AP600 and the effect of the DVI location difference on application of the UPTF Test 21 results to AP600?

The conclusion of page 3-80 in WCAP-14171, Revision 1, that the UPTF Test 21 configuration favors continued ECC bypass relative to the AP600 downcomer geometry still holds. ECC bypass predicted by WCOBRA/TRAC for the AP600 geometry is conservative and bounding.

Open Item - 4662

c. In the discussion on page 3-81 on the LOFT lower plenum refill, provide comparisons between the Westinghouse WCOBRA/TRAC results for LOFT Tests L2-2/2-3 and the test data for L2-2/2-3 already provided in Reference 1. This is a followup to Item 7, May 17, 1996, letter.

The LOFT L2-5 comparison shows that the lower plenum and core refill predicted by WCOBRA/TRAC is conservative (page 3-81). Further documentation of this may be found in the WCOBRA/TRAC "Compensating Errors" Report, NTD-NRC-95-4586, for LOFT Test L2-3 (See Figure a10). Taken together, the L2-3 and L2-5 comparisons are adequate to resolve that the code capably and conservatively predicts AP600 lower plenum filling.

Open Item - 4663

d. In response to RAI 440.348, Westinghouse provided a table comparing UPTF Test 21 test conditions to AP600 conditions. For the comparison in Reference 1, the AP600 table was different from that provided in the RAI response. Clarify the reasons for the differences.

The AP600 conditions in the WCAP-14171 Rev. 1 Table are taken from the WCOBRA/TRAC analysis presented in Chapter 2, which had not been performed at the time of the RAI440.348 response. The condition

differences are not great and are a result of modeling more restrictive accumulator conditions, specifically a higher water temperature and a lower injection flow (Refer to Table 2.2-2) which causes the "Total ECC Injection to Downcomer" and the maximum ECC water subcooling value to be somewhat reduced. The steam flowrate from the core into the downcomer has a lower value because end-of-bypass is delayed with these accumulator conditions.

Open Item - 4664

e. Based on the information in Section 3.2.8, is the INEL correct in assuming that there is not sufficient data to develop a flooding curve for the CCTF and UPTF DVI tests directly from the test data and that other flooding correlations are not applicable for the reasons discussed in that section? This is a followup question to Discussion Item 6a, May 17, 1996, letter.

Yes, the INEL interpretation is correct.

f. On page 3-82 Westinghouse stated that WCOBRA/TRAC predicts the different flow behavior that results from cold leg or downcomer injection. In Test 21, ECC water breakup on the downcomer wall resulted in greater bypass relative to UPTF Test 6 (see page 3-82). This implies that the WCOBRA/TRAC calculated bypass for Test 21 should be greater than the WCOBRA/TRAC bypass calculated for UPTF Test 6. Provide the calculated ECC bypass results for Tests 6 an 21 that support this argument. This also implies that the conservatism of the WCOBRA/TRAC ECC bypass results for UPTF Test 21 should be greater than the conservatism of the WCOBRA/TRAC ECC bypass results for Test 6. Clarify if this is true.

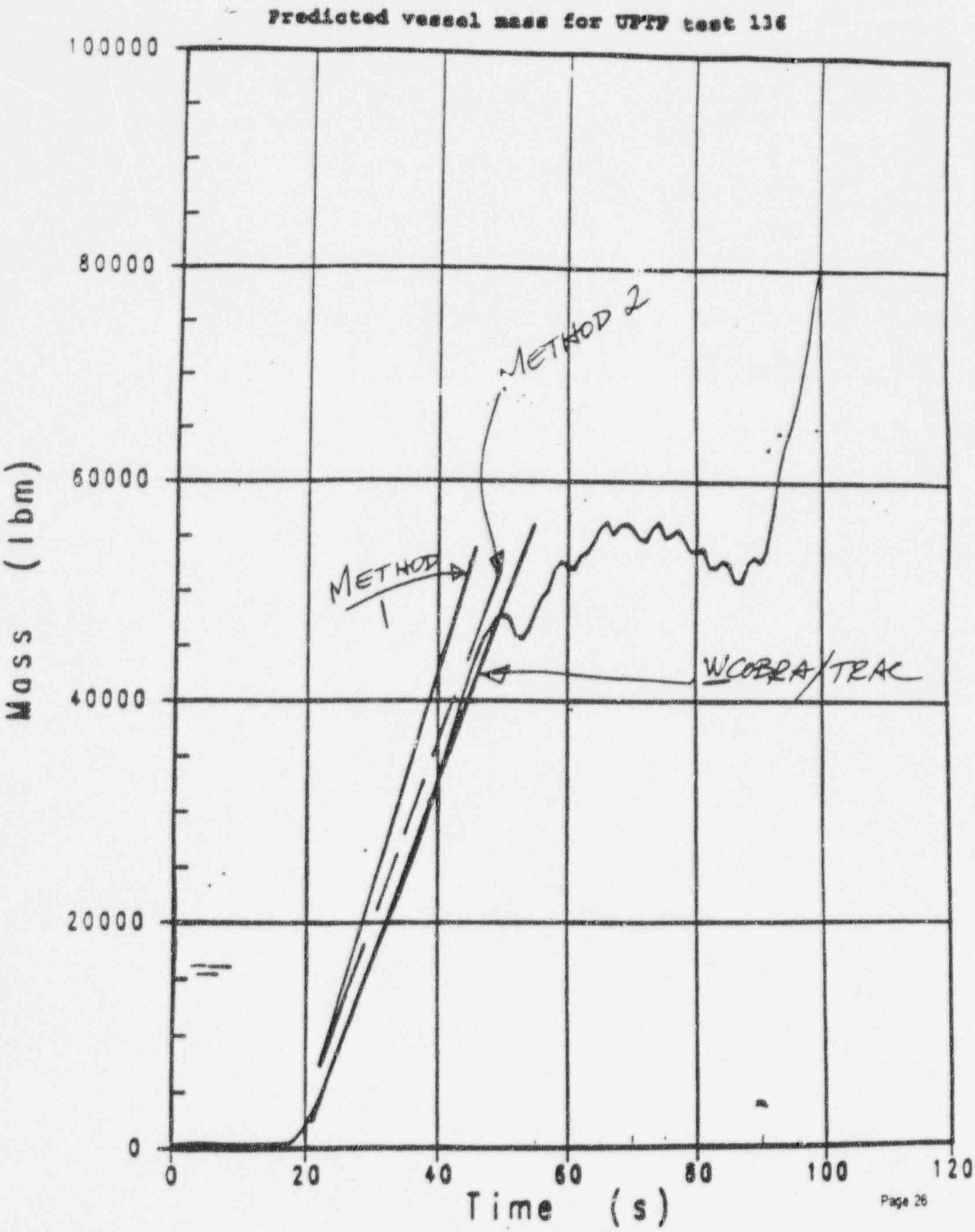
Individual runs from UPTF Test 6 are compared with runs of UPTF Test 21 that were conducted with similar steam mass flowrate and liquid subcooling conditions. Test 6, Run 132 [steam flow 293 kg/s, ECC subcooling 54C] conditions correspond well with those of Test 21, Run 274Bi [steam flow 298 kg/s, ECC subcooling 101C]. Also, Test 6, Run 136 [steam flow 104 kg/s, ECC subcooling 28C] conditions correspond well to those of Test 21, Run 274iii [steam flow 102 kg/s, ECC subcooling 47C].

The attached figures (from Reference 8f-1) show the measured and WCOBRA/TRAC-predicted vessel mass inventories for the two UPTF Test 6 runs. In each figure, the dashed line superimposed is the refilling determined (method 2) from the vessel refill rate, and the solid line superimposed is the refilling identified from a mass balance (method 1). WCOBRA/TRAC predicts a delayed refilling for Run 132 by about 20 seconds, and it predicts the refilling of Run 136 well.

In contrast, consider Figures 3.2-24 and 3.2-32 of WCAP-14171, Revision 1. In both of these simulations, WCOBRA/TRAC predicts ECC bypass to continue throughout the transient such that the vessel is never predicted to refill to the extent observed in the Test 21 run. The WCOBRA/TRAC prediction of ECC bypass is more conservative for UPTF Test 21 than for Test 6.

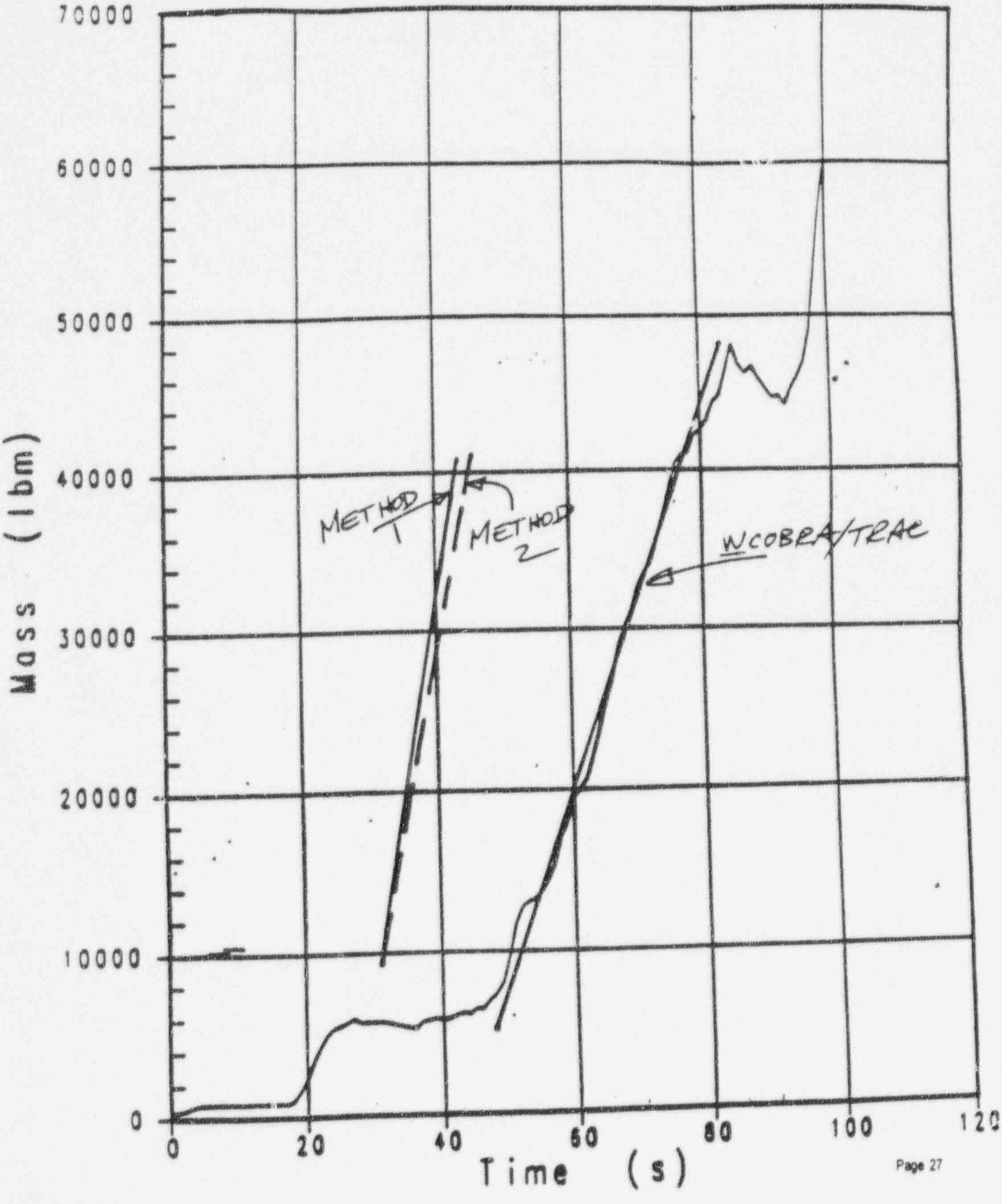
Reference 8f-1: Westinghouse letter to USNRC NTD-NRC-95-4511, Attachment OO.

Response 8(f) - Figure 1



Response 8(f) - Figure 2

Predicted vessel mass for UPTF test 132



Open Item - 4666

g. As a followup to Discussion Item 6b in the May 17, 1996, letter, clarify if the following interpretation by the INEL of the information in Section 3.2.7 is correct. Westinghouse argues:

(1) In the UPTF Test 21 configuration, it is easier to bypass ECC than in AP600.

(2) WCOBRA/TRAC provides a conservative calculation of ECC bypass in Test 21.

(3) The AP600 plant calculation ends bypass at a lower steam flow than end-of-bypass in UPTF.

Based on 1, 2, and 3, Westinghouse concluded that WCOBRA/TRAC provides a conservative ECC bypass calculation for AP600.

Is this argument also the basis for the response to discussion Item 6d?

The WCAP-14171, Revision 1 WCOBRA/TRAC simulations of UPTF Test 21 predicted more flow into the lower plenum for Phase BII than for any other phase. While it is true that the conditions of the Phase BII test more closely resemble those of the AP600 than do those of any other UPTF test, the Phase BII test has much lower injection liquid subcooling than the AP600 calculation. Therefore, an end of ECC bypass as predicted for AP600 is not in conflict with the UPTF Test 21 Phase BII result; as stated on page 3-80 of WCAP-14171, Revision 1, high subcooling helps to facilitate the end of ECC bypass. The INEL interpretation is correct: Westinghouse has determined that WCOBRA/TRAC provides a conservative ECC bypass calculation for AP600.

Open Item - 4667

i. On page 3-80, Westinghouse stated termination of ECC bypass is more easily achieved in AP600 than in UPTF Test 21 configuration. However, based on the information provided by Westinghouse regarding steam flow at end-of-bypass, this is not the case. What are the implications of this difference on determining the applicability of WCOBRA/TRAC to the AP600?

In terms of downcomer steam mass flux, in the AP600 large break LOCA analysis presented in WCAP-14171, Revision 1, Chapter 2, WCOBRA/TRAC does not predict the termination of ECCS bypass and the beginning of the lower plenum refill until the steam flux equals 3.4 lbm/sec-sq.ft. This steam mass flux is well below the lowest value among the UPTF bypass tests at which liquid delivery into the lower plenum begins (5.8 lbm/sec-sq.ft., in Run 274/BIII). The AP600 value predicted by WCOBRA/TRAC is therefore conservative.

9. The following questions relate to Section 4.1.

Open Item - 4669

b. Is the T_{MIN} identified in Section 4.1 used in blowdown only or both blowdown and reflood?

The Tmin value identified in Section 4.1 is used during blowdown only.

Open Item - 4670

c. Table 4.1-1 lists the tests used to determine the T_{MIN} uncertainty for AP600. Section 4.1 also listed the tests not used from the 3-/4-loop review. However, comparison of the tests shown in Section 4.1 to those listed in Table B-7 of the RMR found Westinghouse did not discuss its inclusion or exclusion of all the tests used to develop the T_{MIN} uncertainty for 3-/4-loop plants. For those tests not discussed in Section 4.1, clarify the reasons for Westinghouse's handling of those tests.

This question is very similar to question 9a. Most tests given in Table B-7 were found to not to have the flow and subcooling conditions typical of the AP600 blowdown. Therefore, other G-1 and G-2 tests were used along with the remaining tests from Table B-7, which did have conditions applicable to the AP600 transient.

Open Item - 4671

d. On page 4-4, Westinghouse discussed the temperature criterion used to screen the initial temperatures of the thermocouples used in the T_{MIN} evaluation. The temperature given was an average T_{MIN} based on bundle average data from the RMR analysis. Justify whether it is appropriate to use this bundle average temperature T_{MIN} to screen individual thermocouples as done in Section 4.1.

This approach is designed to be conservative since the only T/Cs that will be considered are those which are initially GREATER than the average.

10. The following questions relate to Section 4.2.

Open Item - 4672

a. Westinghouse revised the database for the blowdown cooling heat transfer uncertainty evaluation to better match the AP600 conditions, but in the end concluded the original uncertainty distribution was better and more conservative because the new distribution had less scatter than the original distribution. Justify this conclusion because the original distribution allows for larger multipliers and a larger average multiplier than the one developed in Section 4.2.

The AP600 blowdown cooling heat transfer multipliers distribution has been established via the direct comparison of WCOBRA/TRAC results with the ORNL high pressure Dispersed Flow Film Boiling heat transfer test data. As presented in WCAP-14171, Revision 1, this new distribution is valid in the AP600-specific blowdown cooling range and is obtained using a conservative value of Tmin. For the AP600 SSAR matrix of cases, the HOTSPOT computer code has been revised to incorporate this new blowdown cooling heat transfer distribution. The cumulative distribution for AP600 analysis is presented as Figure 4.2-2 in WCAP-14171, Revision 1.

Open Item - 4673

b. Clarify what Westinghouse means in Section 4.2 by the original distribution because distributions from the RMR, Reference 2, and the final 3-/4-loop plant distribution from Reference 6 are referenced.

The distribution labelled as "RMR" on Figure 4.2-2 is exactly that, the blowdown cooling heat transfer distribution presented in Reference 10-1. It is shown for illustrative purposes only. The final, approved blowdown cooling heat transfer distribution for 3/4 loop plants is based on Figure 36 of Reference 10-2; it is depicted as a cumulative frequency distribution in the attachment.

References:

10-1. NTD-NRC-95-4575, Letter from N. J. Liparulo (W) to R. C. Jones, Jr. (USNRC), "Revisions to Westinghouse Best-Estimate Uncertainty Report," October 13, 1995.

10-2. NTD-NRC-96-4672, Letter from N. J. Liparulo (W) to R. C. Jones, Jr. (USNRC), "Resolution of Issues Related to Review of WCAP- 12945-P," March 25, 1996.

Open Item - 4677

d. Because Reference 6 contains the final blowdown cooling heat transfer distribution for 3-/4-loop plants, justify why that distribution was not used in Figure 4.2-1.

The distribution labelled as "RMR" on Figure 4.2-2 is exactly that, the blowdown cooling heat transfer distribution presented in Reference 10-1. It is shown for illustrative purposes only. The final, approved blowdown cooling heat transfer distribution for 3/4 loop plants is based on Figure 36 of Reference 10-2; it is depicted as a cumulative frequency distribution in the attachment.

References:

10-1. NTD-NRC-95-4575, Letter from N. J. Liparulo (W) to R. C. Jones, Jr. (USNRC), "Revisions to Westinghouse Best-Estimate Uncertainty Report," October 13, 1995.

10-2. NTD-NRC-96-4672, Letter from N. J. Liparulo (W) to R. C. Jones, Jr. (USNRC), "Resolution of Issues Related to Review of WCAP- 12945-P," March 25, 1996.

Open Item - 4675

e. Clarify the meaning of the word saturated in Table 4.2-1 regarding inlet water temperatures for AP600. Is Westinghouse implying that AP600 sees only saturated water inlet conditions during blowdown? If yes, clarify the temperature range relative to the pressure range which indicates some subcooling for the temperatures given.

The word "saturated" indicates that AP600 liquid conditions for blowdown cooling are saturated or are very nearly so. The pressure range shown in Table 4.2-1 should read "approximately 250-1500 psia".

Open Item - 4676

f. Followup to Discussion Item 5a, May 17, 1996, letter. Based on Table 4.2-1, Westinghouse stated the Oak Ridge National Laboratory data better represented the AP600 during blowdown cooling than the original data base in the RMR/Reference 6. However, Westinghouse decided to use the uncertainty range based on the original database. Therefore, Westinghouse still needs to provide a response to Item 5a to show the mass fluxes for the tests in the database for the original uncertainty range are representative of AP600 or are conservative.

As described in part (a) of this question, the HOTSPOT computer code has been revised to incorporate the AP600 blowdown cooling heat transfer distribution. Therefore, this part of the question is no longer relevant.

12. The following questions relate to Section 4.4.

Open Item - 4679

a. Table 4.4-1: Has the Westinghouse grid deformation analysis been approved by the NRC? If not, will Westinghouse commit to addressing grid deformation if the NRC review results in this becoming a concern for the AP600? For mixed cores, how will Westinghouse address mixed cores if they are used in AP600 in the future?

Since seismic loads are a site-specific parameter, it is difficult to assess their impact at this time. <u>The structural and mechanical integrity of the fuel is evaluated for each fuel cycle</u>. In the event fuel grid deformation becomes a concern for a proposed AP600 site, Westinghouse will address its impact on the large break LOCA analysis. If Westinghouse fuel of a different design or another vendor's fuel is placed into AP600 in the future, an evaluation will be performed of the mixed core; the evaluation will consider any differences in the dimensions, hydraulic resistances and burnup effects between the fuel types to be loaded.

Open Item - 4680

b. Westinghouse identified power shapes (PSs) 2, 3, 4 and 11 as the PSs it would evaluate from the RMR to determine the limiting PS for AP600. Justify the basis for selecting these PSs as the ones to study the AP600. Could the excellent blowdown cooling for the AP600 cause the limiting axial power shape(s) to change for AP600 relative to the 3-/4-loop plants? Also, Westinghouse has an approach to identify limiting axial power shapes to meet Appendix K, Item I.A. Does this approach have any applicability for AP600? Justify your answer.

The 3/4 loop power shapes were established to be bounding for all Westinghouse core designs, and they are bounding for AP600 as well. To further demonstrate the limiting nature of power shapes 2, 3, 4 and 11 for AP600, a bottom-skewed power shape case was also executed and shown to be non-limiting. Power shape 3 is the bounding shape and is applied in all AP600 matrix sensitivity cases. The power shape results will be reported and justified in the SSAR large break LOCA section.

Open Item - 4684

f. Justify the basis for the choice of bounding accumulator conditions on page 4-14. Based on the CQD studies in Section 22, sometimes the limiting PCT was calculated when an accumulator condition other than those proposed for AP600 by Westinghouse was used. Are sensitivity studies needed? Justify your answer.

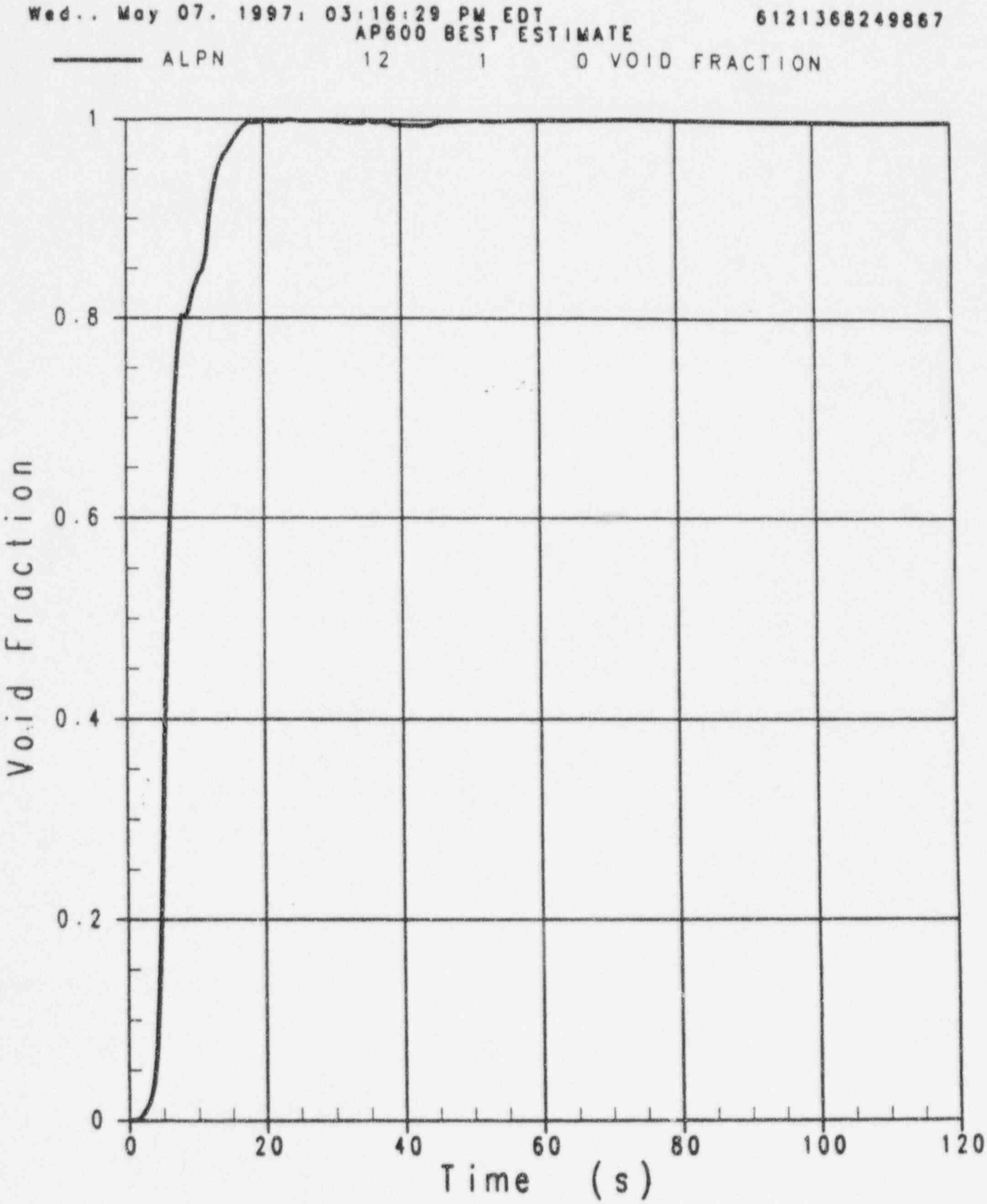
The AP600 is equipped with two large accumulators for large break LOCA mitigation. Because of the limited accumulator capacity which 3/4 loop plants possess, downcomer underfill and downcomer boiling during core reflood associated with a minimum initial accumulator water volume can sometimes result in a more limiting PCT, These phenomena are unimportant for AP600; the significant phenomenon for AP600 reflood PCT is the time required to refill the downcomer. A sensitivity case executed assuming the Technical Specification maximum gas pressure in the accumulator has verified that bounding the accumulator injection rate on the low end is indeed the conservative approach.

g. On page 4-16, Westinghouse discussed the basis for concluding that the uncertainty for reactor coolant pumps in 3-/4-loop plants could be applied to AP600. However, Westinghouse needs to provide a comparison for the AP600 pumps as in CQD, Volume 5, Appendix C. It is the information provided there that determines the pump uncertainty.

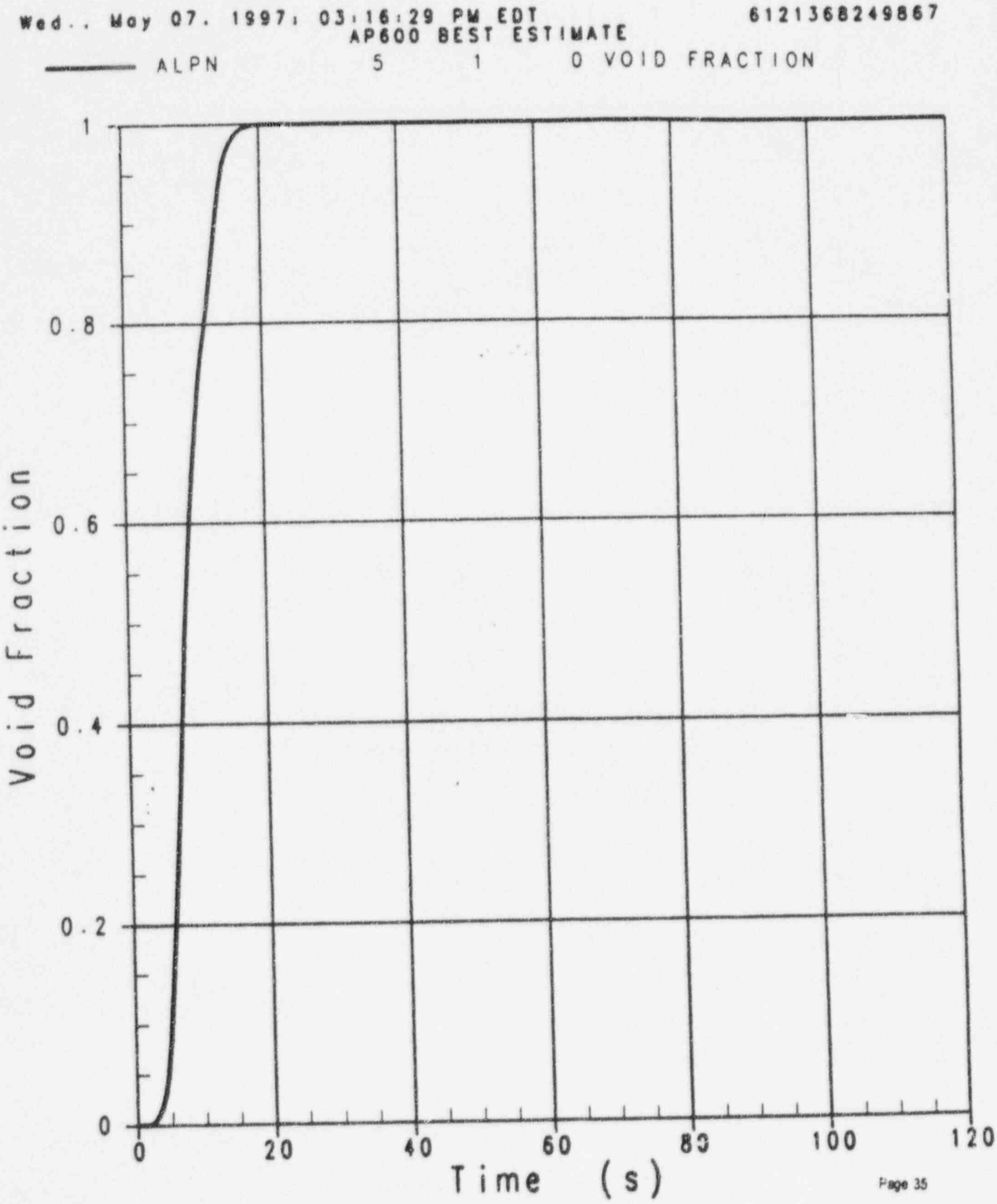
As noted in the response to item 1(i)1, the homologous curves of the AP600 RCP are similar to those of other Westinghouse RCPs. Therefore, the sources used to obtain the uncertainty values for single-phase RCP performance data in 3-loop and 4-loop plants are equally applicable to the AP600 analysis.

As in CQD Volume 5, Appendix C, and RMR Section 3.1.2, the large uncertainty associated with two-phase RCP data in the dissipative mode is not important. The Appendix C discussion that demonstrates this is based on the IP2 WCOBRA/TRAC analysis. CQD Figures 22-2-4 and 22-2-5 show the IP2 intact and broken loop RCP inlet void fractions. For purposes of comparison, the intact and broken loop RCP inlet void fractions from an AP600 DECLG break case are presented as Figures 12.g-1 and 2; these void fraction profiles at the RCP entrance are similar to the identified CQD figures. Because the void fraction inlet condition and the pump homologous curves of the AP600 both agree well with the 3/4-loop plant cases, and the blowdown progression in the intact and broken loops from positive head into the dissipative mode does as well, the pump model uncertainty approach developed for 3-loop and 4-loop plants applies to the AP600 SSAR analysis.

Response 12(g) - Figure 1



Response 12(g) - Figure 2



Open Item - 4691

m. For the single-failure discussed on page 4-17, justify that it is the most limiting that can be assumed for the AP600.

For AP600 design basis large break LOCA events, a single active failure in the passive safety systems is assumed. The single failure of an accumulator check valve is not credible; the large differential pressure which initiates the operation of the accumulator check valve makes its failure a beyond design basis assumption, as it is for current generation plant LOCA analyses. Among the other AP600 passive safety systems, the core makeup tanks and the PRHR are the only ones which operate during the LOCA before the quenching of the core is calculated. Because the piping layout of each features parallel valves, the operation of neither CMT nor the PRHR can be eliminated by a single failure. To minimize any possible beneficial effects of the injection of CMT water prior to accumulator injection, the single failure modeled in WCOBRA/TRAC is the failure of one of the CMT isolation valves to open on receipt of an S signal.

Open Item - 4692

13. On page 4-24, Westinghouse stated the thermal-hydraulic run matrix was developed to include the effects of the limiting split break. Clarify this statement as Table 4.5-1 does not show split breaks. On page 4-25, Westinghouse stated split breaks would be investigated further if it proves more limiting than the double-ended guillotine break. Provide additional information to clarify what Westinghouse meant by this statement.

Table 15.6.5-8 in the AP600 SSAR presents the results of the spectrum of cold leg split breaks performed with the bounding plant initial conditions and power distribution to identify the limiting discharge coefficient. The calculated PCT of the limiting split break (CD = 2.0) is lower than that for the reference DECLG break case. The first reflood peak of the CD = 1.0 split break is slightly higher than the corresponding temperature of the reference DECLG case. Consistent with the general approach outlined in the Reference, the 95th percentile reflood PCT for the limiting split break transient was compared to the 95th percentile PCT result from the initial Monte Carlo simulation for the DECLG break (i.e., the Monte Carlo simulation prior to applying the superposition/ validation correction). Table 15.6.5-9 in the SSAR shows the limiting split break is less limiting in PCT performance than the 95th percentile value for the DECLG break, so no further analysis is necessary.

Per Regulatory Guide 1.157, subsection 4.4, the evaluation of peak cladding temperature at the 95% probability level need only be performed for the worst-case break identified by the break spectrum analysis in order to demonstrate conformance with 10CFR50.46 paragraph (b). The nominal PCT values calculated by WCOBRA/TRAC for the non-limiting split breaks, shown in SSAR Table 15.6.5-8, together with the 95th percentile PCT for the limiting CD = 1.0 split presented in

Table 15.6.5-9, comprise the AP600 large break LOCA best estimate methodology split break results.

Reference: Letter, N. J. Liparulo (W) to F. R. Orr (USNRC), "Docketing of Supplemental Information Related to WCAP-12945-P," NSD-NRC-96-4744, June 12, 1996.

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15. Reference 1 only discussed the PCT calculation. 10 CFR 50.46, part b, includes other criteria to be met. Clarify how the AP600 methodology accounts for the other criteria.

The WCOBRA/TRAC-predicted cladding oxidation associated with the transients analyzed is zero because the calculated cladding temperatures are so low. In the HOTSPOT runs to investigate the local model variable impact on calculated PCT, the 95th percentile oxidation at the peak location is 0.2%. In light of these results, and because the 95th percentile PCT is below 1700F (SSAR Table 15.6.5-9), the local metal-water reaction is minimal for the AP600 large break LOCA event, as is the core average metal-water reaction value. The conclusion drawn from these results is the 10CFR50.46 criteria of 17% maximum local fuel rod oxidation and 1% maximum core-wide fuel oxidation are met with margin, and no further runs are necessary to show compliance (Ref. AP600 SSAR Subsection 15.6.5.4A.3.5).

At the calculated temperatures in Table 15.6.5-9, fuel rod rupture is not predicted to occur. Therefore, the core geometry remains unaffected and remains coolable throughout the transient. Separate calculations are performed in SSAR Section 15.6.5.4C to show that in the long term the AP600 exhibits adequate ECCS performance for the large break (and other) LOCA events.

17. While reviewing Westinghouse's responses to NRC RAIs 440.585, 440.586, and 440.587,[11] the INEL noted that the reflood temperature response for the peak cladding temperature (PCT) calculated by WCOBRA/TRAC[1] (see Figure 2.2-26) is different from the one calculated in the NRC calculations performed by Los Alamos National Laboratory (LANL)[12] (see Figure 13). Provide information to answer the following questions to help clarify the reasons for this difference.

In comparing the different calculated PCT values from the WCOBRA/TRAC CAD (WCAP-14171-Revision 1) and the Los Alamos report on the AP600 large-break calculation using the TRAC code (LA-UR-95-4431) one can not use Figure 13 in the LANL report, because this is a composite plot of the maximum temperature calculated anywhere in the core at that given time for all the fuel rods, whereas the WCOBRA/TRAC calculation is for a single hot rod. (Refer to the footnote on page 15 of the LANL report and note that there is an error in the footnote; the figure that they should refer to is Figure 13, not Figure 5). In response to the specific questions in this RAI:

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(a) In the LANL report, LANL stated their model represented the AP600 design as of November 15, 1994. Are there design changes made to AP600 after that date that would account for the differences in calculated responses? If design differences are affecting the results, clarify the design changes and the impact they have on the PCT differences noted between the two calculations.

As the attached figures indicate, there has been some adjustment in the accumulator and/or DVI line input parameters which is reflected in the Westinghouse WCOBRA/TRAC calculations and not in the LANL calculations. As a result, higher accumulator flow is calculated in the Westinghouse calculation early in time as the lower plenum and downcomer are refilling such that there is a higher liquid level in the core earlier in time. This behavior is shown in Figures 17-1 to 17-3. The more rapid refilling results in a lower calculated reflood WCOBRA/TRAC PCT as compared to the TRAC calculation, as shown in Figure 17-4 for the individual hot rods calculated by TRAC.

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(b) If part (a) did not explain the differences, are they due to code modeling differences? If code modeling differences are affecting the results, Westinghouse should provide information where possible that may explain the reason for the differences between the code results.

There are also modeling differences between the two calculations. WCOBRA/TRAC explicitly models the heat transfer effects of spacer grids in the fuel assembly. The AP600 fuel assembly is the Vantage 5H design which incorporates intermediate flow mixing vane grids in the upper elevations of the fuel assembly. The modeling of the spacer grids will promote improved heat transfer both during the downflow blowdown period in which a significant downflow exists, as well as during the reflood period. The heat transfer improvement of spacer grids was shown in the WCOBRA/TRAC CQD when WCOBRA/TRAC was compared to the ORNL film boiling experiments which showed the effects of the spacer grids. The FEBA reflood tests also showed the effects of the spacer grids. In both the blowdown and the reflood periods, the rod heat transfer will be enhanced by the spacer grids. To our knowledge, the TRAC code does not include modeling of the fuel assembly spacer grids; therefore, the heat transfer calculated in TRAC will be lower than that calculated in WCOBRA/TRAC.

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(c) Are the reflood differences affected by the blowdown cooling differences discussed in RAIs 440.585 and 440.586? If yes, does the calculated reflood PCT difference impact Westinghouse's response to those RAIs or indicate the need to consider other models or phenomena to include the AP600 uncertainty evaluation.

The reflood differences are given in parts (a) and (b) above. They are due to the difference in the accumulator behavior as well as the effects of spacer grids to improve the predicted heat transfer.

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(d) Even accounting for the blowdown cooling differences, there is still approximately 180°F difference in reflood PCT. Can Westinghouse offer any information that may explain the reasons for this difference? Are models and phenomena that affect this reflood PCT difference accounted for in Westinghouse's AP600 uncertainty methodology? If yes, clarify how. If not, justify why not.

The explanation for the differences is given above. The effects of the grid modeling are included in the ranging of blowdown and reflood heat transfer, which is based on tests which cover the calculated AP600 conditions and also includes rod bundle data which includes reactor-type spacer grid (G-1 and G-2) blowdown tests, as well as the ORNL film boiling tests and the G-2, FLECHT-SEASET, and FEBA reflood tests. The uncertainty of these models is included in the calculated code uncertainty as well as in the AP600 ranging calculations. Furthermore, the AP600 SSAR large break LOCA analysis uses bounding accumulator input parameters to minimize the delivery of water and extend the predicted reactor vessel refill time.

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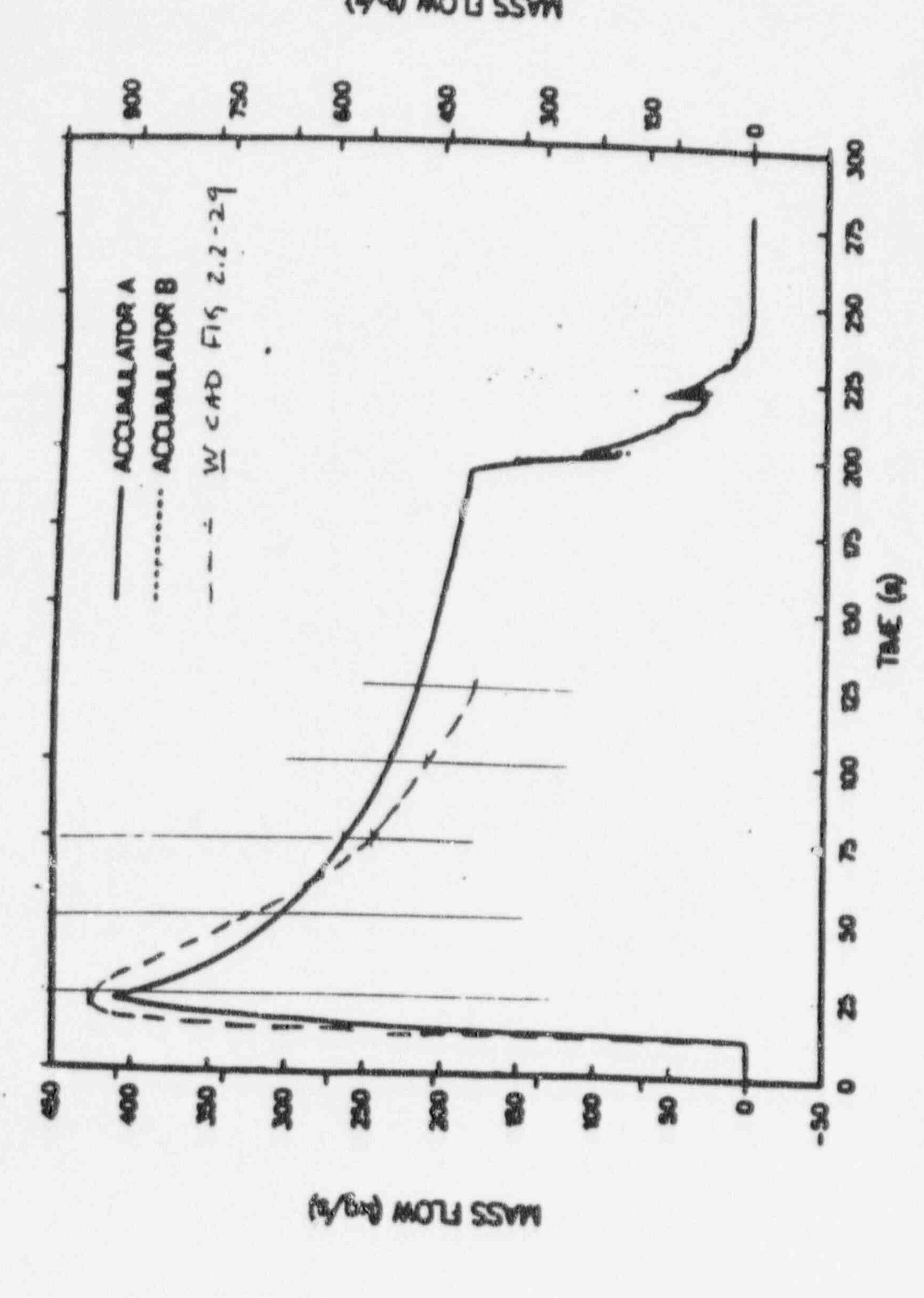
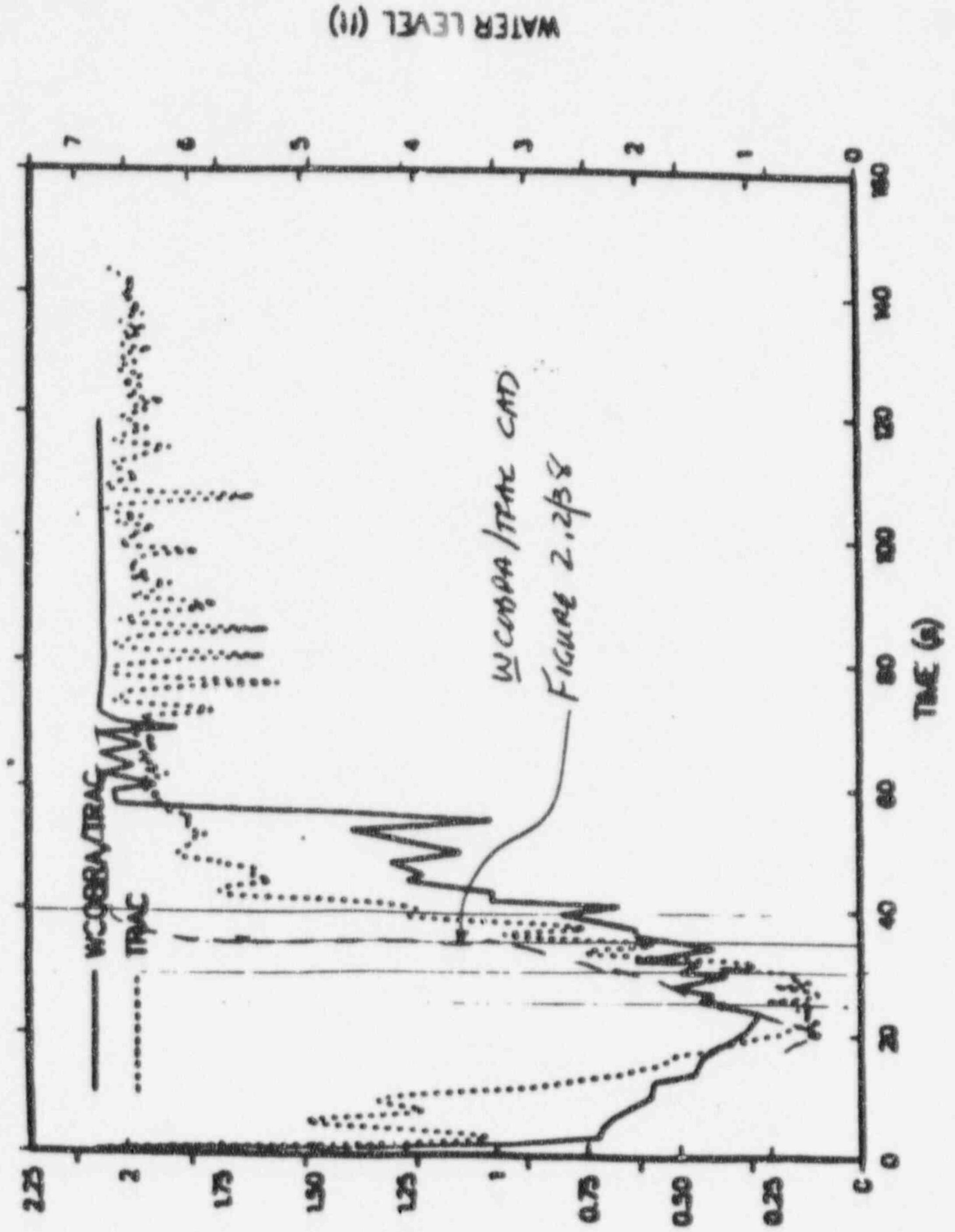
(e) If Westinghouse argues that the parameter variation in the global run matrix covers the models/phenomena that cause the PCT differences, clarify if Westinghouse has completed any of those analyses. If yes, provide the results for review. If no, will Westinghouse commit to performing some of the runs to show the size of the PCT variation in AP600 as a result of the parameter ranges analyzed in the run matrix?

The ranging effects of the hot rod heat transfer were performed in the "hot spot" calculations using the distributions which were developed for the AP600, as documented in the SSAR Revision 12 submittal, and the 95th percentile PCT was calculated. The effects of the spacer grids on the blowdown and the reflood heat transfer are included in the WCOBRA/TRAC code uncertainty, which is a lower bound to the uncertainty value applied to determine the 95th percentile PCT value.

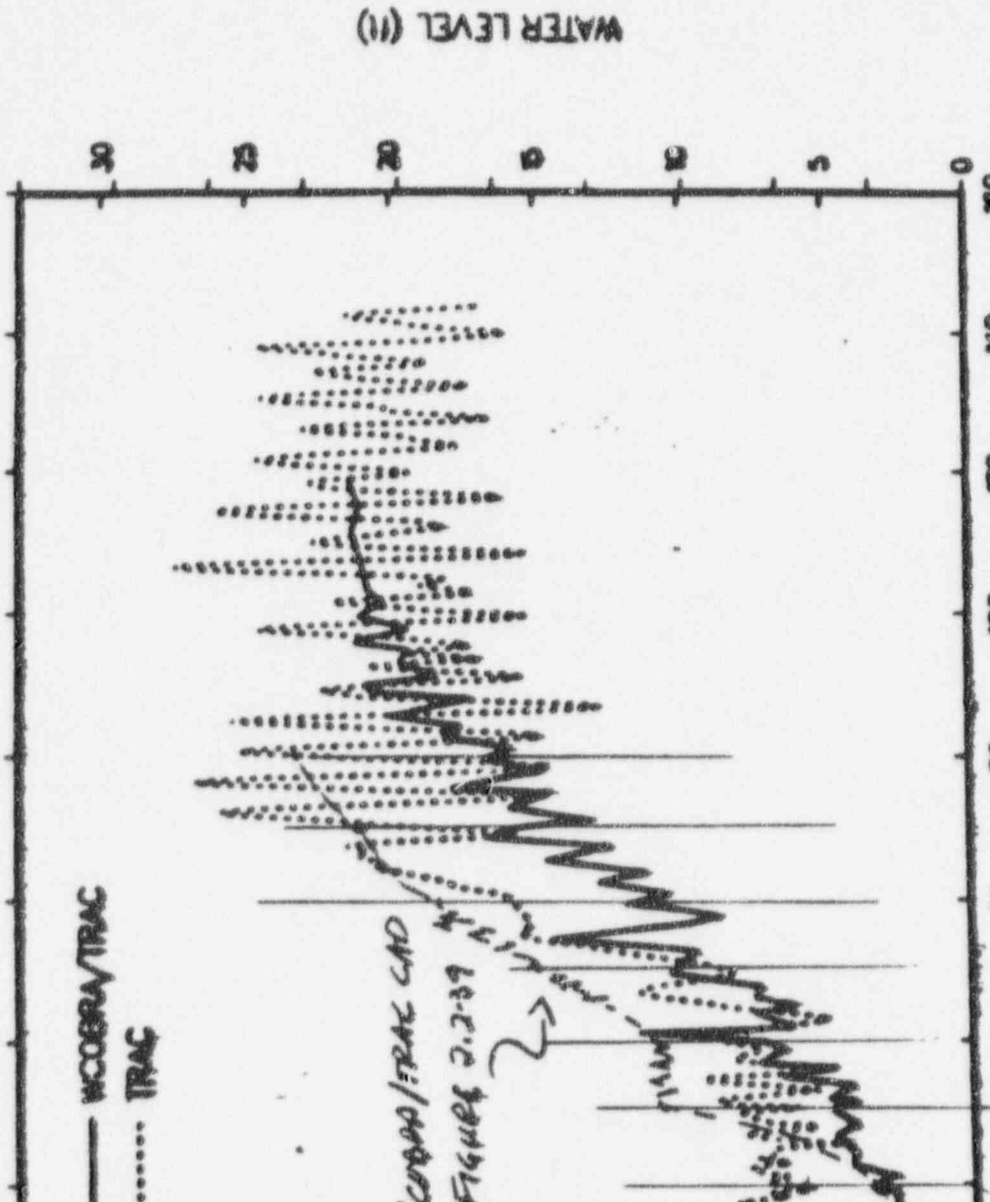


Accumulator mass flows.

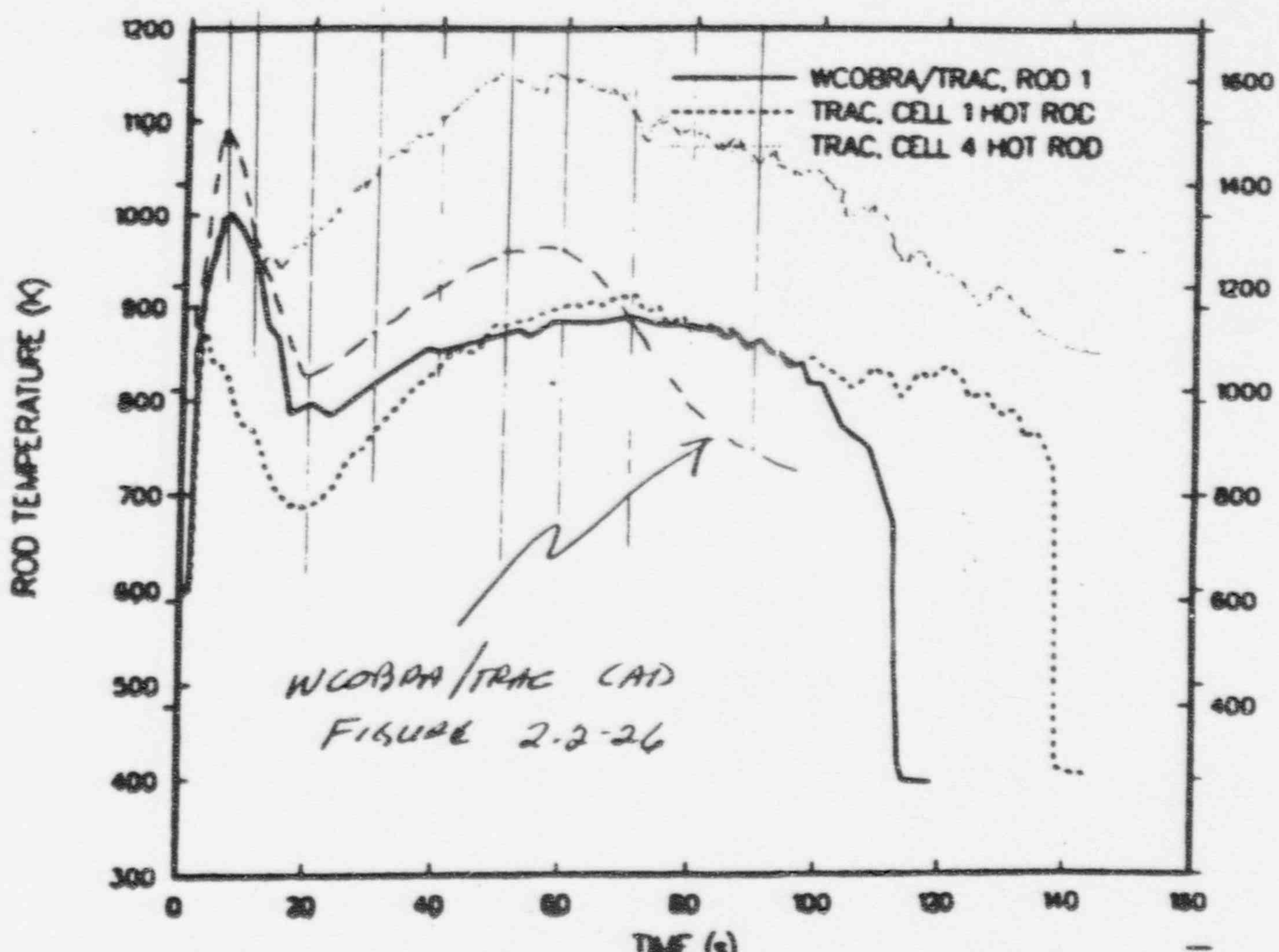


Comparsion of WCOBRA/TRAC and TRAC lower-plenum liquid level

Response 17 - Figure 3



Comparison of WCOBRA/TRAC and TRAC downcomer liquid level



Comparsion of WCOBRA/TRAC and TRAC hot-rod cladding temperatur 6-ft rod elevation.

References

1. L. E. Hochreiter, et al., WCOBRA/TRAC Applicability to AP600 Large-Break Loss-of-Coolant Accident, WCAP-14171-P, Rev. 1, October 1996.

2. N. J. Liparulo, Westinghouse, letter to USNRC, "Revisions to Westinghouse Best-Estimate Uncertainty Report," NTD-NRC-95-4575, October 13, 1996.

3. B. Boyack, et al., Quantifying Reactor Safety Margins, NUREG/CR-5249, EGG-2552, December 1989.

4. B. Boyack, AP600 Large-Break Loss-of-Coolant Accident Phenomena Identification and Ranking Tabulation, LA-UR-95-2718, August 1995.

5. N. J. Liparulo, Westinghouse, letter to USNRC Document Control Desk, "Preliminary Responses to Requests for Additional Information Regarding WCAP-12945-P and the Revised Methodology Report," NTD-NRC-95-4599, November 22, 1995.

6. N. J. Liparulo, Westinghouse, letter to USNRC Document Control Desk, "Resolution of Issues Related to Review of WCAP-12945-P," NSD-NRC-96-4672, March 25, 1966.

7. S. Bajorek, et al., Code Qualification Document for Best Estimate LOCA Analysis, Volumes 1 to 5, WCAP-12945-P, 1992 and 1993.

8. N. J. Liparulo, Westinghouse, letter to USNRC Document Control Desk, "Preliminary Responses to Requests for Additional Information Regarding WCAP-12945-P," NTD-NRC-95-4567, September 27, 1995.

9. S. M. Bajorek, Westinghouse, letter to C. P. Fineman, INEL, NTD-NSA-MYY-95-26, August 25, 1995.

10. S. M. Bajorek, Westinghouse, letter to C. P. Fineman, INEL, NTD-NSA-MYY-95-12, April 21, 1995.

11. B. A. McIntyre, Westinghouse letter to USNRC Document Control Desk, "Westinghouse Responses to NRC Requests for Additional Information on AP600," NSD-NRC-96-4908, dated December 10, 1996.

12. J. F. Lime and B. E. Boyack, Updated TRAC Analysis of 80% Double-Ended Cold-Leg Break for the AP600, LA-UR-95-4431.

ATTACHMENT 2
PROPRIETARY RESPONSES TO OPEN ITEMS:

4642	4674	4686	4690
4650	4678	4687	4693
4668	4683	4688	4696