Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

AW-96-984

July 1, 1996

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

ATTENTION: 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-96-984 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-96-984 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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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 1 day
of July, 1996

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

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(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-96-4765, July 1, 1996 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.

ENCLOSURE 2

NSD-NRC-96-4765

CONTAINS NON-PROPRIETARY MATERIAL

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Question 410.279

Why were the curbs around the sumps used to keep out debris removed from the design in Revision 4 to SSAR Section 9.3.5?

Response:

SSAR subsection 9.3.5.2.2, Revision 7, states that sumps are covered to keep out debris. Covers are removable or manholes are provided for access. In addition, sumps may have other features to aid in minimizing accumulation of debris. For example, depending on location and type of sump, some have curbs or special debris traps or both.

SSAR Revision: NONE

Question 440.366

Re: OSU Scaling Report

Does the term "isochronicity" as used in the report refer to the same "scaled" (dimensionless) time or the same "real" time?

Response:

Isochronicity means "on the same time scale." That is, for the given set of conditions in the test, the events in the reduced scale model would occur at the same time as in the full scale prototype. This is described on page 4-12 of the scaling report for the special case of single phase natural circulation with the power adjusted to simulate system behavior on a 1:1 time scale.

SSAR Revision: NONE

Question 440.369

Re: OSU Scaling Report

One potential weakness of the top-down/bottom-up scaling process, including derivation of characteristic time ratios, is that it may miss situations where two (or more) less important processes might interact to create an important synergistic effect. Describe how this possibility is accounted for in the OSU scaling approach.

Response:

The Hierarchical Two-Tiered Scaling (H2TS) methodology is a repetitive application of the non-dimensionalized mass, momentum and energy conservation equations to the control volumes that make up the total system being investigated. In the top down scaling, since the system, not just the components are modelled, interaction effects should be captured. If a single control volume is used to represent the entire system, the top down scaling analysis produces characteristic time ratios (dimensionless groups) for the system transport processes. Therefore, by fixing the length and volume scale and the initial operating conditions for the model, these characteristic time ratios can be used to develop the scaling criteria necessary to model the phenomena of interest. For example, for system depressurization, these ratios yield the scaling criteria for core power, ADS vent throat area and break area. As the analysis is performed at finer levels of detail, (i.e. component and constituent levels), new characteristic time ratios, describing local transport phenomena, are obtained. If the scaling analysis is performed only at the system level, then the information concerning the local phenomena is lost.

The approach used in the OSU scaling report was to perform the analysis such that all of the important phenomena identified in the Plausible Phenomena Identification and Ranking Tables (PPIRT) were scaled as best as possible. Thus each chapter applies the conservation equations to control volume sizes small enough to address the important phenomena identified in the PPIRT. By numerically evaluating the characteristic time ratios and comparing the results relative to the driving term for the applicable conservation equation, the important processes can be identified. In some cases, several processes were found to have very small characteristic time ratios relative to the driving term ratio. None of these processes, nor their interaction, could impact the overall control volume behavior within the time frame applicable to the phase of the transient being examined. Thus, there was no concern of synergistic effects impacting the behavior of interest for these cases.

For cases where two characteristic time ratios have numerical values close to the driving term ratio, the two transport processes must both be addressed in terms of the facility scaling. If both processes cannot be scaled simultaneously, then a distortion will exist. The degree of distortion will be readily identified when a comparison is made of the facility characteristic time ratios to those of the full scale prototype. The result would be a "known" limitation in the range of conditions in which the test facility could operate.

In conclusion, the potential for synergistic effects does exist. For the OSU APEX scaling, all of the characteristic time ratios were evaluated, including the less important ratios, thus such synergistic effects were identified in advance and addressed. In addition, the most restrictive method of satisfying the system scaling ratios, with respect to experiment design, was applied. See for example the discussion given on page 5-24 of the scaling report.

SSAR Revision: NONE

Question 440.373

Re: OSU Scaling Report

In the conclusion section on p. 4.54, is there a conclusion as to the "best" scaling methodology for single and two-phase natural circulation? Pressure scaling distortions and property similitude distortions are mentioned, but there does not appear to be a final recommendation as to the better approach.

Response:

The goal of Chapter 4 of the scaling report is to address the scaling issues associated with those phases of the AP600 transients involving single and two-phase natural circulation. A typical small break LOCA will evolve through an initial period of two-phase natural circulation. An understanding of pressure scaled two-phase natural circulation during this period is needed. Later in the transient, during IRWST injection and long term cooling, single and two-phase natural circulation will occur with fluid property similitude. Therefore, because of the different phenomena which occurs within the overall transient, both aspects of the natural circulation scaling (pressure scaled and fluid property similitude) are important tc assess the feasibility of simulating a full pressure transient in a reduced pressure facility and to properly interpret the data.

SSAR Revision: NONE

Question 440.374

Re: OSU Scaling Report

On p. 4-81, the characteristic time ratios and distortions are shown for a number of parameters. Ratios greater than unity are claimed to represent "dominant" phenomena, while those less than unity represent secondary phenomena. However, there is no indication of how much distortion is acceptable, nor what criteria are used to make that determination. Provide justification for the use of this method.

Response:

On p. 4-81, a characteristic time ratio of "unity" physically means that the process in question occurs on a time scale equivalent to the transport time of a fluid element through the core. Thus the mass, momentum or energy transport associated with the process in question would occur at a rate that would impact the mass, momentum or energy balance for the core. Simply stated, in order to perform a meaningful mass, momentum or energy balance on the entire core, these transport processes would need to be taken into account (i.e., scaled).

In fact, the selection of the dominant processes by comparing the characteristic time ratios actually represents the standard approach for an order of magnitude analysis of control volume balance equations. In this case, however, the control volume balance equation has been non-dimensionalized using the convective driving groups called characteristic time ratios. If a characteristic time ratio is an order of magnitude less than one, that term in the balance equation can be neglected. It will not significantly impact the control volume balance. This is also true if other non-dimensionalized terms in the balance equation exceed unity by more than one order of magnitude, which is the case on p. 4-81.

SSAR Revision: NONE

Question 440.386

Re: OSU Scaling Report

In the first paragraph on p. 5-38, last sentence, the distortion (in subcooled blowdown) being discussed is not "eliminated;" rather, the pressure scaling starts at the "reference" pressure. However, the mass loss during the subcooled blowdown would not appear to be able to be ignored, as the development starting in equation (5-133) on the same page seems to do. Justify ignoring this mass loss, or show how it is recaptured at some later point in the development of the model. (Same comment applies to p. 5-39, third sentence, after Eq. (5-137)).

Response:

The report correctly states on p. 5-38 that the subcooled blowdown period is not scaled in the facility. This does produce a distortion in the mass inventory as stated in the RAI.

The subcooled blowdown period is relatively short compared to the total transient time. (As confirmed by the SPES and APEX tests). For smaller breaks, this period can be prolonged. The report should state that the mass loss for larger breaks during subcooled blowdown is insignificant relative to the total mass loss (only a fraction of the pressurizer liquid mass) and thus has no significant impact on the transient. An errata to the OSU scaling report will be issued.

For the smaller breaks, the distortion due to mass loss during the subcooled blowdown period can become more important. This distortion in mass inventory could be eliminated in practice for the "saturated blowdown phase" by beginning the test with a reduced pressurizer liquid level. The initial pressurizer level is determined by critical flow calculations for subcooled conditions. For the one-inch break, the pressurizer liquid mass could be reduced by approximately 65% to establish the proper initial mass inventory for the saturated blowdown phase. This represents only 6% of the primary system inventory.

With respect to the development of equation (5-137), this equation is correct for the case where the initial fluid volume has been scaled to 1:192. That is, the compensation method described above has not been implemented. The reason it is correct for these circumstances is that the integration in equation (5-133) is performed over the time it takes to uncover the break. Therefore, all the mass above the break is lost from the system. The small distortion arises in the rate of mass loss not the total mass loss.

SSAR Revision: NONE

Question 440.387

Re: OSU Scaling Report

Eq. (5-135) on p. 5-38 appears to have a sign error. Correct the error or verify the accuracy of the equation.

Response:

The negative sign in equation (5-135) was omitted in the report. The subsequent equations (5-136) and (5-137) were not affected by this omission and therefore the conclusions remain the same. An errata to the OSU scaling report will be issued.

SSAR Revision: NONE

Question 440.389

Re: OSU Scaling Report

For Eq. (5-155), the narrative appears to be in error, in that Eqs. (5-149) and (5-150) cannot be substituted into Eq. (5-142). The staff's calculation gives values for [Cda]i,R of 0.0159 for expansion-dominated conditions and 0.0101 for flow dominated conditions. Correct the error or verify the accuracy of the narrative.

Response:

The narrative as written is incorrect. It should read, "Substituting Equations 5-153 and 5-154 into Equation 5-142 yields the numerical..." In accordance with the correct narrative, the calculated values presented in Equations 5-155 and 5-152 are correct. An errata to the OSU scaling report will be issued.

SSAR Revision: NONE

Question 440.390

Re: OSU Scaling Report

What is meant by equation (5-164)? Is there a term missing or a misprint?

Response:

The (1.780) is a misprint and will be deleted. An errata to the OSU scaling report will be issued.

SSAR Revision: NONE

Question 440.391

Re: OSU Scaling Report

How is the constant 215.8 in Eq. (5-166) determined? What does it signify?

Response:

The constant is obtained by dividing both sides of equation (5-165) by the volume ratio VR, to obtain the average "volumetric" energy release rate ratio. The volume ratio is a constant given by 1/192 (equation 5-72). Multiplying 192 times the constant 1.124 in equation (5-165) yields the numerical value of 215.8. This value physically represents the ratio of the maximum structural temperature change in the system divided by the volume ratio and time ratio. The purpose is to estimate an averaged stored energy release rate from the metal structures.

SSAR Revision: NONE

Question 440.392

Re: OSU Scaling Report

What is the justification for the last sentence on p. 5-50? What does "adequate" mean in this context?

Response:

Equations (5-172) through (5-175) are the most restrictive form of the energy transport scaling equations and require that the net system energy be scaled by the power to volume ratio. These equations also require that the individual energy transport systems be scaled by the same value. The term "adequate" in this context refers to the calculations presented in Chapter 9. By scaling the system heat transfer processes in APEX using the proposed rationale, good comparisons are obtained with the code calculations.

SSAR Revision: NONE

Question 440.396

Re: OSU Scaling Report

In section 7.1, the implementation of the scaling requirements seems to ignore the transition from "scaled" pressure to "real" pressure, i.e., when ADS-4 actuates, the system unchokes, IRWST injects, etc. .ow do the assumptions, for example of fluid property similitude in all injection processes (eqs. (7-3) to (7-7)), accommodate these considerations.

Response:

Unlike the two-phase fluid conditions in the primary loop, all of the injection processes utilize sub-cooled single phase liquid at conditions that can be easily simulated in a reduced scale facility. The injected liquid enthalpy is controlled by temperature, which is typically ambient temperature for the AP600 passive safety systems. The liquid enthalpy is basically unaffected by the system pressure. As a result, the assumption of fluid property similitude is valid and the scaled energy flow rates and mass flow rates into the reduced scaled model are easily achieved.

SSAR Revision: NONE

Question 440.397

Re: OSU Scaling Report

In section 7.6.1 (page 7-27), it appears that many of the potentially important parameters (momentum, phase distribution, etc.) are neglected. Provide additional justification for the assumptions made in the development of this section.

Response:

The objective of the scaling analysis was to develop scaling criteria for sizing the vent line piping to obtain reasonably scaled mass flow rates out of the system. That is, the vent line size was chosen to establish a boundary condition for the system. The transient dynamic effects associated with the initial opening of the vent line need not be scaled because the duration of this effect is very short compared to the time it takes to achieve steady choked flow conditions in the vent line. An analysis that examines the fluid element inertia within piping would be useful if reaction forces acting on the piping were of primary consideration for the OSU scaling analysis.

The scaling analysis was not performed at the "constituent" (i.e., individual phase) level. At this level, characteristic time ratios that include the phase distribution in the lines would have been developed along with time ratios for other local phenomena. However, the limited information required for the test design was obtained at the higher hierarchical level.

SSAR Revision: NONE

Question 440.398

Re: OSU Scaling Report

Justify the statement following Eq. (7-111) on p. 7-30 quantitatively (e.g., order of magnitude analysis).

Response:

The statement following Eq. (7-111) given on p. 7-30 is amplified as follows; the pressure difference from the top of the pressurizer across the ADS Vent Line and to the atmosphere is much greater than the pressure difference in that line associated with gravitational head. For example, at the time of ADS 1 opening in the AP600 plant, the pressure difference from the pressurizer to the atmosphere is approximately 1080 psia, which corresponds to 2500 feet of head. This can be compared to the 30 feet of head associated with a liquid filled ADS 1-3 sparger line. The ratio of the gravitational head to the pressure head is roughly 1:83, nearly double the magnitude.

SSAR Revision: NONE

Question 440.399

Re: OSU Scaling Report

On p. 7-31, in going from Eq. (7-110) to Eq. (7-114), the area ratio term has disappeared. Justify the exclusion of the area ratio term.

Response:

This is a typographical error. Equation (7-114) should be identical to equation (7-110) with the exception that the two-phase friction factor has been included. The area ratios should remain in this equation when calculating the total friction and form loss coefficient for a specific component. In developing the scaling criterion, however, the model to prototype ratio of this area term will cancel as required to satisfy the kinematic similarity requirement for the system components. An errata to the OSU scaling report will be issued.

SSAR Revision: NONE

Question 440.554 Rev-1

Re: 440.554 Re: LTCT-GSR-003
The containment is not part of the OSU simulation, the steam produced during the LTC was reintroduced as condensate into the IRWST. Containment condensation is a major part of the LTC cooling cycle. There is nodiscussion in LTCT-GSR-003 of the process which establishes the adequacy of the containment as a heat exchanger. In particular there is no discussion on: (1) the adequacy of the primary water to fill the containment with steam without core uncovery throughout the transient (2) the interface of the GOTHIC code and WCOBRA/TRAC regarding the time dependent condensation process and (3) the coolant inventory distribution as a function of time during the transient until steady state condensation rate is achieved.

Revised Response:

Removal of decay heat from the AP600 in the long term occurs via condensation of steam on the inside of the containment shell. The AP600 is equipped with gutters to return condensate formed on the containment shell as a result of heat transfer to the environment back into the IRWST. These gutters are not safety-related, so they are not be credited in the SSAR design basis analyses if a more limiting condition exists when they are presumed inoperative.

The AP600 SSAR Revision 8 Chapter 15.6 analysis of post-LOCA long-term cooling will consider the condensate return gutters to be inoperative. When the gutters are credited, condensate returns to the IRWST, maintaining a higher water level throughout the IRWST drain period. This increases the hydrostatic head for IRWST injection into the reactor vessel through the DVI lines throughout the IRWST drain transient and delays IRWST emptying to a later time in long-term cooling. When the gutters are assumed to be ineffective, injection from the full containment sump with its lower liquid head occurs several hours earlier in a LOCA long-term cooling transient. The gutters unavailable scenario is the more limiting case, and it was the scenario simulated in the OSU long-term cooling tests.

In the SSAR long-term cooling analysis, the WCOBRA/TRAC calculations of reactor coolant system performance will utilize WGOTHIC (Reference 440.554-1) predictions of AP600 containment response during postulated LOCA events. In the SSAR long-term cooling analysis methodology, WGOTHIC is executed to provide the following information for use as boundary condition input to the WCOBRA/TRAC long-term reactor coolant system window mode calculations: containment pressure, sump levels in the containment compartments, and the liquid temperatures within those compartments. WGOTHIC is executed for the entirety of the LOCA event to generate information used in the WCOBRA/TRAC long-term cooling ECCS performance analysis. The two computer codes are executed separatly and interfaced as shown in the attached Figure 440.554-1 to accomplish the analysis of breaks postulated to occur in the RCS loop piping.

WGOTHIC is applied in such a manner that it provides a conservative boundary condition for input into the WCOBRA/TRAC computation. The noding of the lumped parameter AP600 WGOTHIC containment evaluation model is applied to compute not only the containment pressure transient but also the filling of the sump with liquid. The long-term cooling ECCS performance analysis use of WGOTHIC involves only containment phenomena for which WGOTHIC is already validated; the code version employed is the one which is used for the AP600 SSAR Chapter 6.2 analyses.

Initial and boundary conditions for WGOTHIC are conservatively established as follows to minimize the computed pressure:

1. best estimate heat sink heat transfer areas * 1.05
2. full PCCS water flow external to containment with maximum coverage fractions
3. initial atmosphere values of 14.7 psia, 99% humidity, 120°F
4. no single failure of any containment system device
5. best estimate net free volume * 1.05
6. containment wall gutters are assumed inoperative
7. communication between compartments as per the design
8. PCCS water temperature at the minimum value of 40°F
9. maximum PCCS tank water volume
10. maximum wetting of the external containment surface
11. no heat and/or mass transfer correlation penalties
12. heat transfer to horizontal surface is modeled

Unlike the AP600 containment integrity analysis, no penalties in heat transfer or in mixing and stratification are included for this application.

Referring to Figure 440.554-1, the mass and energy releases for the pre-long-term cooling portion of a SSAR LOCA transient are supplied to WGOTHIC from the AP600 large or small break LOCA ECCS analysis results. The draining rate of the IRWST, which is based on the minimum initial inventory and the condition at the initiation of long-term cooling, is then calculated for use in the mass and energy release determination. A specific conservatism applied in computing the mass/energy releases during the IRWST delivery period is that all of the IRWST flow injected into the reactor vessel as the tank drains to the Low-3 level setpoint is presumed to pass through the core, and in the process is heated to the saturation temperature. Additional core decay heat beyond that necessary to heat the injected flow to saturation is assumed to vaporize core liquid. In this way, the saturated liquid flow through ADS-4 flow paths is maximized, while steam flow out through ADS-4 is minimized, consistent with the decay heat model employed. As a result, the temperature of the containment sump liquid is maximized while the containment atmospheric pressure is minimized. Consistent with the OSU Facility test data, zero fluid flow is assumed through ADS Stages 1, 2 and 3 and no flow enters the PRHR heat exchanger during IRWST injection (Reference 440.554-2). This modeling maximizes the likelihood that the containment sump, which receives no subcooled break flow, contains saturated liquid at the inception of sump injection; conditions near saturation present a great challenge to the ability of sump injection to continue the removal of decay heat and to provide the core liquid throughput that precludes the concentration of boric acid in the core to any significant extent.

The WGOTHIC computer code also provides containment boundary conditions for long-term cooling analysis of the double-ended DVI line break, which is the limiting case in terms of earliest sump injection initiation. For long-term cooling computations, the DVI piping break location is conservatively modeled at the outlet of the IRWST isolation valve. The IRWST tank drain calculation is performed modeling injection into one DVI line through one of the parallel IRWST outlet lines, while at the same time modeling the other IRWST outlet line as broken and spilling with a minimum line resistance. The WGOTHIC containment calculation then considers the IRWST outlet spill flow as an additional source of liquid directly filling the appropriate compartment. Moreover, WGOTHIC considers break flow communication between the vessel and the reactor cavity only until the cavity liquid level reaches the DVI nozzle elevation. In this way, the delivery of saturated liquid from the core through the fourth stage of ADS is again maximized, in order to obtain a maximum sump temperature.

The containment parameters from WGOTHIC are supplied to WCOBRA/TRAC as input conditions at the time of the window being analyzed. An ECCS performance calculation of a sump injection window can employ constant values of the sump level and enthalpy and the containment pressure because these parameters vary little during the duration of a calculational window. Any changes of significance in the rate of condensation in containment will have occurred long before sump injection begins. The quantity of steam present and the condensation behavior in the containment are relatively constant for the stable, quasi-steady-state condition existing within the AP600 containment at the sump injection intervals of interest for WCOBRA/TRAC window mode calculations.

References:

440.554-1 WCAP-14382, "WGOTHIC Code Description and Validation".

440.554-2 Andreychek, T.S. et. al., "AP600 Low-Pressure Integral Systems Test at Oregon State University Test Analysis Report," WCAP-14292, Revision 1, September 1995.

SSAR Revision: NONE

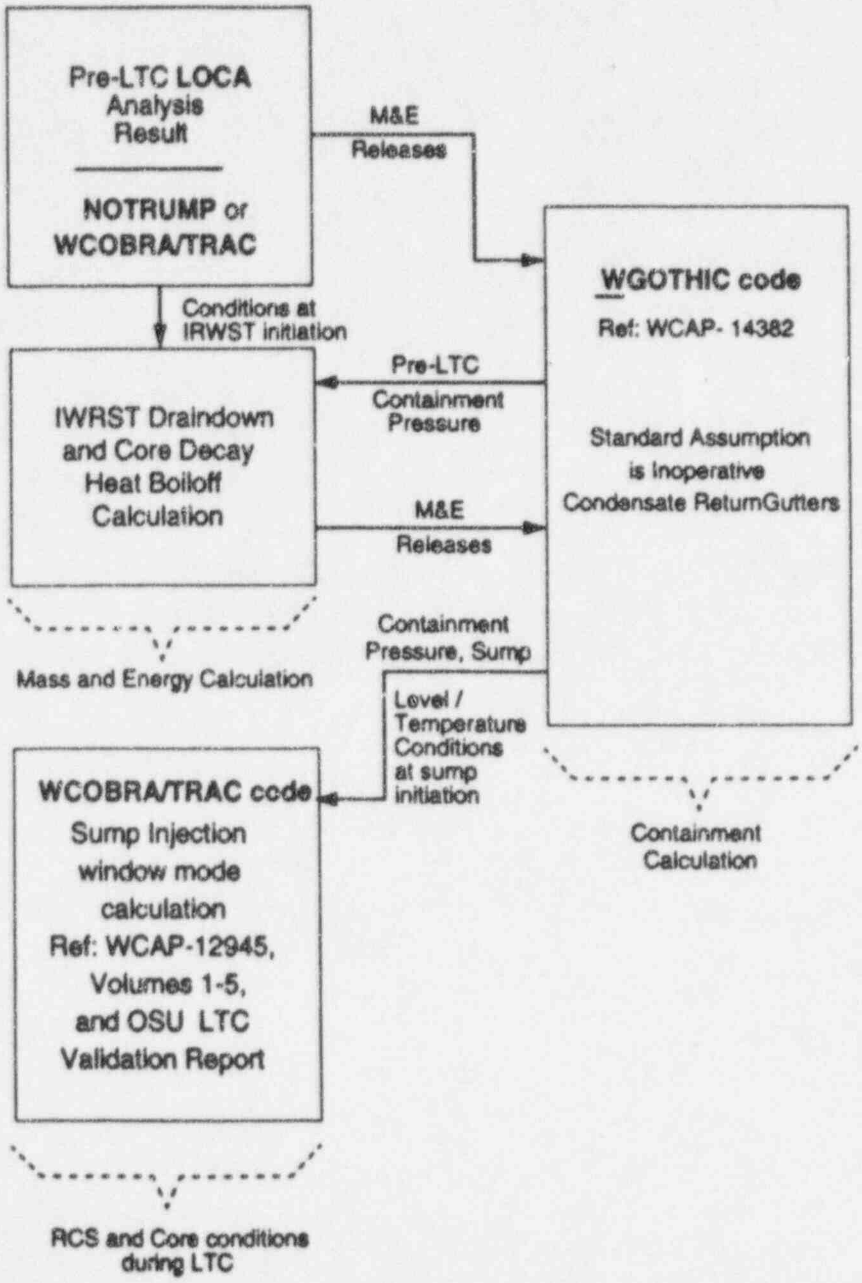

Figure 440.554-1 Long Term Cooling Calculation Code Stream

Question 440.555 Rev-1

Re: 440.555 Re: LTCT-GSR-003
The LTC window is supposed to represent a stable set of conditions demonstrating that the core remains covered and the system is able to dissipate the decay heat. Yet this does not seem to be the case in that there are still evolutions in the system parameters for the following figures: (1) the break flow integrals (Figures 5.5-4, 5.6-4, 5.7-4 and 5.8-5) (2) the ADS flow integrals (Figures 5.5-16, 5.6-16, 5.7-12 and 5.8-17) and the steam flow generated in the core (Figures 5.5-23, 5.6-23 and 5.7-19). In view of the above: why is the code converging?, why is the code stable? and why is the code suitable for the problem?

Revised Response:

The initial response to Question 440.555 noted that the measured flows identified and the WCOBRA/TRAC predictions are esentially stable, except for some oscillations in the Figures 5.7-4 and 5.8-5 measured flows. In this revision, break flow is discussed further.

The average break flows measured in the test windows analyzed are negative in tests SB01, SB12 and SB21 (i.e. flow from the break separator into the cold leg) and approximately zero in test SB10. There are small oscillations in the measured break flows of tests SB01 and SB10, and there are larger oscillations in test SB21. There are several surges of liquid flow out the break in test SB12, against the negative flow trend. The WCOBRA/TRAC calculations do not show negative break flow because the break separator was not modelled. The break separator is modeled in the calculations to be presented in the Final Validation Report; the negative break flow may then be predicted. Although oscillations are seen in the break flow data of tests SB01, SB10 and SB21, and surges are seen in test SB12 break flow data, the general trends are sufficiently constant to justify the existence of a quasi-steady state system condition. The predicted and measured ADS flow integrals and core steam flow integrals are fairly constant for all the OSU tests analyzed. These same comparisons will be presented for the final OSU WCOBRA/TRAC cases in the Final Validation Report.

SSAR Revision: NONE

Question 440.563 Rev-1

Re: 440.563 Re: LTCT-GSR-003
The upper plenum pressure is underpredicted in Figures 5.6-2, 5.7-2 and 5.8-3. The corresponding break flows in Figures 5.6-4, 5.7-4 and 5.8-5 are inconsistent in that they should all be overpredictions. Aren't pressure predictions crucial for the core LTC behavior in that small pressure differences (from the real ones) can change the outcome of the transient? What are the step decreases in the beginning of these windows?

Revised Response:

Figures 5.5.2, 5.6.2, 5.7.2 and 5.8.3 of Reference 440.563-1 show the vessel upper plenum pressure to be well predicted for Test SB01 and poorly predicted for Tests SB10, SB12, and SB21. After Reference 440.563-1 was issued in August 1995, the methodology for extracting upper plenum pressure from the test measurements has improved. The Test Analysis Report (Reference 440.563-2) is based on the revised methodology. Corrected measured values of the upper plenum pressure for the four tests are attached. The data for Test SB01 is similar to that originally reported in Reference 440.563-1, where good agreement with WCOBRA/TRAC was reported. The corrected measured pressures of Tests SB12 and SB21 are lower than reported in Reference 440.563-1, and good agreement is now obtained with the WCOBRA/TRAC predictions, shown in the Reference 440.563-1 figures, Figures 440.563-5, 440.563-6, 440.563-7 and 440.563-8. The revised measured pressure for Test SB10 is similar to that reported in Reference 440.563-1, and WCOBRA/TRAC apparently underpredicts the pressure in this test by 2 psi. However, for Test SB10 the pressure measurement transducer was classified as unreliable, so the upper plenum pressure is based on a different pressure transducer than is true for the other tests. For this reason, the WCOBRA/TRAC prediction of pressure in Test SB10 relative to the data is not considered to be appropriate in assessing the capability of WCOBRA/TRAC to model the OSU tests. Pressure predictions are important in modeling long term cooling core brhavior and the proper comparisons will be presented in the Final Validation Report.

References:

440.563-1 LTCT-GSR-003, "WCOBRA/TRAC OSU Long-Term Cooling Preliminary Validation Report, August 1995.

440.563-2 Andreychek, T. S. et. al., "AP600 Low-Pressure Integral Systems Test at Oregon State University Test Analysis Report, WCAP-14292, Revision 1, September 1995.

SSAR Revision: NONE

Question 480.218

In SSAR Fig. 6.2.1.2-1, sheet 9 (p. P6.2-35), is the flow path labeled 29-28 actually flow path 29-30 (see also p. P6.2.31)?

Response:

Figure 6.2.1.2-1, of the SSAR was revised to correctly show flowpath 29-28 as 29-30 (Revision 5). As the entire Figure has been revised, Sheet 11 of 12 contains the revisions.

SSAR Revision: None

Question 480.219

Re: Questions on AP600 Sump Design:

In the same figure referred to in the previous question, should there not be a flow path from Volumes 30 to 22 (or 21), and should there not be a small volume to represent the pipeway between the two volumes? The figure shows only a flow path and pipeway going from one of the reactor cavity volumes (30) to the accumulator room (45) via pipeway Volume 40. This configuration causes the DVI line piping to skip the steam generator access room, which appears to be impossible.

Response:

The models for the flow paths have been revised (See SSAR Figure 6.2.1.2-1, Sheet 11, Revision 5) and a flow path exists from Volume 30 to Volume 40 to Volume 22. There is no flow path to Volume 45 from Volume 22.

SSAR Revision: NONE