10 NRC RAIS AND WESTINGHOUSE RESPONSES – WCAP-16608

Westinghouse

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Our ref: LTR-NRC-08-25

May 16, 2008

Subject: Response to NRC Request for Additional Information on WCAP-16608-P, Addendum 1, "Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology" (Proprietary/Non-Proprietary) dated May, 2008

Enclosed are five (5) copies of the proprietary and one (1) copy of the non-proprietary version of, "Response to NRC Request for Additional Information on WCAP-16608-P, Addendum 1, 'Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology'."

Also enclosed is:

One (1) copy of the Application for Withholding, AW-08-2422 (Non-Proprietary) with Proprietary Information Notice, and
One (1) copy of the Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to this affidavit or Application for Withholding should reference AW-08-2422 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: Jon Thompson (NRC O-7E1A)

Distribution for LTR-NRC-08-25

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Our ref: AW-08-2422

May 16, 2008

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-08-25 P-Attachment, "Responses to NRC Request for Additional Information on WCAP-16608-P, Addendum 1, 'Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology," (Proprietary)

Reference: Letter from J. A. Gresham to U.S. NRC Document Control Desk, LTR-NRC-08-25, dated May 16, 2008

The Application for Withholding is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of Paragraph (b) (1) of Section 2.390 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 10 CFR Section 2.390, Affidavit AW-08-2422 accompanies this* Application for Withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this Application for Withholding or the accompanying affidavit should reference AW-08-2422 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

cc: Jon Thompson, NRC O-7E1A

Enclosures

AW-08-2422

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

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

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed before me
this 16th day of May, 2008

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Sharon L. Markle, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 29, 2011
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 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 Westinghouse 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 2.390 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 that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

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

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

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

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

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

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

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-08-25 P-Attachment, "Responses to NRC Request for Additional Information on WCAP-16608-P, Addendum 1, 'Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology,'" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-08-25) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-16608-P, Addendum 1, 'Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology."

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

(a) Obtain NRC approval of WCAP-16608-P, Addendum 1, 'Westinghouse Containment Analysis Methodology, Addendum 1 Appendix C, PWR LOCA Mass and Energy Release Input Calculation Methodology."

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of this information to its customers for purposes of design basis containment licensing analyses.

(b) Westinghouse can sell support and defense of design basis containment licensing analyses.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 calculations 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.

Further the deponent sayeth not.

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 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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LTR-NRC-08-25 NP-Attachment
TAC NO. MD6380

Response to NRC Request for Additional Information on WCAP-16608-P, ADDENDUM 1 REVISION 0, "WESTINGHOUSE CONTAINMENT ANALYSIS METHODOLOGY, ADDENDUM 1, APPENDIX C, PWR [PRESSURIZED WATER REACTOR] LOCA [LOSS-OF-COOLANT ACCIDENT] MASS AND ENERGY RELEASE INPUT CALCULATION METHODOLOGY"

May, 2008

Westinghouse Electric Company LLC
P.O. Box 355
Pittsburgh, PA 15230-0355

Westinghouse Non-Proprietary Class 3

REQUEST FOR ADDITIONAL INFORMATION (RAI)
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
WCAP-16608-P, ADDENDUM 1, REVISION 0, "WESTINGHOUSE CONTAINMENT ANALYSIS METHODOLOGY, ADDENDUM 1, APPENDIX C, PWR [PRESSURIZED WATER REACTOR] LOCA [LOSS-OF-COOLANT ACCIDENT] MASS AND ENERGY RELEASE INPUT CALCULATION METHODOLOGY"
WESTINGHOUSE ELECTRIC COMPANY
PROJECT NO. 700

Westinghouse Response in Italics

1. Section C.3.1, Item 5: Please justify that a [$]^{a,c}$ increase in volume due to thermal expansion is conservative. Refer to sentence: [$]^{a,c}$ Please explain (a) which vessel calculation is being referred to in this sentence, (b) why it is conservative to add the thermal expansion volume [$]^{a,c}$, and (c) whether guide tubes are part of the model.

   Westinghouse Response: Westinghouse is not requesting a change to the currently approved [$]^{a,c}$ *value that is used to account for the RCS volume increase due to thermal expansion [* $]^{a,c}$ *and measurement uncertainty [* $]^{a,c}$ *as documented in WCAP-10325-P-A, page 5-1. This meets the ANS 56.4-1983 requirement listed as item 1 in Table C.3-2.*

   a. *The WC/T vessel volume input calculation is being described in this sentence. The WC/T vessel model consists of a number of sections. Each section contains several channels. The total vessel volume is the sum of the various channel volumes.*
   b. *[* $]^{a,c}$
   c. *The metal structures and fluid volumes associated with the control rod guide tubes are modeled in the upper head and upper plenum sections of the WC/T vessel.*

2. Section C.3.1, Item 2: Please explain why a different set of [$]^{a,c}$ flows is required [$]^{a,c}$ for the pump suction and the hot leg breaks LOCA mass and energy (M&E) calculations and explain how these flows are calculated?

   Westinghouse Response: [

1

]^{a,c}

3. Section C.3.1, Item 16: Please justify that [ ]^{a,c} increase in steam generator (SG) secondary side volume due to thermal expansion and measurement uncertainty is conservative.

   Westinghouse Response: The percentage increase in SG secondary side volume due to thermal expansion and measurement uncertainty should not be any different than the RCS. The SG pressure is substantially lower and the temperature is slightly lower than the RCS.

4. Section C.3.3, for minimum net positive suction head available analysis. Please explain why is it conservative to [ ]^{a,c}

   Westinghouse Response: [

   ]^{a,c}

5. Section C.4.1, second paragraph, last sentence: Please further explain the 60 second steady-state case used to adjust the SG secondary side pressure and steam/feed flow rates to maintain the desired reactor coolant system operating conditions.

   Westinghouse Response: The WC/T ECCS evaluation model input must be initialized at hot full power steady state conditions. The LOCA transient analysis case is started from the end of the steady state case. Typically, the initial SG secondary pressure and steam/feed flow rates must be adjusted slightly to maintain the desired RCS steady state conditions. For example, the input SG secondary side steam and feed flow rates may have to be decreased if the RCS pressure and average temperature decrease during the steady state period.

6. Section C.3 Item 1: States that the LOCA Emergency Core Cooling System evaluation model PIRT [phenomena identification and ranking table] is very similar to the LOCA M&E release model PIRT, so WC/T [Westinghouse COBRA/TRAC] already contains models for most of the important M&E phenomena identified in the PIRT. Please explain what other phenomena besides the SG reverse heat transfer were required to be modeled in the WC/T code and how they were validated?

   Westinghouse Response: The SG metal energy must be considered in the LOCA mass and energy release calculation. Aside from the SG tubes, the SG metal energy was not modeled in the WC/T code calculation. The capability to model the primary and secondary SG metal was added to the code. This is described in Section C.2.3 of WCAP-16608-P, Addendum 1. The WC/T SG metal energy conduction model was validated by comparing the code calculated transient SG metal temperature response with the analytic solution for a step change in temperature at the conductor surface.

   Although not required by the PIRT, coupling the RCS and containment response eliminates the potential need for iteration during the post-blowdown phases of the LOCA event. The WC/T code was updated to allow it to exchange information with GOTHIC. This is described in Section C.2.4 of WCAP-16608-P, Addendum 1. This code change was validated by

comparing the interface variables sent by WC/T and received by GOTHIC over the course of a transient.

7. Table C.3-1, Item 7: Under the column titled "New Westinghouse Methodology" states an exception of not modeling heat transfer from reactor coolant system hot metal during the long term decay heat removal phase. Please provide the reasons for this exception and the appropriate justification as to why it is biasing for the M&E release for the containment analysis? Please note Item 19 under the new Westinghouse methodology which states that "...a long term decay heat boil-off model, which also accounts for the remaining energy in the primary metal ...." appears to be in contradiction to the statement in Item 7. Please reconcile these two statements.

   Westinghouse Response: The text in Table C.3-1 will be clarified; Westinghouse is not taking an exception to modeling the metal heat release during the long-term decay heat removal phase. [

   ]a,c

8. Table C.3-1, Item 10: Does the new Westinghouse methodology use the alternate approach given in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix K, Section I.A, of assuming a constant blowdown profile using the initial conditions with an acceptable choked-flow correlation? What choked-flow correlation is used?

   Westinghouse Response: If a utility were to request Westinghouse to use the WC/T LOCA M&E release model to generate the break mass and energy releases for a short-term sub-compartment analysis, the input would be biased differently than for the containment peak pressure and temperature analysis. The short-term LOCA M&E release calculation input would be biased to maximize the initial break flow rate for the sub-compartment analyses. [

   ]a,c

   The TRAC PF1 break flow correlation is programmed into WC/T (see Section 4-8 of the CQD, WCAP-12945).

9. Table C.3-1, Item 15: Please provide references to experimental data reports used to validate the refill calculations.

   Westinghouse Response: The predictions of end of ECC bypass and subsequent refill have been validated by comparisons with full scale and scaled tests. These comparisons are provided in the WC/T CQD, WCAP-12945-P-A as follows:

   UPTF Test 6 (full scale) - Sections 14-4 and 15-1-9
   Creare tests (1/15-th and 1/5th scale) - Section 15-1-5

   The data references are provided in each of these sections. In addition, Section 25-6 provides a summary of the comparisons with data.

10. Table C.3-2, Item 9: Please confirm that an evaluation was performed to verify that M&E added due to feedwater flow from the event initiation to feedwater isolation has no effect on the containment response.

Westinghouse Response: A loss of offsite power is assumed at the start of a LOCA event. The loss of offsite power causes the feedwater pumps to trip and the flow rate to coast down. An SI signal causes the feedwater control valve to start to close. The SI signal is generated fairly quickly in a large LOCA event. Therefore, following the design basis large LOCA event, the main feedwater flow would continue for only a short period of time. This time would depend on how long it takes for the pumped flow rate to coast down and the flow control valve to close.

*A sensitivity case was run during the initial WC/T LOCA M&E model development program to examine the containment response to modeling the feedwater flow coast down. WC/T uses the feedwater velocity as input to the feedwater FILL component. For the sensitivity case, the feedwater FILL velocity was ramped from 19.5 ft/s to 0.0 ft/s over the first 10 seconds of the transient. This added approximately 1100*5 = 5500 lbm of water and approximately 5500*450 = 2.5 MBTU of energy to each steam generator. This represents about 2% of the total energy in each steam generator.*

The transient fluid energy plots for an intact loop SG and the broken loop SG are shown in Figures 1 through 4. Both the intact loop and broken loop SG energy increase by approximately 1.5 MBTU shortly after trip in the base case (Figures 1 and 3). The SG energy for the sensitivity case increases by approximately 4 MBTU shortly after trip (Figures 2 and 4). As expected, this is about 2.5 MBTU higher for each SG than the base case. At the end of the transient, the total fluid energy remaining in the sensitivity case steam generators is about 18 MBTU greater than the base case steam generators. Therefore, the sensitivity case steam generators are cooling down slower than the base case steam generators.

The transient containment pressure, temperature and sump temperature are shown in Figures 5 through 7. The containment transient response is not impacted by modeling the feedwater flow coastdown. Therefore, after finding no impact on the containment peak pressure and temperature response, Westinghouse decided not to model the feedwater flow coastdown in the WC/T LOCA M&E release calculation.

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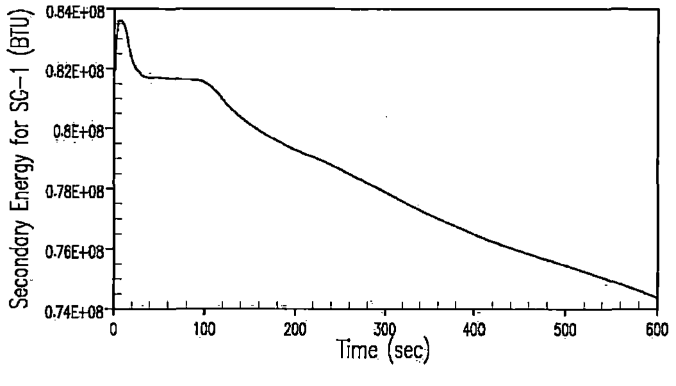

Figure 1 – Intact Loop SG Energy w/o Feedwater Coastdown

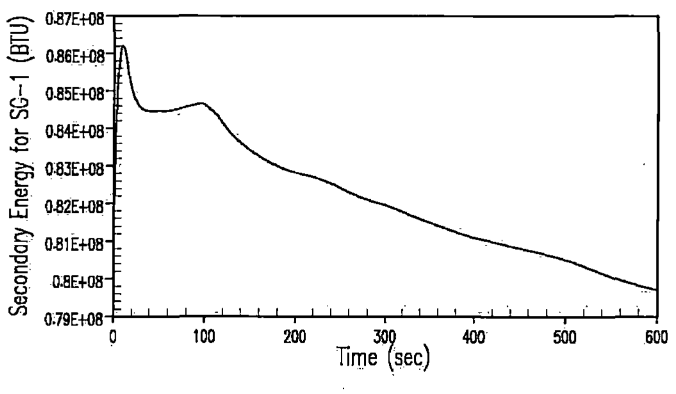

Figure 2 – Intact Loop SG Energy with Feedwater Coastdown

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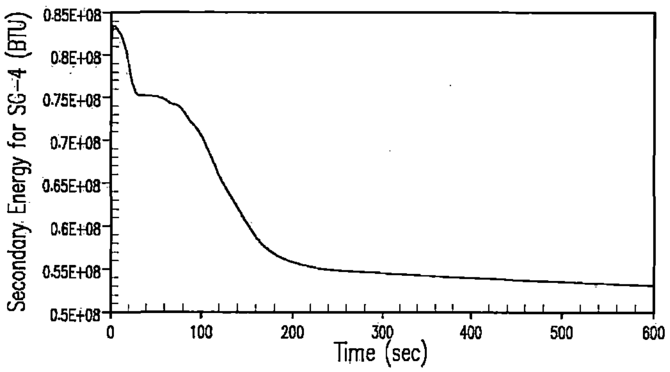

Figure 3 – Broken Loop SG Energy w/o Feedwater Coastdown

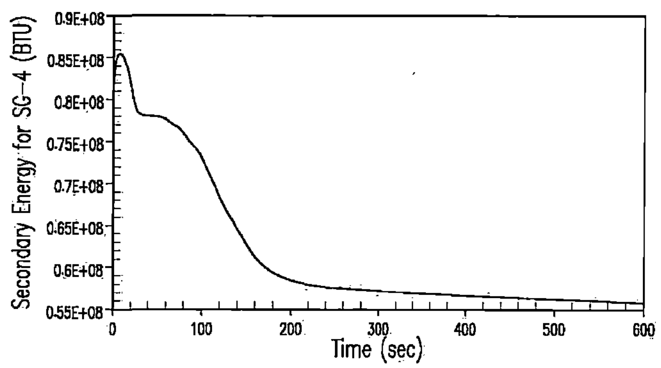

Figure 4 – Broken Loop SG Energy with Feedwater Coastdown

6

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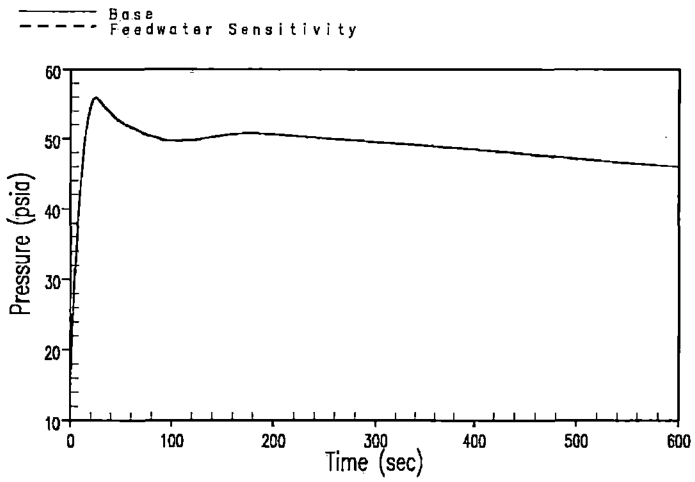

Figure 5 – Containment Pressure Comparison

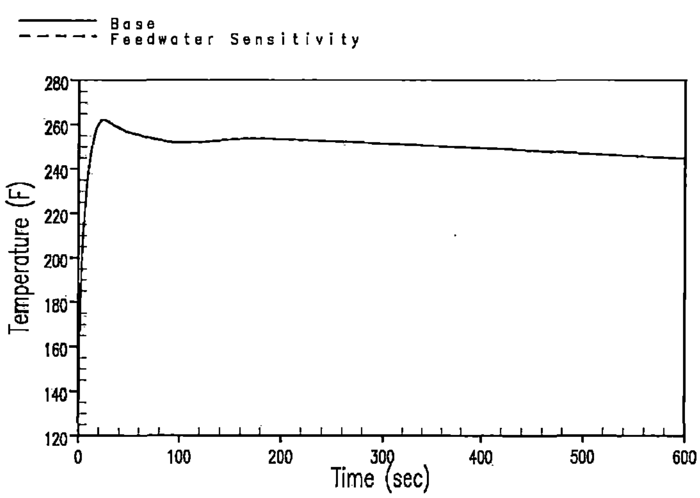

Figure 6 – Containment Temperature Comparison

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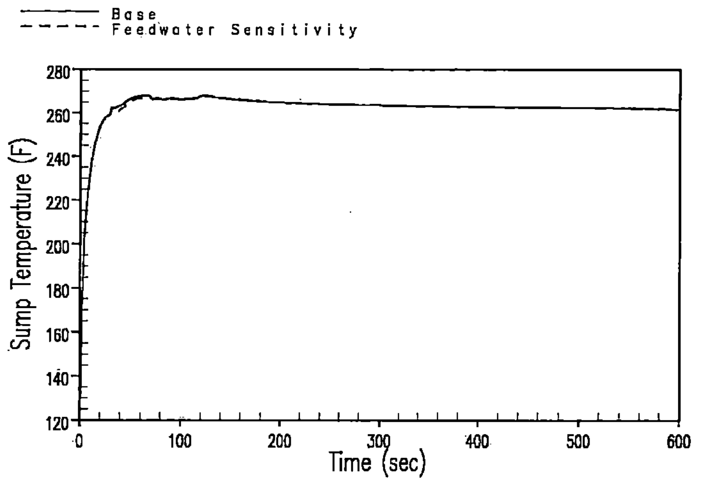

Figure 7 – Containment Sump Temperature Comparison

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11. Table C.3-2, Item 25: Please justify that the proposed LOCA M&E release model nodalization [ ]^{a,c} is conservative for all phases of LOCA and meets the American Nuclear Society (ANS) 56.4-1983, Section 3.2.4.1 guidance.

    Westinghouse Response: The WC/T [ ]^{a,c} noding structure is much more detailed than what is used in the current approved LOCA M&E release model, particularly during the reflood and post-reflood phases.

    Nodalization studies performed with WC/T are summarized in Section 19-6 of the CQD, WCAP-12945-P-A. These include LOFT L2-5 (integral test, all phases of the transient), ORNL 3.08.6c (high pressure film boiling heat transfer test, blowdown phase conditions), G-2 Refill Test 743 (refill heat transfer test) and FLECHT-SEASET (reflood heat transfer test).

12. Table C.3-2, Item 33: Please justify that the use of same heat transfer correlation as used in the WC/T ECCS model is conservative for the LOCA M&E calculations and will predict high containment pressure.

    Westinghouse Response: The WC/T ECCS evaluation model uses a standard set of heat transfer correlations (McAdams, Dittus-Boelter, and Chen) to calculate the heat transfer to the RCS from the fuel, RCS metal, SG fluid (through the tubes), and SG metal (to the fluid). The correlations were assessed for a large number of separate and integral tests over a large range of scale and were found to be acceptable for calculating the heat transfer during the LOCA event.

    In order to address the over-prediction of the SG heat transfer as noted in Section C.2.1, the SG heat transfer model was modified and verified adequate for the LOCA M&E calculations as described in Section C.2.2.

13. Section C.3.2: It is not clear from the explanation given for the [ ]^{a,c} as to how this maximizes the long term containment pressure and temperature. Please explain further the contents of second paragraph of this section.

    Westinghouse Response: The long-term containment pressure and temperature increase as the steam mass release rate increases. [

    ]^{a,c}

14. Figure C.4.2-1: Please provide the GOTHIC input file electronic and hard copy for this containment model nodal diagram.

    Westinghouse Response: The GOTHIC containment model input file will be provided. This model was used to test the capability of the codes to run in parallel and to compare the calculated containment response with WC/T LOCA M&E input to the response with WCAP-10325 M&E input.

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Note, Westinghouse intends to run the WC/T LOCA M&E release model in a stand-alone mode for plants that do not use GOTHIC for their containment DBA calculations. The following text changes (strikeouts and underlines indicate deletions and additions, respectively) will be made to help clarify this:

Page C-12, Section C.2.1 – The containment response for the M&E calculations ~~is~~ can be calculated with the GOTHIC code (Reference C-24 through C-26). In order to calculate the RCS thermal-hydraulics with WC/T and the containment calculations with GOTHIC, WC/T ~~needs to be~~ was modified to allow running the code in parallel with GOTHIC.

Page C-40, item 1 – The new WC/T LOCA M&E release model ~~will~~ can be coupled with a GOTHIC containment model to calculate the containment response into the post-reflood phase of the event. The SG fluid, metal, and RCS metal energy remaining at the end of the ~~coupled~~ WC/T~~+GOTHIC~~ calculation will be released, along with the decay heat, in the long-term ~~GOTHIC~~ containment response calculation.

Page C-58, item 26 – ~~The accepted GOTHIC code steam tables are used for the long term LOCA M&E release calculation.~~

Page C-61, item 32 – [

$]^{a,c}$

Page C-68, Section C.3.2, second paragraph – The long-term decay heat boil-off calculation is performed in the ~~GOTHIC~~ containment response model.

Page C-68, Section C.3.3 – [

$]^{a,c}$

Page C-91, Section C.5.2 – As described in Section C.3.2, the long-term LCOA steam release rate is maximized for the ~~GOTHIC~~ long-term EQ analysis.

Page C-94, Section C.5.3 – As described in Section C.3.3, the LOCA steam release rate is minimized for the ~~GOTHIC~~ minimum NPSHa analysis.

15. Section C.6, third paragraph, first sentence: Please specify what acceptance criteria and which NRC regulation are referred to in this sentence.

Westinghouse Response: The text will be modified as follows to clarify this sentence: The WC/T ECCS evaluation model input was biased to produce conservative LOCA M&E releases in accordance with the acceptance criteria documented in NUREG-0800, Section 6.2.1.3.

The standard review plan (SRP) provides guidance for the NRC safety review of various applications. The SRP for the LOCA mass and energy release calculations is provided in NUREG-0800, Section 6.2.1.3. This document lists the areas of review, acceptance criteria, and review procedures. The relevant requirements of the applicable NRC regulations are listed under the acceptance criteria section. Although compliance with the SRP specific acceptance criteria is not required, a comparison of both the new and old Westinghouse LOCA M&E release calculation methodology with the SRP acceptance criteria is provided in Table C.3-1 of WCAP-16608-P, Addendum 1.

16. Figure C.4.3-6: Please explain why the long term containment pressure WC/T curve deviates considerably from the WCAP-10325 curve.

    Westinghouse Response: The WCAP-10325 model performs a deterministic calculation of the LOCA mass and energy releases after blowdown. The remaining post-blowdown RCS and SG energy is assumed to be released in one hour. This assumption is very conservative based on comparisons with test data. The WC/T model performs a mechanistic calculation of the LOCA mass and energy releases. As shown in Figure C.4.3-4, the post-blowdown LOCA energy release rates calculated with the WC/T model are lower than those calculated with the WCAP-10325 model. The lower energy release rate yields a lower calculated long-term containment pressure and temperature.

17. Figure C.4.3-8: Please explain why the WC/T long term containment vapor temperature transient deviates considerably from the WCAP-10325 transient.

    Westinghouse Response: See the response to item 16.

The following RAI questions are requested to clarify the WCOBRA/TRAC (WC/T) model changes to address heat transfer in the steam generators, as described in Section C.2.2 of the topical report:

18. Regarding p C-14,
    a. Provide comparisons between the range of Westinghouse's intended use Unal's correlation and the parametric ranges given in Table 1 from Reference 16 of WCAP-16608 (which include pressure, mass flux, dryout quality, and heat flux). Also provide a comparison between the hydraulic diameters of the test sections from the data provided in Table 1 and the hydraulic diameters which Westinghouse intends to use with Unal's correlation.

    Westinghouse Response: Unal specifies the ranges for which his correlation fits the experimental data. There are three sets of data cited. The table below summarizes/combines all three sets of data.

	Unal
Pressure	*0.1 - 7 MPa*
Mass Flux	*7-100 kg/(m^{2}s)*
Dryout quality	*0.0-0.99*
Heat flux	*0.8 – 22.5 W/cm^2*

    Given the broad range of operating conditions, it is expected that any application of Unal's correlation for expected LOCA conditions would be appropriate.

    For a round tube, the hydraulic diameter is the same as the tube diameter. For the FLECHT tests (WCAP-8583), the ID of the SG tubes were 0.775 inches. For older PWR's, a typical outer diameter of the SG tubes is around 7/8" (with a wall thickness of 40 to 50 mils). Newer PWR's have a typical outer diameter of the SG tubes around 11/16" (with a wall thickness of 40 to 50 mils). Thus, the FLECHT tests represent the expected hydraulic diameters in PWRs.

Unal uses the experimental data from Unal Reference 18 to develop the model and then uses the experimental data from Unal References 12 and 13 to verify the model. Unal Reference 18 is for a 3x3 rod bundle experiment while Unal References 12 and 13 are for single tube experiments. The hydraulic diameter for the tests in Unal Reference 12 is 0.606." Unal Reference 13 could not be found. An article compiling the data from Unal Reference 13 ("Assessment of Post Critical Heat Flux Models with Lehigh Nonequilibrium Data", April 1986) does not contain the actual test dimensions.

For Unal Reference 18, the OD is 0.374" with a pitch of 0.496". This results in a hydraulic diameter of 0.464".

The overall range of hydraulic diameters (including the FLECHT tests) indicate the applicability of Unal's correlation to Westinghouse applications. The table below summarizes the hydraulic diameters.

	Hydraulic Diameter	*Notes*
Unal Reference 12	*0.606"*	*Round tube*
Unal Reference 13	*unknown*	
Unal Reference 18	*0.464"*	*Rod bundle*
Westinghouse	*0.835" or 0.6475"*	*Assuming 40 mil thick walls*
FLECHT	*0.775"*	*Round U- tubes*

b. Depending on the results from above, additional information may be required to justify the use of Unal's correlation. For example, if Westinghouse intends to use Unal's correlation at lower heat fluxes than those listed in Table 1 (i.e. in ranges where the radiative heat transfer may no longer be insignificant compared to the convective heat transfer) additional work may be needed to account for radiative heat transfer. Also, if Westinghouse intends to use the correlation over a small subset of the ranges given in Table 1, a further review of the correlation compared to only the data in the intended range may be necessary. Further considerations may be identified after the comparisons in part 'a' of this question have been addressed.

Westinghouse Response: Unal's correlation will be used within the parametric ranges outlined in his paper.

19. Regarding p C-15, a. Provide comments on Reference 20, with respect to Pasamehmetoglu's requirement that 'there are no non-condensable components in the steam environment.' Is this a correct assumption for the steam generator when this model will be used? If there are non-condensables in the steam generator at this time, justify the use of this correlation, or address the WC/T treatment of non-condensables.

    Westinghouse Response: In reality, it is likely that there will be some non-condensable components in the steam environment. WC/T ignores the presence of non-condensable gas in the steam flow. For the post-blowdown LOCA M&E release calculations, the main concern is the transfer of heat from the SG tubes to the RCS steam/water/air mixture flowing through them. Ignoring the non-condensable gas would conservatively over predict the SG heat transfer rate and thus increase the energy release rate to containment. This is a conservative assumption since the presence of any non-condensable gas (e.g. air, N_2, H_2, He, etc.) in the steam results in a significant reduction in heat transfer during condensation.

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Accumulation of non-condensable gases near the condensate film restricts the diffusion of vapor from the steam flow mixture to the liquid film on the droplet.

b. Provide the derivation for the dimensionless instantaneous cup temperature found on page C-15 from equation 4 of Pasamehmetoglu's paper. Define terms not defined by Pasamehmetoglu, specifically t_d, D_H, and Vr_{drop}.

Westinghouse Response: [

13

]^{a,c}

20. Regarding the Biasi correlation, will the parameters in the steam generator be within the ranges for the Biasi correlation?

    Westinghouse Response: The Biasi correlation has been developed based on Critical Heat Flux test data for tubes ranging from 0.12 inches to 1.47 inches (diameters) and tube lengths up to 20 feet. This range of test data covers typical geometry of steam generator tubes (see end of response to question 18). Also, the range of conditions in the test data cover the expected PWR steam generator conditions during reflood. There should be no scaling bias. [Reference: WCAP-12945-P-V1, Section 6.3-4]

21. The comparisons of the proposed revised WC/T results to the currently approved methods do not show the impact of the changes within WC/T. Regarding section C.4.3, provide the same plots with the addition of calculations from the unmodified version of WC/T (without the code updates). Include additional results to show the quench behavior at a few selected locations, and discuss the results comparing the modified WC/T model to the unmodified model for steam generator heat transfer.

    Westinghouse Response: A comparison of the LOCA mass and energy release results from the unmodified WC/T code with WCAP-10325 results was not included in the topical report; however, this was done as part of a feasibility assessment. The results were documented internally and presented in a paper that was published as part of the ICONE14 conference proceedings (ICONE14-89258). The unmodified WC/T RCS model does not include the improved SG noding structure, SG secondary metal, the interfacial heat and mass transfer model, or run in parallel with the GOTHIC containment model.

    The LOCA ECCS evaluation model input deck for a Westinghouse 4-loop, 3600 MWth PWR was used to test the feasibility of using WC/T for LOCA M&E calculations. The LOCA ECCS evaluation model input was biased to generate bounding LOCA M&E release data for the containment model. The system volume was increased to account for measurement uncertainty and thermal expansion. The WC/T STGEN component did not include metal, so the SG secondary water volume was increased to account for the SG secondary metal stored energy and uncertainty in the secondary volume. Additional RCS pipe volumes were

incorporated in the WC/T ECCS evaluation model to include the metal in the SG inlet and outlet plenums. The initial core thermal power, RCS pressure, and RCS temperatures were also increased to include uncertainties. After making these changes, a steady state restart point was created. The initial WC/T model mass and energy was compared with the benchmark LOCA M&E release model mass and energy on a component by component basis to verify the model initial conditions were equivalent before running the transient benchmark comparisons.

The mass and energy release output from the biased WC/T models was compared with the current LOCA M&E release model output for a double ended pump suction LOCA event. The integrated blowdown mass and energy release comparison for the 4-loop plant model is shown in Figures 8 and 9. The biased WC/T model calculated approximately the same blowdown break mass and energy release. The integrated long-term mass and energy release comparison is shown in Figure 10 and 11; the biased WC/T model calculated a lower long-term energy release. An investigation identified the cause of the difference. The calculated SG heat transfer in the biased WC/T model was lower than the non-mechanistic SG heat release from the current LOCA M&E release model; the WC/T SG model was cooling down from the bottom up and the secondary fluid had become stratified.

The mass and energy releases were fed into the corresponding GOTHIC containment model to determine the impact on the containment pressure. As can be seen in Figure 12, the blowdown peak pressure is the same, but because the biased WC/T long-term energy release is lower, the long-term peak containment pressure is at least 5 psi lower than that predicted using the current LOCA M&E release model.

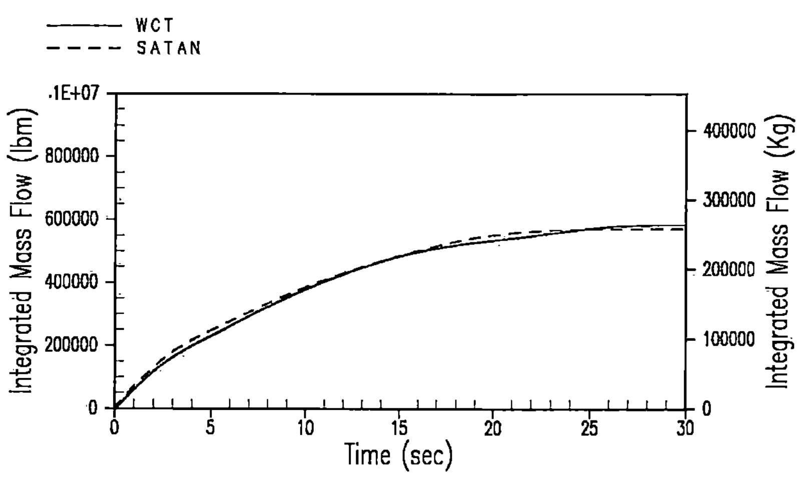

Figure 8 – Biased WCT Integrated Blowdown Mass Release Comparison

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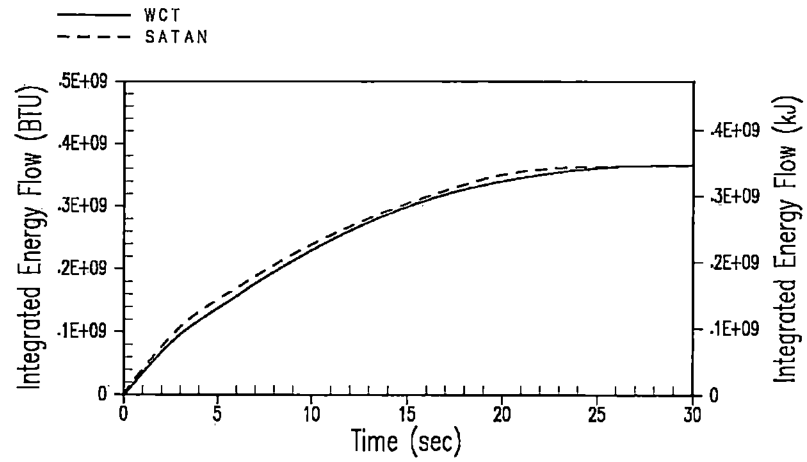

Figure 9 – Biased WCT Integrated Blowdown Energy Release Comparison

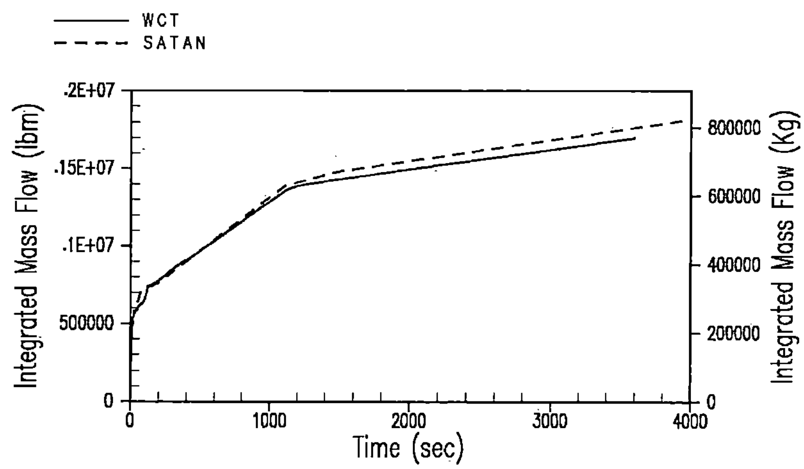

Figure 10 – Biased WCT Integrated Long-Term Mass Release Comparison

Westinghouse Non-Proprietary Class 3

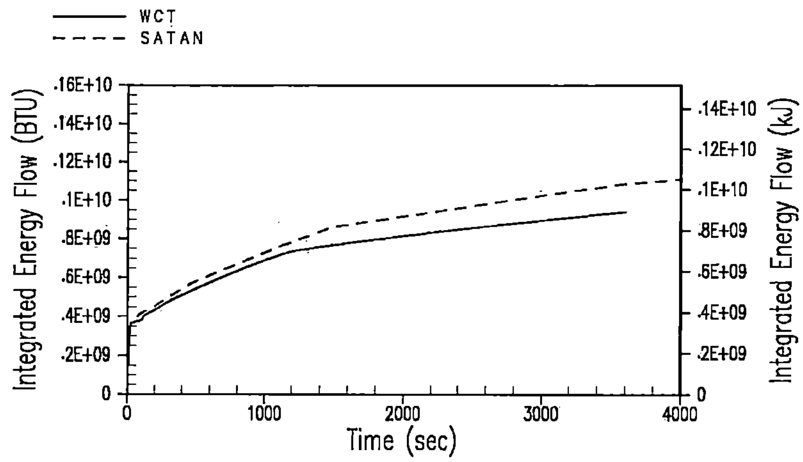

Figure 11 – Biased WCT Integrated Long-Term Energy Release Comparison

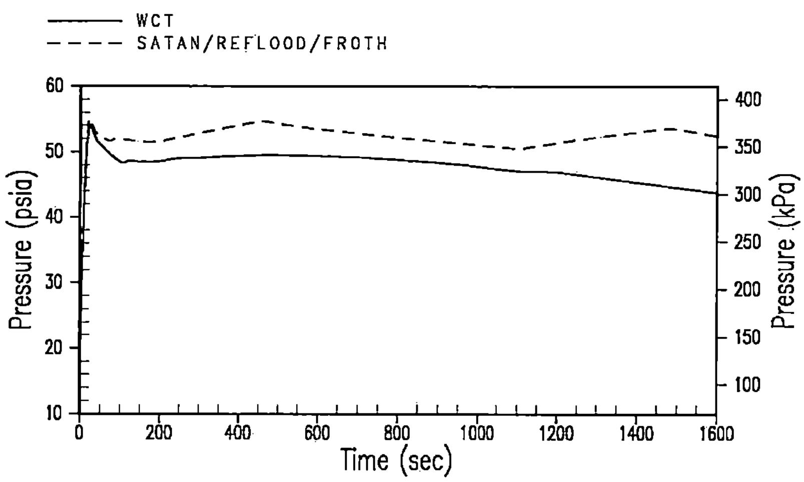

Figure 12 – Biased WCT Containment Pressure Response Comparison

The following RAI questions are requested in order to clarify the WCOBRA/TRAC (WC/T) to GOTHIC interface methodology, as described in Section C.2.4 of the topical report:

22. On page C-35, reference to Figure 3.2, which does not exist, should be changed to the correct Figure, C.2.4-2.

    Westinghouse Response: The text will be corrected in the final report.

23. The mass and energy averaging, described on page C-35, appears to under predict the values if a quantity is monotonically decreasing over the GOTHIC time step range. As presented, it seems that the average is based on the quantity at the end of the WC/T time step multiplied by the time step size instead of using the average quantity over the time step. Address the apparent under prediction of the mass and energy entering the containment, and include the process used to establish and justify the time step size in both WC/T and GOTHIC.

    Westinghouse Response: Figure C.2.4-2 on page C-39 will be corrected; the current figure does not show the calculation of the average break flow and enthalpy in WC/T and the transfer of the average values to GOTHIC. The modified Figure C.2.4-2 is shown on the next page. The highlighted text will be added. The text on page C-34 (Code Implementation-Output interfaces from WC/T to GOTHIC) will also be corrected to be consistent with the changes in Figure C.2.4-2. The mass and energy averaging that was implemented conserves mass and energy transfer across the interfaces from WC/T to GOTHIC.

    The time step size used in WC/T and GOTHIC is consistent with the time step size used in WC/T LOCA calculations and GOTHIC containment analysis calculations, respectively.

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Figure C.2.4-2 Schematic of the GOTHIC – WC/T Parallel Execution

24. The SI flow can come from GOTHIC (during recirculation) or come from WC/T to GOTHIC for RWT inventory calculations. Please describe the SI modeling in terms of how the flows are obtained in each code, and how the energy in the SI flow is modeled. Is there a period of time, for example during recirculation, when both codes are calculating the SI flow separately? If so, is this one of the verification parameters?

    Westinghouse Response: The SI flow rate is calculated in the WC/T SI FILL boundary conditions by interpolating an input SI velocity vs. RCS pressure table. The RWST temperature is input for the SI temperature in the WC/T LOCA M&E model. WC/T continues to calculate the SI flow rate and temperature until a non-zero recirculation flow rate is received from GOTHIC. At this point, the WC/T SI FILL boundary condition will use the recirculation flow rate and temperature specified by GOTHIC.

    GOTHIC models the RWST. The combined SI flow rate for all loops is passed from WC/T to GOTHIC. The SI and containment spray flow rates are subtracted from the RWST water volume.

    The recirculation flow rate is determined by GOTHIC after the RWST level reaches the setpoint to transfer to recirculation. A constant recirculation flow rate input value was used in the GOTHIC model for the topical report cases. The recirculation flow rate and calculated RHR heat exchanger outlet temperature are passed to WC/T.

    There is no period of time when both codes are calculating the SI flow rates separately.

The following RAI questions are requested to clarify the use of WC/T to obtain the mass and energy releases for the containment peak pressure LOCA analysis:

25. Address how uncertainties in the WC/T core heat transfer models are to be applied. Specifically, during core safety analysis the overall heat transfer coefficient in WC/T would be conservatively decreased due to uncertainties if there was not enough data to justify a more realistic heat transfer coefficient. This decrease in the heat transfer coefficient would be conservative for core safety analysis, as it would decrease core heat removal resulting in more energy remaining in the fuel. However, this decrease in the heat transfer coefficient would not be conservative for mass and energy (M&E) release, as it would decrease core heat removal resulting in less energy transferred into containment. Therefore, consider the uncertainties in the core heat transfer models in WC/T and provide the rationale for applying them to the containment M&E analysis.

    Westinghouse Response: Heat transfer uncertainties are not applied in the WC/T ECCS Evaluation Model. They are applied in the HOTSPOT code, which is a one-dimensional conduction model that uses WC/T calculated fluid conditions as boundary conditions.

    The WC/T ECCS evaluation model uses a standard set of heat transfer correlations (McAdams, Dittus-Boelter, and Chen) to calculate the heat transfer to the RCS from the fuel, RCS metal, SG fluid (through the tubes), and SG metal (to the fluid).The correlations were assessed for a large number of separate and integral tests over a large range of scale and were found to be acceptable for calculating the heat transfer during the LOCA event.

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The uncertainty in the core heat transfer correlations has not been considered for the new WC/T LOCA M&E calculation. Likewise, the uncertainty in the core heat transfer correlations is not considered in the currently approved LOCA mass and energy release methodology.

26. Provide justification of the break flow model in WC/T, with respect to its 20 percent uncertainty. Address the guidance provided in SRP 6.2.1.3, "Mass release rates should be calculated using a model that has been demonstrated to be conservative by comparison to experimental data."

    Westinghouse Response: The TRAC PF1 break flow correlation is programmed into WC/T (see Section 4-8 of the CQD, WCAP-12945-P-A). The WC/T break flow model predictions of the Marviken critical flow data are presented in Section 25-2 of the CQD. The resulting cumulative distribution function is shown in Figure 25-2-10. The 50th percentile value of measured/predicted break flow is about 1.0. Over 90% of the comparisons are within +/- 15%.

    The measured-to-predicted break flow is higher for small values of L/D (<1), but decreases as L/D increases. Most of the uncertainty occurs in the transition from subcooled to saturated flow conditions, which occurs early in the event (see Section 16-4 of the CQD, WCAP-12945-P-A). The L/D for a large double ended pipe break located near the vessel is greater than 1.5. Therefore, for these types of breaks, the TRAC PF1 break flow correlation will slightly over-predict the break flow.

    The WC/T calculated DEHL and DEPS LOCA M&E releases were compared with those calculated using the approved SATAN LOCA M&E model and were found to be very close over the blowdown period. The SATAN break flow correlations were compared with data from other test facilities and were found to over-predict the data (see WCAP-8264).

27. What sensitivity studies were performed to justify the level of detail necessary to adequately model the steam generator? Address both the FLECHT-SEASET model and the PWR model. Is the PWR model expected to be sensitive to the steam generator design, for example the tube design, or pre-heated sensors? If so, please describe the process to be used for other steam generator designs.

    Westinghouse Response: [

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    The WC/T code was revised to improve the calculation of the SG tube quenching process. A standalone SG model was built to compare the revised WC/T code results with the FLECHT test data. A SG noding study was performed using the standalone FLECHT SG model and convergence was obtained when the SG was modeled with [ ]^{a,c} cells in the primary and [ ]^{a,c} cells in the secondary.

    The SG noding in the WC/T LOCA M&E plant model was increased to be similar to the noding structure used for the FLECHT model. The primary side was modeled with [ ]^{a,c} cells and the secondary side was modeled with [ ]^{a,c} cells.

    [

    ]^{a,c}

21

28. Does Westinghouse plan to use the revised steam generator interface mass/heat transfer exchange package for other accident analyses to be used to support licensing actions? Are there plans to incorporate the model into other computer programs for use in supporting licensing actions?

    Westinghouse Response: No, Westinghouse does not plan on incorporating the revised steam generator interface heat and mass transfer model into other computer programs.

APPENDIX A : NRC RAIS AND WESTINGHOUSE RESPONSES – WCAP-17721

The NRC RAIs for the WCAP-17721-P-A/WCAP-17721-NP-A submittal were supplied to Westinghouse via References 30-32. The following pages contain the RAI text along with the accepted Westinghouse responses. Note that the RAI responses are presented in the order in which they were answered, not in the order they were received.

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LTR-NRC-14-64

September 25, 2014

References:
1. WCAP-17721-P, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology," April 2013.
2. U.S. Nuclear Regulatory Commission [NRC] Request for Additional Information [RAI] Ragrding (sic) the review of the Westinghouse Electric Company [Westinghouse] Topical Report [TR] WCAP-17721-P, Revision 0 and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology – PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology."

Subject: Submittal of "WCAP-17721-P NRC Confirmatory Study Inputs - Response to RAIs" (Non-Proprietary).

The purpose of this letter is to transmit responses to the Nuclear Regulatory Commission's request for additional information (RAI) [2] for a confirmatory study relative to the WCAP-17721-P [1] submittal.

The responses are presented in Attachment 1, and they contain no proprietary information.

Correspondence concerning this submittal should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Attachment 1: "WCAP-17721-P NRC Confirmatory Study Inputs - Response to RAIs"

bcc: James A. Gresham
Cheryl Robinson
Christopher P. Logan
Anne M. Stegman

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WCAP-17721-P NRC Confirmatory Study Inputs - Response to RAIs

Attachment 1: Westinghouse Responses

Introduction

Per the clarification call, the information presented below is limited to the large dry 4 loop WCOBRA/TRAC (WCT) and coupled GOTHIC model presented in WCAP-17721-P [1] and WCAP-17721-NP [2].

RAI # 1

NRC - Specify if the broken loop safety injection water goes directly to the sump pool, or mixes with the containment atmosphere and condenses vapor. If it mixes provide details on the mixing such as what percentage mixes and the basis for that value.

Westinghouse Response - The liquid effluent which exits the pump side break location does not mix with the containment atmosphere and condense vapor. The containment code (GOTHIC in this case) transports liquid break flow directly to the sump.

RAI # 2

NRC - The initial SI (RWST) and accumulator water temperature. (2 values)

Westinghouse Response – The initial safety injection temperature, supplied by the refueling water storage tank, was 120°F. The initial accumulator water temperature was 130°F.

RAI # 3

NRC - Specify the water volume held in the RWST at the beginning of the event. (1 value)

Westinghouse Response – Per the clarification call, Westinghouse understands that the RWST water volume was requested to determine when core cooling and containment spray systems switch to recirculation. Therefore, Westinghouse is supplying injection and recirculation core cooling flow rates and containment spray flow rates (see Figures 1 and 2 below) in addition to the total RWST water volume of 48710 ft^3. Safety injection recirculation is reached after 24,180 ft^3 of water has been delivered from the RWST. Containment spray recirculation is reached after 43,710 ft^3 of water has been delivered from the RWST.

Attachment 1: Westinghouse Responses

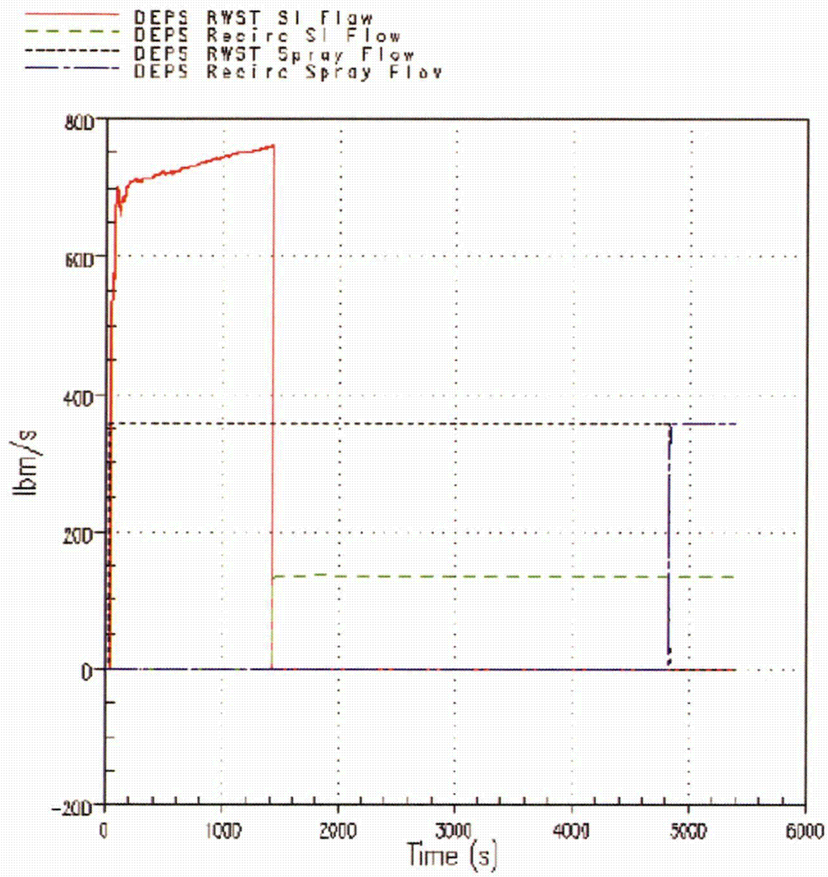

Figure 1: DEPS SI and Containment Spray – Injection and Recirculation

Attachment 1: Westinghouse Responses

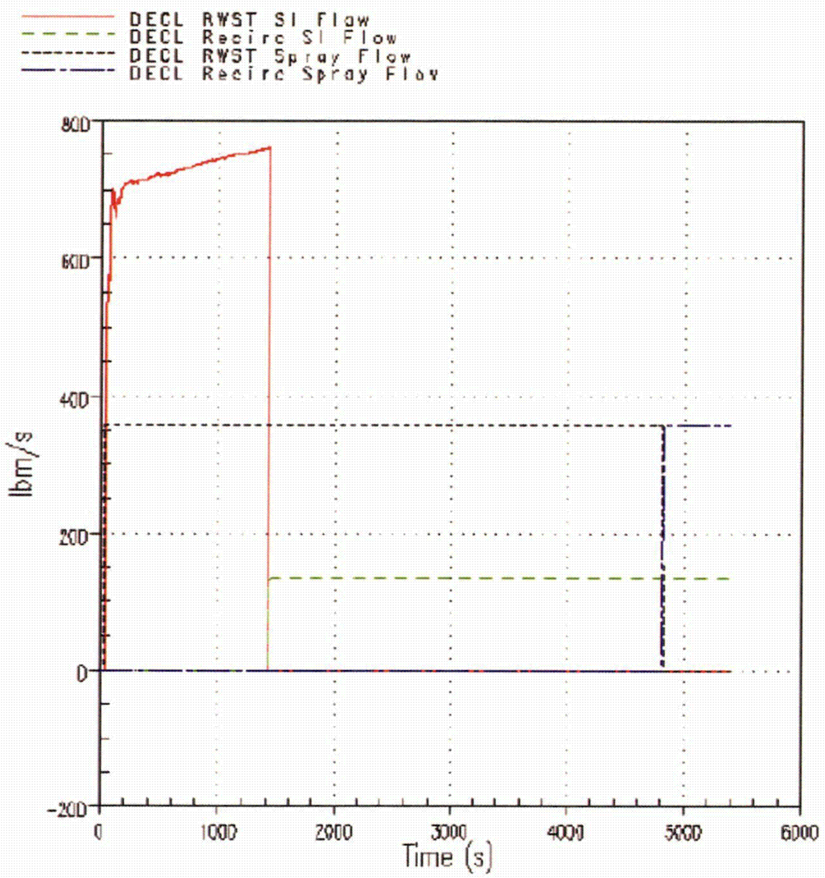

Figure 2: DECL SI and Containment Spray – Injection and Recirculation

Attachment 1: Westinghouse Responses

RAI # 4

NRC - During switchover, is any period of no injection assumed? If so, how long is that period of no injection?

Westinghouse Response – Core cooling flow and containment spray flow were uninterrupted during the switchover process. There was not a period of time without core cooling flow or containment spray flow.

RAI #5

NRC - Provide plots of the liquid and vapor mass flow rates and liquid and vapor temperatures from both sides of the break as a function of time. (8 plots)

Westinghouse Response – Figures 3 through 12 below provides the requested information from the WCOBRA/TRAC transient.

Attachment 1: Westinghouse Responses

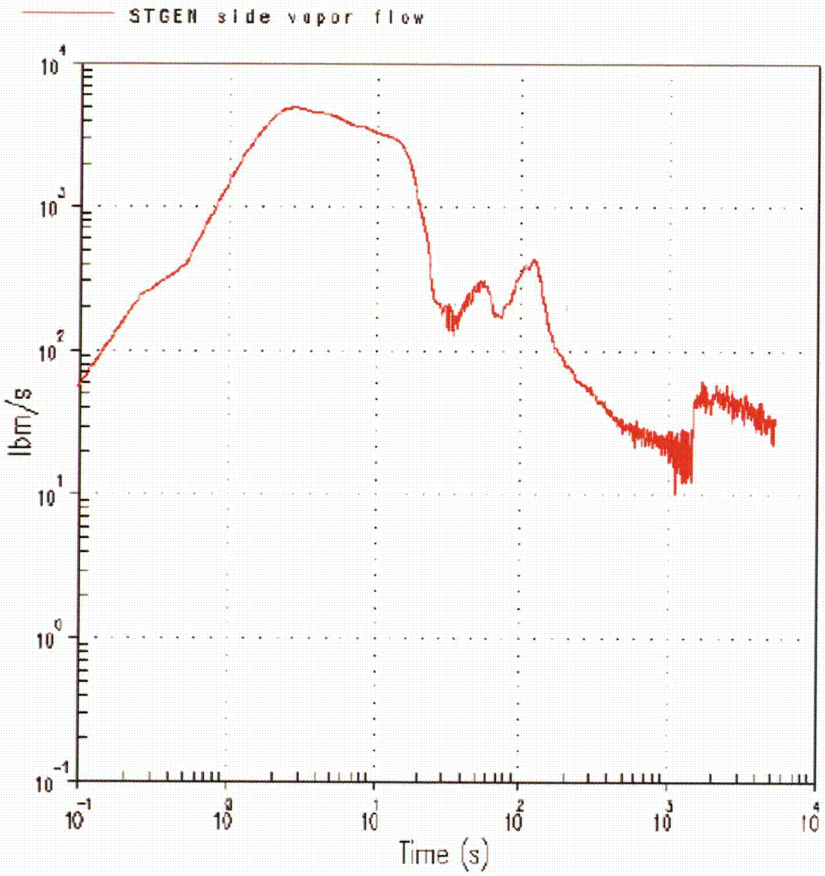

Figure 3: DEPS Break SG side Vapor Flow

Attachment 1: Westinghouse Responses

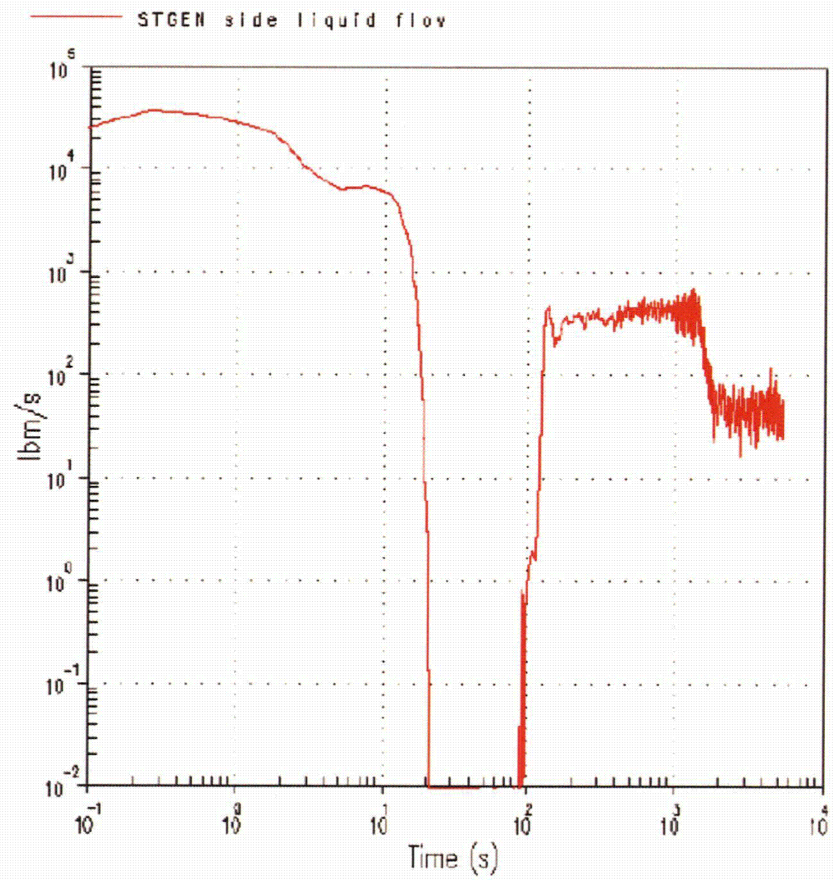

Figure 4: DEPS Break SG Side Liquid Flow

Attachment 1: Westinghouse Responses

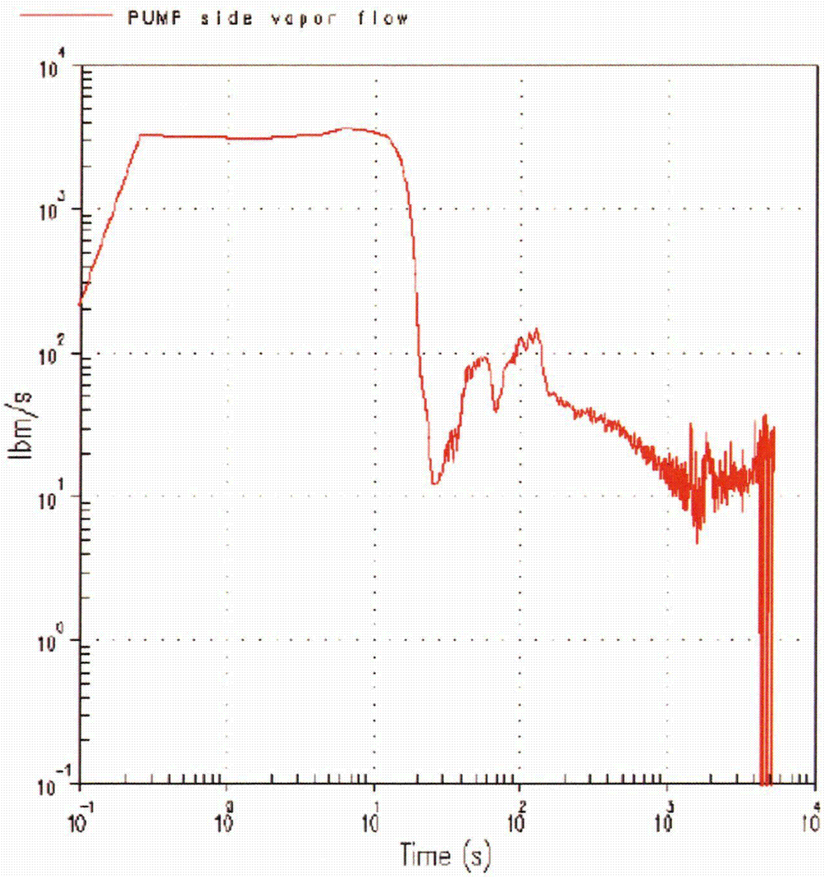

Figure 5: DEPS Break Pump Side Vapor Flow

Attachment 1: Westinghouse Responses

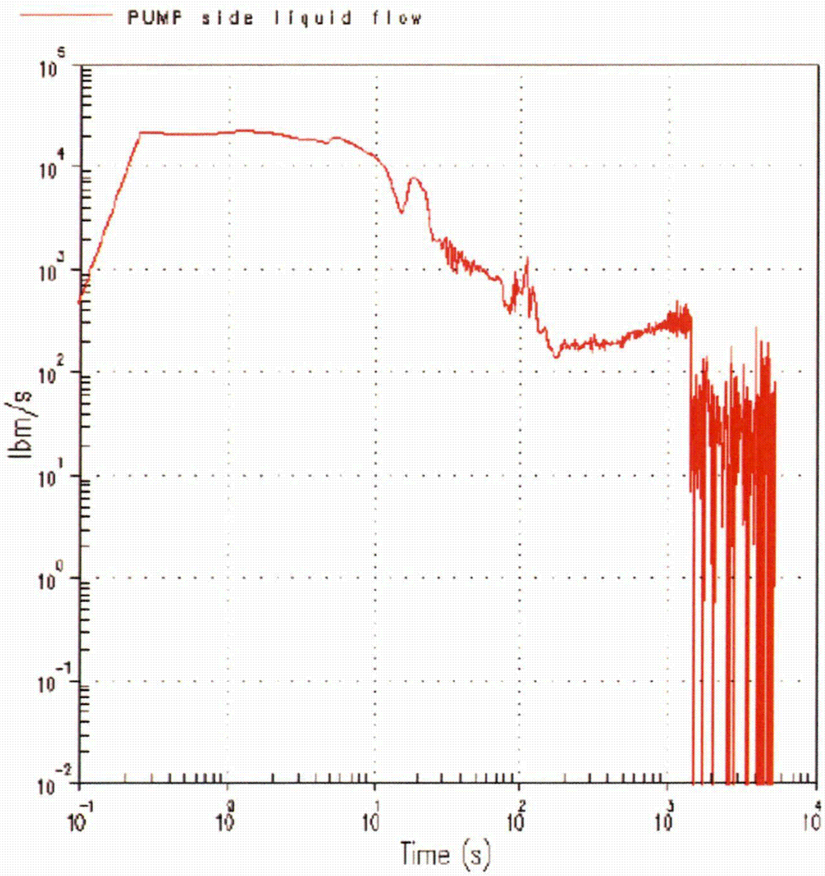

Figure 6: DEPS Break Pump Side Liquid Flow

Attachment 1: Westinghouse Responses

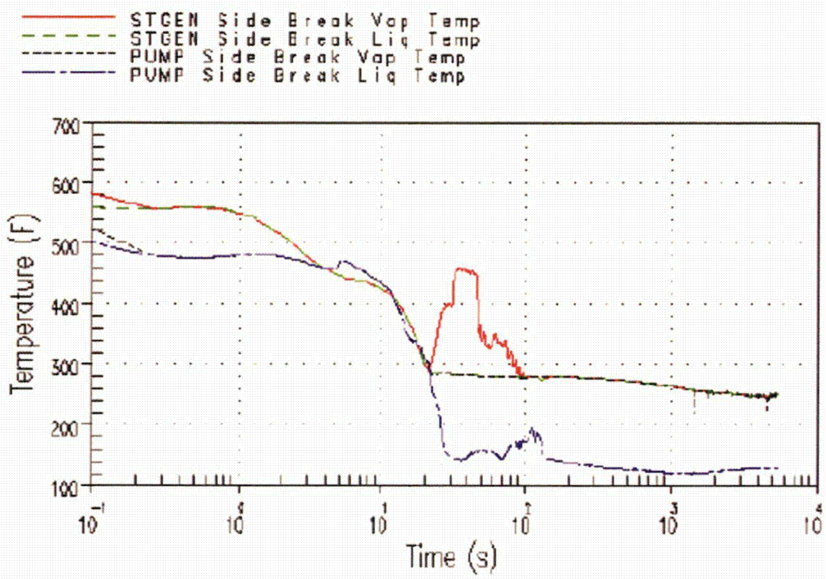

Figure 7: DEPS Break Vapor and Liquid Temperatures

Attachment 1: Westinghouse Responses

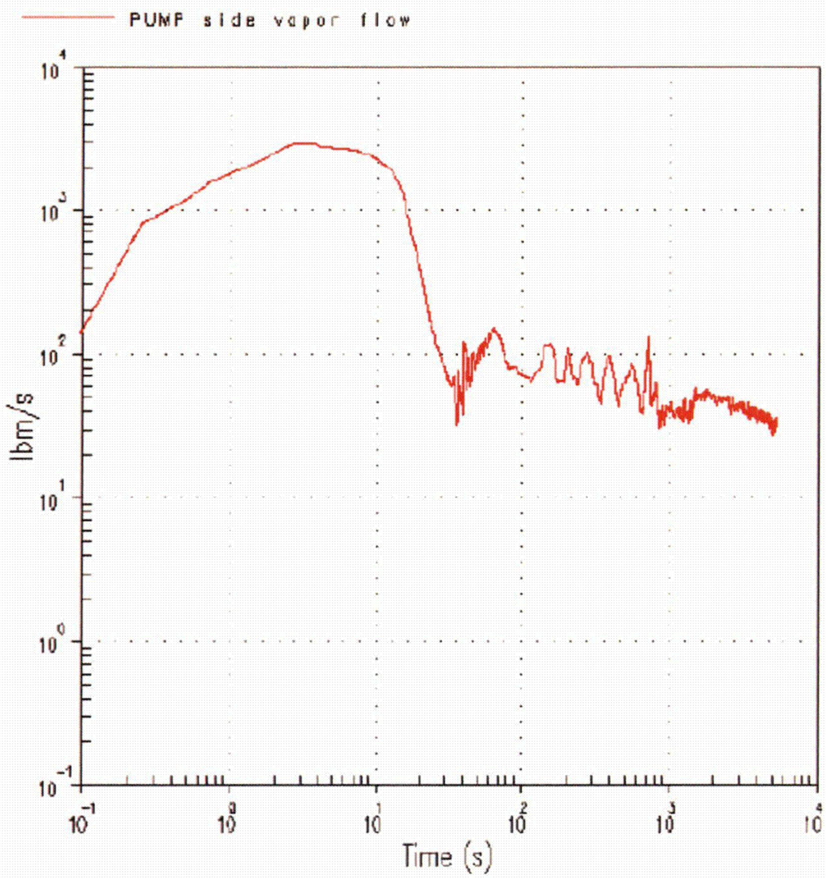

Figure 8: DECL Break Pump Side Vapor Flow

Attachment 1: Westinghouse Responses

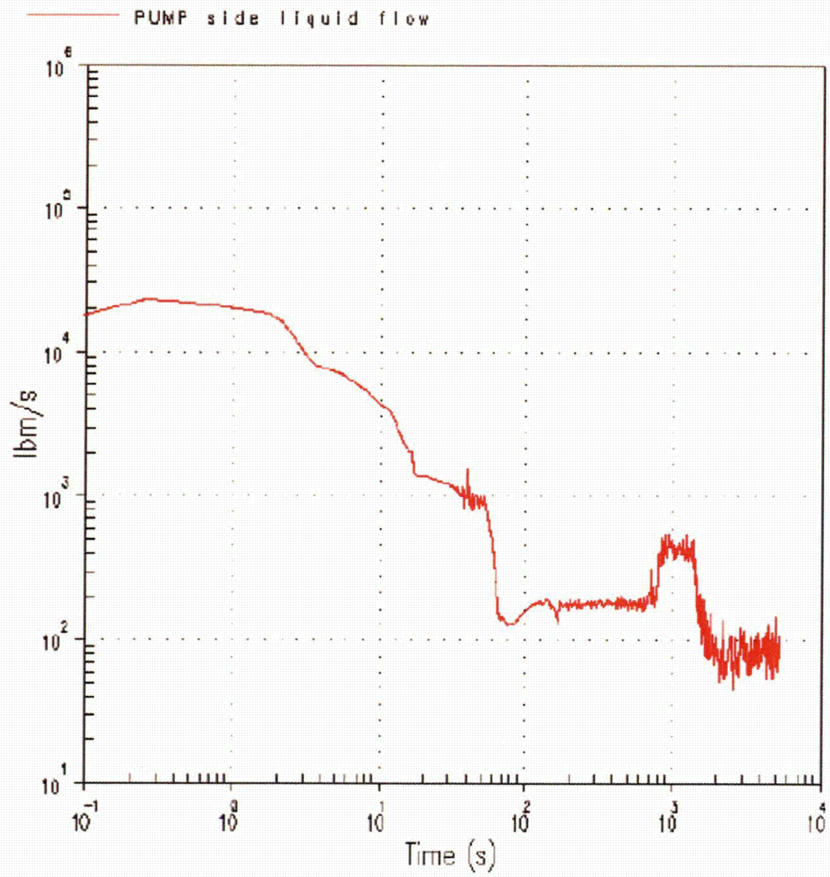

Figure 9: DECL Break Pump Side Liquid Flow

Attachment 1: Westinghouse Responses

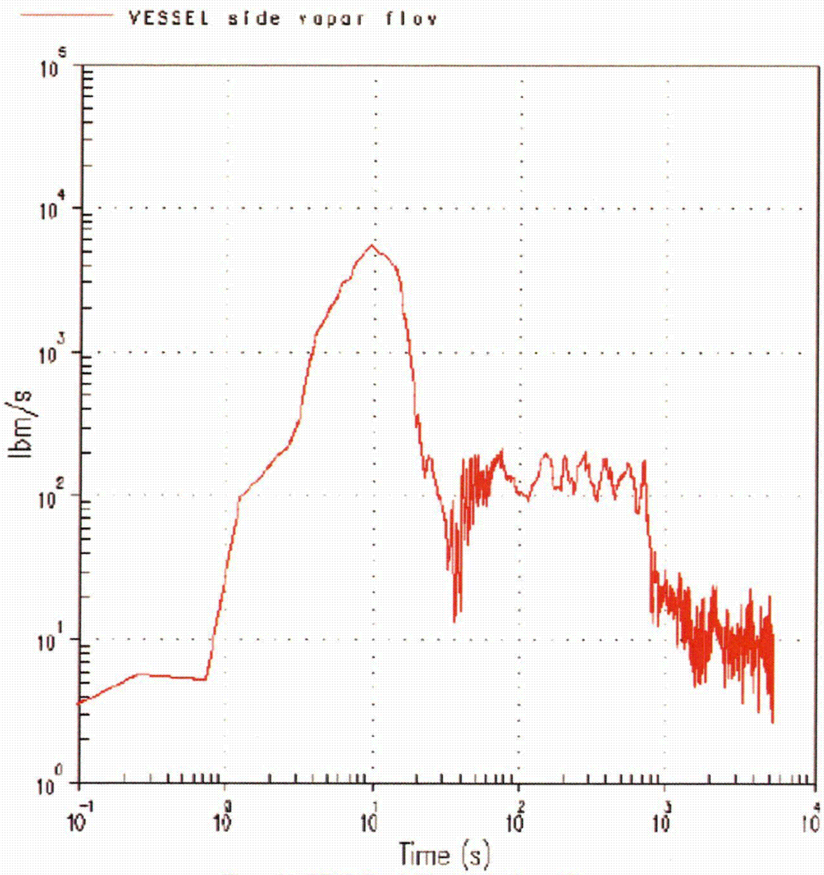

Figure 10: DECL Break Vessel Side Vapor Flow

Attachment 1: Westinghouse Responses

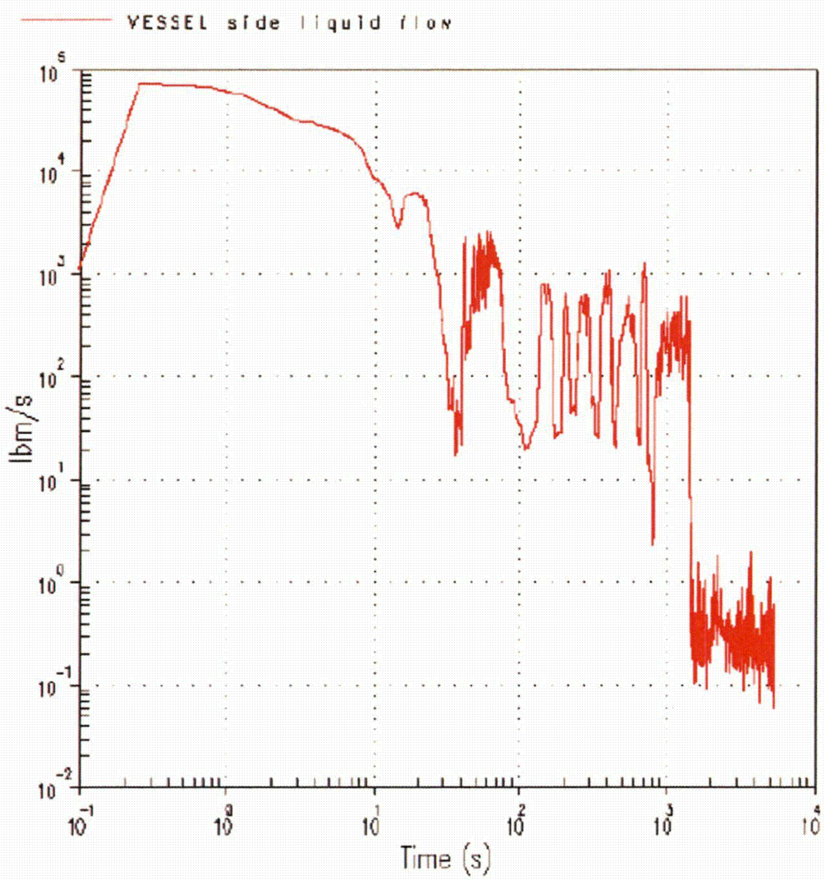

Figure 11: DECL Break Vessel Side Liquid Flow

Attachment 1: Westinghouse Responses

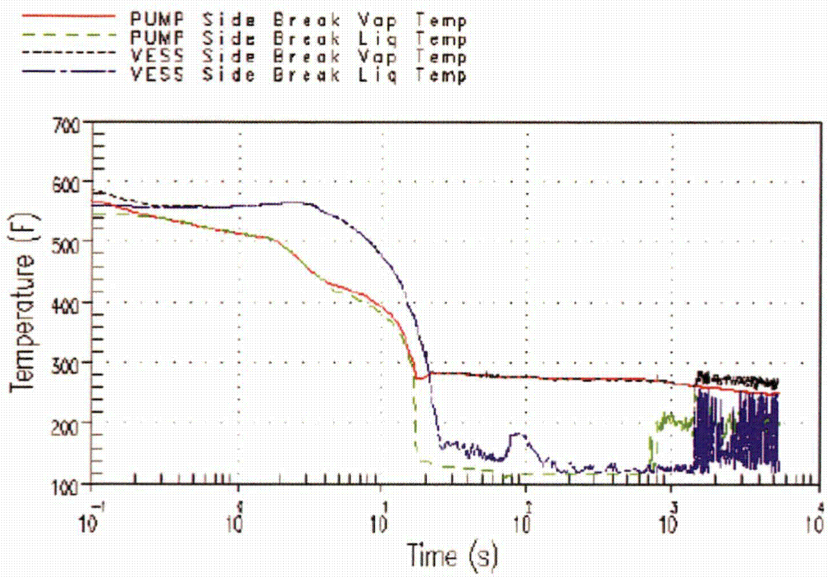

Figure 12: DECL Break Vapor and Liquid Temperatures

Attachment 1: Westinghouse Responses

RAI #6
NRC - Provide a plot of the Steam Generator (SG) tube heat transfer power to the primary system for the broken and intact loops, include decay heat. (5 plots)

Westinghouse Response – Figures 13 through 20 provide the requested information. Note that all 4 steam generators are explicitly modeled in WCOBRA/TRAC, and the heat transfer from the intact loop is the sum of the 3 intact loop steam generator heat transfer rates.

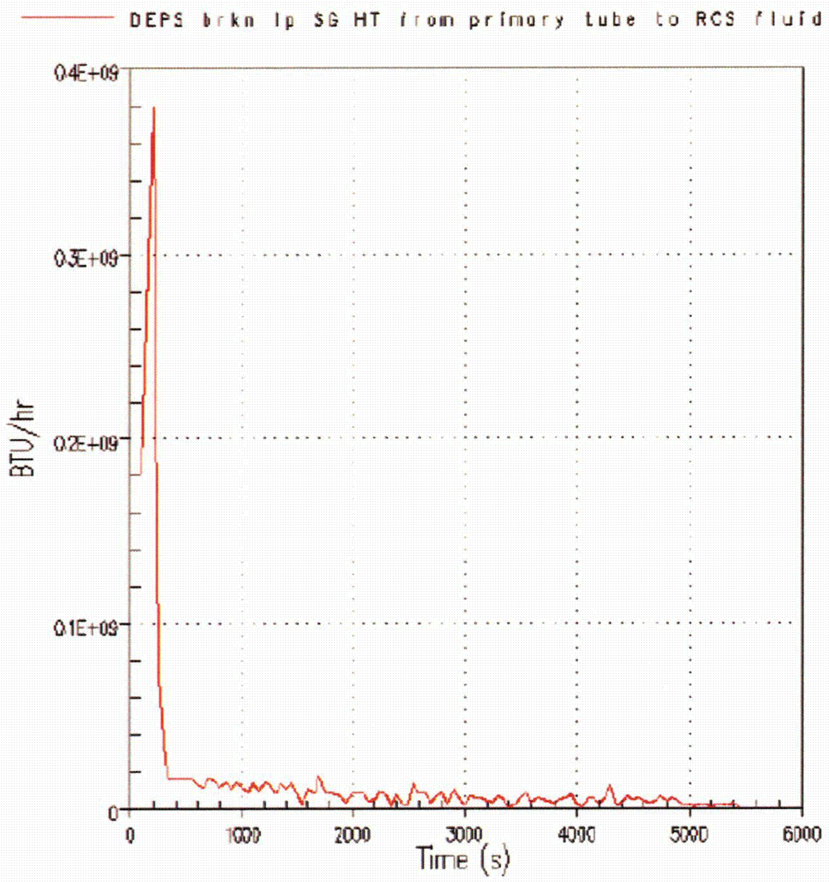

Figure 13: DEPS Break Broken Loop SG Heat Transferred from Primary Tube Surface to Fluid

Attachment 1: Westinghouse Responses

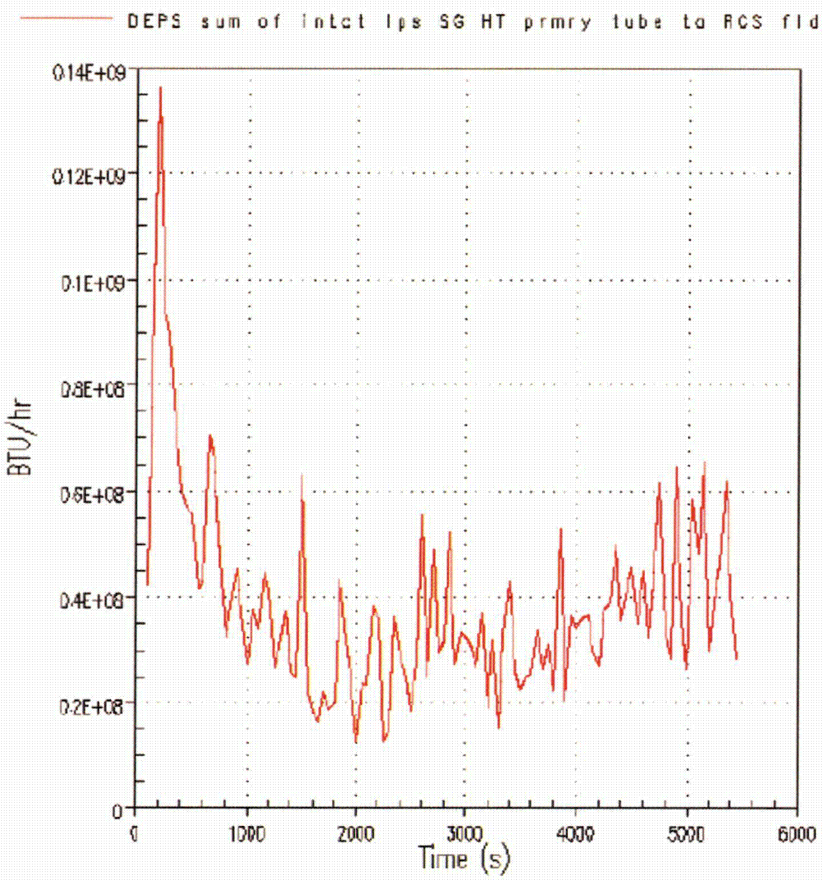

Figure 14: DEPS Break Intact Loop SG Heat Transferred from Primary Tube Surface to Fluid

Attachment 1: Westinghouse Responses

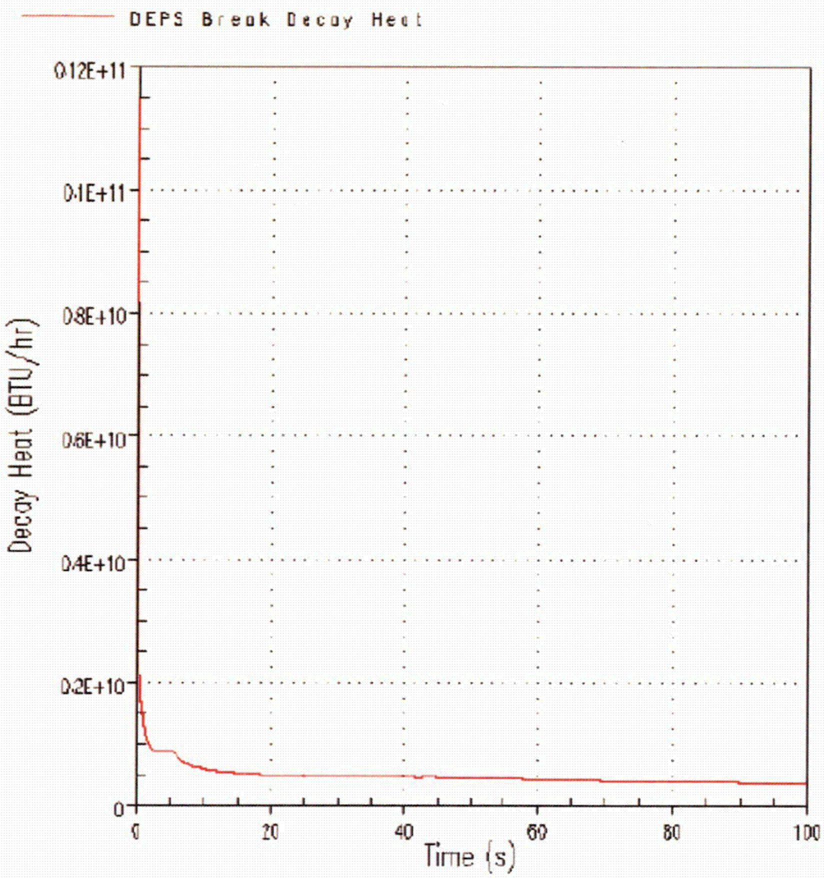

Figure 15: DEPS Break Decay Heat – Blowdown

Attachment 1: Westinghouse Responses

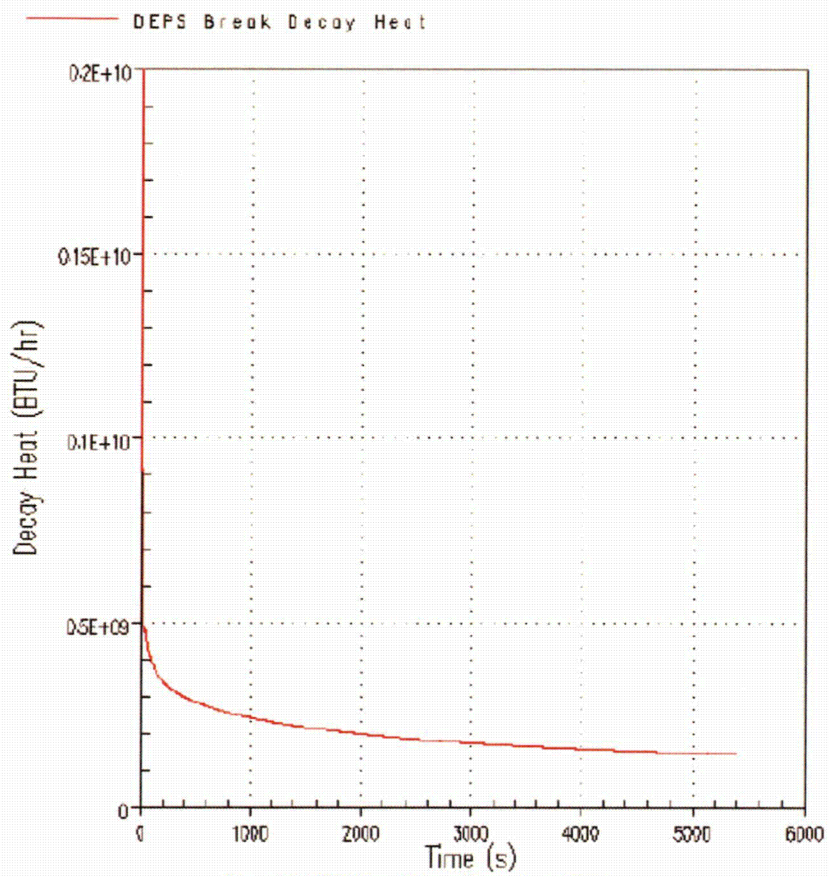

Figure 16: DEPS Break Decay Heat – Long Term

Attachment 1: Westinghouse Responses

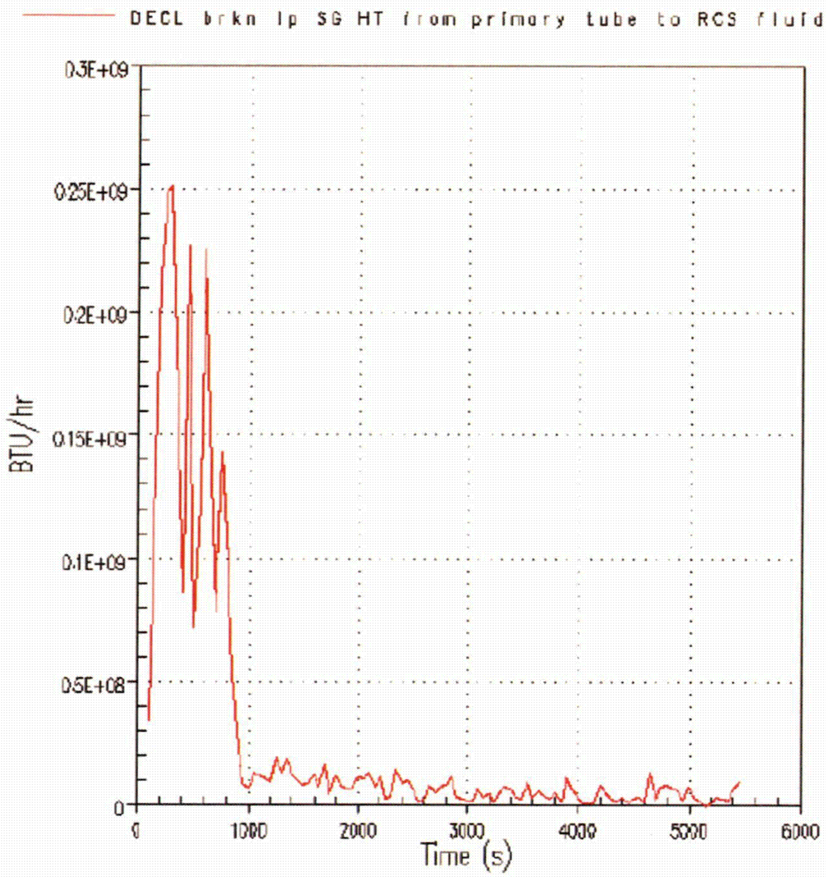

Figure 17: DECL Break Broken Loop SG Heat Transferred from Primary Tube Surface to Fluid

Attachment 1: Westinghouse Responses

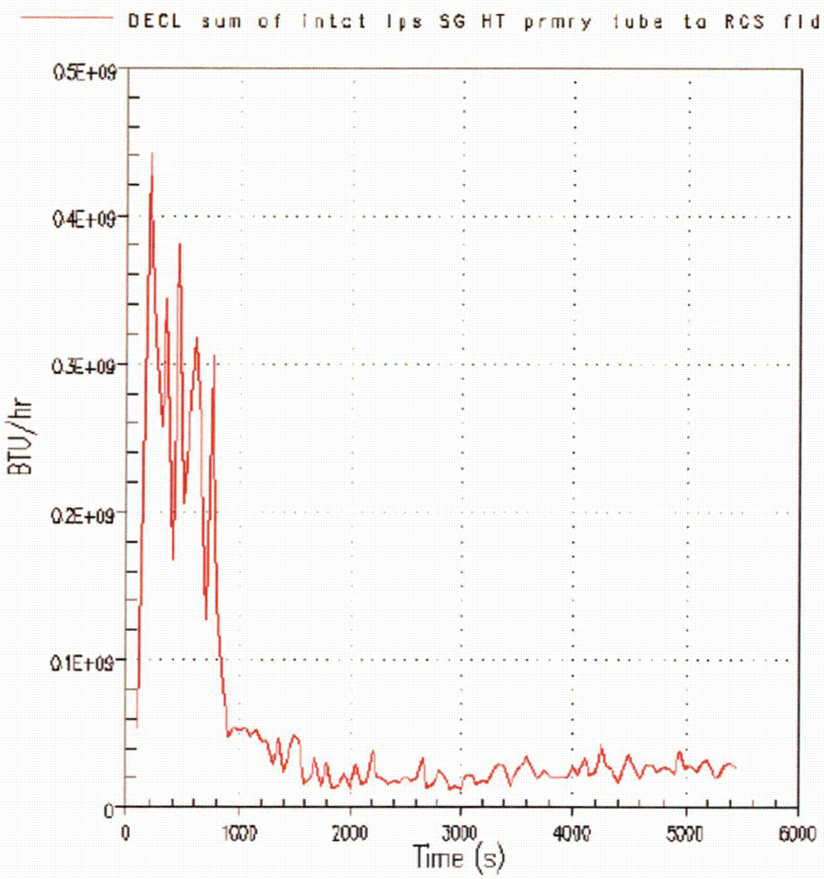

Figure 18: DECL Break Intact Loop SG Heat Transferred from Primary Tube Surface to Fluid

Attachment 1: Westinghouse Responses

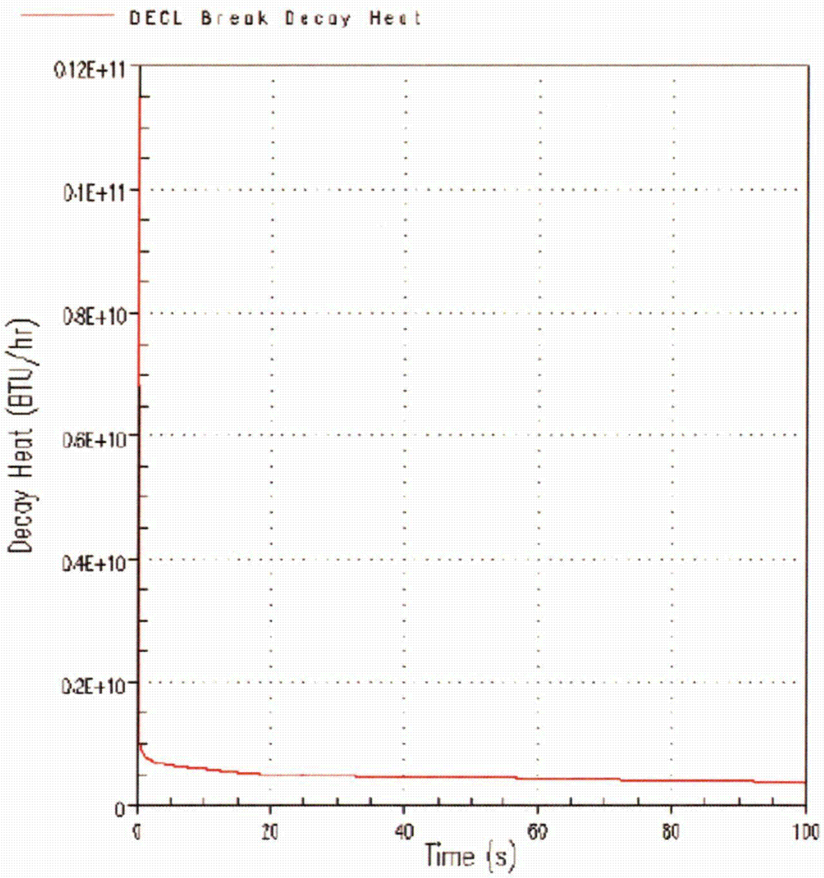

Figure 19: DECL Break Decay Heat – Blowdown

Attachment 1: Westinghouse Responses

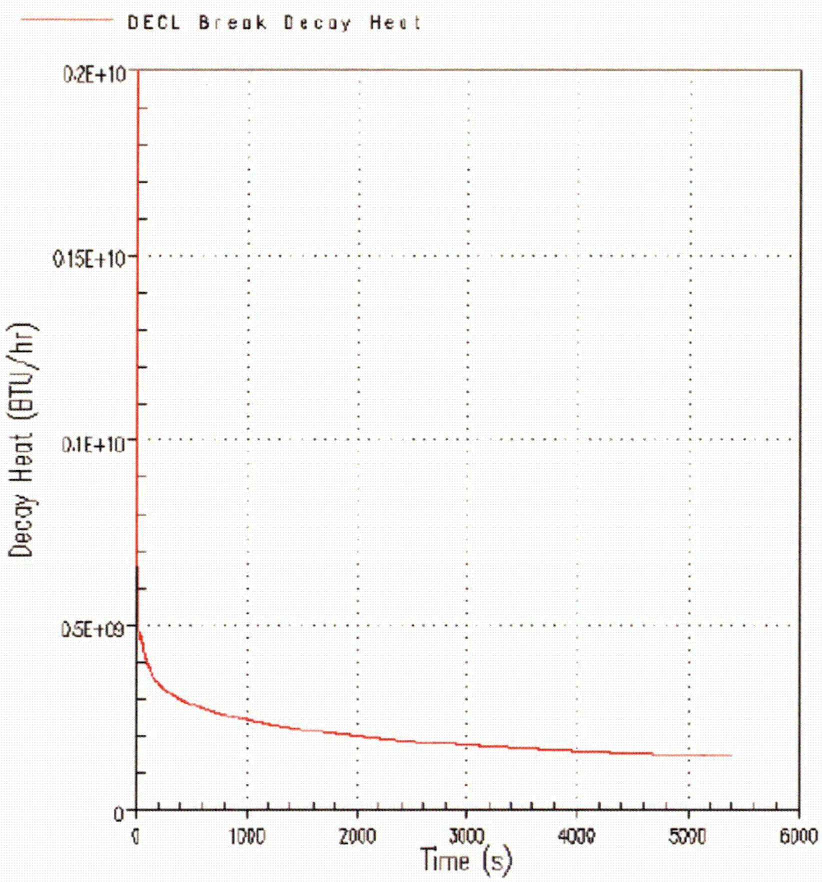

Figure 20: DECL Break Decay Heat – Long Term

Attachment 1: Westinghouse Responses

RAI #7

NRC - Provide plots of the SG pressure for the broken and intact loops. (4 plots)

Westinghouse Response – Figure 21 and Figure 22 below show the steam generator secondary side pressure history for the DEPS and DECL breaks. The pressure was taken from the uppermost steam generator secondary side node.

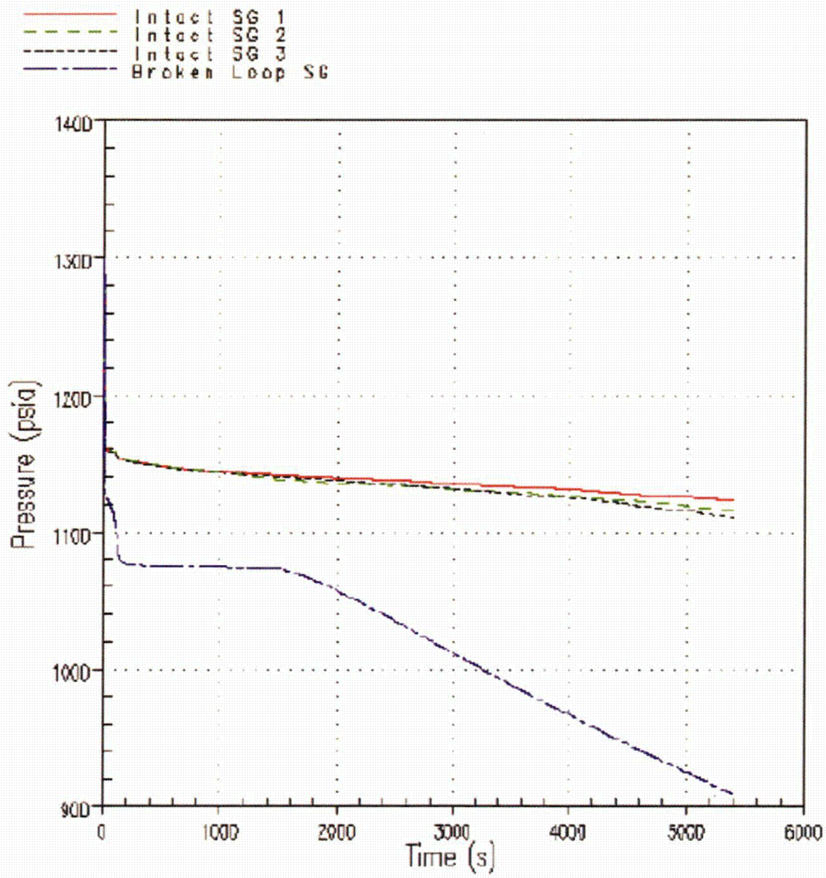

Figure 21: DEPS Break Steam Generator Pressure

Attachment 1: Westinghouse Responses

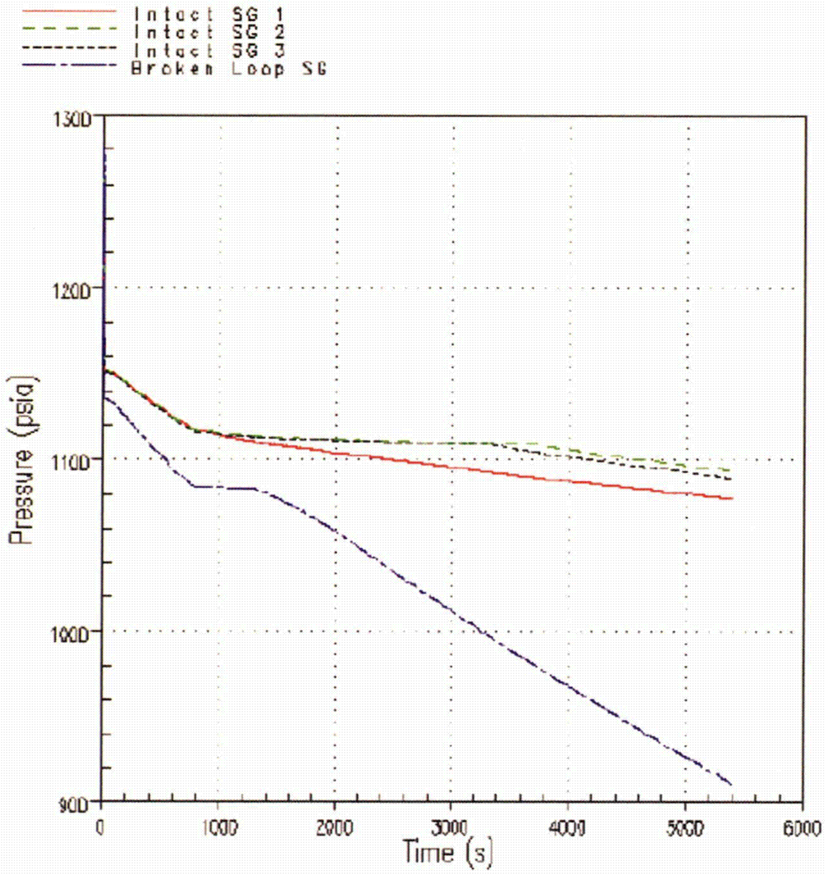

Figure 22: DECL Break Steam Generator Pressure

Attachment 1: Westinghouse Responses

RAI #8

NRC - Provide plots of the SG wall temperatures at 1, 4 and 10 foot elevations for the broken and intact loops as a function of time. (12 plots)

Westinghouse Response – Figures 23 through 30 below provide the SG shell wall temperatures at the requested elevations. The temperatures presented are from the innermost node of the SG shell.

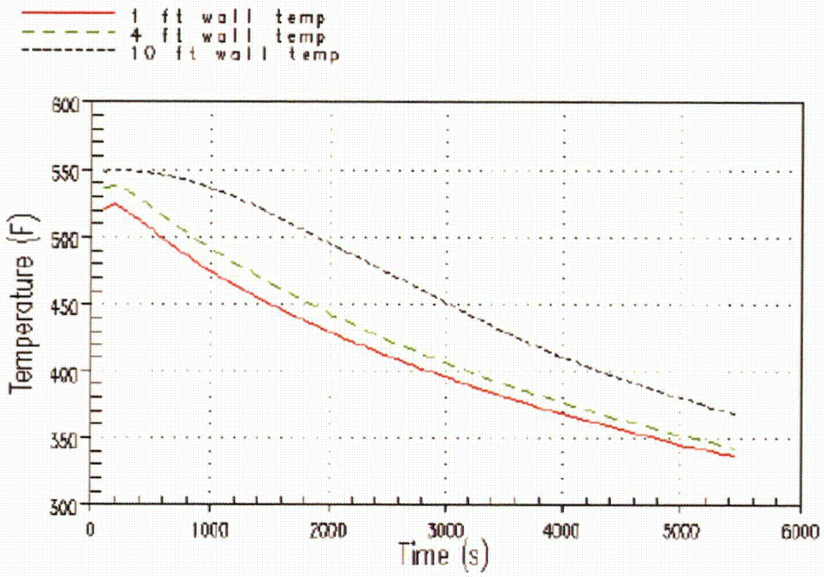

Figure 23: DEPS Break Intact SG 1 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

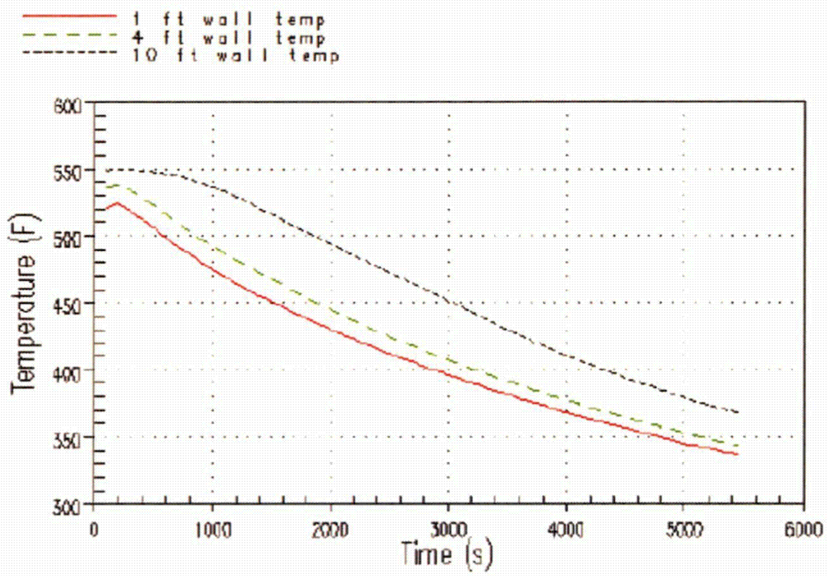

Figure 24: DEPS Break Intact SG 2 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

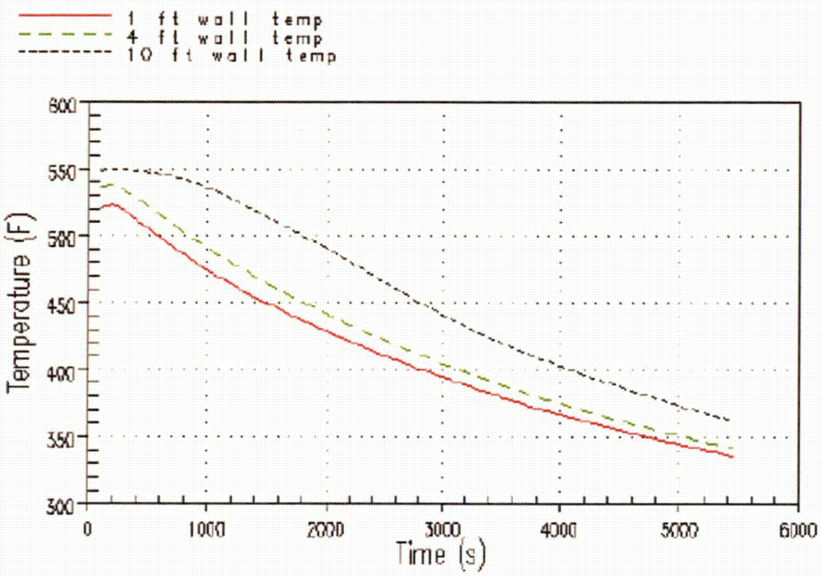

Figure 25: DEPS Break Intact SG 3 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

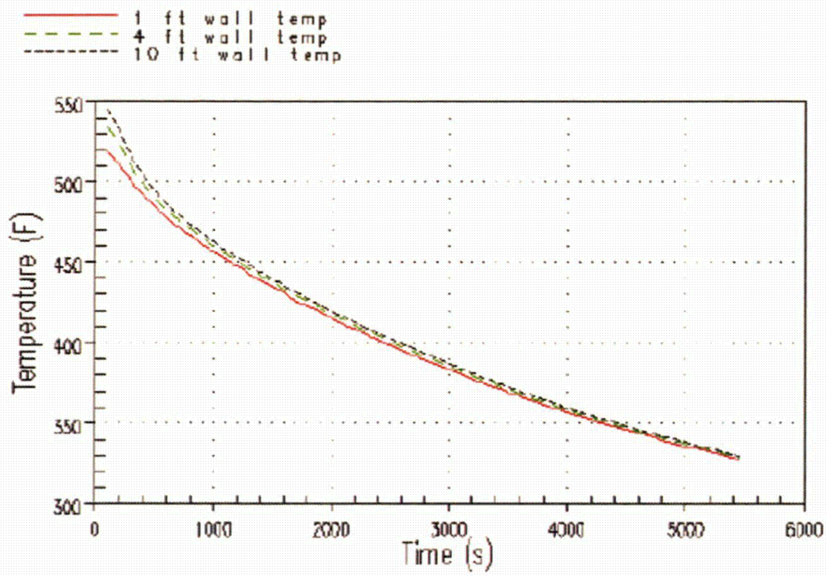

Figure 26: DEPS Break Broken Loop SG Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

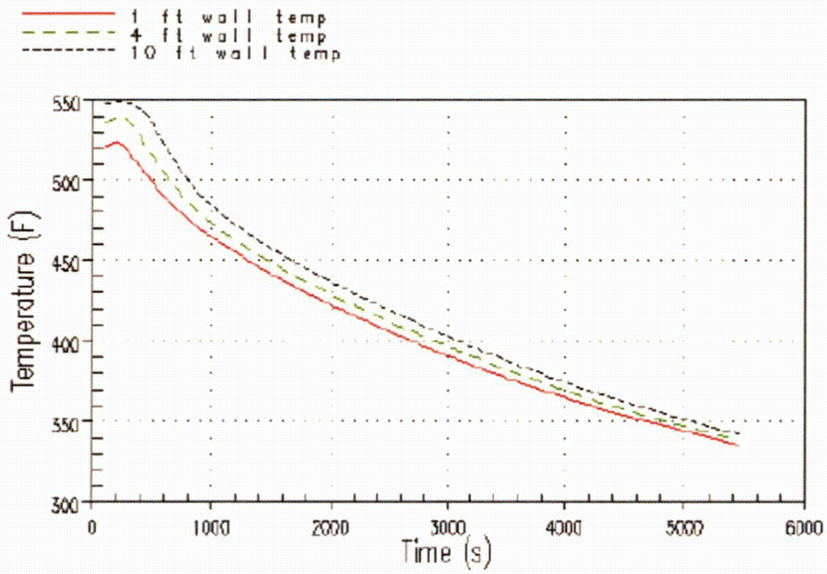

Figure 27: DECL Break Intact SG 1 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

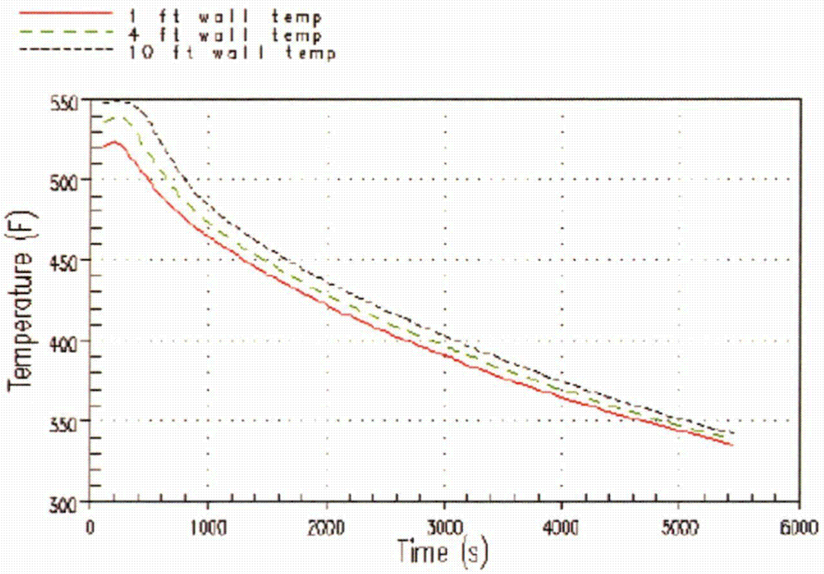

Figure 28: DECL Break Intact SG 2 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

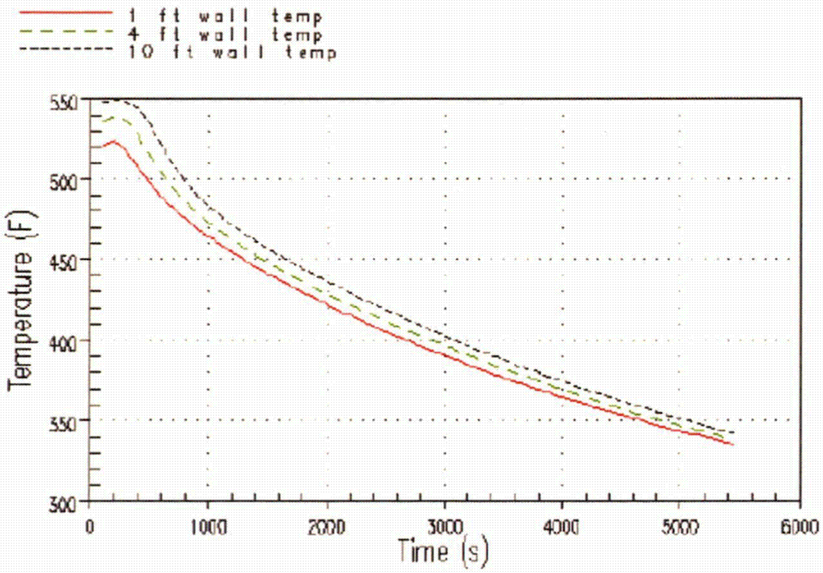

Figure 29: DECL Break Intact SG 3 Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

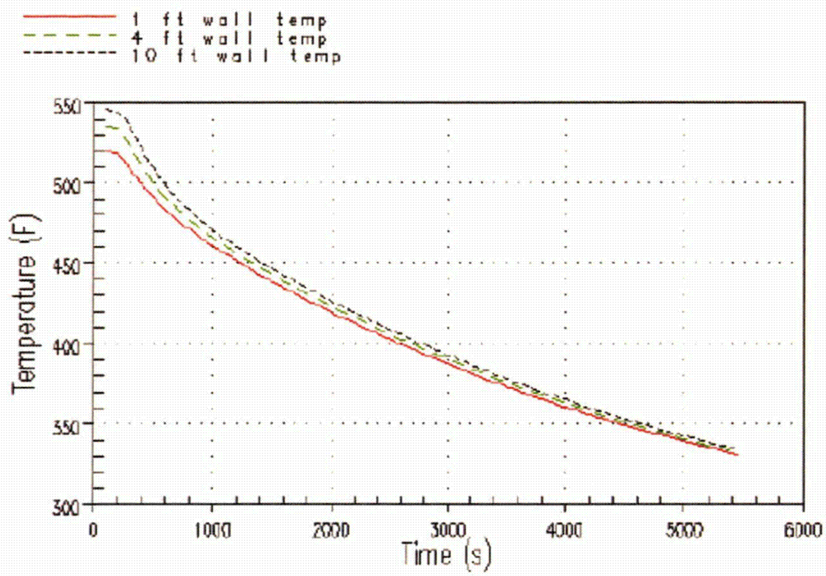

Figure 30: DECL Break Broken Loop SG Secondary Side Wall Temperatures

Attachment 1: Westinghouse Responses

References

1) WCAP-17721-P, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology," April 2013.
2) WCAP-17721-NP, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology," April 2013.

Westinghouse

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LTR-NRC-15-5

January 22, 2015

Subject: Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs" (Proprietary/Non-Proprietary).

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4080 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4080 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
Dr. Shie-Jeng Peng (NRC)

LTR-NRC-15-5
Page 2 of 2

bcc: James A. Gresham
Cheryl Robinson
Anne M. Stegman

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AW-15-4080

January 22, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-5 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-5, dated January 22, 2015

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-15-4080 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the accompanying Affidavit should reference AW-15-4080 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

AW-15-4080
January 22, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

James A. Gresham, Manager
Regulatory Compliance

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

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse 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 2.390 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 constitute Westinghouse policy and provide 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.

(iii) 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 that 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.

(vi) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-15-5 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-15-5, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721-P, and may be used only for that purpose.

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

(i) Obtain NRC approval of the LOCA Mass and Energy Release Calculation Methodology documented in WCAP-17721-P, "Westinghouse

Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of assisting customers in obtaining license changes for a Westinghouse pressurized water reactor (PWR).

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

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 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

WESTINGHOUSE NON-PROPRIETARY CLASS 3

LTR-NRC-15-5 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs (Non-Proprietary)

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066

The table below summarizes the Set 2 RAIs from the Safety and Code Review Branch[1] which have responses included in this attachment.

RAI #	Title
2.1	RAI-3 – Downcomer stored energy release
2.3	RAI-3 – Break flow model
2.5	RAI-3 - Core Flooding
2.6	RAI-3 - Liquid Entrainment
2.7	RAI-3 - Upper Plenum Entrainment
2.8	RAI-2 – Hot leg entrainment
2.9	RAI-3 – Steam Quenching
2.20	RAI-3 - Col Leg/Accumulator Condensation
2.21	RAI-3 - Downcomer Condensation
2.22	RAI-3 - Loop Flow Split

Note: These Set 2 RAIs are addressed by reference to the response to Set 3 RAI SCVB-RAI-11.

The table below summarizes the Set 3 RAIs from the Containment and Ventilation Branch[2] which have responses included in this attachment.

RAI #	Title
SCVB-RAI-1	Methodology on Modeling Containment Condition
SCVB-RAI-2	Direct Vessel Injection and ADS-4 Operation
SCVB-RAI-5	GOTHIC Topical Report
SCVB-RAI-6	GOTHIC Running In Parallel With WCOBRA/TRAC
SCVB-RAI-7	24-hr Containment Pressure
SCVB-RAI-8	24-hr Integrated Mass and Energy Release via Break
SCVB-RAI-9	Conservatism of Calculated Containment Pressure Peak
SCVB-RAI-10	Limitation of Containment Modeling for WCAP-17721 Methodology
SCVB-RAI-11	Conformance of Regulatory Guide (RG) 1.203, "Transient and Accident Analysis Methods"

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A251)

[2] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology" - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260)

2.1 RAI-3 – Downcomer stored energy release

RAI:Demonstrate that the method for modeling the downcomer stored energy release in WCOBAR(sic)/TRAC) (WC/T) is appropriate for the Mass and Energy (M&E) evaluation model such that the mass and energy release is adequately predicted.

Comment:In section 2.11 of their initial submittal, Westinghouse stated that the same downcomer stored energy release model was used for the emergency core cooler system evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of peak cladding temperature. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

<u>Westinghouse Response</u>

See the response to Set 3 RAI SCVB-RAI-11.

2.3 RAI-3 – Break flow model

RAI:Demonstrate that break flow model used in WC/T provides an appropriate prediction of the break flow for the M&E evaluation model such that the mass and energy release is adequately predicted.

Comment:In table 4-1, row 12 of their initial submittal [1], Westinghouse stated that the same break flow model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

<u>Westinghouse Response</u>

See the response to Set 3 RAI SCVB-RAI-11.

2.5 RAI-3 – Core flooding

RAI:Describe the validation data which supports WC/T ability to model the core flooding rate and demonstrate that this data justifies WC/T ability to predict the Reactor Coolant System (RCS) transient response for the M&E evaluation model.

Comment:In table 4-1 row 16 of their initial submittal [1], Westinghouse stated ECCS evaluation model had been validated for the core flooding rate by comparison with experimental data. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.6 RAI-3 – Liquid Entrainment

RAI:Describe the validation data which supports WC/T ability to model liquid entrainment and demonstrate that this data justifies WC/T ability to predict the RCS transient response for the M&E evaluation model.

Comment:In table 4-1 row 16 of their initial submittal [1], Westinghouse stated ECCS evaluation model had been validated for liquid entrainment by comparison with experimental data. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.7 RAI-3 – Upper plenum entrainment

RAI:Demonstrate that method for modeling the upper plenum entrainment/de-entrainment and condensation in WC/T is appropriate for the M&E evaluation model such that the mass and energy release is adequately predicted.

Comment:In section 2.5 of their initial submittal [1], Westinghouse stated that the same upper plenum entrainment/de-entrainment and condensation model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.8 RAI-2 – Hot leg entrainment

RAI:The justification for the hot leg entrainment/de-entrainment being independent of the pressure seems to suggest that all entrainment/de-entrainment modeling is independent of the final pressure calculation as the RCS steam temperatures will match those on the secondary side within minutes after event initiation. However, this concept seems to be in contradiction with the M&E Phenomena Identification and Ranking Table (PIRT) which has entrainment and de-entrainment as high ranked phenomena as well as the other changes to the M&E model to better model the heat transfer from the secondary side to the primary side in the steam generators. Provide further clarification on this topic.

Comment:In section 2.7 of their initial submittal [1], Westinghouse stated that the sensitivity study performed which varied the slip in the hot leg demonstrated that the mass and energy release (i.e., peak pressure) was relatively insensitive to the hot leg entrainment/de-entrainment. This was verified through a sensitivity which varied the slip ratio in the hot leg.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.9 RAI-3 – Steam Quenching

RAI:Describe the validation data which supports WC/T ability to model steam quenching and demonstrate that this data justifies WC/T ability to predict the RCS transient response for the M&E evaluation model. Both the steam quenching during reflood and post-reflood should be considered.

Comment:In table 4-1 row 18 of their initial submittal [1], Westinghouse stated ECCS evaluation model had been validated for steam quenching by comparison with experimental data. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.20 RAI-3 – Cold leg/accumulator condensation

RAI: Describe the validation data which supports WC/T ability to model cold leg/accumulator condensation and demonstrate that this data justifies WC/T ability to predict the RCS transient response for the M&E evaluation model.

Comment:In section 2.9 of their initial submittal [1], Westinghouse stated that the same cold leg/accumulator condensation model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.21 RAI-3 – Downcomer condensation

RAI:Describe the validation data which supports WC/T ability to model downcomer condensation and demonstrate that this data justifies WC/T ability to predict the RCS transient response for the M&E evaluation model.

Comment:In section 2.10 of their initial submittal [1], Westinghouse stated that the same downcomer condensation model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

2.22 RAI-3 – Loop flow split

RAI:Describe the validation data which supports WC/T ability to model the loop flow split and demonstrate that this data justifies WC/T ability to predict the RCS transient response for the M&E evaluation model.

Comment:In section 2.13 of their initial submittal [1], Westinghouse stated that the same loop flow split modeling was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

See the response to Set 3 RAI SCVB-RAI-11.

SCVB-RAI-1: Methodology on Modeling Containment Condition

Please describe the input requirement or disposition of the containment condition. The containment condition may include the containment pressure and temperature conditions at the break locations and safety injection flow conditions during recirculation phase. Provide information about whether a containment model like the one developed with GOTHIC as shown in WCAP-17721, Revision 0, TR is required in order to provide the required containment condition. If a containment model is required, please prescribe such a requirement in WCAP-17721, Revision 0. Otherwise, please specify how the containment condition shall be input and justify its conservatism for the containment response.

Westinghouse Response

The containment pressure, recirculation start time, recirculation flow rate, and recirculation enthalpy are required as input for the WC/T LOCA M&E release calculation. All of these input values can be conservatively defined when not running the WC/T LOCA M&E model in parallel with a containment model.

Using a higher containment backpressure will [

]^{a,c}. This is consistent with the recommendation in ANS 56.4-1983.

The recirculation flow rate is calculated using a resistance model and, like the safety injection flow rate, is [ ]^{a,c}. Because the recirculation water temperature is typically higher than the injection water temperature, starting recirculation [ ]^{a,c} will increase the steam release to containment and result in a higher calculated containment pressure and temperature. Therefore, when running the WC/T LOCA M&E model in stand-alone mode, the recirculation start time is typically [ ]^{a,c}. The recirculation start time is [

]^{a,c}. The calculated recirculation water temperature output value from the containment model is used in subsequent iterations.

SCVB-RAI-2: Direct Vessel Injection and ADS-4 Operation

Provide the reason to introduce the direct vessel injection and ADS-4 operation in WCAP-17721, Revision 0, that, as described, are applicable to the passive plant design. If WCAP-17721, Revision 0, TR covers these two operations, then a complete description and justification of modeling with WCOBRA/TRAC should be provided in WCAP-17721, Revision 0. Otherwise, they should be removed from TR WCAP-17721, Revision 0.

Westinghouse Response

These two important phenomena are listed in the referenced LOCA M&E phenomena identification and ranking table document. Westinghouse feels that it is important to include them in the WCAP-17721-P Table 2-1 for completeness. The methodology that is described in WCAP-17721-P does not consider these two phenomena because they are related to the passive plant design. Instead, Sections 2.12 and 2.14 refer to another document that has not yet been submitted to the NRC for review. Therefore, to eliminate a reference to a report that has not yet been officially submitted, the last sentence in those two Sections will be revised in the final version of the topical report as follows: The LOCA M&E release calculation methodology for the passive plant design is described in a separate document that is not a part of this topical report.

SCVB-RAI-5: GOTHIC Topical Report

Section 5.2 stated that an approved GOTHIC TR was used in the proposed WCAP-17721, Revision 0, TR methodology. Please add the approved GOTHIC TR in the reference section (Section 9). In addition, specify the GOTHIC version that can be as used with COBRA/TRAC.

Westinghouse Response

WCAP-17721-P describes the PWR LOCA M&E release calculation methodology and how the WC/T code has been modified to allow it to run in parallel with the GOTHIC containment analysis code. The WC/T code can run in parallel with GOTHIC code versions that have the InterProcess Communications option; this includes GOTHIC version 7.2 and subsequent versions. Running the WC/T LOCA M&E release calculation coupled with a GOTHIC containment model is an option for utilities that use GOTHIC to calculate the containment response, but this is not a requirement for the LOCA M&E release calculation methodology.

A number of plants have amended their licensing basis to use the GOTHIC code for their containment evaluation model. Typically, this has been done as part of a power uprate submittal. The GOTHIC large dry containment model that is described in this topical report was developed following the methodology that is presented in WCAP-17152-P, which supports an extended power uprate submittal.

SCVB-RAI-6: GOTHIC Running In Parallel With WCOBRA/TRAC

Provide the methodology for the requirement of time steps, e.g. maintaining relative magnitude or ratio of time steps, used in both GOTHIC and WCOBRA/TRAC when GOTHIC is running in parallel with WCOBRA/TRAC. Provide these time steps used in both Sec. 5.3 and 6.1 cases."

<u>Westinghouse Response</u>

The time step sizes of the representative cases presented in topical report WCAP-17721-P are consistent with Westinghouse guidance for each of the respective codes. Table 1 shows the Westinghouse guidance recommendations for GOTHIC time steps for a loss-of-coolant accident (LOCA) transient. The representative GOTHIC model uses the time step data that is shown in Table 2. These time steps are more restrictive than the guidance recommends to capture all important containment response phenomena.

Table 1: Recommended Time Steps for LOCA

a,c

[

]

Table 2: GOTHIC Time Domain Data used in the Representative Case

a,c

[

]

Section 22-5 of the WC/T Code Qualification Document (CQD) (WCAP-12945-P-A Volume 4, Revision 1) describes the development of the approved time step controls and the maximum allowable time step sizes. A large number of WC/T simulations were performed for selected experimental facilities and pressurized water reactors (PWRs) to determine the sensitivity of calculated results to timestep controls and maximum allowable timestep sizes. [

]a,c The representative WC/T LOCA mass and energy release (M&E) model input follows the CQD recommendations, as shown in Table 3.

Table 3: WC/T Time Domain Data used in the Representative Case

a,c

[ ]

When WC/T and GOTHIC are coupled the codes execute in parallel with their own time steps and are synchronized through the read/write run-time files to provide to each other time-consistent information. The code with the larger time step (typically GOTHIC) waits at the end of each time step for the other code to catch-up in time to continue. Although GOTHIC typically runs with larger time steps than WC/T, the code interface logic has been constructed such that this is not a requirement, as a more complicated containment model could potentially run with very small time steps.

WCAP-17721-P does not document a requirement for setting the maximum time step size for each of the codes, because the interface was written to be able to work properly regardless of the time step size of the WC/T and GOTHIC processes.

The representative runs documented in Sections 5.3 and 6.1 use a GOTHIC maximum time step which is [ ]a,c. The first of the representative cases is a double-ended pump suction (DEPS) LOCA with minimum safety injection (SI). The time step sizes are primarily [ ]a,c for GOTHIC and WC/T, respectively. Figure 1 shows a comparison of the time steps used in WC/T and GOTHIC for the DEPS Min SI case. The double-ended cold leg (DECL) and double-ended hot leg (DEHL) runs presented in Section 6.1 of WCAP-17721-P yielded similar time step sizes for WC/T and GOTHIC. Results from these cases were presented in WCAP-17721-P.

In order to demonstrate the null-effect of reducing the GOTHIC maximum timestep size, the DEPS Min SI case was run again with a GOTHIC maximum time step size of [ ]a,c, consistent with the maximum WC/T time step size. Figure 2 compares the GOTHIC and WC/T time step sizes from this sensitivity case.

a,c

Figure 1: Comparison of WC/T and GOTHIC Time Step Size from the Representative DEPS LOCA Case Presented in WCAP-17721-P

a,c

Figure 2: Comparison of WC/T and GOTHIC Time Step Size from the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

A comparison of the primary figure of merit, peak containment pressure, is shown in Figure 3. Visually, the figure shows little to no difference in results with the reduced GOTHIC time step size. A finer look at the data reveals that the containment pressure remains within [ ]^{a,c} psi of the results presented in the topical report.

Figure 4 shows that the vapor temperature is initially slightly higher than the reduced time step case for the first couple seconds, but then levels out for approximately 2000 seconds before the sensitivity case calculates a higher temperature. The long term vapor temperature from the reduced time step case never reaches more than [ ]^{a,c}°F above the base case results.

Differences in the sump temperature are as large as [ ]^{a,c}°F in the first 10 seconds, but beyond 150 seconds the sump temperatures remain within [ ]^{a,c}°F of the results shown in the topical report shown in Figure 5.

The instantaneous break releases, Figure 6 through Figure 9, are much harder to compare because of the oscillatory nature of results from WC/T therefore a comparison of integrated break mass releases is also included in Figure 10. The integrated break releases of the sensitivity case always remain within less than [ ]^{a,c} of the base case. Please note that the break flow is calculated as a negative value because of the GOTHIC flow path orientation. The minimal differences between these two cases demonstrate that even if the GOTHIC DTMAX is reduced to the WC/T DTMAX the effect on the transient results is negligible.

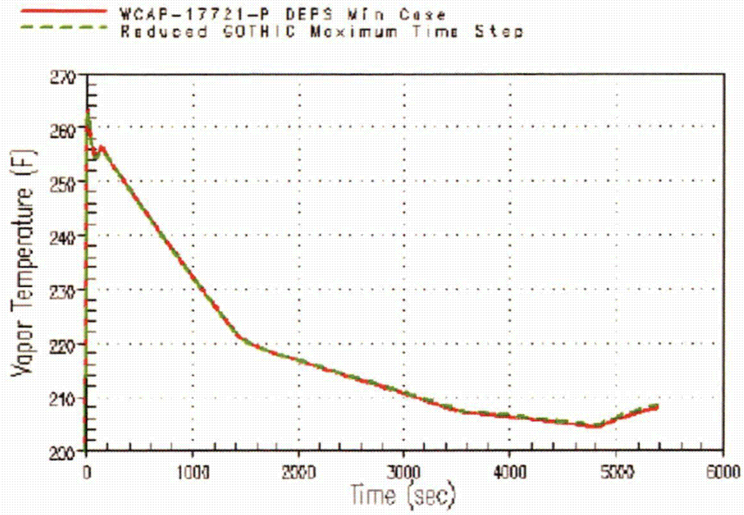

Figure 3: Comparison of Calculated Containment Pressure between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

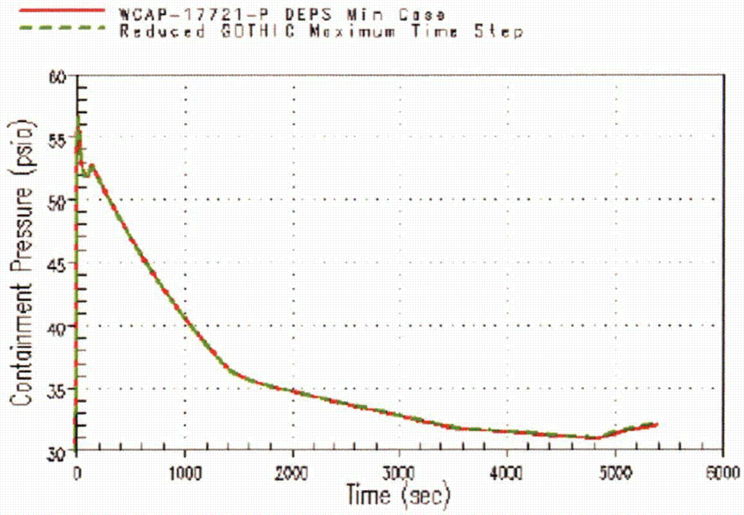

Figure 4: Comparison of Calculated Containment Temperature between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

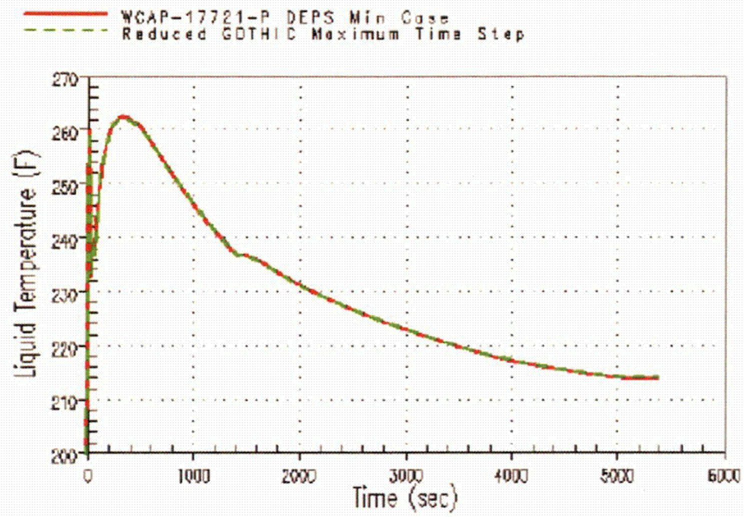

Figure 5: Comparison of Calculated Sump Temperature between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

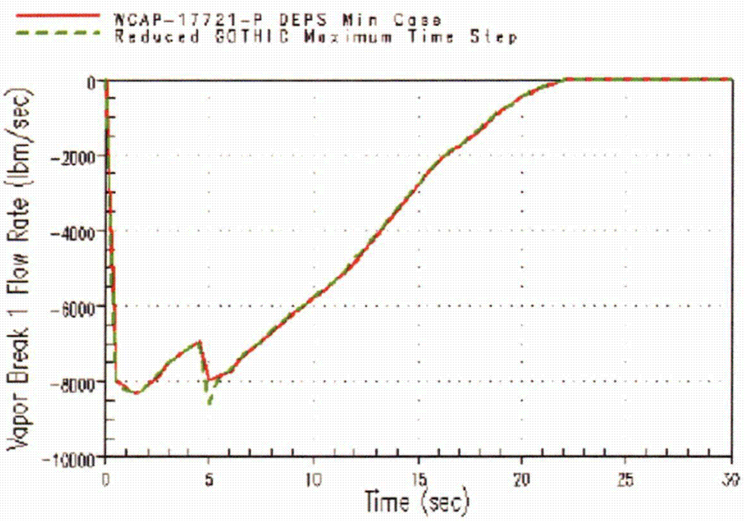

Figure 6: Comparison of Calculated Vapor Break Flow from the Pump Side of the Break between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

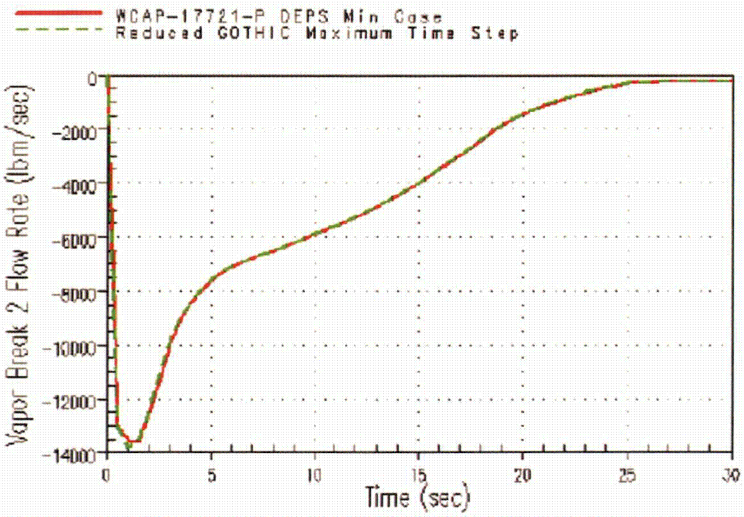

Figure 7: Comparison of Calculated Vapor Break Flow from the Steam Generator Side of the Break between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

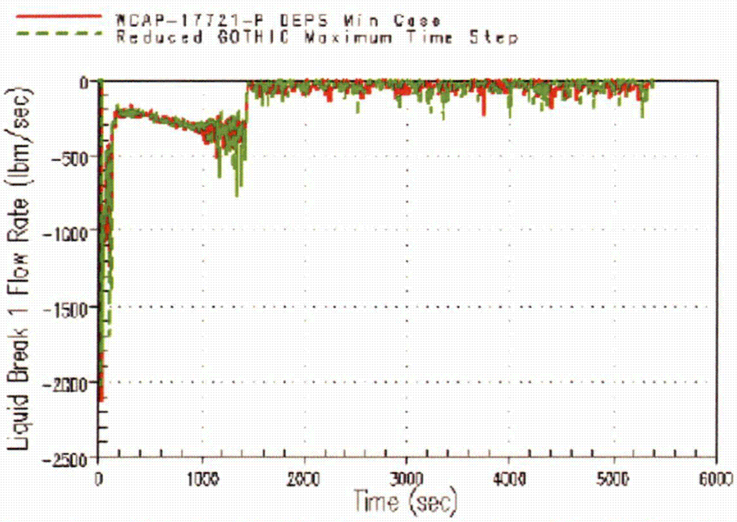

Figure 8: Comparison of Calculated Liquid Break Flow from the Pump Side of the Break between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

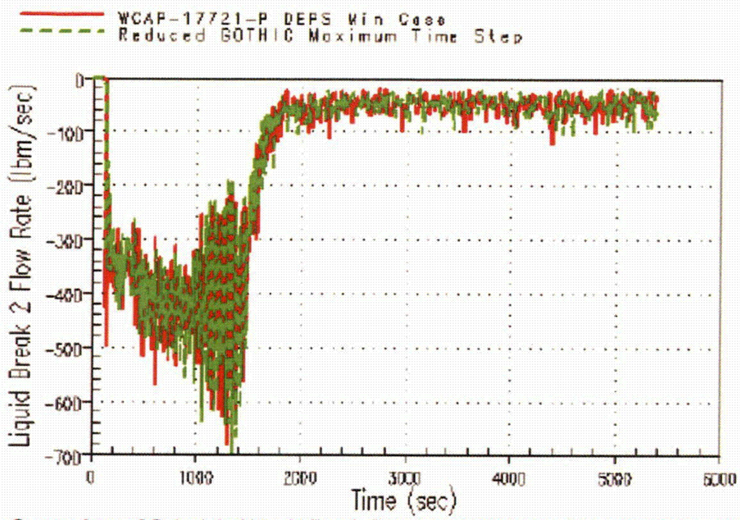

Figure 9: Comparison of Calculated Liquid Break Flow from the Steam Generator Side of the Break between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

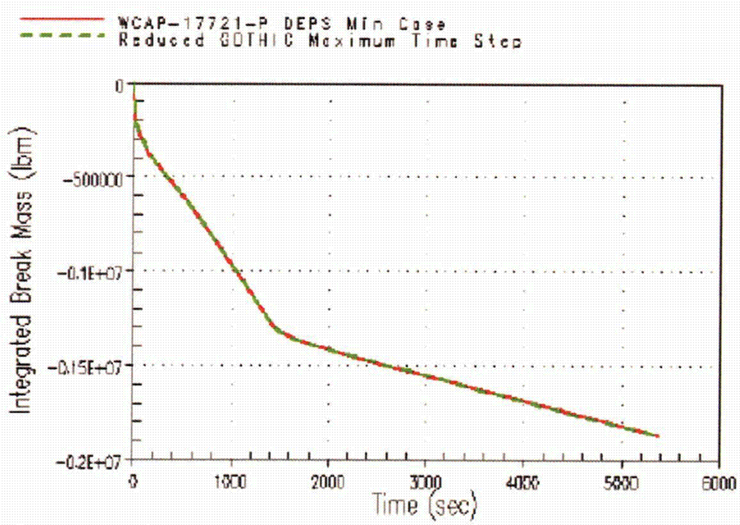

Figure 10: Comparison of the Integrated Total Break Flow between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Case with the Reduced Maximum GOTHIC Time Step Size

One additional sensitivity case was completed to further demonstrate that even if the GOTHIC DTMAX is reduced below the WC/T DTMAX the impact on the results is still negligible. The calculated peak containment pressure and vapor temperature are equal to the previous sensitivity case results where the maximum time step size is equal in both of the codes. The maximum calculated liquid temperature is within [ ]°F of the base case. Figure 11 compares the time step size used in each of the transients. Figure 12, Figure 13 and Figure 14 compare the figures of merit.

It has been demonstrated that transient results from the coupled codes are not sensitive to time step size.

a,c

Figure 11: Comparison of WC/T and GOTHIC Time Step Size from the Sensitivity Case where the Maximum GOTHIC Time Step Size << the Maximum WC/T Time Step Size

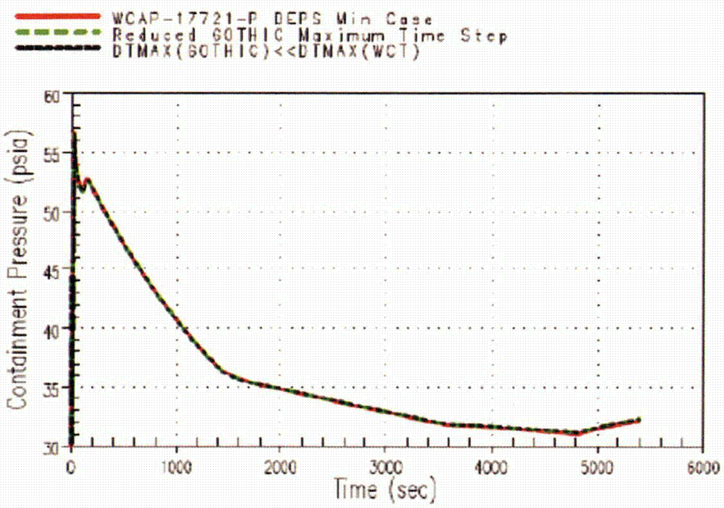

Figure 12: Comparison of Calculated Containment Pressure between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Cases with Reduced Maximum GOTHIC Time Step Sizes

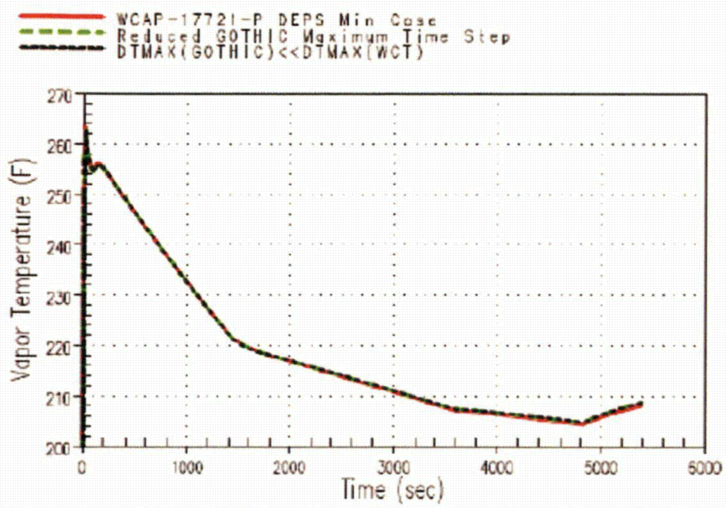

Figure 13: Comparison of Calculated Containment Vapor Temperature between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Cases with Reduced Maximum GOTHIC Time Step Sizes

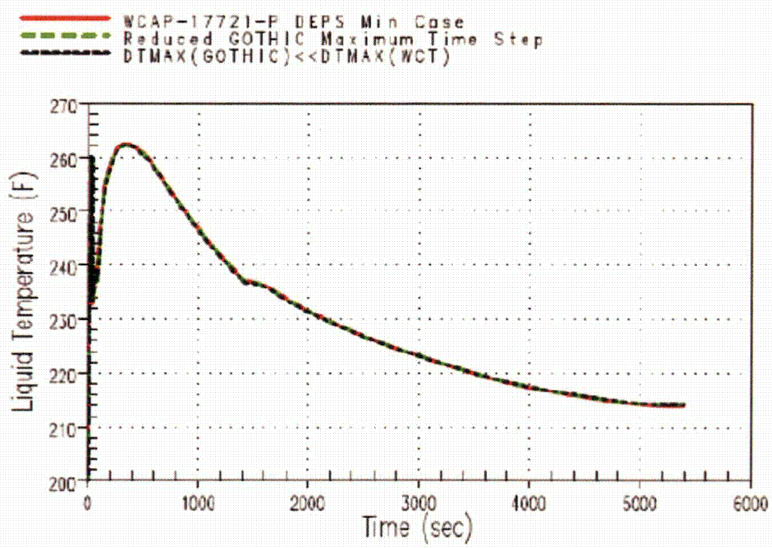

Figure 14: Comparison of Calculated Containment Liquid Temperature between the Representative DEPS LOCA Case presented in WCAP-17721-P and the Sensitivity Cases with Reduced Maximum GOTHIC Time Step Sizes

SCVB-RAI-7: 24-hr Containment Pressure

Figure 6-2 shows that the containment pressure, especially for double-ended pump suction (DEPS) case, is rising after 5000 sec. Provide 24-hour (86400 seconds) containment response for both DEPS (Section 5.3) and double-ended hot leg (DEHL) (Section 5.4) cases. Provide the analysis procedure (methodology) to assure the adequacy of containment heat removal system by demonstrating, for example, that the containment pressure will be below 50% of peak pressure after 24-hour into LOCA (NUREG-0800, "Standard Review Plan 6.2.2," "Containment Heat Removal Systems.").

Westinghouse Response

The LOCA M&E calculation for the long-term equipment qualification (EQ) application is biased to maximize the calculated long-term containment pressure and temperature. The biasing for this application is described in Section 4.2 of WCAP-17721-P and the corresponding containment response for the DEPS, DECL, and DEHL cases is shown in Figures 6-1 and 6-2. As shown in Figure 6-1, the calculated pressure for the DEHL case increases the fastest during blowdown phase, but continues to decrease after the end of blowdown and becomes less than the DEPS and DECL cases after about 300 seconds.

After the end of blowdown, the LOCA M&E releases for the DEHL case will always be lower than the DEPS and DECL cases because [

]^{a,c}. Therefore, the calculated containment pressure for the DEHL case will always be lower than the DEPS or DECL cases within a short period of time after the end of blowdown. This is confirmed in Figure 6-2. Figure 6-2 also shows that the calculated pressure for the DEPS and DECL cases is less than 50% of the peak by 3000 seconds, but starts trending upward just before 5000 seconds.

Figure 6-12 in Section 6.2 shows that the calculated pressure for the DEPS case levels off at about 33 psia, which is still less than 50% of the peak pressure, then continues to trend downward out to 50000 seconds as the core decay heat continues to decrease. As shown in Figure 15, this case was extended to 24 hours to demonstrate that the containment pressure would remain less than 50% of the peak at 24 hours after the LOCA event.

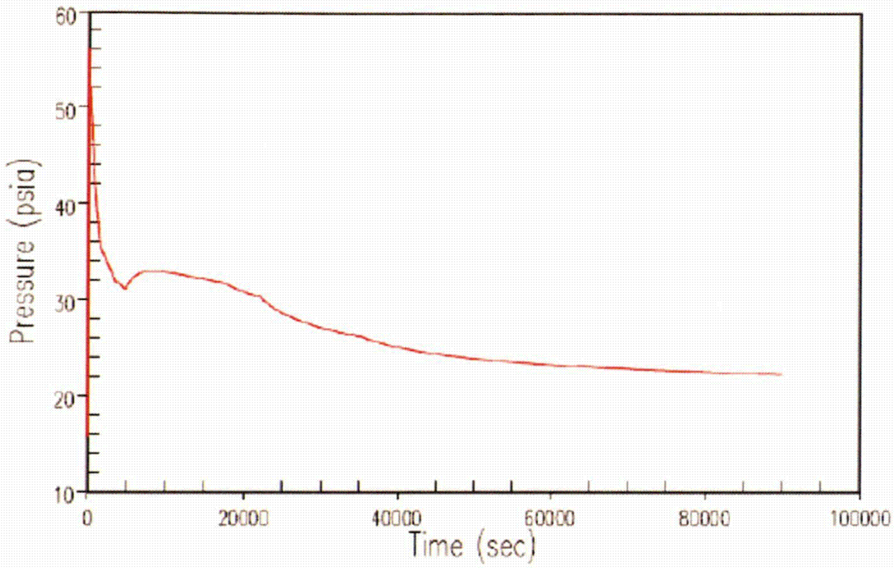

Figure 15: Long-term Containment Pressure for DEPS LOCA

SCVB-RAI-8: 24-hr Integrated Mass and Energy Release via Break

Please provide the integrated mass and energy release from break up to 24-hour (86400 seconds) for Figures 5-7 and 5-8; similarly, for DEHL case (Section 5.4).

Westinghouse Response

The integrated mass and energy release comparison for the DEPS case has been extended out to 24 hours and is shown in Figure 16 and Figure 17. After 5400 seconds (the end of the WC/T calculation), the DEPS case mass and energy releases are calculated following the method that is described in Section 4.2 of WCAP-17721-P. The integrated mass release comparison shows that the mass release from WC/T remains higher than the benchmark case after about 1000 seconds. This is because WC/T calculates the recirculation time to begin about 300 seconds later than the time that was assumed in the benchmark case. The integrated energy release comparison shows that the energy release from WC/T is lower than the benchmark until about 20000 seconds. This is because WC/T calculates lower steam generator and metal energy release rates than were assumed in the benchmark case. Because the initial stored energy in the WC/T model is slightly higher than the benchmark case, the integrated energy release remains slightly higher after 20000 seconds.

The DEHL mass and energy releases for the benchmark case are only available through the end of blowdown. Therefore, a long-term comparison of the integrated DEHL mass and energy release cannot be made.

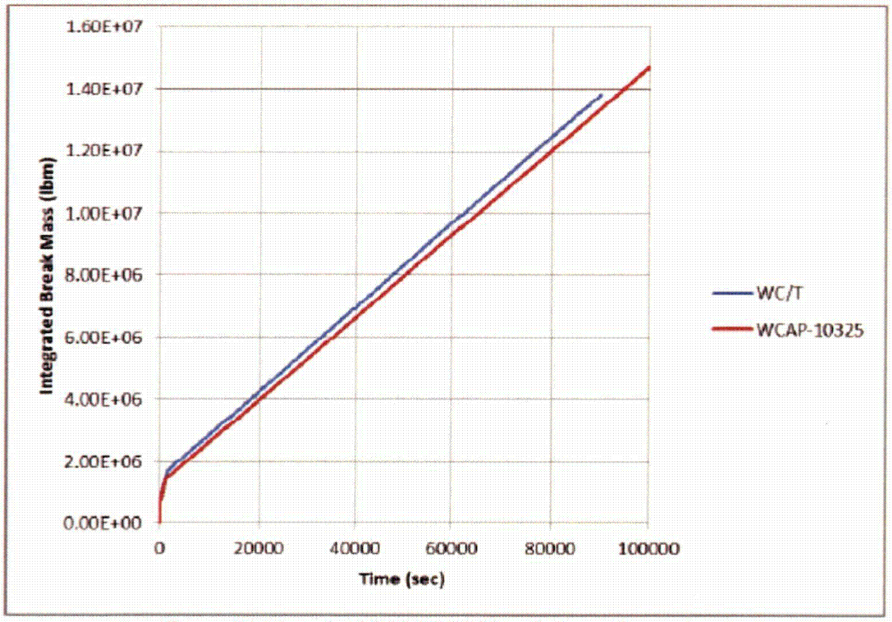

Figure 16: Integrated DEPS LOCA Mass Release Comparison

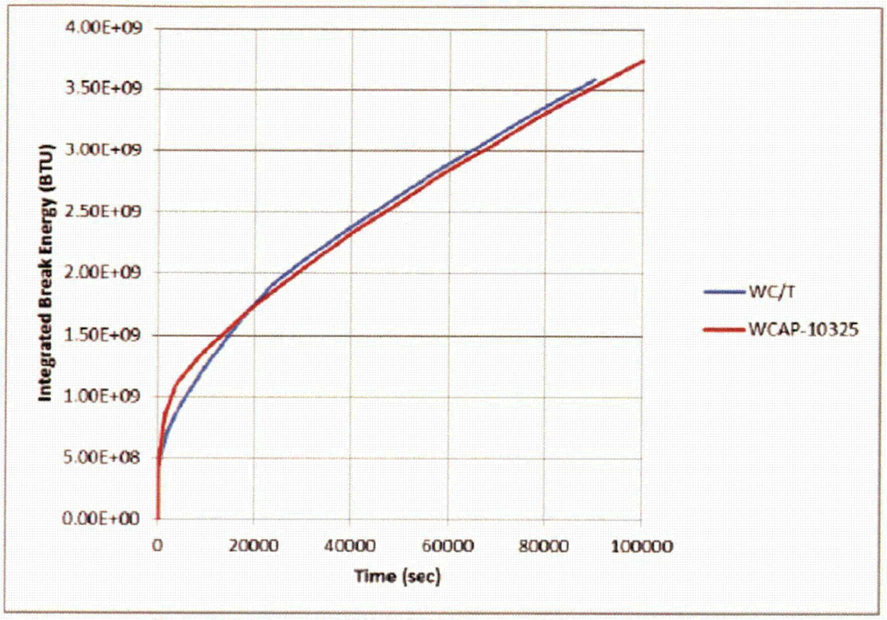

Figure 17: Integrated DEPS LOCA Energy Release Comparison

SCVB-RAI-9: Conservatism of Calculated Containment Pressure Peak

Use the sample cases in Sec. 5.3 or 6.1 as examples to provide the order of magnitude of the conservatism of containment peak pressure by assuming that the conservatism is completely due to the mass and energy release calculation with WCAP-17721, Revision 0, methodology.

Westinghouse Response

In order to quantify the amount of loss-of-coolant accident (LOCA) containment peak pressure margin due to conservatisms in WCAP-17221-P, two additional break cases were created for the large dry representative plant. These cases are based on those presented in WCAP-17721-P Sections 5.3 and 6.1, except that the LOCA M&E model conservatism has been removed in the following ways: [

]^{a,c}

The majority of the operating plants in the PWR fleet have large dry containment designs. These are typically limited by the double-ended hot leg (DEHL) blowdown peak containment pressure. As shown in Figure 18, the blowdown peak pressure of the DEHL LOCA case with the LOCA M&E model conservatism removed has over [ ]^{a,c} psi of margin and the pressure is as much as [ ]^{a,c} psi lower. A comparison of the peak calculated pressures is presented in Table 4.

Table 4: Summary of Results from the DEHL Cases

Description	Base Case	Nominal Case	Difference
Containment Pressure (psia)	59.36	[	]a,c

Figure 18 compares the containment pressure for a 600 second DEHL LOCA transient.

a,c

Figure 18: Containment Pressure Comparison for DEHL LOCA

A double-ended pump suction (DEPS) LOCA transient with minimum safety injection (SI) flows case was run with the same LOCA M&E model conservatisms removed as the previous DEHL case. The results in Table 5 show that there is approximately [ ]^{a,c} in peak pressure margin as compared to the case presented in WCAP-17721-P. The long term calculation demonstrates an increased pressure margin is primarily due to the [ ]^{a,c} (Figure 19).

Table 5: Summary of Results from the DEPS Min SI Cases

Description	Base Case	Nominal Case	Difference
Containment Pressure (psia)	56.58	[	]^{a,c}

Figure 19 compares the containment pressure for the first 600 seconds of a 5000 second transient.

a,c

Figure 19: Containment Pressure Comparison for DEPS LOCA with Minimum SI Flow Rates

The limiting ice condenser case was also run with the same LOCA M&E model conservatisms were removed as described for the large, dry containment design.

The peak pressure and temperatures of the DEPS LOCA with Minimum SI flow case show that there is over [ ]a,c psi margin on the peak calculated pressure. The larger benefits are seen in the long-term transient effects. The nominal case extends the time to melt out the ice and maintains a lower containment pressure for a longer duration. A summary of the peak calculated pressure and temperatures is seen in Table 6.

Table 6: Summary of Results from the DEPS Min SI Cases in an Ice Condenser Containment

Description	Base Case	Nominal Case	Difference
Containment Pressure (psig)	8.402	[	]a,c

Figure 20 compares the containment pressure for a 20,000 second transient.

a,c

Figure 20: Containment Pressure Comparison for DEPS LOCA with Minimum SI Flow Rates in an Ice Condenser Containment

Note that the LOCA M&E model conservatisms that were removed for these sensitivity cases are based solely on the conservatisms that are explicitly stated in WCAP-17721-P Section 4.1. Many inputs to a LOCA M&E analysis are specified by various entities within Westinghouse, and in many cases utilities specify the input. For example, if containment pressure margin was needed in a licensing basis analysis, efforts may be made to recalculate SI flows with less conservative assumptions. Though not directly a WC/T input, another example could be less restrictive heat exchanger (HX) performance provided by the utilities which would yield cooler recirculation SI.

In summary, approximately [ ]^{a,c} of margin are available in the WCAP-17721-P peak pressure cases for the large dry and ice condenser plants, respectively, based on remaining conservatism from inputs [ ]^{a,c}. However, it is expected a licensing basis calculation, which relies on many inputs external to the analysis, could yield additional margin.

SCVB-RAI-10: Limitation of Containment Modeling for WCAP-17721, Revision 0, Methodology

Provide the limitations on the containment model in order to employ the coupling methodology between WCOBRA/TRACT (sic) and GOTHIC as described in WCAP-17721, Revision 0. Note that Table 5-2 indicates that the containment is modeled as one single lumped volume. Will the multi-volume containment model not be applicable to the methodology?

Westinghouse Response

The only potential limitation on the type of GOTHIC containment model that could be coupled with WC/T would be associated with the time step size selection. The time step size selection logic that is used in GOTHIC is independent from the time step size selection logic that is used in WC/T. Typically, the time step size that would be used in a GOTHIC single lumped parameter volume containment model would be much larger than the time step size that would be used in a WC/T model. [

]^{a,c} It is possible that the time step size for a multi-node lumped parameter or distributed parameter GOTHIC model could be smaller than the one selected in a WC/T model. However, the response to SCVB-RAI-6 provides the results of two sensitivity cases that demonstrate the coupled GOTHIC containment code results are not affected by the time step size selection logic.

Therefore, there are no known limitations on the type of GOTHIC containment model that could be used to employ the coupling methodology with WC/T. [

]^{a,c}

to calculate the containment response in parallel with the LOCA M&E releases.

SCVB-RAI-11: Conformance of Regulatory Guide (RG) 1.203, "Transient and Accident Analysis Methods."

Please justify the applicability of WCAP-12945-P-A, "Code Qualification Document for Best Estimate LOCA Analysis," March 1998, to the demonstration of WCAP-17721, Revision 0, conforming to RG 1.203, "Transient and Accident Analysis Methods." Note that all development and assessment made in WCAP-12945-P-A is focused on the figure-of-merit of peak cladding temperature (PCT) while the expecting development and assessment for WCAP-17721, Revision 0, is known to be the figure-of-merit of the peak of containment temperature and pressure. The timing (order of 100 seconds) and thermal-hydraulic conditions (reflood phase) determining PCT are not necessarily the same as those for peak containment temperature and pressure (i.e., order of 10 and 1000 seconds for blowdown and post-reflood phase, respectively). An equivalent code qualification document for TR WCAP-17721, Revision 0, is expected to be developed and assessed with respect to the peak containment temperature and pressure, or, at least, the corresponding mass and energy release.

Westinghouse Response

Regulatory Guide 1.203 describes a process that the US Nuclear Regulatory Commission (NRC) staff considers acceptable for use in developing and assessing evaluation models that will be used for analyzing design basis accidents as described in Chapter 15 of the Standard Review Plan (NUREG-0800). This RAI questions whether key aspects of RG 1.203 are adequately documented for the Loss of Coolant Accident (LOCA) Mass and Energy (M&E) methodology described in WCAP-17721-P. The basis of the question is largely focused on whether the code validation that was used to assess the figures of merit for a large break LOCA to demonstrate compliance with 10 CFR 50.46 can be applied to the generation of LOCA M&E input for the containment integrity analyses.

It is recognized that the figures of merit for a LOCA analysis meant to validate the ECCS performance (i.e., ensure compliance with peak cladding temperature and maximum local oxidation, along with other criteria as identified in 10 CFR 50.46), and a LOCA analysis meant to assess containment integrity (i.e., peak containment pressure and equipment qualification requirements), are different. For legacy methods this has led to different emphasis on the conservative biases applied to the physical modelling (e.g., bias modelling to obtain minimum containment backpressure for ECCS performance calculations, versus bias modelling to obtain maximum containment backpressure for containment integrity).

With the advent and successful licensing of realistic LOCA analysis codes, an alternate approach is to use a mechanistic code to provide the realistic system response to a given set of inputs, while biasing the inputs to ensure a conservative calculation of the LOCA M&E release. It is acknowledged that the goal of a completely realistic calculation of the complex phenomena associated with a large break LOCA cannot be perfectly realized. Therefore, it is important that the imperfections in the code calculation of the key parameters affecting the figures of merit be quantified via comparisons with applicable data, and the consequences explained. In this

manner, any biases (conservative or non-conservative, depending on the figure of merit) can be clearly explained in the context of the given application.

From Section 2 of WCAP-17721-P, the following high ranked phenomena have been identified for the LOCA M&E application. Each of these is considered to be realistic or appropriately biased to be used with the WCOBRA/TRAC (WC/T) code for calculation of the LOCA M&E release, as explained in the following.

Break Flow – As discussed in Section 2.1 of WCAP-17721-P, the break flow model in WC/T has been compared with relevant data from the Marviken facility, and is considered to be an appropriate predictor of critical flow. The critical flow model is important during the blowdown phase of the transient. Section 25 of WCAP-12945-P-A addresses code and experiment accuracy according to Step 9 of the Code Scaling, Applicability and Uncertainty (CSAU) methodology[1]. Step 9 of the CSAU methodology is similar to Step 14 of RG 1.203, where assessment of code accuracy is considered. Section 25-2 of WCAP-12945 focuses on the critical flow comparisons to test data, specifically the Marviken separate effects tests. As described in WCAP-17721-P, Figure 25-2-1 indicates [

]^{a,c}. The WC/T break flow model has been shown to generally agree well with the Marviken test data.

For the LOCA M&E application to PWR analyses, the RCS volume is [ ]^{a,c} and uncertainties on RCS temperature are skewed in the conservative direction to maximize the blowdown M&E release. Therefore, the WC/T break flow model with these input biases provides an adequately conservative prediction of the LOCA M&E release.

This response also addresses Set 2 RAI 2.3.

Core Stored Energy Release – As explained in Section 2.2 of WCAP-17721-P, the initial core stored energy is biased conservatively (high) via inputs for the LOCA M&E application.

Decay Heat – The figure of merit between LOCA M&E (containment pressure) and LOCA PCT (peak cladding temperature) differ; however, high decay heat is conservative in both applications. As explained in Section 2.3 of WCAP-17721-P, the inputs required to specify the decay heat model in WC/T are biased very conservatively, unless otherwise specified in a plant-

[1] NUREG/CR-5249, Rev. 4, "Quantifying Reactor Safety Margins, Application of Code, Scaling, Applicability, and Uncertainty Evaluation Methodology to a Large Break, Loss-of-Coolant Accident," December 1989

specific application. The key inputs for decay heat in the ANS-1979 model are fuel burnup and fuel enrichment. Values are typically selected that would bound plant operation.

In the event a more realistic treatment is taken for a plant-specific application, then the applicant would have to clearly describe the approach. Cycle specific checks would have to be made to verify plant operation would not violate the LOCA M&E decay heat modelling assumptions.

Reflood Heat Transfer – Section 2.4 of WCAP-17721-P summarizes the performance of the WC/T reflood heat transfer predictions, and references WCAP-12945-P-A. For the reflood heat transfer assessment, WCAP-12945-P-A contains WC/T simulations of experiments in five separate effects test facilities (Volume 2) and three integral effects test facilities (Volume 3). Although the focus of the assessments was the LOCA PCT application, data useful relative to the LOCA M&E application is presented. From the perspective of LOCA M&E releases, the most relevant conclusion is that [

]^{a,c}.

[ ]^{a,c} can be observed in Table 7 below, which summarizes the WC/T reflood test comparisons from WCAP-12945-P-A. It should be noted that [

]^{a,c}

This response also addresses Set 2 RAI 2.5 and Set 2 RAI 2.6.

Table 7: WCOBRA/TRAC CQD Test Comparison [

]a,c

Upper Plenum Entrainment/De-Entrainment and Condensation – The discussion in Section 2.5 of WCAP-17221-P is similar to the Reflood Heat Transfer discussion directly above. The CCTF tests (Section 14-2 of WCAP-12945-P-A) provide good integral test data relative to

these upper plenum phenomena because it includes 4 loops, a full length core, and simulated upper plenum construction. As indicated above in Table 7, the WC/T model [

]^{a,c}.

WCAP-12945-P-A Section 14-2-6-1 in particular describes how WC/T [

]^{a,c}.

This response also addressed Set 2 RAI 2.7.

Hot Leg Condensation – This phenomenon is ranked high after the transfer from cold leg to hot leg recirculation. As noted in Section 2.6 of WCAP-17721-P, the transfer to hot leg recirculation is not considered in the WC/T LOCA M&E model. Hot leg recirculation would condense most, if not all, of the core steam release going through the broken loop (especially long term), and reverse the direction of core flow. Therefore, modelling of this phenomenon has been neglected in the WCAP-17721-P methodology to conservatively maximize the steam release from the RCS to containment.

Hot Leg Entrainment/De-Entrainment – This phenomenon is ranked high in Section 2.7 of WCAP-17221-P because of its relationship to the liquid droplet transport from the core to the steam generator (via the upper plenum and the hot leg). In the WC/T model, [

]^{a,c}, which enhances secondary to primary heat transfer. Appendix A of WCAP-12945-P-A provides a discussion of loop flow characteristics in pages A-38 through A-40 for the CCTF Test 62. The overall conclusion is that [

]^{a,c}

In response to Set 2 RAI 2.8, hot leg entrainment and de-entrainment were high ranked phenomena because [

]^{a,c}. Subsequent WC/T studies indicated that [

]^{a,c}

Steam Generator Heat Transfer – Secondary to primary heat transfer is ranked high for the long term period. As noted in Sections 2.8 and 3.2 of WCAP-17721-P, the WC/T calculated

steam generator secondary fluid temperature decreases faster than the FLECHT-SEASET test data. This indicates that the model over predicts this phenomenon. This is conservative for the LOCA M&E release calculation.

Cold Leg/Accumulator Condensation – The UPTF experiments included a test designed to examine steam/water mixing in the cold legs and downcomer. This is documented as UPTF Test 8 in Sections 14-4-12 through 14-4-14 of WCAP-12945-P-A. Figures 14-4-175 through 14-4-178 indicate that WC/T provides a [

]^{a,c}, indicating realistic prediction of interfacial heat transfer and condensation. UPTF Test 8 Figures 14-4-167 and 14-4-168 show the relatively constant steam flow rate of approximately 100 kg/s and the varying ECCS injection rates, which range from 150 kg/s to 600 kg/s. These test conditions indicate that WC/T is capable of modelling steam/water mixing consistent with test data over a significant range of steam flow to ECCS flow ratios, including those applicable to the post reflood portion of a LOCA transient.

This response also addresses Set 2 RAI 2.9 and Set 2 RAI 2.20.

Downcomer Condensation – Tests that do not model a forced reflood condition (i.e. no blocked downcomer) are the most useful for validation of the modelling of this phenomenon. UPTF Test 8 (WCAP-12945 Sections 14-4-12 through 14-4-14) provides the best basis for condensation performance comparisons. Phase A is the relevant part of Test 8 to this discussion, as Phase B considers hot leg recirculation which is not modelled in the WC/T LOCA M&E methodology. Figures 14-4-177 and 14-4-178 show measured and predicted fluid temperatures near the vessel in Loop 2, downstream of the safety injection location. The measured and predicted fluid temperatures [

]^{a,c}. The liquid slug formation cycle as described in Section 14-4-12 is allowing a non-equilibrium mixture, consisting of saturated steam and subcooled water, to enter the downcomer. These conditions will provide significant condensation in the downcomer. Condensation is not a parameter that can be directly measured in the test facilities, so the condensation performance must be compared in a somewhat qualitative manner. [

]^{a,c}. Therefore, this phenomenon is adequately predicted by WC/T through the reflood phase. The accumulator and safety injection input parameters are conservatively biased for the long-term LOCA M&E release calculation, as described in Section 2.10 of WCAP-17721-P.

This response also addresses Set 2 RAI 2.21.

Downcomer Stored Energy Release – The WC/T vessel heat transfer package breaks up wall heat transfer models into two large categories based on local fluid flow and wall temperature

conditions, as discussed in WCAP-12945-P-A Sections 3 and 6. The first of these is the 'hot wall' flow regime, which is selected when a heated surface (i.e., nuclear or heater rod) is present and the wall surface temperature exceeds the critical heat flux temperature. This is largely observed in the core on the fuel rod outer surfaces during the reflood phase of the transient. The second flow regime is referred to as 'normal wall' or 'cold wall,' where the wall surface is able to be fully wetted. This is typically the situation for the bulk of downcomer metal heat transfer to the primary fluid where the heat transfer mode may be nucleate boiling in a saturated environment or nucleate boiling in a subcooled liquid environment, both effective means of heat transfer. The contribution of downcomer stored energy is considered to be conservative for both the LOCA M&E and PCT calculations. Removing stored RCS metal energy rapidly results in a high steam generation rate and accordingly a high RCS break energy release rate. The generation of steam in the downcomer, while conservative for the LOCA M&E calculation, is also conservative for PCT [

]^{a,c}. UPTF Test 25 was initiated with superheated vessel wall and barrel/baffle metal. The test pressure in the vessel varied between 240 kPa and 320 kPa (35 psia and 46 psia) according to Figures 14-4-144 and 14-4-145, with corresponding saturation temperatures of 126°C and 135°C (259°F to 275°F). The measured and predicted fluid temperatures shown in Figures 14-4-16 through 14-4-149 are [

]^{a,c}

This response also addresses Set 2 RAI 2.1.

Loop Flow Split – The loop flow split, or the ratio of steam exiting the core into the intact loop(s) versus the broken loop, is dictated by differences in the loop flow resistances. The most significant flow resistances occur in the steam generators and the pumps. [

]^{a,c}

Just after transient initiation, the pumps will trip and begin to coast down according to the homologous curves, which account for the various flow conditions that may exist in each loop (e.g. forward flow, reverse flow, two phase). This model is described in WCAP-12945-P-A Section 9-4. Relative to transient test data, WCAP-12945-P-A Figures 14-1-18 and 14-1-19 indicate that WC/T accurately predicts the broken loop hot leg flow rate for the LOFT blowdown for tests L2-5 and LB-1 (tests with tripped pumps). Figures 14-1-26 and 14-1-27 indicate reasonable agreement for measured and predicted intact cold leg flow rates for L2-5 and LB-1, respectively. This agreement indicates that the WC/T calculated core exit flow split is acceptable relative to applicable test data.

The steam generator flow resistances are based on the amount of fluid entering the steam generators from the core, which is typically a relatively high quality two phase mixture. The steam generator secondary fluid temperature is much higher than the RCS fluid temperature after blowdown. Until the steam generator secondary fluid temperatures equilibrate with the

primary side temperature, liquid entering the tubes will boil. This will create a large volume of steam and the associated pressure drop will be based on the loss coefficient input values. As the transient progresses, the amount of steam and water exiting the core changes, and the steam generators progressively cool down. These parameters vary dynamically as the transient progresses, and the associated ratio of intact and broken loop flow is considered to vary appropriately.

In very long term WC/T LOCA M&E calculations, there is the potential for liquid to enter the intact loop seals. This phenomenon, referred to as loop seal plugging, is described in WCAP-17721-P Section 2.13. While loop seal plugging affects loop flow resistances and thus the loop flow split, it is considered to be realistic.

This response also addresses Set 2 RAI 2.22.

Conclusion - In summary, the previous code assessments documented in WCAP-12945-P-A for the LOCA PCT calculation also provide an adequate assessment of the WC/T code from the perspective of the LOCA mass and energy release calculation. For the most part, the predictions can be considered realistic or conservative for the LOCA M&E application when biased appropriately. A conservative LOCA M&E analysis result is obtained by conservatively biasing the code inputs. Where the predictions of important phenomena are biased, they are adequate and appropriate for use in mass and energy release calculations. WCAP-12945-P-A, as supplemented by WCAP-17721-P, serves as an appropriate vehicle for documenting the informational needs identified in RG 1.203.

Westinghouse

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LTR-NRC-15-18

March 10, 2015

Subject: Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs" (Proprietary/Non-Proprietary).

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4118 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4118 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
Dr. Shie-Jeng Peng (NRC)

LTR-NRC-15-18
Page 2 of 2

bcc: James A. Gresham
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AW-15-4118

March 10, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-18 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-18, dated March 10, 2015

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-15-4118 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the accompanying Affidavit should reference AW-15-4118 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager

Regulatory Compliance

AW-15-4118
March 10, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

James A. Gresham, Manager
Regulatory Compliance

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

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse 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 2.390 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 constitute Westinghouse policy and provide 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.

(iii) 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 that 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.

(vi) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-15-18 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-15-18, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721-P, and may be used only for that purpose.

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

(i) Obtain NRC approval of the LOCA Mass and Energy Release Calculation Methodology documented in WCAP-17721-P, "Westinghouse

Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of assisting customers in obtaining license changes for a Westinghouse pressurized water reactor (PWR).

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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WESTINGHOUSE NON-PROPRIETARY CLASS 3

LTR-NRC-15-18 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs (Non-Proprietary)

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066

The table below summarizes the Set 2 RAIs from the Safety and Code Review Branch[1] which have responses included in this attachment.

RAI #	Title
2.7	RAI-3 – Upper plenum entrainment
2.10	RAI-3 – Equipment Qualification (EQ) and Net Positive Suction Head analysis (NPSHa)
2.11	RAI-3 – Long term boil-off
2.12	RAI-3 – Event definitions
2.13	RAI-3 – Main feedwater
2.14	RAI-2 – Auxiliary feedwater
2.16	RAI-3 – Safety Injection (SI) water volume and temperature
2.17	RAI-3 – Nodalization
2.23	RAI-3 – Hot leg condensation in NPSHa and EQ
2.28	RAI-3 – Heat transfer directly to containment
2.29	RAI-3 – Inactive metal
2.33	RAI-3 – Secondary side heat transfer
2.34	RAI-6 – Definitions for acronyms

Note: RAI 2.7 was previously addressed via LTR-NRC-15-5[2] by reference to the Westinghouse response to SCVB-RAI-11 which was included in that transmittal. Subsequent clarification calls with the NRC reviewer responsible for set 2 have led to a request for Westinghouse to supplement the previously supplied response with additional information relative to upper plenum entrainment and de-entrainment. This supplemental information is provided in the attachment to this letter.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A251)

[2] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

2.7 RAI-3 – Upper plenum entrainment

RAI: Demonstrate that method for modeling the upper plenum entrainment/de-entrainment and condensation in WC/T is appropriate for the M&E evaluation model such that the mass and energy release is adequately predicted.

Comment: In section 2.5 of their initial submittal [1], Westinghouse stated that the same upper plenum entrainment/de-entrainment and condensation model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

Upper Plenum Entrainment/De-Entrainment and Condensation are discussed in the Westinghouse response to SCVB-RAI-11[1] which was transmitted to the NRC via LTR-NRC-15-5[2]. Subsequent clarification calls between Westinghouse and the NRC have led to a request for Westinghouse to supplement the previously supplied response with additional information regarding upper plenum entrainment and de-entrainment. This supplemental information is provided below.

Supplemental Information Re: RAI 2.7 – Upper Plenum Entrainment / De-entrainment

SCVB-RAI-11 questioned the applicability of WCAP-12945-P-A (WCOBRA/TRAC loss of coolant accident (LOCA) peak clad temperature (PCT) code qualification document) to the LOCA mass and energy (M&E) methodology, considering the figures of merit for LOCA PCT and LOCA M&E are different. The Westinghouse response to SCVB-RAI-11 contained a summary of key LOCA M&E phenomena and related them back to WCAP-12945-P-A from a LOCA M&E perspective.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology" - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260).

[2] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

One of the phenomena addressed in the Westinghouse response to SCVB-RAI-11 was upper plenum entrainment and de-entrainment, which was specifically mentioned in RAI 2.7. The Westinghouse response, documented in LTR-NRC-15-5, was focused on how test simulations with WCOBRA/TRAC suggested that [ ]^{a,c} during the reflood process, and the two phase core effluent was transported out of the upper plenum. A key figure used in this argument was WCAP-12945-P-A Figure 14-2-24, which showed that WCOBRA/TRAC predicted a [ ]^{a,c} for the Cylindrical Core Test Facility (CCTF) Run 62. In subsequent discussions, it was agreed that the [ ]^{a,c}

It is recognized that the ability of WCOBRA/TRAC to predict upper plenum entrainment and de-entrainment must be determined [ ]^{a,c}. There are other aspects of CCTF Run 62 that aid in determining the level of de-entrainment occurring in the upper plenum. WCAP-12945-P-A Figure 14-2-25 shows general good agreement in the [ ]^{a,c}. The pressure drop from the lower plenum to the upper plenum is influenced mainly by [ ]^{a,c} in the prediction than the test data. Additionally, WCAP-12945-P-A Figures 14-2-29 and 14-2-30 demonstrate that the measured vs. predicted flow rates through the broken and intact loops are well predicted as compared to test data. Taken in conjunction with the [ ]^{a,c}, the good agreement on the [ ]^{a,c} and the good agreement on the broken and intact hot leg fluid flow rates indicate that WCOBRA/TRAC is accurately predicting the net effect of the upper plenum entrainment / de-entrainment phenomena.

Additionally, Section 15-2-3 of WCAP-12945-P-A provides information on the Upper Plenum Test Facility (UPTF) Test 29B. This was a separate effects test where a two phase mixture was injected into an upper plenum simulator, and the predicted upper plenum fluid mass was compared to the value calculated from test data. The conclusion of this comparison is that WCOBRA/TRAC tends to [ ]^{a,c}

2.10 RAI-3 – Equipment Qualification (EQ) and Net Positive Suction Head analysis (NPSHa)

RAI: Provide an explanation of the methodology for EQ and NPSHa analysis. With this methodology, define the acceptance criteria which are used, how those criteria are demonstrated to be met. Provide this explanation for each of the three containment types (large dry, sub-atmospheric, and ice-condenser). Additionally, address the relevant phases of each methodology, including the post-reflood phase and the decay heat phase. Also address the determination of the single active failure for both types of analyses.

Comment: In table 4-1 row 20 their initial submittal [1], Westinghouse stated that they would assume no steam-water mixing during the long-term containment pressure and temperature analysis for EQ and complete steam-water mixing for minimum NPSHa analysis. However, Westinghouse did not provide an explanation of the methodology for EQ or NPSHa analysis, what acceptance criteria were used, and how those criteria were demonstrated to be met.

Westinghouse Response

WCAP-17721-P includes information on how Westinghouse intends to calculate mass and energy releases used for input to the EQ and NPSHa analyses. Because the loss of coolant accident mass and energy (LOCA M&E) release calculation is considered to be input to the EQ and NPSHa calculations, the acceptance criteria relative to EQ and NPSHa do not lie within the methodology described in WCAP-17721-P. Westinghouse may supply mass and energy releases biased to maximize steam release to the containment atmosphere to a third party responsible for containment response. If Westinghouse is cognizant of the containment response, limiting long term transients will be supplied to the party responsible for determining if equipment will remain operational under the calculated conditions (typically utilities are responsible for EQ programs). The NPSHa calculations are analogous, except that the biases applied maximize sump liquid temperature.

The acceptance criteria for EQ are described in NUREG-0588 Revision 1. Item (1) under Section 1.1 indicates that the time dependent temperature and pressure transients established for the containment design may be used for EQ purposes (i.e. peak containment pressure transient). For large dry and sub-atmospheric containments, WCAP-17721-P Section 4.2 states that mass and energy releases with WCOBRA/TRAC (WC/T) will be calculated for at least one hour in order to capture the transfer to sump recirculation. During this one hour period, the blowdown, reflood, and post reflood (long term) phases are covered. After the WC/T mass and energy release calculation is terminated, the long term boil off (decay heat phase) calculation is initiated (see Westinghouse response to RAI 2.11). The long term boil off calculation, or steaming calculation as it may be called, conservatively maximizes steam release to the containment atmosphere. The WC/T M&E release calculations for ice condenser plants are run through the time of peak containment pressure. A transient time of 20,000 seconds is typically long enough to capture ice bed meltout, reach the resulting peak containment pressure, and demonstrate a downturn in containment pressure subsequent to the peak. After the WC/T

release calculation is terminated, an enhanced version of the typical steaming calculation is used to calculate M&E releases (see Westinghouse response to RAI 2.11). The ice condenser steaming calculation conservatively maximizes steam release to the containment atmosphere. Note that long term EQ containment calculations are normally 30 day containment integrity runs; therefore the WC/T mass and energy releases are used only in a short portion of the overall transient. Whether the subject plant is a large dry, sub-atmospheric, or ice condenser design, the mass and energy releases used for EQ purposes will be a composite of WC/T calculated results (3,600-20,000 seconds) and steaming calculation results (up to 30 days).

Sump conditions become limiting when various pumps providing either core cooling or containment spray flow switch from refueling water storage tank (RWST) injection mode to sump recirculation mode, challenging NPSHa. These changeovers occur prior to 1 hour after the double ended reactor coolant system (RCS) pipe rupture. At this time, the sump is at an elevated temperature and the concern is that cavitation may occur due to the warm sump fluid and pressure drop associated with the pumps and piping, and reduce the emergency core cooling system (ECCS) or containment spray effectiveness. This is true for large dry, sub-atmospheric, and ice condenser designs. The WC/T LOCA M&E release calculation is biased to maximize energy in the liquid phase of the break releases. This is completed by calculating the [

]^{a,c} Specific calculations for a plant application would determine the limiting single failure, which could either be the loss of an emergency diesel generator, the loss of a containment spray pump, or loss of a train of containment fan coolers (if the plant analysis models safety grade fan coolers).

2.11 RAI-3 – Long term boil-off

RAI: Describe how the steam-water mixing is calculated in this long-term boil off calculation.

Comment: In table 4-1 row 22 of their initial submittal [1], Westinghouse discussed the long-term phases of the event, but the definitions of each phase were not entirely clear. Additionally, some additional phases were discussed, but not defined. Also, further documentation was needed to clarify the differences between the event itself and how that event was simulated. During an audit at Westinghouse, the information requested above was discussed and the NRC staff believed the information helped to provide a clearer understanding of the event and how the event was simulated.

Westinghouse Response

The LOCA M&E transient can be broken down into four phases; blowdown, reflood, post-reflood, and long term decay heat removal. The blowdown through post-reflood phases are calculated using the WC/T code, and are characterized by the blowdown peak calculated pressure followed by an established trend of decreasing containment pressure after reflood for a large dry containment, or after ice bed meltout for an ice condenser containment. The long term decay heat removal phase is not calculated by WC/T. The long term decay heat removal phase, also known as the boil-off calculation or steaming calculation, is calculated either in the containment code (for example, using control variable logic in GOTHIC), or through hand calculations (typically with a spreadsheet type application). The information provided below details how the long term decay heat removal phase is modelled for the large dry, sub-atmospheric, and ice condenser plant designs.

Large Dry and Sub-atmospheric Containments

The WC/T calculation is terminated at approximately 1-1.5 hours after break initiation. At this time, there is energy stored in the RCS metal, steam generator metal, and steam generator fluid. The quantity of stored energy for each of these terms is reported in WC/T output. Using the code output, [

Page 7 of 26

]a,c

This calculation maximizes the steam release to containment, as described in WCAP-17721-P Table 4-1 row 22. Although this calculation is non-mechanistic, the large dry containment heat removal systems are capable of continuous depressurization in the long term transients.

Ice Condenser Containments

Ice condenser containments have a low design pressure and the containment heat removal capabilities are not as robust as a large dry plant once the ice bed is melted out. If after 20,000 seconds the mass and energy releases in an ice condenser containment model were changed from WC/T to the large dry steaming calculation described above, a drastic increase in containment pressure would result from the instantaneous change to the non-mechanistic steaming calculation. In addition, the ice condenser containment volume is approximately 1/3 of a large dry containment. For these reasons, the steaming calculation was enhanced for ice condenser applications [

]^{a,c}

2.12 RAI-3 – Event definitions

RAI: Provide a table which contains the following:

1. The phase of the event (e.g., Blowdown, Refill, Reflood)
2. The conditions which define the beginning of that phase.
3. The conditions which define the end of that phase
4. An approximate duration of that phase (in seconds)
5. An approximate starting time of that phase (in seconds – with 0 being the event initiation)
6. A description of how the phase is simulated (e.g., mechanistically in WC/T, conservatively using certain approximations)

Additionally, provide a second table which contains a description of the energy sources which impact each of the phases listed in the above table:

1. List each major energy source. The sources of energy should include, but not be limited to: Initial stored energy in the fuel, primary water, water in the broken loop SG, water in the intact SGs, primary metal, metal in the broken loop SG, metal in the intact loop SGs, decay heat.
2. The approximate initial energy of that energy source at the beginning of the event (in kW).
3. The approximate amount of energy which is released during phase 1 (include both kW and %)
4. The approximate amount of energy which is released during phase 2 (include both kW and %)
5. The approximate amount of energy which is released during every other phase of the event (include both kW and %)

Comment: In their initial submittal [1], Westinghouse discussed the different phases of the event, but the definitions of each phase were not entirely clear. Additionally, some additional phases were discussed, but not defined. Also, further documentation was needed to clarify the differences between the event itself and how that event was simulated. During an audit at Westinghouse, the information requested above was discussed and the NRC staff believed the information helped to provide a clearer understanding of the event and how the event was simulated.

Westinghouse Response

The requested tables are attached. Table 1 lists the various phases for the double-ended pump suction (DEPS) loss of coolant accident (LOCA) event. It also includes the time frames, the conditions at the beginning and end of each phase, and a brief description of how the transient response for that phase is calculated. Table 2 presents the transient energy inventory and releases for a DEPS LOCA at a typical 4-loop plant with a large dry containment. The units for the energy release are given in MBTU. The percentage values represent the fraction of the total initial energy that is stored in that component or the fraction of the energy released by that

component during the period. The fluid energy is referenced to 32°F, and the fuel and metal energy are referenced to 212°F.

Table 1 – Phases of the Large DEPS Break LOCA Event

Phase	Start Time (seconds)	Conditions at Start	Approximate Duration (seconds)	Conditions at End	How Simulated
Blowdown	0	Full power steady state	20-30	The containment pressure has increased substantially due to the rapid mass and energy release. The reactor coolant system (RCS) is mostly voided and the pressure is approximately equal to the containment pressure. The steam generator (SG) pressure is at or near the safety valve setpoint because the turbine is tripped and the main steam isolation valves (MSIVs) are closed.	WCOBRA-TRAC (WC/T)
Refill	20-30	The accumulators are injecting into the cold legs, but the downcomer and lower plenum of the vessel are mostly voided. The lower plenum pressure is starting to increase. The containment pressure is constant or slowly decreasing.	10-20	Accumulator injection has filled the vessel lower plenum to the bottom of the active fuel. The SG pressure remains high. The containment pressure is constant or slowly decreasing.	WC/T
Reflood	30-50	The fuel temperature is slowly increasing. Safety injection has actuated and water is just starting to cover the active fuel.	100-200	Safety injection has quenched the core, the collapsed liquid level in the core is stable and slowly increasing, and the fuel temperatures are dropping. A frothy 2-phase mixture is exiting the vessel. The SG pressure remains high. Containment pressure could be constant or slowly increasing (depending on the design).	WC/T

Table 1 – Phases of the Large DEPS Break LOCA Event (continued)					
Phase	Start Time (seconds)	Conditions at Start	Approximate Duration (seconds)	Conditions at End	How Simulated
Post-Reflood	150-250	The core is quenched. A frothy 2-phase mixture is entering the SG tubes and the lower inlet section has started to quench.	5000 (dry) 20000 (ice)	Sump recirculation has started. The SG tubes have quenched and the remaining secondary-side energy is being transferred to containment. The SG fluid and metal is cooling from the tubesheet up. Containment pressure is past peak and decreasing.	WC/T
Long-term Steaming	5400 (dry) 20000 (ice)	Primarily a liquid release from the vessel side and a saturated steam or two-phase release from the SG side of the break.	Until End of Transient		Conservatively calculated, as described in Section 4.2 of WCAP-17721-P and in the response to RAI 2.11.

a,c

2.13 RAI-2 – Main feedwater

RAI: Provide an estimate of the additional energy which the inclusion of main feedwater flow would add to the secondary side of the steam generator and demonstrate that including this additional energy is negligible compared to the total energy already stored in the steam generator.

Comment: In table 4-2 row 9 of their submittal [1], Westinghouse discussed how the main feedwater flow would be ignored in the modeling of the event. Main feedwater flow is relatively hot and will increase the energy stored in the steam generators, which will also increase the mass and energy released to containment and could increase the peak containment pressure and temperature. Therefore, ANS 56.4 suggests that this flow should be considered during analysis. Westinghouse stated that they did not need to consider this flow for their analysis as the additional energy was negligible, but did not any quantitative analysis.

Westinghouse Response

A loss of offsite power is assumed at the start of a LOCA event. The loss of offsite power causes the feedwater pumps to trip and the flow rate to coast down. A safety injection (SI) signal causes the feedwater control valve to start to close. The SI signal is generated fairly quickly in a large LOCA event. Therefore, the main feedwater flow would continue for only a short period of time following the design basis large LOCA event.

During the initial WC/T LOCA mass and energy (M&E) model development program, a sensitivity case was made to examine the containment response to modeling the coast down of feedwater flow. For the sensitivity case, the feedwater flow was ramped down to zero over the first 10 seconds of the transient. This added approximately 5500 lbm of hot water and approximately 2.5 MBTU of energy to each steam generator. This represented about 2% of the total energy in each steam generator. The calculated containment pressure and temperature were not affected by this small increase in the steam generator energy (see response to RAI 10 on page 10-14 of WCAP-17721-P).

From RAI 2.12, the total energy release to containment at the end of the reflood phase is approximately 470 MBTU. Of this amount, about [

]^{a,c} Assuming the additional energy from modeling the coast down of main feedwater would be released at the same rate as the rest of the steam generator energy, the increase in the amount of energy that would be released at the end of reflood phase would be about 0.7 MBTU. This represents 0.15% of the total energy release at the end of the reflood phase and is considered to be negligible.

2.14 RAI-2 – Auxiliary feedwater

RAI: Clarify the modeling of the auxiliary feedwater and extraction steam. If both of these systems are being modeled in the M&E evaluation model, justify the modeling of both of these systems when the modeling of the main feedwater has been deemed negligible.

Comment: In table 4-2 row 10 of their submittal [1], Westinghouse discussed how the auxiliary feedwater flow would be modeled in the event. Auxiliary feedwater flow is relatively cool and will decrease the energy stored in the steam generators, as will extraction steam. In turn, this could decrease the calculated mass and energy released to containment which would decrease the calculated peak containment pressure and temperature. While modeling of these system can be appropriate, the NRC staff questioned the validity of modeling extraction steam and auxiliary feedwater (which would reduce the mass and energy released to containment) but ignoring main feedwater flow (which would increase the mass and energy released to containment).

Westinghouse Response

Row 10 of Table 4-2 in WCAP-17721-P indicates that [

]^{a,c} Revised text will be supplied in a future transmittal collecting changes resulting from responses to all RAIs.

2.16 RAI-3 – Safety Injection (SI) water volume and temperature

RAI: Are measurement uncertainties considered for the values of the initial safety injection tank water volume and water temperature?

Comment: In table 4-2 row 21 of their initial submittal [1], Westinghouse stated that measurement uncertainties were considered in the modeling of the accumulator pressure, but did not state whether measurement uncertainties were considered in the model of the water volume and temperature in the accumulator.

Westinghouse Response

Core cooling fluid is supplied prior to sump recirculation by the accumulators and pumped injection from the refueling water storage tank. The accumulators are located inside containment, [

]^{a,c} The refueling water storage tank (RWST) is located outside containment. The boundary conditions representing pumped safety injection in WC/T [

]^{a,c}

2.17 RAI-3 – Nodalization

RAI: Provide justification which demonstrates that the nodalization used in WC/T results in appropriate predictions of the break flow and flow in the broken and intact loops such that the resulting predictions of mass and energy release will result in appropriate calculations of containment temperature and pressure. Additionally, provide a sensitivity study which demonstrates that the noding sensitivity in the steam generator.

Comment: In table 4-2 row 25 of their initial submittal [1], Westinghouse stated that the same nodalization was used for the ECCS evaluation model as was used in the M&E evaluation model. However, the in section 2.8 of their submittal, Westinghouse stated that the noding was increased to account for physical phenomena. However, there is no data which demonstrates that the solution is not sensitive to the noding chosen and a further increase in noding may be needed.

<u>Westinghouse Response</u>

The break flow modelling and the loop flow split, which are dependent upon the WC/T noding structure, are discussed in the Westinghouse response to SCVB-RAI-11 which was transmitted to the NRC via LTR-NRC-15-5[1].

The statement in Table 4-2 row 25 of WCAP-17721-P was in reference to the general vessel and loop layout, [

]^{a,c} also described in WCAP-17721-P Section 4.1.

The LOCA PCT SG model includes [ ]^{a,c} In order to more accurately model the post-LOCA SG cool down, the LOCA M&E SG model uses [ ]^{a,c} The level of subdivision in the LOCA M&E model has been demonstrated to be sufficient through a FLECHT-SEASET simulation sensitivity study. The number of secondary nodes was [

]^{a,c} The SG outlet vapor temperatures in Figure 2 show that the temperatures of the sensitivity case remain within 2% of the base case results during the first 50 seconds of the transient and within 1% for the rest of the transient. The SG tube wall temperatures were also similar as shown in Figure 3, Figure 4 and Figure 5. This demonstrated

[1] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

that the current SG secondary noding structure [ ]^{a,c} was adequate.

a,c

Figure 2: FLECHT Steam Generator Outlet Vapor Temperature Comparison

a,c

Figure 3: FLECHT Steam Generator Wall Temperature Comparison at 1 ft

a,c

Figure 4: FLECHT Steam Generator Wall Temperature Comparison at 4 ft

a,c

Figure 5: FLECHT Steam Generator Wall Temperature Comparison at 10 ft

2.23 RAI-3 – Hot leg condensation in NPSHa and EQ

RAI: Demonstrate that the assumption to ignore any hot leg condensation is also appropriate for NPSHa and EQ analysis.

Comment: In section 2.6 of their initial submittal [1], Westinghouse stated that the hot leg condensation would be ignored as this was conservative for a contaminant pressure as it insured the maximum amount of steam to containment. However, Westinghouse did not address how this assumption would impact the other two purposes of an M&E analysis, NPSHa and EQ analysis.

Westinghouse Response

The NPSHa for the recirculation pumps is only a concern when the operator transfers from the injection mode to the cold leg recirculation mode. This occurs within about an hour after the start of the large break LOCA event. Hot leg condensation is not possible at this time; there is no source of cold water or metal in the hot legs that would condense the steam coming from the core. Therefore, ignoring hot leg condensation has no effect on the NPSHa analysis.

Hot leg condensation does not become important until after the operator transfers from cold leg to hot leg recirculation. This occurs several hours after the start of the large break LOCA event. The relatively cold recirculation water that enters the hot legs condenses steam coming from the core. This reduces the amount of steam released to containment and allows the containment pressure and atmosphere temperature to decrease. This reduction is beneficial when comparing the calculated containment response to the equipment qualification pressure and temperature envelopes. Therefore, ignoring the effect of hot leg condensation is conservative for the EQ analysis.

2.28 RAI-3 – Heat transfer directly to containment

RAI: Is heat transfer from the primary and secondary metal to containment directly calculated and if not why is this appropriate?

Comment: None.

Westinghouse Response

Direct heat transfer to containment is not modeled from the active RCS and SG metal. Because most of the RCS and SG metal is insulated, the direct heat transfer rate to the containment atmosphere would be fairly low when compared with the heat transfer rate to the corresponding RCS or SG fluid that is in contact with the active metal.

The heat transfer rate from the active RCS and SG metal is modeled in the WC/T LOCA M&E release calculation. The active RCS metal energy that is transferred to the RCS fluid will be released to containment via the break. The active SG metal energy that is transferred to the SG fluid will be transferred through the SG tubes to the RCS fluid, and then released to containment via the break. This approach, to transfer the active metal energy to produce steam from the RCS, is more conservative than direct heat transfer from the metal to containment through the insulation.

2.29 RAI-3 – Inactive metal

RAI: Define inactive metal and discuss how it is treated.

Comment: None.

Westinghouse Response

Inactive metal is defined as metal that is not in direct contact with water at the end of the blowdown phase of the large LOCA event. This includes the RCS upper head and pressurizer metal, along with the metal in the upper regions of the steam generators.

Because the inactive RCS and SG metal is not in direct contact with the RCS fluid, it does not cooldown as quickly as the active metal. If modeled, free convection and radiation from the outside surface, along with conduction to active metal components, would allow the inactive metal energy to be transferred to containment at a much slower rate.

Currently, the inactive metal in the WC/T model is [

]a,c

2.33 RAI-3 – Secondary side heat transfer

RAI: Specify how the heat is treated between the secondary side metal to the secondary side coolant, and from the secondary side coolant to the steam generator tubes.

Comment: In their initial submittal [1], Westinghouse did not specify have this heat transfer was treated.

Westinghouse Response

Heat transfer between the active SG metal and the secondary side coolant, and between the secondary side coolant and the SG tubes, is included in the WC/T LOCA M&E release model. During steady state (prior to the LOCA), nucleate boiling from the tubes to the secondary fluid is the dominant heat transfer mode. After the LOCA starts, the MSIVs close and the feedwater flow stops, causing the steam generators to be isolated. After SG isolation occurs, the heat transfer mode is primarily natural convection from the secondary fluid to the tubes, and either natural convection or nucleate boiling from the secondary shell to the fluid.

The WC/T secondary side heat transfer calculation uses the same correlations that are applied to the TRAC components; the TRAC wall heat transfer model is described in detail in Section 6-3 of WCAP-12945-P-A, Volume 1, Revision 2. The TRAC correlations are: single phase liquid natural convection (the maximum of McAdams – laminar and Holman - turbulent), single phase liquid forced convection (the maximum of Rohsenow/Choi – laminar and Dittus/Boelter – turbulent), nucleate boiling (Chen), critical heat flux (Biasi), transition boiling (Jones/Bankoff), film boiling (Forslund/Rohsenow for wall-to-liquid, when the vapor void fraction is [ ]^{a,c}, and the maximum of Dougall/Rohsenow, Bromley, or McAdams for wall-to-vapor, when the vapor void fraction is [ ]^{a,c}), and single phase vapor (the maximum of McAdams – turbulent natural convection and Dittus/Boelter – turbulent forced convection when the vapor void fraction is [ ]^{a,c}).

2.34 RAI-6 – Definitions for acronyms

RAI: Provide the definition for the following acronyms: PCWG, DEPSG, EQ, NPSHa, DEHLG, GENF

Comment: None

Westinghouse Response

PCWG – Performance Capability Working Group
DEPSG – Double-ended Pump Suction Guillotine
EQ – Equipment Qualification
NPSHa – Net Positive Suction Head – Available
DEHLG – Double-ended Hot Leg Guillotine
GENF – This is not an acronym; it is the name of a computer program that calculates the steady state thermal performance for a steam generator.

Westinghouse

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LTR-NRC-15-19

March 16, 2015

Subject: Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs" (Proprietary/Non-Proprietary).

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4126 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4126 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
Dr. Shie-Jeng Peng (NRC)

LTR-NRC-15-19
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bcc: James A. Gresham
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AW-15-4126
March 16, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-19 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-19, dated March 16, 2015

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-15-4126 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the accompanying Affidavit should reference AW-15-4126 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

AW-15-4126
March 16, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

James A. Gresham, Manager
Regulatory Compliance

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

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse 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 2.390 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 constitute Westinghouse policy and provide 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.

(iii) 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 that 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.

(vi) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-15-19 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-15-19, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721-P, and may be used only for that purpose.

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

(i) Obtain NRC approval of the LOCA Mass and Energy Release Calculation Methodology documented in WCAP-17721-P, "Westinghouse

Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of assisting customers in obtaining license changes for a Westinghouse pressurized water reactor (PWR).

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

LTR-NRC-15-19 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs (Non-Proprietary)

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066

The table below summarizes the Set 2 RAIs from the Safety and Code Review Branch[1] which have responses included in this attachment.

RAI #	Title
2.2	RAI-3 – Break size
2.4	RAI-3 – Refill
2.15	RAI-3 – Steady state steam generator pressure
2.18	RAI-5 – Steam tables
2.19	RAI-3 – Flow modeling
2.24	RAI-3 – Dynamic pump model
2.35	RAI-4 – Clarification on quench front paragraph

The table below summarizes the Set 3 RAIs from the Containment and Ventilation Branch[2] which have responses included in this attachment.

RAI #	Title
SCVB-RAI-3	Control of Applicability
SCVB-RAI-4*	Break Spectrum

*Note: This Set 3 RAI is addressed by reference to the response to Set 2 RAI 2.2.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A251)

[2] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology" - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260)

2.2 RAI-3 – Break Size

RAI: Westinghouse stated that the break size used for the M&E evaluation model is the double ended break. Provide information on the consideration of slot breaks. If the breaks are considered, when are they used? If the breaks are not considered, what is the justification for ignoring them?

Comment: In table 4-1, row 9 of their initial submittal [1], Westinghouse stated that their previous M&E evaluation model used a slot break to maximize M&E release in the Combustion Engineering (CE) Nuclear Steam Supply System (NSSS) designs. For the proposed Evaluation Model (EM), they did not specify if they considered slot breaks.

<u>Westinghouse Response</u>

Several slot breaks of varying sizes on both the hot leg and pump suction leg were performed using the 4 loop plant models described in Section 5 of WCAP-17721-P to demonstrate the sensitivity of the results to break type and to break size. The slot break sizes considered were CD = 1.6, 1.8 and 2.0 where CD for a slot break is defined as:

$$C_D(\text{Slot}) = \left(\frac{\text{break area}}{\text{main loop pipe area}}\right)$$

Therefore, a slot break with $C_D = 2.0$ has a flow area equal to that of a double-ended break. The split break differs from the double-ended guillotine break, in that, the slot break allows full communication between the approach regions on either side of the break; whereas, the guillotine break models a complete severance of both ends of the severed pipe.

Comparing the $C_D = 2.0$ slot break to the double-ended guillotine break as shown on Figure 1 and Figure 2, the peak mass release rate for the guillotine breaks is approximately 6000 lbm/s greater than for the slot break on both the hot leg and pump suction leg. The peak energy release rate ranges from 4×10^5 Btu/s to 6×10^6 Btu/s higher for guillotine breaks relative to slot breaks as shown on Figure 2 and Figure 4 for hot leg and pump suction leg breaks, respectively.

The slot break peak mass and energy release rates during blowdown are proportional to the slot break flow area regardless of break location. Referring to Figure 1 through Figure 4, as the break area (C_D) decreases, so does the peak mass and energy release rate.

Therefore, the maximum peak containment pressure and long-term containment pressure occurs for double-ended guillotine breaks as shown on Figure 5 through Figure 8. These same figures show that peak containment pressure decreases as the slot break flow area (C_D) decreases further reinforcing the conclusion that double-ended guillotine breaks are the limiting break type and size for the mass and energy (M&E) evaluation model.

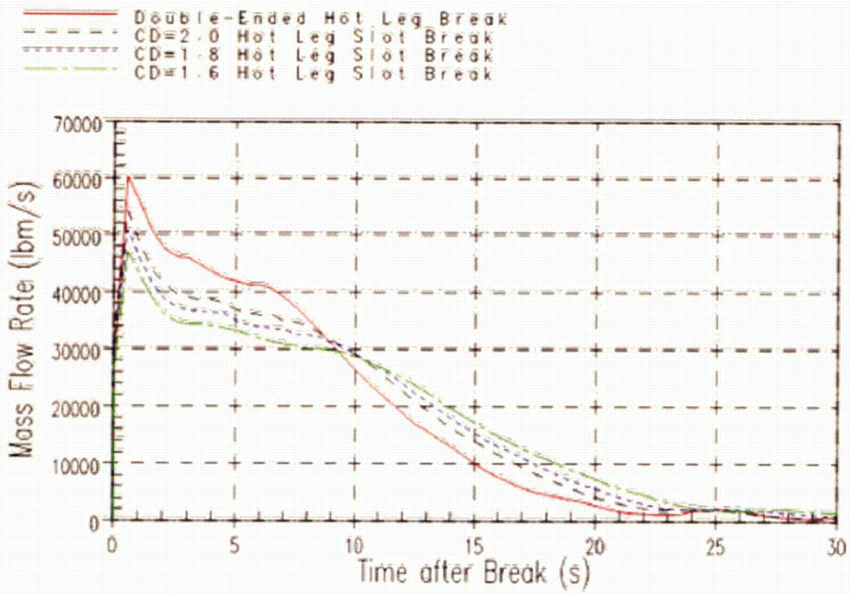

Figure 1: Blowdown Mass Release Rate for Hot Leg Breaks

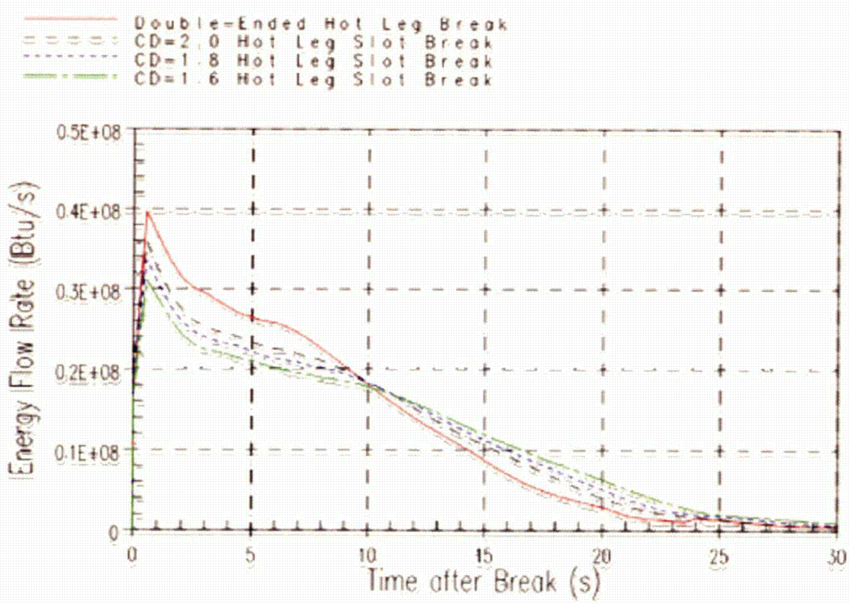

Figure 2: Blowdown Energy Release Rate for Hot Leg Breaks

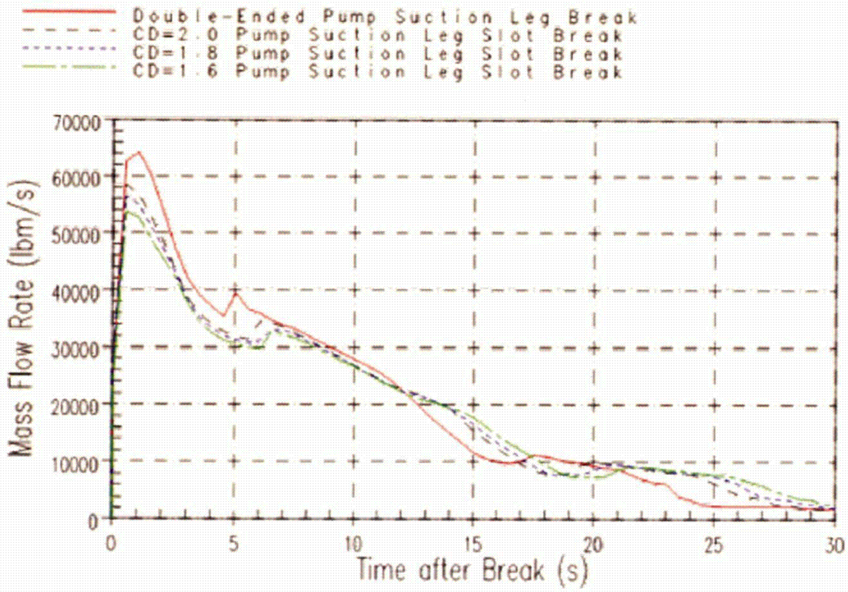

Figure 3: Blowdown Mass Release Rate for Pump Suction Leg Breaks

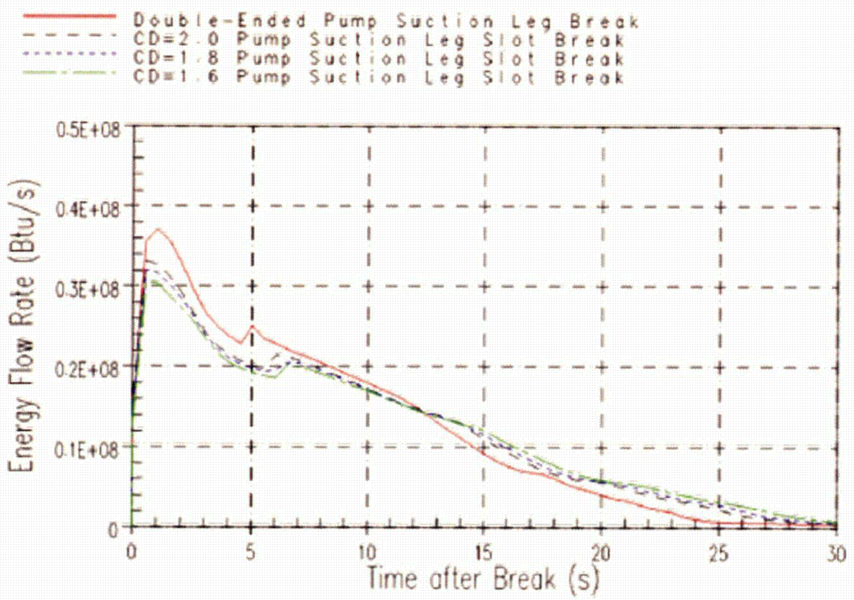

Figure 4: Blowdown Energy Release Rate for Pump Suction Leg Breaks

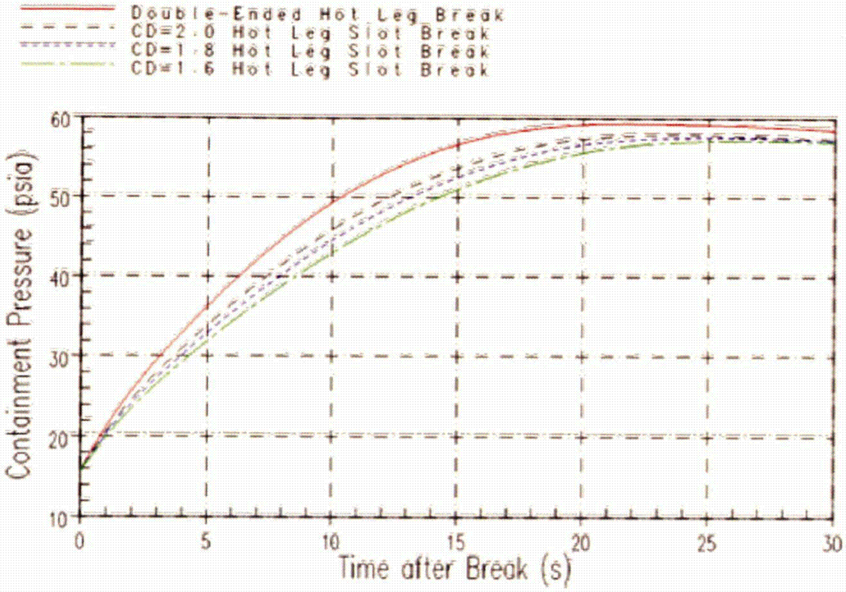

Figure 5: Peak Containment Pressure for Hot Leg Breaks

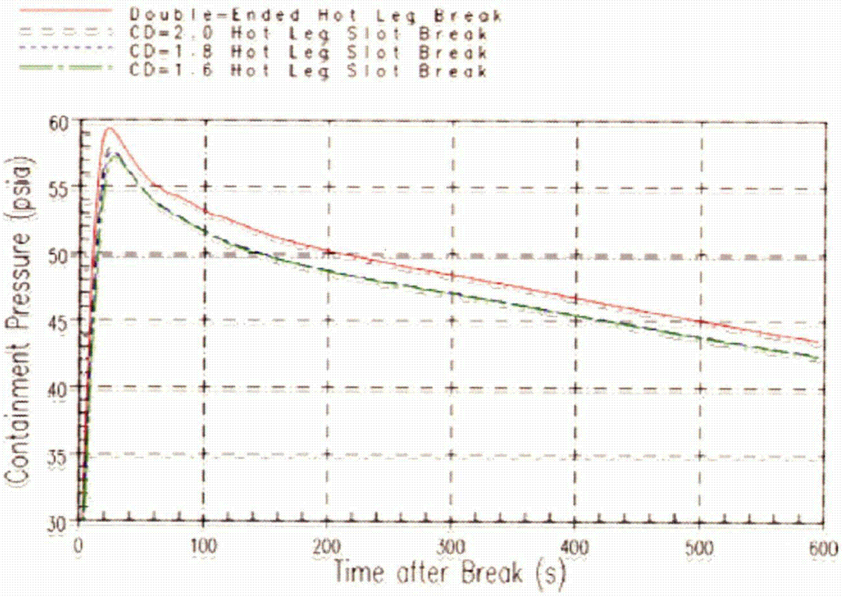

Figure 6: Long-Term Containment Pressure for Hot Leg Breaks

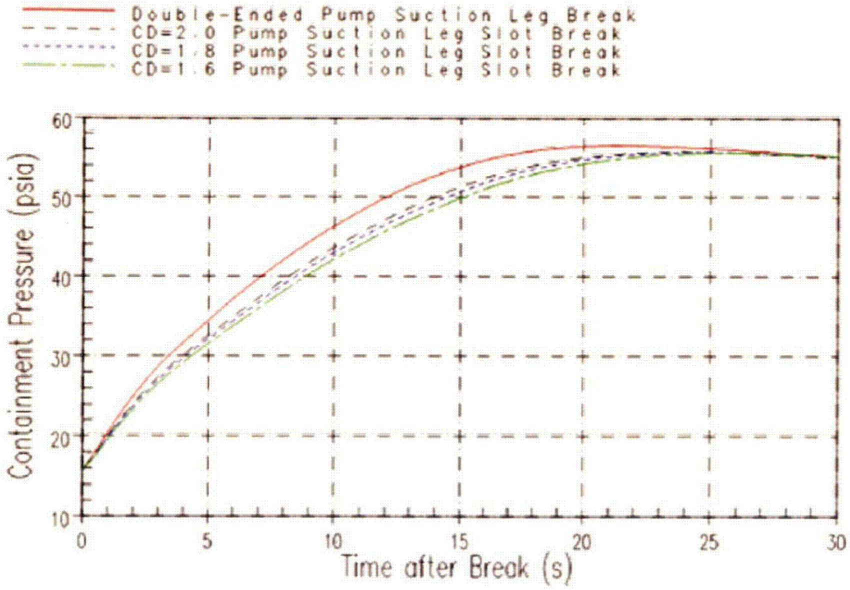

Figure 7: Peak Containment Pressure for Pump Suction Leg Breaks

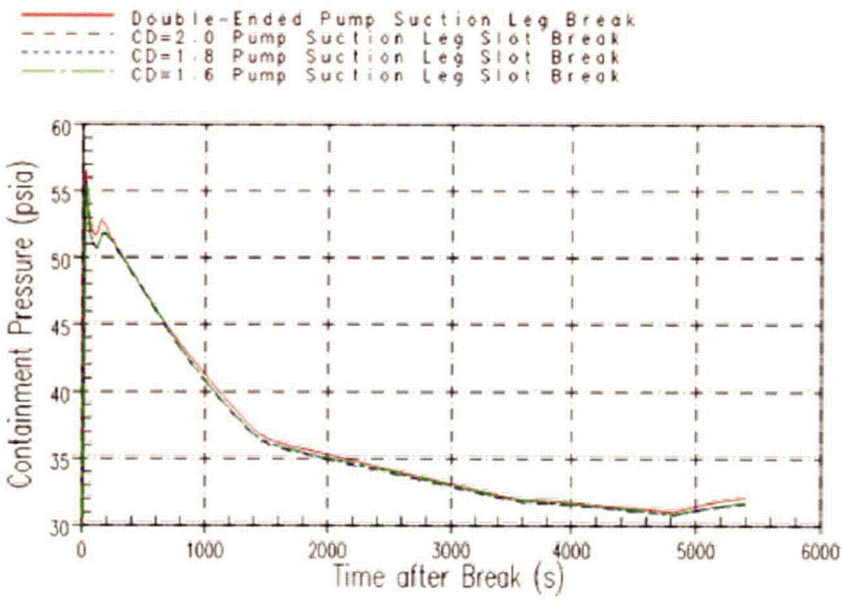

Figure 8: Long-Term Containment Pressure for Pump Suction Leg Breaks

2.4 RAI-3 – Refill

RAI: Describe the validation data which supports WC/T ability to model the refill phase and demonstrate that this data justifies WC/T ability to predict the RCS transient response during the refill phase for the M&E evaluation model.

Comment: In table 4-1 row 15 of their initial submittal [1], Westinghouse stated ECCS evaluation model had been validated for refill calculations by comparison with experimental data. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

Refill is calculated based on the realistic modelling of the key physical processes (e.g., end of critical flow in the broken pipe; interfacial heat transfer and interfacial drag in the intact cold legs and downcomer). The most relevant validation is based on comparisons of WCOBRA/TRAC predictions with full-scale ECC bypass tests in the Upper Plenum Test Facility (UPTF Test 6). As summarized in Section 25-6 of WCAP-12945-P-A[1], WCOBRA/TRAC tends to slightly under-predict the penetration of ECC water into the lower plenum at the end of blowdown. This trend would tend to be conservative for PCT calculations (prolonged heat up prior to cladding temperature turnaround during reflood), but could potentially be non-conservative for LOCA mass and energy release applications (delay of onset of reflood). A more detailed consideration of the timing of interest leads to the conclusion that a few second delay in the onset of reflood (same as end of refill) is inconsequential. That is because the limiting time periods from a LOCA mass and energy release perspective are either; 1) blowdown for the hot leg break, in which case refill is irrelevant, or 2) post-reflood, in which case the amount of energy addition to the containment is not sensitive to a few seconds of timing in the end of refill/beginning of reflood. This post-reflood conclusion is applicable to both pump suction and cold leg break scenarios.

Additional information illustrating the relative unimportance of the refill time period for the LOCA M&E release calculation is provided in the response to RAI 2.12[2].

[1] WCAP-12945-P-A, Volume 5, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis Volume V: Quantification of Uncertainty," March 1998.

[2] LTR-NRC-15-18, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," March 2015.

2.15 RAI-3 – Steady state steam generator pressure

RAI: Justify the use of the steam generator pressure calculated from the steady state calculation. Is this initial pressure always greater than or equal to the initial measured pressure in the steam generator plus uncertainty? If not, provide justification for using a pressure below the steam generator pressure plus uncertainty.

Comment: In table 4-2 row 17 of their initial submittal [1], Westinghouse discussed how the steam generator pressure was calculated from the steady state calculation, but did not confirm that they will ensure this calculated value would be greater than or equal to the expected value plus uncertainty.

Westinghouse Response

There are parameters that are known as the nuclear steam supply system (NSSS) design parameters. These NSSS design parameters are established for use throughout the Westinghouse design and safety analyses and these parameters serve as the common basis for the NSSS, fuel design, and safety analyses. For each aspect of the design and analyses, the appropriate adjustments are included by the designer or analyst in the conservative direction to account for uncertainty. With respect to steam pressure, Westinghouse recognizes that there are aspects of the design for which a high steam pressure is limiting; including the long term loss-of-coolant-accident (LOCA) mass and energy releases used for containment integrity. To address this safety analysis aspect, [

]^{a,c} This effectively corresponds to ideal steam generator heat transfer. As a result of assuming ideal heat transfer, no additional uncertainty is deemed appropriate. In practice, the NSSS design steam pressure [

]^{a,c}

With the value established above for the NSSS design pressure, the WCOBRA/TRAC steady state calculation attempts to use this value, [

]^{a,c} to converge on a reasonable set of steady state conditions. The steam generator secondary pressure may require some minor adjustment in order to meet the desired set of conditions [

]^{a,c} Current experience

indicates that the final steam generator pressure required to meet the RCS temperature is generally very close to the desired designed NSSS value [ ]^{a,c} or exceeds the desired value by a few psi. Hence, no additional adjustment to steam generator steam outlet pressure for instrument uncertainty is made while converging on all of the steady state conditions.

2.18 RAI-5 – Steam tables

RAI: Which steam tables are used in the M&E evaluation model? Are those steam tables consistent with the 1967 ASME Steam Tables?

Comment: In table 4-2 row 26 of their initial submittal [1], Westinghouse stated that the same steam tables were used for the ECCS evaluation model as was used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

The bases for the steam tables used in the WCOBRA/TRAC code are described in Section 10-2 of WCAP-12945-P-A[1]. The properties used in the code are based on 1968 and 1983 versions of the ASME Steam Tables[2,3], and the 1984 National Bureau of Standards/National Research Council (NBS/NRC) Steam Tables[4]. Comparisons of code properties with those from the reference steam tables are provided in Figures 10-1 through 10-16 for the vessel component, and Figures 10-17 through 10-28 for the 1-D components. Good agreement is observed.

Note that there is no attempt to bias steam tables in safety analysis applications. The intent is to closely replicate the best-estimate properties in both M&E and ECCS evaluation models. The WCOBRA/TRAC representation of the steam tables has previously been approved for use in realistic ECCS evaluation models.

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[1] WCAP-12945-P-A, Volume 1, Revision 2, "Code Qualification Document for Best Estimate LOCA Analysis Volume I: Models and Correlations," March 1998.

[2] ASME Steam Tables, 1968, American Society of Mechanical Engineers, 2nd Edition.

[3] ASME Steam Tables, 1983, Thermodynamic Transport Properties of Steam, 5th Edition, The American Society of Mechanical Engineers, New York.

[4] Haar, L., Gallagher, J.S., and Kell, G.S., 1984, NBS/NRC Steam Tables, Hemisphere Publishing Corporation, New York.

2.19 RAI-3 – Flow Modeling

RAI: Confirm that the following effects have been taken into account in the flow modeling used in the M&E evaluation model:

(1) temporal change of momentum,
(2) momentum convection,
(3) forces due to wall friction,
(4) forces due to fluid pressure,
(5) forces due to gravity, and
(6) forces due to geometric head loss effects (for example, contractions, expansions, bends, and pump losses).

Additionally confirm that the frictional losses in pipes and other components are calculated using models that include realistic variation of friction factor with Reynolds number, and realistic two-phase friction multipliers that have been adequately verified by comparison with experimental data.

Additionally confirm that if an uncertainty in a pressure loss exists, the pressure loss shall be conservatively minimized.

Comment: In table 4-2 row 27 of their initial submittal [1], Westinghouse stated that the same flow modeling was used for the ECCS evaluation model as was used in the M&E evaluation model. However, they did not provide details on that flow modeling.

Westinghouse Response

The recommendations from ANS 56.4-1983[1] with regard to flow modelling are very similar to those in Regulatory Position C.3.7, "Momentum Equation," of Regulatory Guide (RG) 1.157[2], "Best-Estimate Calculations of Emergency Core Cooling System Performance." Compliance with this Regulatory Position is discussed in Section 28-2 of WCAP-12945-P-A[3], starting on page 28-17. Items (1) through (6) in this RAI can be mapped to the Section 28-2 discussion of the WCOBRA/TRAC momentum equation as follows:

(1) temporal change of momentum – maps to item 1) in Section 28-2
(2) momentum convection – maps to item 2)
(3) forces due to wall friction – maps to item 5)
(4) forces due to fluid pressure – maps to item 4)

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[1] ANS 56.4-1983, "pressure and temperature transient analysis for light water reactor containments," December 1983.

[2] Regulatory Guide (RG) 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance," May 1989.

[3] WCAP-12945-P-A, Volume 5, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis Volume V: Quantification of Uncertainty," March 1998.

(5) forces due to gravity – maps to item 7)
(6) forces due to geometric head loss effects – maps to items 3) and 6); additionally, pump losses when in the dissipative mode are reflected in the homologous curves (Sections 9-4[4] and 16-3[5] of WCAP-12945-P-A)

The frictional losses are calculated using models that include realistic variation of friction factor with Reynolds number, and realistic two-phase friction multipliers that have been verified by comparison with experimental data. This is discussed with respect to Regulatory Position C.3.6 of RG 1.157, "Frictional Pressure Drop," starting on page 28-16 of WCAP-12945-P-A[3].

The pressure losses for PWR applications of the WCAP-17721-P methodology will be calculated in a best-estimate manner. See "Loop Flow Split" in the response to SCVB-RAI-11[6] for additional discussion. In addition to the LOFT flow split predictions discussed there, it is noted that the CCTF Run 62 flow split is also well predicted; see Figures 14-2-29 and 14-2-30 of WCAP-12945-P-A[5]. The ability of WCOBRA/TRAC to accurately predict the loop flow split in these large scale facilities indicates there is no need to apply additional biases on pressure losses due to uncertainty.

[4] WCAP-12945-P-A, Volume 1, Revision 2, "Code Qualification Document for Best Estimate LOCA Analysis Volume I: Models and Correlations," March 1998.

[5] WCAP-12945-P-A, Volume 3, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis Volume III: Hydrodynamics, Components and Integral Validation," March 1998.

[6] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non-Proprietary)." January 2015.

2.24 RAI-3 – Dynamic pump model

RAI: Demonstrate that the dynamic pump model used in WC/T provides an appropriate prediction of the pump dynamics for the M&E evaluation model such that the mass and energy release is adequately predicted. Additionally, justify the rationale for assuming the rotor remains locked following the flow reversal during blowdown in a double ended pump suction break.

Comment: In table 4-2 row 28 of their initial submittal [1], Westinghouse stated that the same dynamic pump was used for the ECCS evaluation model as was used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation. Additionally, Westinghouse did not provide justification for the assumption of a locked rotor.

Westinghouse Response

The reactor coolant pump (RCP) model was ranked as "medium" and "low" for all phases of the long term loss-of-coolant-accident (LOCA) transient for mass and energy releases for containment integrity when the phenomena identification and ranking table (PIRT) was documented in BE-2004 Proceedings[1]. Thus, the standard dynamic pump model in WCOBRA/TRAC was not modified for the long term LOCA mass and energy release calculation. While many modeling assumptions differ between the PCT analysis and the long term LOCA M&E analysis, when considering the RCP modeling, the approach is the same. It is conservative to empty the initial inventory in the reactor vessel as quickly as-is physically possible. The pump model includes transfer of momentum from the pump to the fluid, as described by Equation 9-1 in WCAP-12945-P-A[2]. The speed of the pump is taken into account through Equation 9-9 in WCAP-12945-P-A. The pressure difference through the pump, and the torque applied by the fluid on the pump impeller, are calculated using empirically determined single and two-phase homologous curves. The data used to obtain these curves is described in WCAP 12945-P-A, Volume 3, Section 16-3[3].

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[1] R. P. Ofstun and L. C. Smith, "PIRT for Large Break LOCA Mass and Energy Release Calculations," BE-2004 Proceedings, International Meeting on Updates in Best Estimate Methods in Nuclear Installation Safety Analysis, November 2004.

[2] WCAP-12945-P-A, Volume 1, Revision 2, "Code Qualification Document for Best Estimate LOCA Analysis Volume I: Models and Correlations," March 1998.

[3] WCAP-12945-P-A, Volume 3, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis Volume III: Hydrodynamics, Components and Integral Validation," March 1998.

The standard assumption when generating mass and energy releases from a large break LOCA for containment integrity is that offsite power has been lost at the initiation of the event. Thus, the reactor coolant pumps would be free to coast down or spin based on the loop flow rates. WCOBRA/TRAC has an input option for locking the RCP rotor. Locking the rotor could be necessitated in order to model the reverse rotation pawls that exist on Westinghouse standard designed reactor coolant pumps. The locked rotor option is used only in the event of reverse rotation in any RCP. When a double-ended break is modeled in the pump suction piping or in the hot leg, there is a very brief period of time during the initial blowdown when the flow in the broken loop continues to be directed toward the reactor vessel cold leg inlet nozzle. The flow quickly reverses because the break is on the inlet side of the RCP. At this point (tenths of a second), the RCP forward speed is quickly reduced to zero and from that time on the RCP rotor is prevented from spinning in reverse. Flow reversal is not predicted for a double-ended cold leg break so the RCP will gradually coast down and then spin freely in the forward direction as the flow and RCP moment of inertia dictate.

2.35 RAI-4 – Clarification on quench front paragraph

RAI: The first full paragraph on page 3-5 does not make sense. Revise this paragraph and re-submit it.

Comment: None

Westinghouse Response

Replace the first full paragraph on page 3-5 with the following paragraph:

According to Collier (Reference 21, Section 4.5.2), the heat transfer processes in the vicinity of the quench front are characterized by two main heat transfer regimes separated by the liquid film dryout location. Downstream of the quench front, and before the dry saturated vapor region, there is a flow pattern characterized by a liquid deficient region, where dispersed flow heat transfer takes place, and an interfacial heat transfer correlation which can deal with nonequilibrium superheated steam conditions needs to be applied. Upstream of the quench front there is a region characterized by a thin liquid film wetting the tube walls. The thickness of this film is often such that the effective thermal conductivity is able to prevent the liquid in contact with the wall from being superheated to a temperature which would allow bubble nucleation. The energy is transferred by forced convection in the film to the liquid-vapor core interface, where evaporation takes place. This heat transfer process can no longer be called nucleate boiling because nucleation is suppressed. This region is called the two-phase forced convective region. According to Figure 4.14 in Reference 21, the heat transfer coefficient in this region raises as the film becomes thinner and, when the dryout occurs, there is an abrupt reduction in the value of this parameter.

SCVB-RAI-3: Control of Applicability

Provide the control measure that is put in place to prevent the analyst from applying the WCAP-17721, Revision 0, TR methodology beyond its scope and range of applicability. Provide the details and associated basis for this control measure.

Westinghouse Response

The means to control the applicability of the WCAP-17721-P methodology and ensure it is not applied beyond its approved scope is through the development of methodology specific guidance. This guidance is currently being developed concurrently with the as-submitted WCAP-17721-P methodology, and an up-to-date copy will be provided for review at the Nuclear Regulatory Commission and Westinghouse audit scheduled for April 2015. Upon receiving a safety evaluation and compiling the approved version of WCAP-17721-P, Westinghouse will update the guidance to include any applicable conditions placed on the methodology.

SCVB-RAI-4: Break Spectrum

For the Item 9 of Table 4-1, justify why the result of break spectrum sensitivity studies using the previous methodology is applicable to the proposed WCAP-17721, Revision 0, TR methodology in which the double-ended break will still be limiting when the proposed methodology is used for break spectrum studies.

Westinghouse Response

See the response to Set 2 RAI 2.2 (RAI-3 – Break size).

Westinghouse

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LTR-NRC-15-20

March 26, 2015

Subject: Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs" (Proprietary/Non-Proprietary).

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4147 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4147 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
Dr. Shie-Jeng Peng (NRC)

LTR-NRC-15-20
Page 2 of 2

bcc: James A. Gresham
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AW-15-4147

March 26, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-20 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-20, dated March 26, 2015

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-15-4147 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the accompanying Affidavit should reference AW-15-4147 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

AW-15-4147
March 26, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

James A. Gresham, Manager
Regulatory Compliance

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

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse 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 2.390 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 constitute Westinghouse policy and provide 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.

(iii) 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 that 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.

(vi) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-15-20 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-15-20, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721-P, and may be used only for that purpose.

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

(i) Obtain NRC approval of the LOCA Mass and Energy Release Calculation Methodology documented in WCAP-17721-P, "Westinghouse

Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of assisting customers in obtaining license changes for a Westinghouse pressurized water reactor (PWR).

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

LTR-NRC-15-20 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs (Non-Proprietary)

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066

The table below summarizes the Set 2 RAIs from the Safety and Code Review Branch[1] which have responses included in this attachment.

RAI #	Title
2.25	RAI-3 – GOTHIC time step sensitivity
2.26	RAI-3 – WC/T coupled vs. standalone
2.27	RAI-3 – Heat transfer correlations
2.30	RAI-3 – Unal's Correlation
2.31	RAI-3 – Biasi Range
2.32	RAI-2 – FLEACHT (sic) heat release rate

Pages from WCAP-17721-P will change as a result of the RAI responses provided in this transmittal and the RAI responses provided in LTR-NRC-15-18[2] and LTR-NRC-15-19[3]. Mark-ups of the affected pages are included at the end of this attachment. Due to code modifications implemented as part of the response to RAI 2.31, the FLECHT-SEASET comparison, large dry containment plant comparison, and ice-condenser containment plant comparison figures needed to be revised. This transmittal includes the revised figures for the FLECHT-SEASET and large dry containment plant comparisons. The revised figures for the ice-condenser plant comparison are forthcoming.

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1 Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A251)

2 LTR-NRC-15-18, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non-Proprietary)," March 2015.

3 LTR-NRC-15-19, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch - Response to Selected RAIs" (Proprietary/Non-Proprietary)," March 2015.

2.25 RAI-3 – GOTHIC time step sensitivity

RAI: Provide justification that WC/T mass and energy predictions are not sensitive to all possible time steps which are able to be used in GOTHIC in the M&E evaluation model. Additionally, demonstrate that the mass and energy are conserved between codes under all possible times steps and that no time step will result in numerical instabilities. Additionally, provide clarification on how the GOTHIC and WC/T time steps interface and when information is passed from code to code.

Comment: In sections 3.3 and 3.4 of their initial submittal [1], Westinghouse described the interface between WC/T and GOTHIC, but the NRC staff was not able to understand this description. Additionally, because of this coupling, there is a possibility that the mass and energy passed between WC/T and GOTHIC is not conserved and the NRC staff wanted to ensure this was not the case.

Westinghouse Response

The user specifies the maximum and minimum time step sizes for both WCOBRA/TRAC (WC/T) and GOTHIC for parallel execution of the codes. Time step sensitivities were performed and discussed in the response to SCVB-RAI-6, which was transmitted to the Nuclear Regulatory Commission (NRC) via LTR-NRC-15-5[1]. The transient results were not sensitive to changes in the selected maximum and minimum time step sizes.

An inter-process communication option is available in GOTHIC. This option allows the user to specify read/write run-time data files through which data written by one code can be read by the other. WC/T was modified to incorporate the capability to read from and write to these run-time data files to allow it to run in parallel with GOTHIC. This process is explained in Section 3.4 of WCAP-17721-P.

The two codes, WC/T and GOTHIC, execute in parallel with their own independent time step sizes and are synchronized through the read/write run-time files "brk_cond" (break conditions written by WC/T) and "cont_cond" (containment conditions written by GOTHIC) to provide time-consistent information to one another. The variables in these two files are described in Section 3.4 of WCAP-17721-P. The code with the larger time step size (typically GOTHIC) waits at the end of its large time step for the code with the smaller time step size (typically WC/T) to catch-up. This discussion focuses on WC/T having the smaller time step size, but the method was developed so it could be used no matter which code had the smaller time step size.

For loss-of-coolant accident (LOCA) mass and energy (M&E) release calculations, WC/T usually executes with time steps that are significantly smaller than GOTHIC. The response to

[1] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non-Proprietary)," January 2015.

SCVB-RAI-6 shows that GOTHIC typically executes with time steps that are [ ]^{a,c} larger than those used by WC/T (see Figure 1 in SCVB-RAI-6).

[

]^{a,c} This information is passed to GOTHIC through the "brk_cond" run-time data file. Figure 3-51 of WCAP-17721-P provides both the equations and a visual representation showing how the release rates calculated by WC/T are [

]^{a,c}

[

]^{a,c} This data passing cycle continues until the end of the transient.

The transfer of information between the codes is illustrated in Figure 3-56 in WCAP-17721-P. A schematic of the implementation of the [ ]^{a,c} in WC/T is shown in Figure 3-55 in WCAP-17721-P.

The coupling method, which uses the [

]^{a,c} was developed to conserve mass and energy between the codes. The transfer between WC/T and GOTHIC was validated by comparing the interface variables from WC/T and GOTHIC. The results coincided identically.

A description of the GOTHIC time step control is given in Section 15.11 of the GOTHIC Technical Manual[2]. The time steps in GOTHIC are limited by the user specified maximum time step size and by GOTHIC control models for implicit or semi-implicit implementation of the models. The current implementation uses the [ ]^{a,c} solution in GOTHIC which limits the time step by stability consideration of the component models. Explicit quantities in the transport terms require that the time step be limited by Courant type limit conditions which take into account the cell's volume and the total volumetric flow out of the cells.

As mentioned earlier, the GOTHIC time step size is typically larger than the WC/T time step size, but this does not introduce inaccuracies in the calculation of the containment pressure for a couple of reasons. First, the [

]^{a,c} Second, unlike subcompartment analyses, the containment is a large, open volume; the size of the volume is such that it does not respond

[2] NAI 8907-06, Revision 17, "GOTHIC Containment Analysis Package Technical Manual Version 7.2b (QA)," March 2009.

immediately to changes in the M&E releases. As described in the response to SCVB-RAI-6, transferring WC/T data to GOTHIC over a time interval of [ ]^{a,c} or less is sufficient to maintain accuracy in the calculation of the containment response.

2.26 RAI-3 – WC/T coupled vs. standalone

RAI: Provide a comparison between results from a WC/T analysis which has been coupled to GOTHIC and a WC/T analysis which is run in standalone mode. Demonstrate that the results of the WC/T run in standalone mode are conservative compared to those coupled with GOTHIC.

Comment: In section 3.4 of their initial submittal [1], Westinghouse stated that using WC/T in standalone mode was conservative compared to the more mechanistic calculation of using it coupled to GOTHIC. However, Westinghouse did not provide any supporting analysis.

Westinghouse Response

The calculated containment pressure, temperature, and sump temperature response during a loss of coolant accident (LOCA) are dependent on the LOCA mass and energy release input. After the blowdown phase, the LOCA mass and energy (M&E) releases are somewhat dependent on the [

]^{a,c}

Section 3.4 of WCAP-17721-P discusses WCOBRA/TRAC (WC/T) running in parallel with GOTHIC. Inter-process communication is available in GOTHIC by specifying read/write data files. WC/T was modified to incorporate the same read/write data files; this allows WC/T to run in parallel with GOTHIC.

When WC/T is run standalone (i.e. not coupled to a containment code), assumptions must be made relative to the [

]^{a,c} When WC/T and GOTHIC are coupled, the "real" values for these parameters are communicated between the codes. In a standalone case, values must be assumed in the WC/T run, and then confirmed to be conservative via the containment response. The [

]^{a,c} calculated with the containment code. [

]^{a,c} compared to a coupled case.

The final parameter that must be assumed in the standalone run is the containment backpressure. WCAP-17721-P indicated that Westinghouse will assume [

]^{a,c} for the backpressure in the WC/T LOCA M&E calculation. This statement was based on a sensitivity run that demonstrated elevated containment pressure with WC/T M&Es using a backpressure set to [

]^{a,c} More recently, it has been recognized that due to variances in plant parameters (containment design, safety injection system design, etc) there is no [

]^{a,c} for the containment backpressure.

A series of standalone WC/T and GOTHIC runs were completed where the containment backpressure input was manipulated [

]^{a,c} These standalone sensitivity cases isolated the differences in the calculation to the containment pressure seen by WC/T. Each case modeled a double-ended pump suction break with an emergency diesel generator (EDG) failure, which is typically a limiting post-blowdown peak pressure scenario for a large dry containment.

The containment pressure results of these cases are shown below in Figure 1. The most important conclusion that can be drawn from Figure 1 is that the containment peak pressure is unaffected by backpressure assumptions. Therefore, if the definition of "conservative" in the RAI is taken in the context of peak containment pressure, the backpressure assumed in WC/T is irrelevant for blowdown limited containment designs. The post-blowdown long term pressure is not sensitive to the backpressure assumed in the WC/T calculation, as long as the assumed backpressure is within reason. Varying the backpressure input within [ ]^{a,c} psi of the final calculated containment pressure does not significantly affect the results; significant margin to the containment design pressure exists. Therefore, rather than use a [ ]^{a,c} for standalone WC/T runs as stated in WCAP-17721-P, Westinghouse will assume a backpressure curve that lies within [ ]^{a,c} psi of the final calculated containment pressure response from the containment code.

Regarding ice-condenser applications, WCAP-17721-P indicated that Westinghouse would conservatively [ ]^{a,c} the back pressure for the WC/T M&E release calculation. Sensitivity studies showed that a [ ]^{a,c} backpressure was clearly limiting for this application. In the event that a GOTHIC ice-condenser containment model is developed and coupled with WC/T, the transfer of the real time containment pressure from GOTHIC to WC/T should yield a [ ]^{a,c}

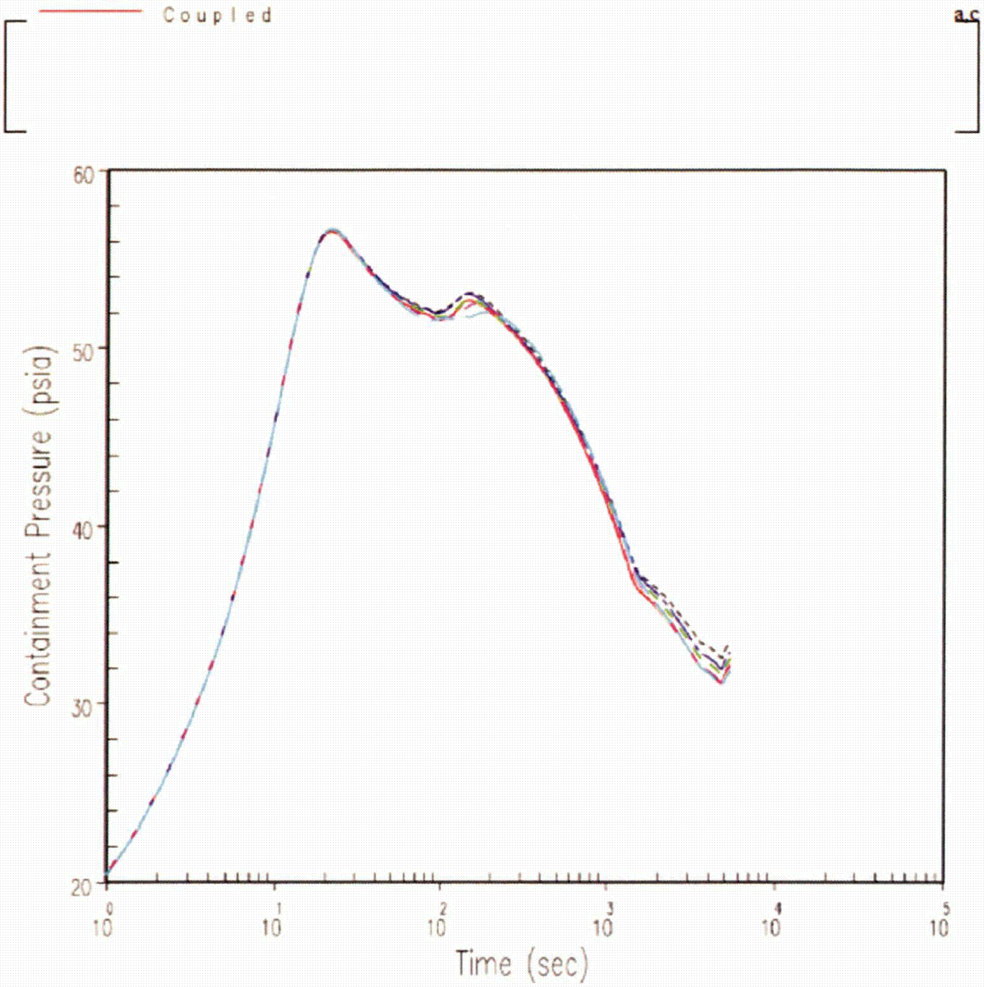

Figure 1: Containment Pressure Comparison

2.27 RAI-3 – Heat transfer correlations

RAI: Demonstrate that the heat transfer correlations used in WC/T provide an appropriate prediction of the heat transfer for the M&E evaluation model such that the mass and energy release is adequately predicted. Both the primary and secondary side heat transfer correlations should be considered.

Comment: In table 4-1 row 13 and 14 and table 4-2 row 33 of their initial submittal [1], Westinghouse stated that the same heat transfer correlations were used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

The WCOBRA/TRAC (WC/T) heat transfer correlations have not been biased for either the loss of coolant accident (LOCA) peak clad temperature (PCT) or the LOCA mass and energy (M&E) release calculations. Inside the reactor vessel, the heat transfer calculation uses the correlations from the COBRA code; the COBRA heat transfer model is described in detail in Section 6-2 of WCAP-12945-P-A[1]. The COBRA correlations are listed in Table 1. Outside of the reactor vessel, the heat transfer calculation uses the correlations that are applied to the TRAC components; the TRAC wall heat transfer model is described in detail in Section 6-3 of WCAP-12945-P-A. The TRAC correlations are listed in Table 2.

The WC/T vessel heat transfer correlations have been validated for the LOCA application using scalable data from both separate effects and integral tests (see Section 13 of WCAP-12945-P-A). The validation tests were designed to support development of the emergency core cooling system (ECCS) evaluation models, and they cover the expected range of the reactor coolant system (RCS) conditions during a LOCA event. The blowdown heat transfer validation tests included: six tests in the Westinghouse G-1 Loop facility, four tests in the Westinghouse G-2 Loop facility, and three tests from the Oak Ridge Nation Lab THTF series. The refill heat transfer validation tests included seven tests from the Westinghouse G-2 Loop facility. The reflood separate effects heat transfer validation tests included: five FLECHT-SEASET Reflood tests, three FLECHT Low Flooding Rate tests, five FLECHT Skewed Power Reflood tests, four FEBA Reflood tests, and three Westinghouse G-2 Reflood tests.

[1] WCAP-12945-P-A, Volume 1, Revision 2, "Code Qualification Document for Best Estimate LOCA Analysis Volume I: Models & Correlations," March 1998.

Outside the reactor vessel, it is important to model the heat transfer from the steam generators in the LOCA M&E release calculation; this calculation is performed in TRAC. A modification was made to the [ ]^{a,c} in TRAC to improve the calculation of heat transfer at the [ ]^{a,c} This modification is only used inside the steam generator tubes for the LOCA M&E application, and is described in Section 3.1 of WCAP-17721-P. The revised steam generator tube heat transfer correlation has been validated by comparison with data from seven of the FLECHT-SEASET steam generator heat transfer tests, as described in Section 3.2 of WCAP-17721-P.

Table 1: COBRA Heat Transfer Correlations

Phase	Regime	Correlation
Vapor $\alpha >$ [ ]^{a,c}	Laminar natural convection	Constant Nu=10
	Turbulent natural convection	McAdams
	Laminar forced convection	Constant Nu=10
	Turbulent forced convection	Dittus-Boelter, Wong-Hochreiter
Liquid	Laminar natural convection	Kim
	Turbulent natural convection	N/A
	Laminar forced convection	N/A
	Turbulent forced convection	Dittus-Boelter
Two-phase	Subcooled pool boiling	Chen
	Nucleate boiling	Chen
	CHF	
	Pool Boiling	Zuber
	Forced Convection	Biasi
	Transition boiling	Maximum of: q1 = qwv+qrwv+qrwe+qdcht, where qwv is the vapor phase value, qrwv and qrwe are the radiation heat transfer values, and qdcht uses the Forslund and Rohsenow model. q2 = qwv+qrwv+qwet, where qwv is the vapor phase value, qrwv is the radiation heat transfer value, and qwet is the CHF value with a multiplier by Bjorand and Griffith. q3 = qwv+qrwv+qrwe+qtq, where qwv is the vapor phase value, qrwv is the radiation heat transfer value, and qtq is based on a model by Zuber.
	Film boiling	
	Inverted Annular ($\alpha <$[ ]^{a,c})	($\alpha <$ [ ]^{a,c}) Bromley ([ ]^{a,c}) Interpolate between Bromley and dispersed flow value
	Dispersed Flow ($\alpha >$[ ]^{a,c})	qdf = qcwv+qrwv+qrwe+qdwc, where qcwv is the vapor phase value with two-phase and grid heat transfer enhancement factors, qrwv and qrwe are the radiation heat transfer values, and qdwc uses the model by Forslund and Rohsenow.
	Radiation (to vapor, drops, and films)	Sun, Gonzalez, and Tien

Table 2: TRAC Heat Transfer Correlations		
Phase	Regime	Correlation
Vapor	Laminar natural convection	N/A
	Turbulent natural convection	McAdams
	Laminar forced convection	N/A
	Turbulent forced convection	Dittus-Boelter
Liquid	Laminar natural convection	McAdams
	Turbulent natural convection	Holman
	Laminar forced convection	Rohsenow/Choi
	Turbulent forced convection	Dittus-Boelter
Two-phase	Subcooled pool boiling	Chen
	Nucleate boiling	Chen
	CHF	Biasi
	Transition boiling	Jones/Bankhoff
	Film boiling	
	(wall-to-liquid, α ≤ [ ]^{a,c})	Forslund-Rohsenow
	(wall-to-vapor, α > [ ]^{a,c})	Maximum of Dougall-Rohsenow, Bromley, and McAdams

2.30 RAI-3 – Unal's correlation

RAI: Provide validation for Unal's correlation over its application domain as used in the M&E evaluation model.

Comment: Unal's correlation is a highly empirical correlation fitted to a specific range of data. Therefore, validation is needed to justify the use of the correlation.

Westinghouse Response

The Unal correlation[1] is used to calculate the interfacial heat transfer for post-CHF conditions in the steam generator tubes during the reflood and post-reflood periods of a LOCA, for mass and energy release calculations performed for large dry and ice-condenser containment plants with WCOBRA/TRAC (WC/T). The predicted vapor superheat with the correlation was compared by Unal et al for 530 single tube data points from the EWC test data[2], 509 single tube data points from INEL experiments[3], and 348 3 x 3 rod bundle data points from UTC test data[4]. The range of the post CHF non-equilibrium test data is shown in Table 3.

Table 3: Unal Correlation Test Data Range			
	EWC Test Data[2] (single tube)	INEL Test Data[3] (single tube)	UTC Test Data[4] (rod bundle tube)
Pressure (k-Pa)	240 – 539	200 – 7000	105 – 120
(psia)	34.8 – 78.2	29.0 – 1015.	15.2 – 17.4
Mass Flux (kg/m²-sec)	14 – 78	72 – 100	7 – 26
(lbm/ft²-sec)	2.9 – 16.0	14.7 – 20.5	1.4 – 5.3
Dryout Quality	0 - 0.99	0.01 – 0.66	0. – 0.5

The pressure in the steam generator tubes during the period of time when the correlation is being applied are 30 – 60 psia for large dry containment plants (Figure 2), and between 28 and 30 psia for ice-condenser containment plants (Figure 5). The broken loop steam generator tubes mass flux values range between 5 and 30 lbm/ft^2 sec (Figure 3 and Figure 6). Its magnitude depends on the safety injection fluid conditions and the time during the transient. Although the intact loops show much lower steam flux than the steam flux for the broken loop

[1] "Vapor Generation Rate Model for Dispersed Droplet Flow," C. Unal et al., Nuclear Engineering and Design 125 (1991)161 - 173.

[2] "Axially varying vapor superheats in convective film boiling," D. Evans et al., ASME J. Heat Transfer 107 (August 1985) 663 – 669.

[3] "Forced convective nonequilibrium post-CHF heat transfer experiments in a vertical tube," R. C. Gotula et al., ASME – JSME, Thermal Engineering Conference, Honolulu, March 1983.

[4] "Thermodynamic nonequilibrium in post-CHF boiling in a rod bundle," K. Tuzla et al, Vols 1 – 4, NUREG/CR-5095 (1988).

(see Figure 4 and Figure 7, most of the steam exits through the broken loop steam generator), the cooling of the intact loop steam generators is still significant. See Figure 8 through Figure 11 for a comparison of the SG secondary side liquid temperature for the broken and intact loops for both the large dry and ice-condenser containment plants. The quality near the quench front in the steam generator tubes is within the range of validation in Table 3. The pressure and fluid conditions for which the correlation was developed covers a large range of conditions in the steam generator tubes during reflood and post-reflood for both dry and ice-condenser containments.

Applicability of the WC/T code with the Unal correlation was validated with the test comparisons of the FLECHT-SEASET steam generator tests documented in Section 3.2 of WCAP-17721-P. The FLECHT-SEASET tests had prototypical steam generator tube lengths and diameters. The mass flux for the FLECHT-SEASET tests used for the validation of the LOCA M&E model ranges from 4.7 lbm/ft^2-sec to 9.4 lbm/ft^2-sec (see WCAP-17721-P, Table 3-1). The steam generator tubes inlet quality ranges from 0.1 to 1.

As noted in Section 3.1.1 of WCAP-17721-P, the reference version of WC/T [

]^{a,c} The modified version of WC/T calculates [
]^{a,c} exiting the steam generator tubes and [ ]^{a,c} exiting the steam generator tubes consistent with experimental data. Comparison of the steam temperature exiting the steam generator tubes (with the modified version of WC/T) against test data is shown in the following figures from WCAP-17721-P for the high pressure tests,

Figure 3-2, FLECHT-SEASET Test 22701 SG Outlet Temperature.

Figure 3-8, FLECHT-SEASET Test 23402 SG Outlet Temperature.

Figure 3-20, FLECHT-SEASET Test 22314 SG Outlet Temperature.

Figure 3-26, FLECHT-SEASET Test 21806 SG Outlet Temperature.

Figure 3-32, FLECHT-SEASET Test 21909 SG Outlet Temperature.

Figures 3-2 and 3-8 from WCAP-17721-P are reproduced here to illustrate the improvement in the comparisons against experimental data of the steam temperatures exiting the steam generator tubes.

The impact of the steam generator heat transfer modifications on the steam generator exit quality for these high pressure tests is shown in Figures 3-7, 3-13, 3-25, 3-31, and 3-37 of WCAP-17721-P. Figures 3-7 and 3-13 of WCAP-17721-P are reproduced here using a different scale on quality and show liquid carryover out of the steam generators consistent with experimental data.

Regarding the application of the modified steam generator heat transfer logic for the low pressure (24 psia) FLECHT-SEASET Test R22503, WCAP-17721-P, Section 3.2 noted that it
[

]^{a,c}

This limitation was resolved in the response to RAI 2.31 by extending the range of applicability of the Biasi correlation [ ]^{a,c} This was done by specifying that, if the local pressure value for the calculation of CHF with the Biasi correlation is [ ]^{a,c} An evaluation of this "pressure-bounded" Biasi correlation was done as part of the response to RAI 2.31 and showed that this extension of the critical heat flux calculated by Biasi bounds the critical heat flux calculated by Groeneveld (see Figure 12 through Figure 17 in the response to RAI 2.31) and is appropriate for LOCA M&E calculations.

Application of the modified version of the code to the low pressure FLECHT-SEASET Test R22503 is shown in Revised Figures 3-14 through 3-19 in the response to RAI 2.31. Revised Figure 3-14 in the response to RAI 2.31 shows the improvement in the calculation of the SG outlet temperature compared to experimental data. Revised Figure 3-19 in the response to RAI 2.31 shows a lower SG plenum exit quality for the revised model consistent with test data. Revised Figures 3-15 through 3-17 in the response to RAI 2.31 show the occurrence of stratification on the SG secondary side consistent with experimental data.

The conservative calculation of results for the low pressure FLECHT-SEASET Test R22503 using the pressure-bounded Biasi correlation supports the use of the modified heat transfer logic in WC/T for ice-condenser as well as large dry containment plants.

Conclusion:

Use of Unal's correlation for the calculation of post-CHF thermal-hydraulics in the steam generator tubes during the reflood and post-reflood periods of a LOCA for mass and energy release calculations was validated for large dry and ice-condenser containment plants with WC/T. Application of the correlation improves the WC/T standard version of the code [ ]^{a,c} exiting the steam generators for FLECHT-SEASET steam generator tests. Application with the pressure-bounded Biasi correlation yielded a conservative comparison to data for the low pressure FLECHT-SEASET Test R22503 and supported the application of the WC/T LOCA M&E model for ice-condenser as well as large dry containments.

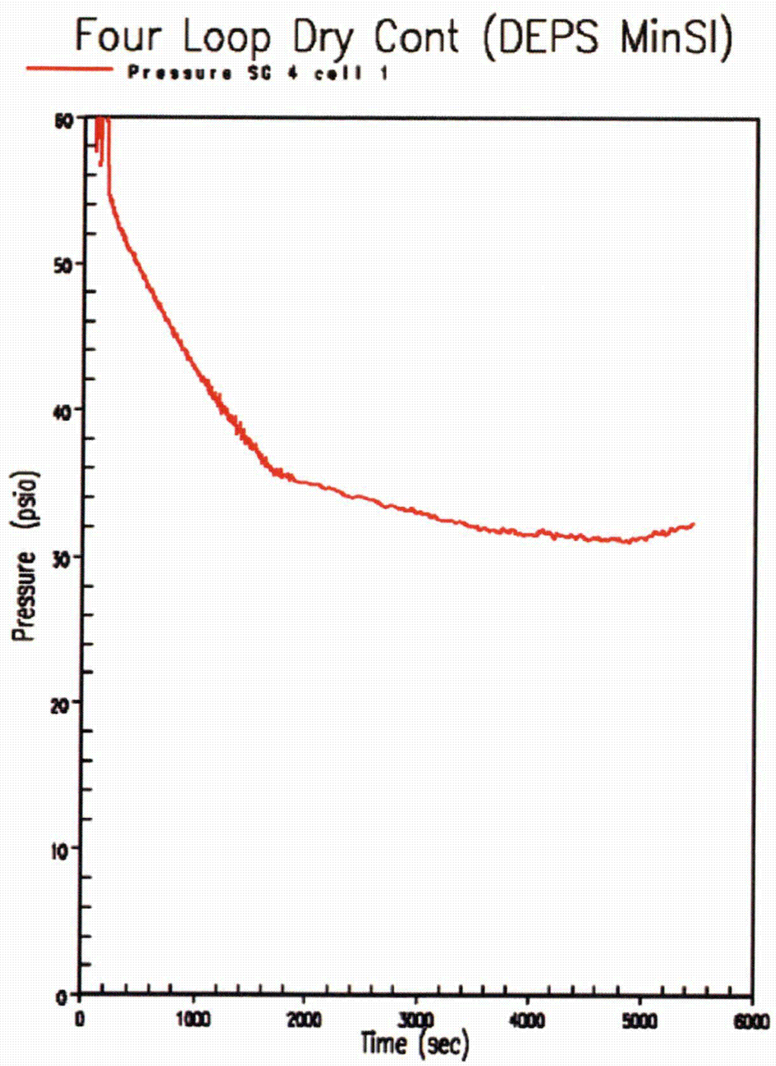

Figure 2: Steam Generator Tube Pressure
Large Dry Containment Plant
Suction Leg Break, Minimum SI

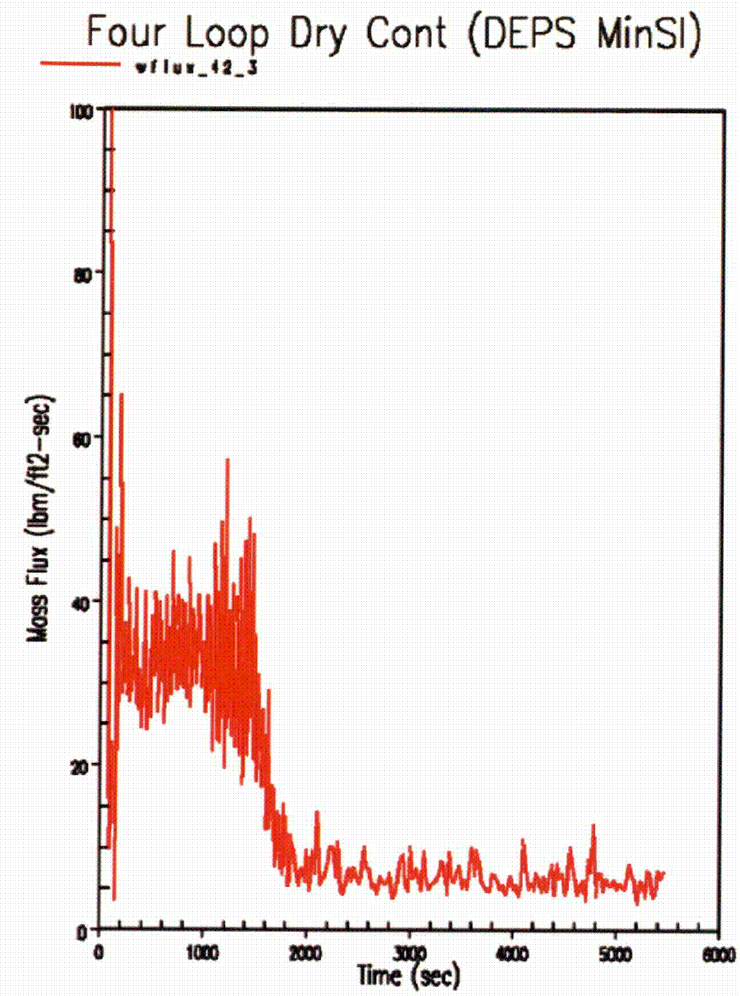

Figure 3: Broken Loop Steam Generator Inlet Mass Flux
Large Dry Containment Plant
Suction Leg Break, Minimum SI

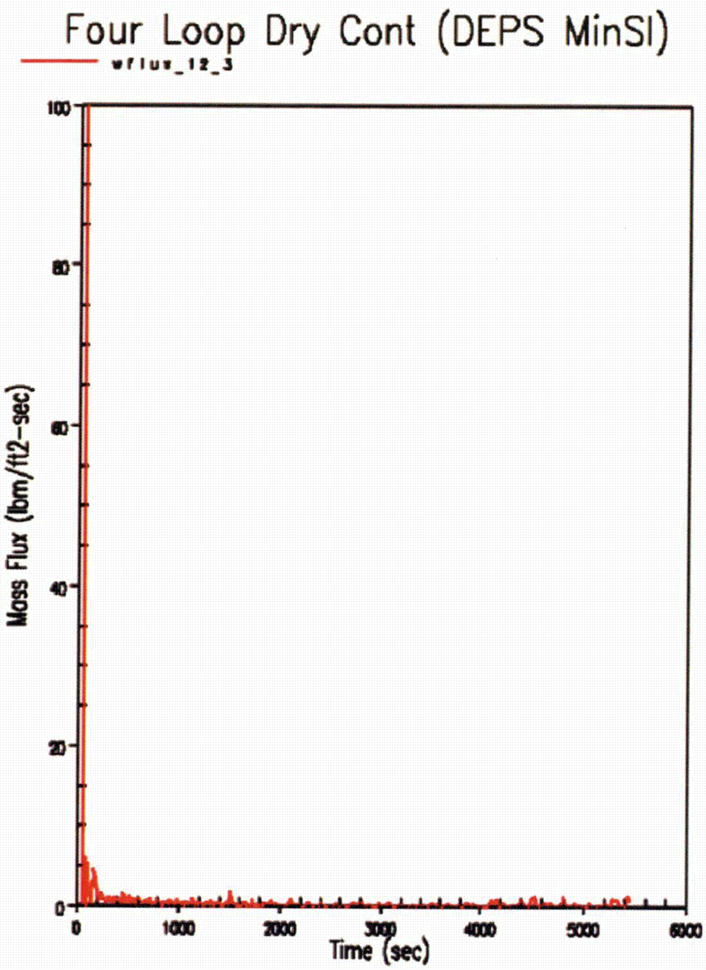

Figure 4: Intact Loop Steam Generator Inlet Mass Flux
Large Dry Containment Plant
Suction Leg Break, Minimum SI

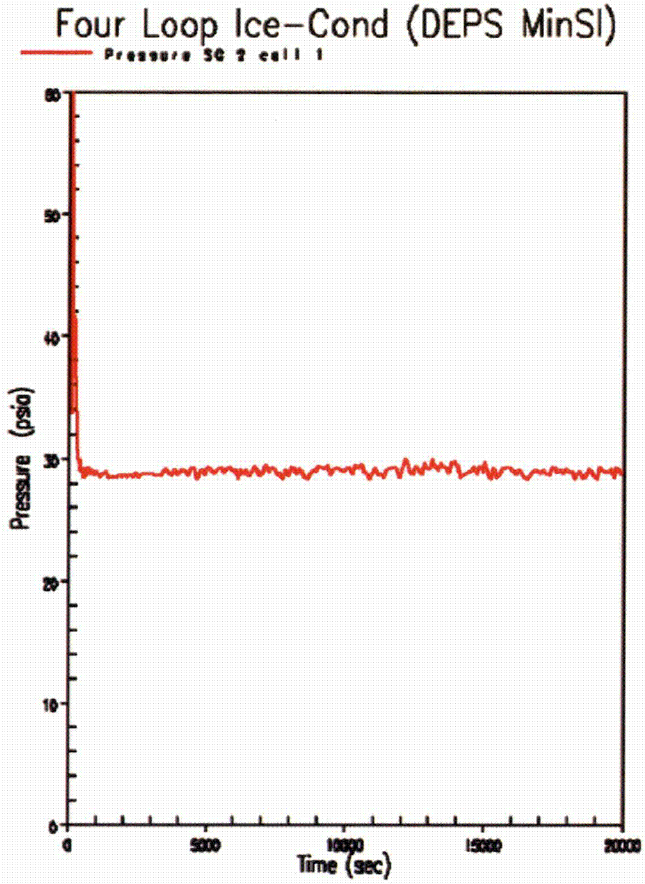

Figure 5: Steam Generator Tube Pressure.
Ice-Condenser Containment Plant
Suction Leg Break, Minimum SI

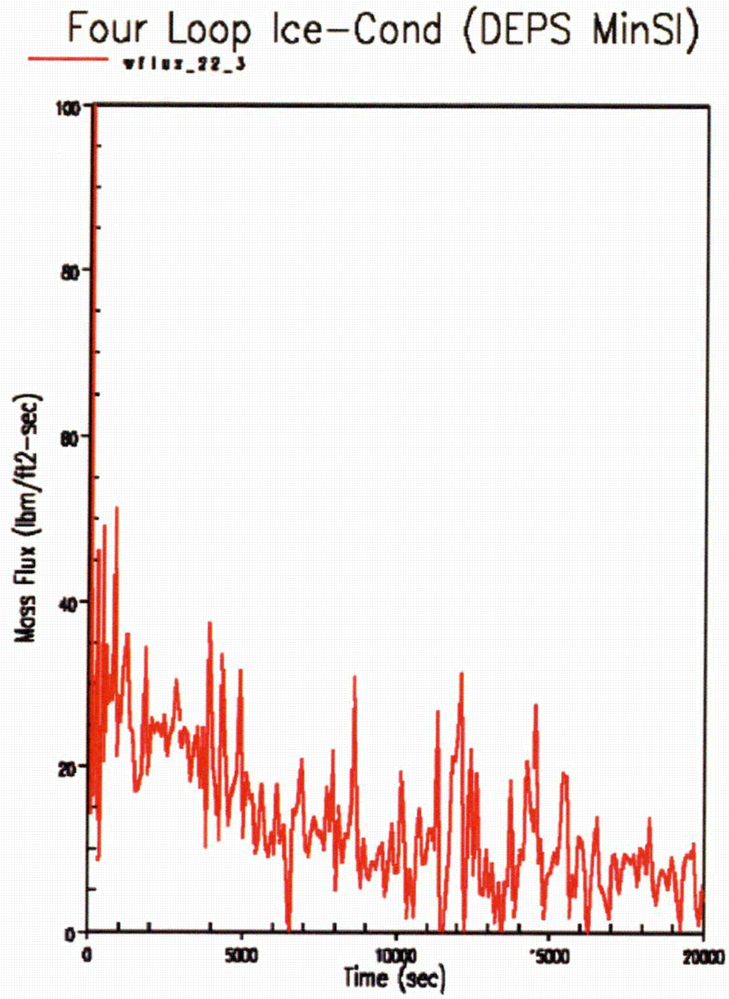

Figure 6: Broken Loop Steam Generator Inlet Mass Flux
Ice-Condenser Containment Plant
Suction Leg Break, Minimum SI

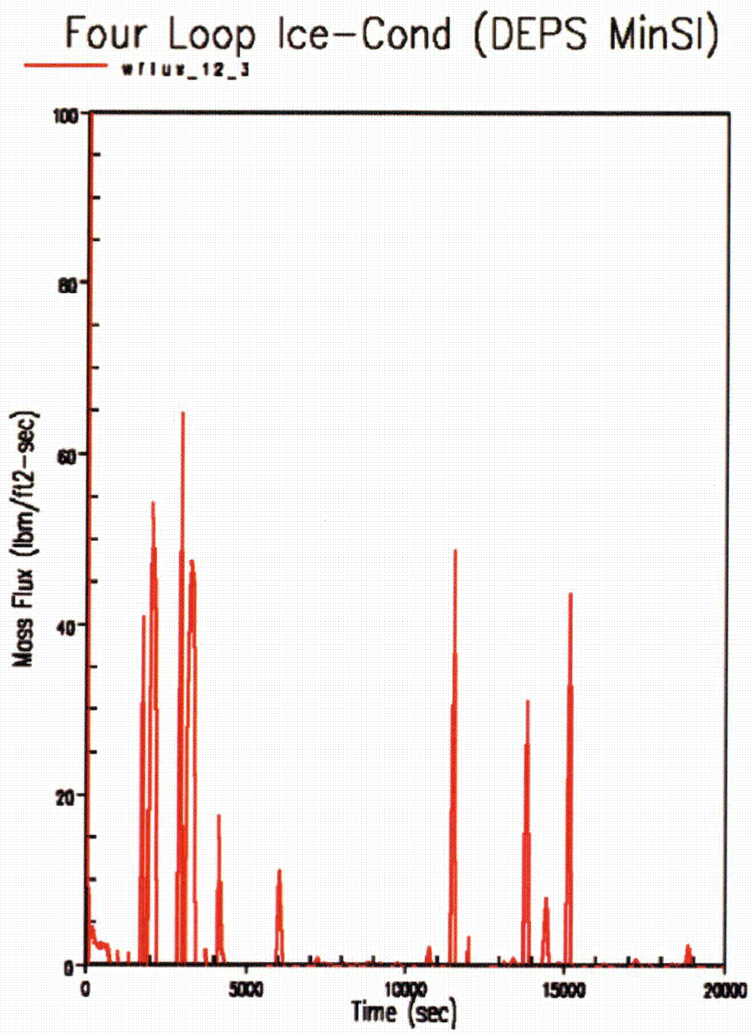

Figure 7: Intact Loop Steam Generator Inlet Mass Flux
Ice-Condenser Containment Plant
Suction Leg Break, Minimum SI

Four Loop Dry Cont (DEPS–MinSI)

a,c

[ ]

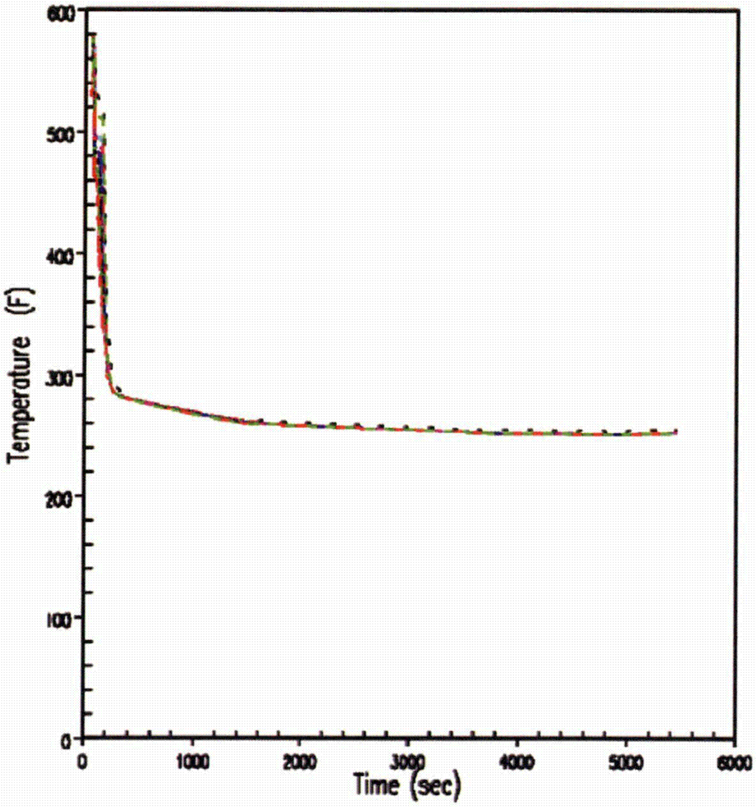

Figure 8: Broken Loop SG Secondary Side Liquid Temperature
Large Dry Containment Plant
Suction Leg Break, Minimum SI

Four Loop Dry Cont (DEPS–MinSI)

a,c

[ ]

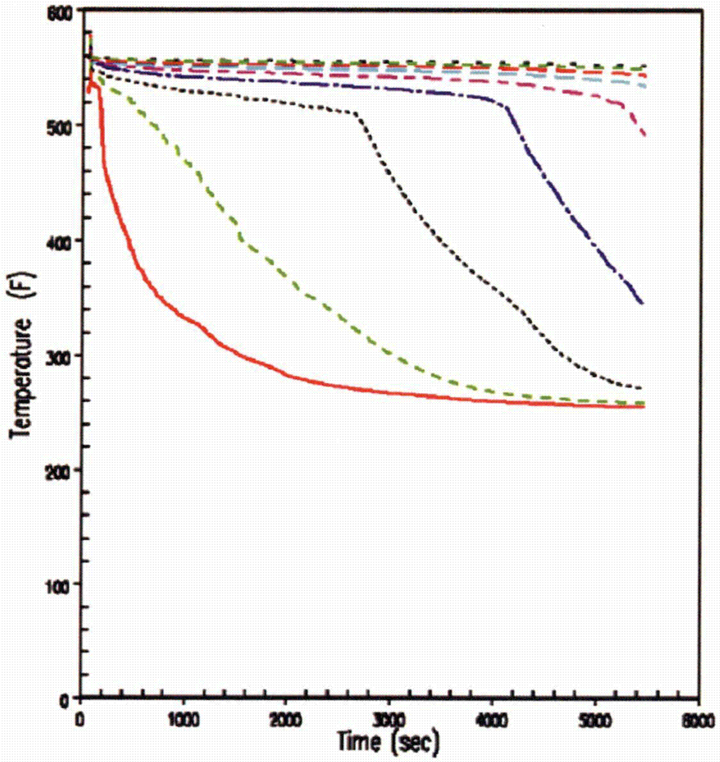

Figure 9: Intact Loop SG Secondary Side Liquid Temperature
Large Dry Containment Plant
Suction Leg Break, Minimum SI

Four Loop Ice-Cond (DEPS-MinSI)

a,c

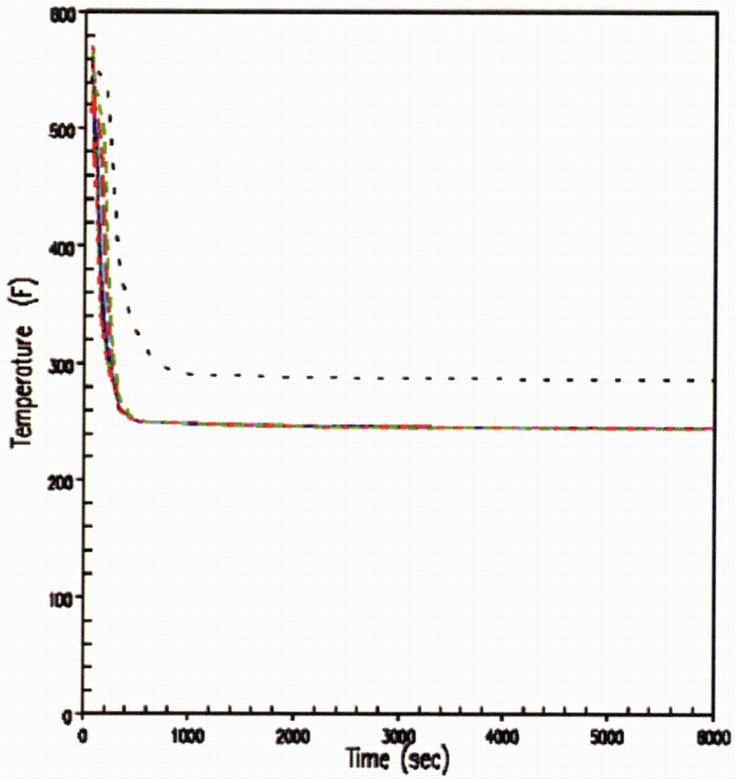

Figure 10: Broken Loop SG Secondary Side Liquid Temperature
Ice-Condenser Containment Plant
Suction Leg Break, Minimum SI

Four Loop Ice-Cond (DEPS-MinSI)

a,c

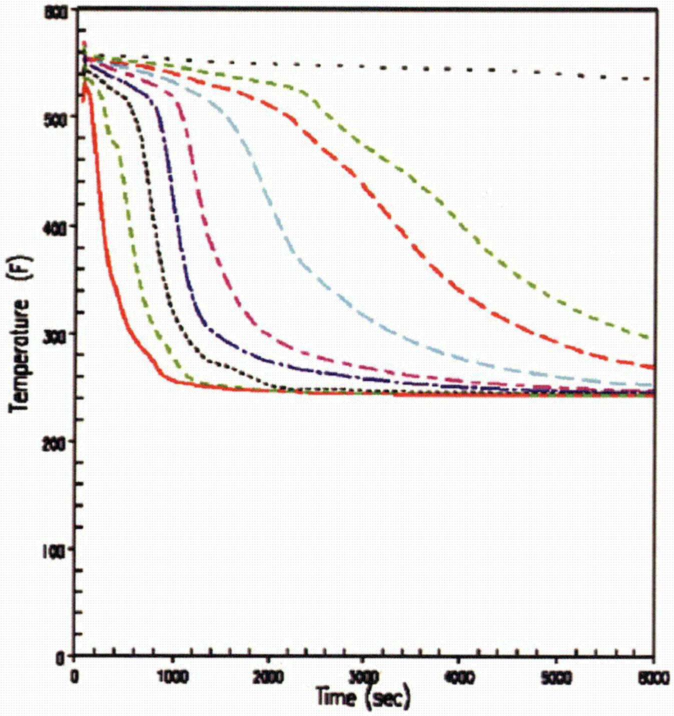

Figure 11: Intact Loop SG Secondary Side Liquid Temperature
Ice-Condenser Containment Plant
Suction Leg Break, Minimum SI

a,c

Reproduced Figure 3-2 of WCAP-17721-P
FLECHT-SEASET Test 22701 SG Outlet Temperature

a,c

Reproduced Figure 3-8 of WCAP-17721-P
FLECHT-SEASET Test 23402 SG Outlet Temperature

a,c

Reproduced Figure 3-7 of WCAP-17721-P
FLECHT-SEASET Test R22701 SG Exit Quality

a,c

Reproduced Figure 3-13 of WCAP-17721-P
FLECHT-SEASET Test R23402 SG Exit Quality

2.31 RAI-3 – Biasi Range

RAI: Demonstrate that the Biasi critical heat flux correlation will provide a conservative estimate of the critical heat flux (which in this case is used to determine the when rewet occurs) for the range over which the correlation is being applied.

Comment: In section 3.1.1 of their initial submittal [1], Westinghouse stated that the condition for rewet was going to be based on the critical heat flux calculated from the Biasi correlation. However, in the original paper for the Biasi correlation [2], the correlation's predictive capability was only validated over a small range of application domain due to the current state of computational resources. Therefore, the NRC staff questioned the correlation's predictive capability over its entire application domain.

Westinghouse Response

WCOBRA/TRAC (WC/T) uses the Biasi[1] correlation in the steam generator tubes to calculate rewet of the tubes during the reflood and post reflood periods of a LOCA. The correlation is based on nearly 5000 experimental burnout data from laboratories all over the world. The correlation was established using data over the following ranges of conditions:

0.3 cm < Diameter < 3.75 cm

(0.12 inch < Diameter < 1.48 inch)

20 cm < Length < 600 cm

(0.6 ft < Length < 19.7 ft)

2.7 ata < Pressure < 140 ata

(39.7 psia < pressure < 2058 psia)

(2.74 bar < pressure < 141.9 bar)

10 g /cm^2-sec < Mass flux < 600 g/cm^2-sec

(20.48 lbm/ft^2-sec < Mass flux < 1228.8 lbm/ft^2-sec)

(100 kg/m^2-sec < Mass flux < 6000 kg/m^2-sec)

$X_{inlet} < 0$

$1 / (1 + \rho_l / \rho_v) < x < 1$

Pressure and inlet mass flux conditions occurring at the steam generator tubes inlet for a large dry containment plant during a typical LOCA M&E analysis (suction leg break with minimum safety injection flow) are shown in Figure 2 through Figure 4 in the response to RAI 2.30. The quality near the dry out point in the tubes is within the validation range. The range of fluid

[1] "Studies on Burnout: Part 3 – A New Model for Round Ducts and Uniform Heating and Its Comparison with World Data", L. Biasi et al., 1967, Energia Nucleare 14: 530-536.

conditions for which the Biasi correlation is being applied is within the range of applicability of the correlation with the following exceptions.

- The mass flux for the broken loop may fall below the minimum data base value for the correlation (20.48 lbm/ft^2-sec), particularly after the start of recirculation from the containment sump at approximately 1500 seconds (see Figure 3 in the response to RAI 2.30).
- The intact loops mass flux lies below the minimum data base value for the correlation during most of the transient (see Figure 4 in the response to RAI 2.30).
- The SG tube pressure falls below the minimum value of the correlation (39.7 psia) starting at approximately 1400 seconds (Figure 2 in the response to RAI 2.30).

Figure 5 though Figure 7 in the response to RAI 2.30 provide pressure and mass flux conditions at the steam generator tubes inlet for a typical four-loop ice-condenser plant. The pressure is below the lower limit of applicability of the Biasi correlation (39.7 psia) during the entirety of the reflood and post-reflood. Figure 6 in the response to RAI 2.30 shows that the broken loop steam generator mass flux for ice-condenser plants may fall below the lower limit of the correlation (20.48 lbm/ft^2-sec) during the latter part of the transient. The mass flux for the intact loops is below the minimum data base value for the correlation during most of the transient.

The Biasi correlation, as implemented in TRAC, has been modified to limit the minimum mass flux input. This is discussed in NUREG/CR-6724[2] Section F.2.1.8.4, where it is noted that the Biasi correlation over predicts the CHF value at low mass fluxes. As implemented in the TRAC-M code[2], the minimum mass flux was limited to 20 g/cm^2-sec. The minimum value in WC/T is [ ][a,c] (WCAP-12945-P-A[3]), which is conservative for LOCA M&E calculations due to the CHF over prediction at low mass flux values (i.e. there will be a tendency to remain in nucleate boiling with the higher calculated CHF).

WCAP-17721-P Section 2.8 and text in Section 3.2 stated that Westinghouse will not use the modified LOCA M&E steam generator heat transfer logic for low backpressure plant applications (i.e. ice-condensers and subatmospheric designs) due to the fact that [ ][a,c] Further investigation revealed that this was largely due to the fact that [

][a,c] Hereafter in this RAI response this modification to the application of the Biasi correlation will be referred to as the "pressure-bounded Biasi" correlation. This change

[2] NUREG/CR-6724, "TRAC-M/FORTRAN 90 (Version 3.0) Theory Manual," July 2001.

[3] WCAP-12945-P-A, "Code Qualification Document for Best Estimate LOCA Analysis," March 1998.

eliminates the [

]^{a,c} The pressure limit modification to the Biasi correlation was validated using data from the low pressure FLECHT-SEASET test R22503 (24 psia). See Revised Figures 3-14 through 3-19 in this RAI response. Comparison of Revised Figure 3-18 to the original Figure 3-18 in WCAP-17721-P shows that the calculated [
]^{a,c} more closely matching test data.

The pressure-bounded Biasi correlation was further validated by comparison to the Groeneveld[4] data (see Figure 12 through Figure 17). Figure 12 through Figure 15 show the effect on CHF of the low pressure limit, as the critical heat flux reaches a minimum value as the pressure decreases for given mass flux and quality values representative of conditions near the quench front in plant calculations. Similarly, Figure 16 and Figure 17 show the effect of the limitation on the minimum mass flux value in comparisons to Groeneveld predictions.

Conclusions:

Comparison of the pressure-bounded Biasi correlation to the Groeneveld et al CHF look-up table for conditions occurring in the steam generator tubes during the reflood and post-reflood periods of a LOCA showed that, in general, the pressure-bounded Biasi over-predicts Groeneveld et al. Thus, for LOCA M&E release calculations use of the pressure-bounded Biasi is conservative compared to Groeneveld.

Application of the Biasi CHF correlation to low mass flux conditions limits the mass flux to the lower bound of the database. This is also conservative relative to Groeneveld.

Application of the pressure-bounded Biasi correlation has no impact on LOCA M&E calculations for large dry containment plants with WC/T. This was confirmed through a regression test. The comparison results shown in Figure 18 through Figure 23 demonstrate that the calculated results are the same between the WC/T versions with and without the pressure limit on the Biasi correlation.

Application of the pressure-bounded Biasi correlation yielded conservative results for the low pressure FLECHT-SEASET Test R22503. Revised Figures 3-14 through 3-19 similar to those documented in this RAI will replace Figures 3-14 through 3-19 in WCAP-17721-P. These are included in the change pages provided at the end of this attachment.

The results of the revised low pressure FLECHT-SEASET Test R22503 support the application of the WC/T LOCA M&E model for ice-condenser containments. Text dispersed in WCAP-17721-P related to the application of the WC/T LOCA M&E model for ice-condenser containments will be updated to indicate that the model is applicable to ice-condenser containments. See the change pages provided at the end of this attachment.

[4] "The 2006 CHF look-up-table," D. C. Groeneveld et al., Nuclear Engineering and Design 237 (2007) 1909-1922.

a,c

Figure 12: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Pressure)

a,c

Figure 13: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Pressure)

a,c

Figure 14: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Pressure)

a,c

Figure 15: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Pressure)

a,c

Figure 16: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Flow)

a,c

Figure 17: Comparison of Q_{CHF} Biasi vs. Q_{CHF} Groeneveld for Low Pressure Conditions (Function of Flow)

a,c

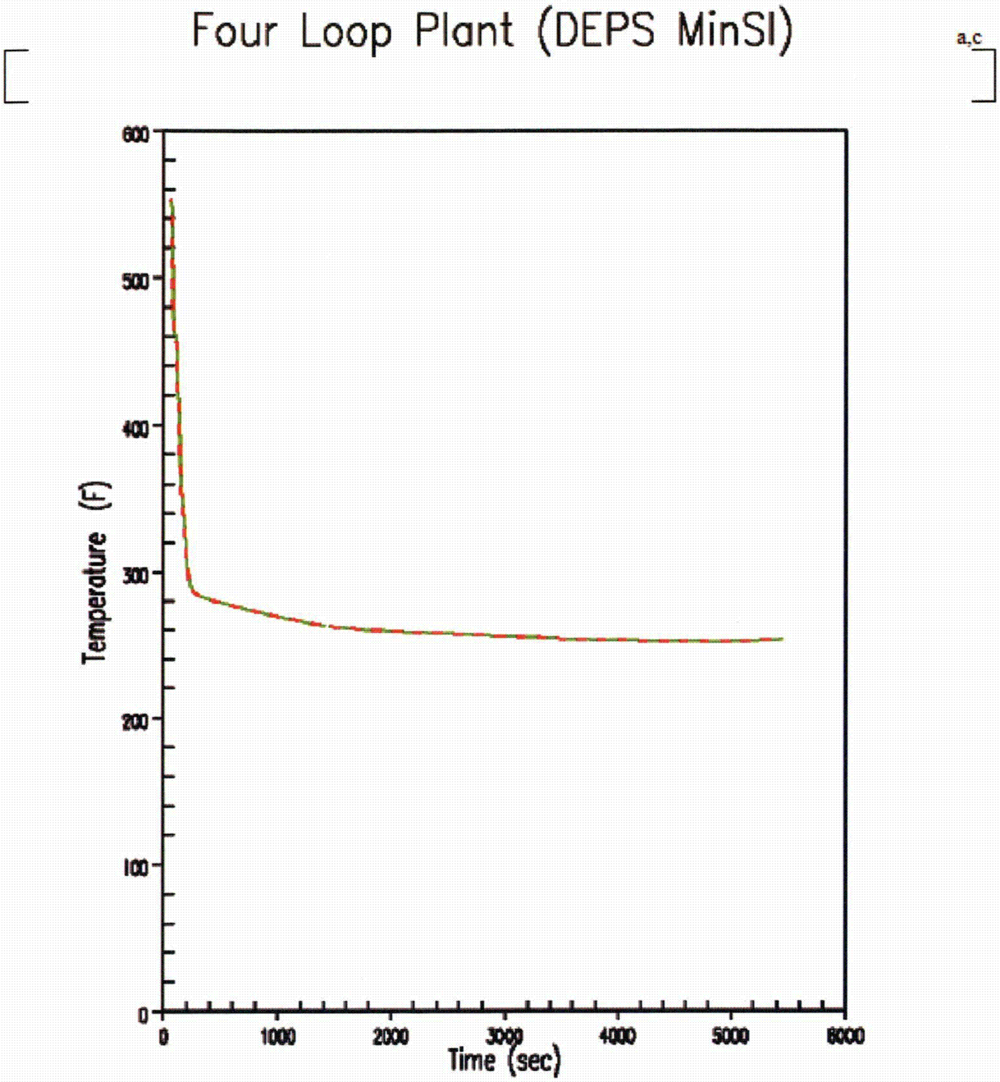

Figure 18: Steam Generator Secondary Side Liquid Temperature (Broken Loop)
(Bottom of Steam Generator)
Large Dry Containment Plant

Four Loop Plant (DEPS MinSI)

[ ]a,c

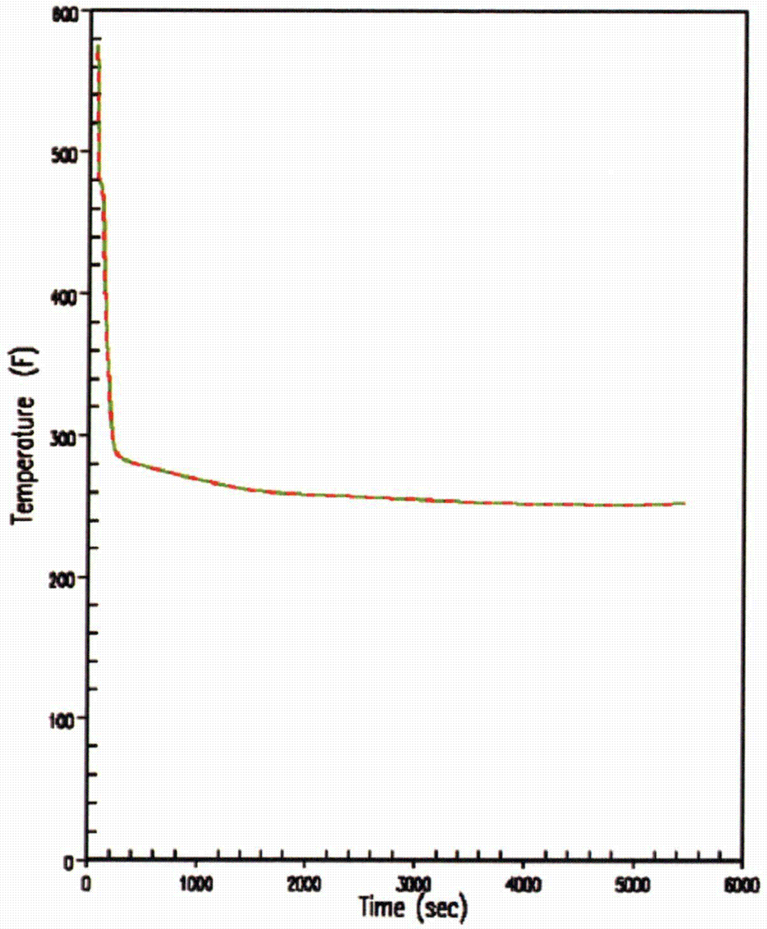

Figure 19: Steam Generator Secondary Side Liquid Temperature (Broken Loop)
(8 ft. Elevation)
Large Dry Containment Plant

Four Loop Plant (DEPS MinSI)

a,c

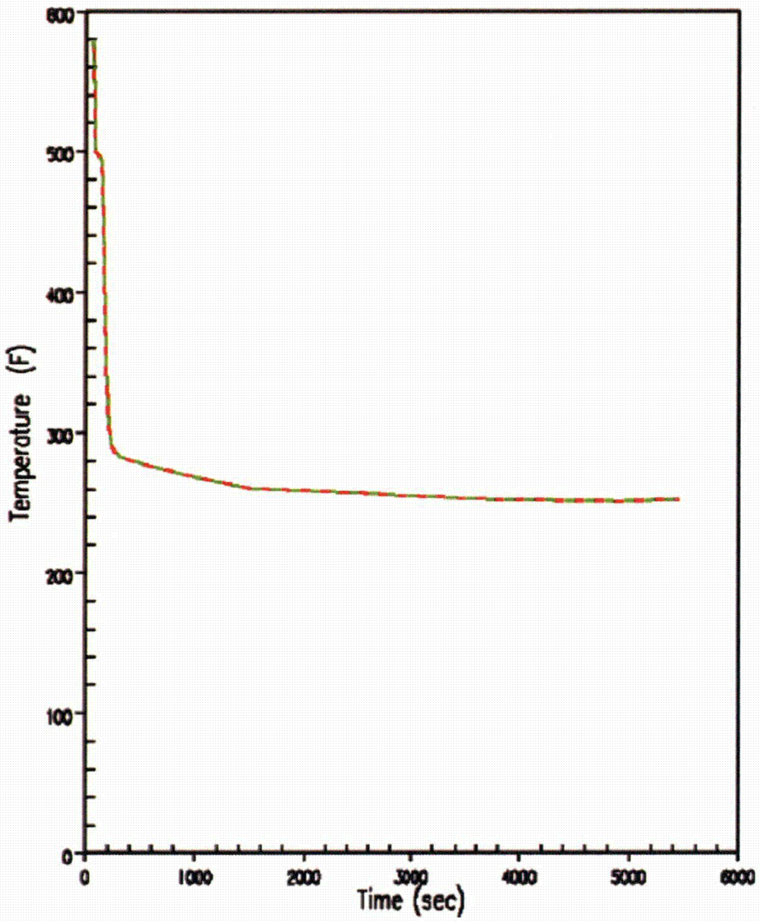

Figure 20: Steam Generator Secondary Side Liquid Temperature (Broken Loop) (17 ft. Elevation)
Large Dry Containment Plant

a,c

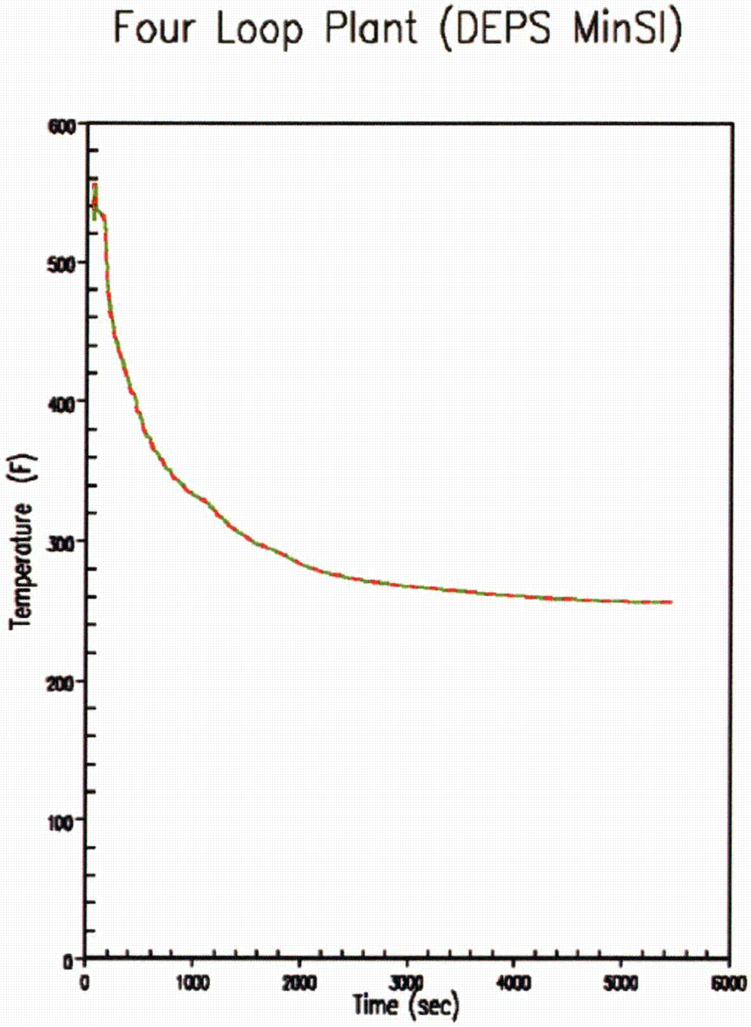

Figure 21: Steam Generator Secondary Side Liquid Temperature (Intact Loop)
(Bottom of Steam Generator)
Large Dry Containment Plant

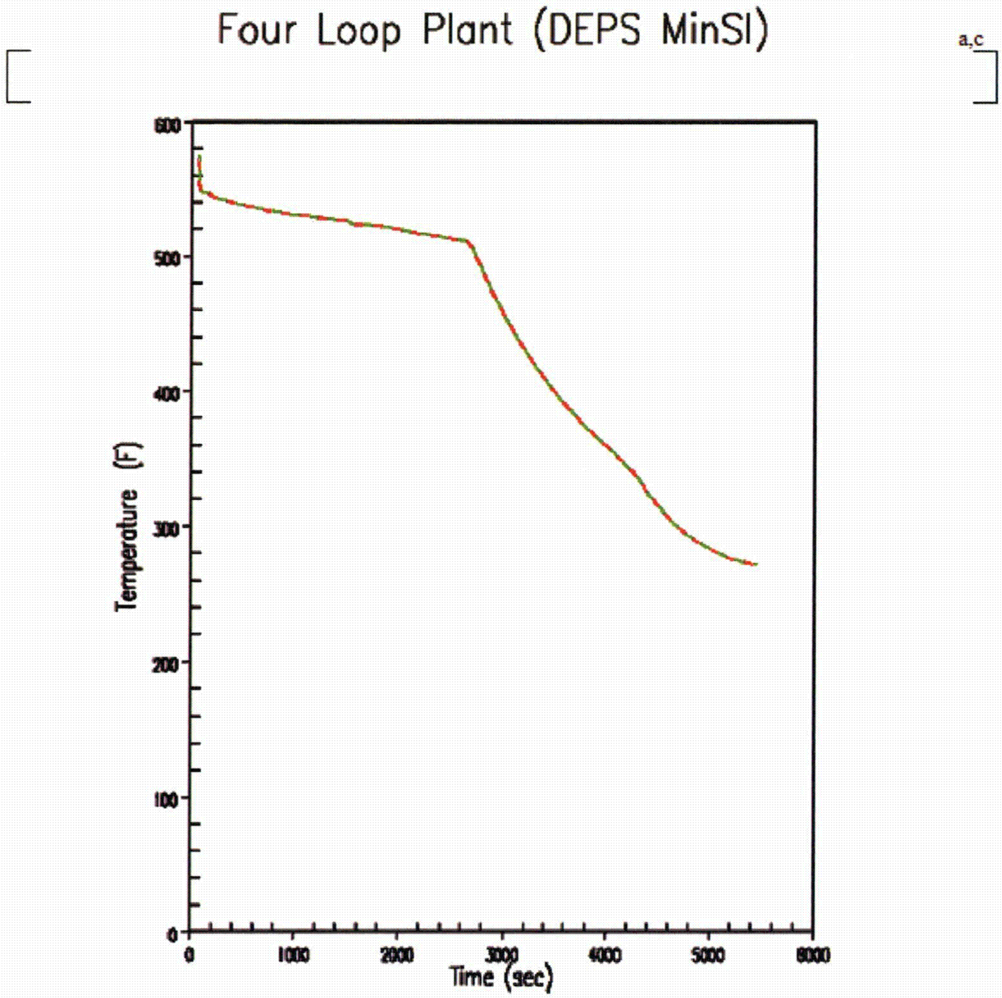

Figure 22: Steam Generator Secondary Side Liquid Temperature (Intact Loop)
(8 ft. Elevation)
Large Dry Containment Plant

Four Loop Plant (DEPS MinSI)

a,c

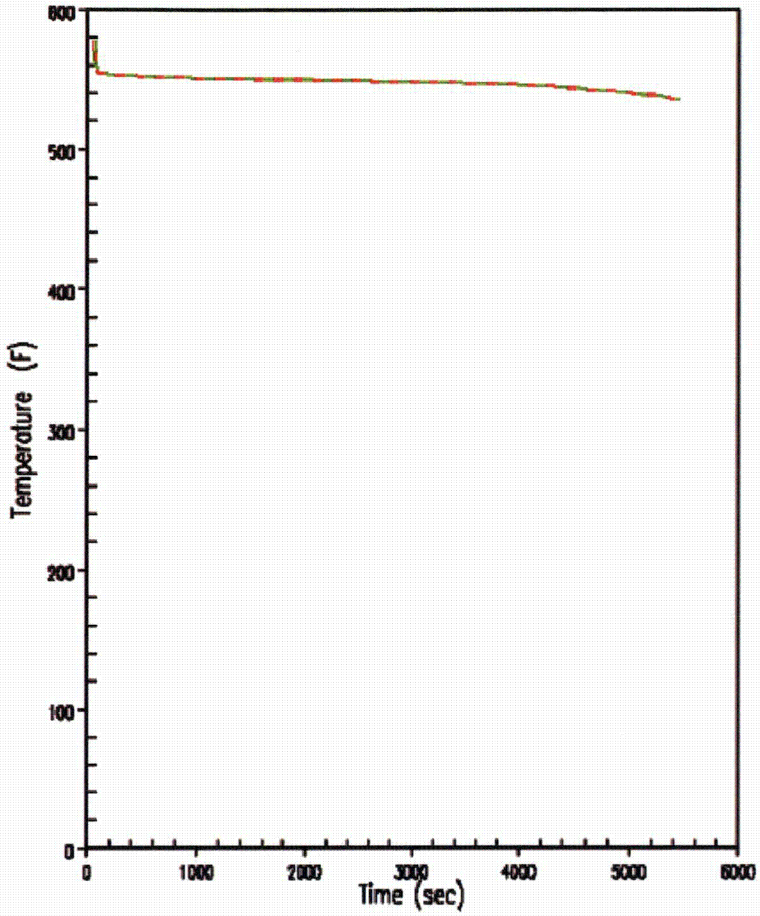

Figure 23: Steam Generator Secondary Side Liquid Temperature (Intact Loop)
(17 ft. Elevation)
Large Dry Containment Plant

a,c

Revised Figure 3-14 FLECHT-SEASET Test R22503 SG Outlet Vapor Temperature

a,c

Revised Figure 3-15 FLECHT-SEASET Test R22503 SG Tube Wall – 1 ft

a,c

Revised Figure 3-16 FLECHT-SEASET Test R22503 SG Tube Wall – 4 ft

a,c

Revised Figure 3-17 FLECHT-SEASET Test R22503 SG Tube Wall – 10 ft

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a,c

Revised Figure 3-18 FLECHT-SEASET Test R22503 SG Heat Release Rate

a,c

Revised Figure 3-19 FLECHT-SEASET Test R22503 SG Exit Quality

2.32 RAI-2 – FLEACHT (sic) heat release rate

RAI: Provide plots of the integrated secondary heat release rate as a function of time for the FLEACHT-SEASET (sic) data and for the WC/T prediction (with the proposed interfacial heat transfer and steam generator heat transfer changes) for the seven FLECHT-SEASET cases described in the topical. Provide a discussion which demonstrates that WC/T with the proposed changes provides an adequate prediction of the FLECHT data.

Comment: In section 3.2 of their initial submittal [1], Westinghouse provided plots of the secondary heat release rate. However, those plots seemed to indicate that WC/T with the proposed modifications consistently under predicted the heat release from the steam generator. Under predicting the heat release would be non-conservative and may result in an inadequate prediction of the mass and energy release.

<u>Westinghouse Response</u>

The data for the measured FLECHT-SEASET steam generator secondary heat release rates were taken from plots that were provided in WCAP-9724[1] (NUREG/CR-1524) and WCAP-9621[2]. The information that is shown in those plots was calculated using the measured temperature differences and heat transfer areas, but with estimated heat transfer coefficients. Therefore, the plot data only provide an estimate of the measured FLECHT-SEASET steam generator secondary heat release rates.

The transient secondary heat release rates can be compared indirectly by comparing the measured and code calculated transient secondary fluid temperatures. This information is shown in Figures 3-44 through 3-50 from WCAP-17721-P. This comparison shows that the <u>W</u>COBRA/TRAC (<u>W</u>C/T) calculated secondary fluid temperatures [

]^{a,c}

The plots for the FLECHT-SEASET steam generator test cases have been re-generated as part of the response to the request for additional information (RAI) 2.31. These plots also show that the <u>W</u>C/T calculated secondary fluid temperatures are [

]^{a,c} (see the change pages provided at the end of this attachment for these revised plots).

The requested plots, which compare the measured and <u>W</u>C/T calculated secondary heat release as a function of time, follow (Figure 24 through Figure 30). The measured steam generator (SG) heat release rate test data for case 21909 is not available between 50 and 550 seconds, so the integrated SG heat release comparison for this case is not good. For 3 of

[1] WCAP-9724, Revision 0, "PWR FLECHT SEASET Steam Generator Separate Effects Task Data Analysis and Evaluation Report," February 1982.

[2] WCAP-9621, Revision 0, "PWR FLECHT SEASET Steam Generator Separate Effects Task Data Report," January 1980.

the 7 cases (21806, 22314, and 22503), the WC/T calculated transient heat release, with the special SG tube heat transfer models, [ ]^{a,c} The WC/T calculated secondary fluid temperatures for these cases, as shown in new Figures 3-48, 3-47, and 3-46 in the change package, are [ ]^{a,c} This also implies the code is calculating a higher transient heat release rate than the test. For the other 3 cases (22701, 22920, 23402), the WC/T calculated transient heat release, with the special SG tube heat transfer models, is [ ]^{a,c} However, the WC/T calculated secondary fluid temperatures, as shown in new Figures 3-44, 3-50, and 3-45 in the change package, are [

]^{a,c}

a,c

Figure 24: Secondary Heat Release Comparison (R21806)

a,c

Figure 25: Secondary Heat Release Comparison (R21909)

a,c

Figure 26: Secondary Heat Release Comparison (R22314)

a,c

Figure 27: Secondary Heat Release Comparison (R22503)

a,c

Figure 28: Secondary Heat Release Comparison (R22701)

a,c

Figure 29: Secondary Heat Release Comparison (R22920)

a,c

Figure 30: Secondary Heat Release Comparison (R23402)

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LTR-NRC-15-33

April 22, 2015

Subject: Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – RAI 2.32 Response Supplement" (Proprietary/Non-Proprietary).

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - RAI 2.32 Response Supplement."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4166 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4166 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
Dr. Shie-Jeng Peng (NRC)

bcc: James A. Gresham
Cheryl Robinson
Anne M. Stegman

Westinghouse

Westinghouse Electric Company
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AW-15-4166

April 22, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-33 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - RAI 2.32 Response Supplement"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-33, dated April 22, 2015

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-15-4166 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the accompanying Affidavit should reference AW-15-4166 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

AW-15-4166
April 22, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

James A. Gresham, Manager
Regulatory Compliance

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

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse 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 2.390 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 constitute Westinghouse policy and provide 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.

(iii) 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 that 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.

(vi) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-NRC-15-33 P-Attachment, "WCAP-17721-P NRC Set 2, Safety and Code Review Branch - RAI 2.32 Response Supplement" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-15-33, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721-P, and may be used only for that purpose.

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

(i) Obtain NRC approval of the LOCA Mass and Energy Release Calculation Methodology documented in WCAP-17721-P, "Westinghouse

Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of assisting customers in obtaining license changes for a Westinghouse pressurized water reactor (PWR).

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

LTR-NRC-15-33 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch – RAI 2.32 Response Supplement (Non-Proprietary)

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066

Background

Request for Additional Information (RAI) 2.32[1] requested Westinghouse to generate plots of integrated secondary side energy release for the FLECHT SEASET steam generator (SG) test case simulations presented in WCAP-17721-P Section 3.2. The RAI also requested that Westinghouse provide a discussion which demonstrates that WCOBRA/TRAC (WCT) provides an adequate prediction of the FLECHT SEASET data. The response to the RAI is documented in Westinghouse letter LTR-NRC-15-20[2] and provided the requested plots. The response indicated that 3 of the 7 FLECHT SEASET simulations calculated secondary to primary heat transfer rates that [ ]^{a,c} than the test data (R21806, R22314, and R22503). Test data was unavailable for a large portion of R21909, and code calculated secondary to primary heat transfer was [ ]^{a,c} for 3 tests (R22701, R22920, and R23402). The response to RAI 2.32 indicated that the SG heat transfer data from the test was only an estimate, and it was based on the primary side energy balance. Plots showing calculated and measured secondary side temperature vs. elevation were referred to, and largely the WCT simulations calculated [ ]^{a,c}, even for R22701, R22920, and R23402. During the April 8-9 Nuclear Regulatory Commission (NRC) audit, the NRC pointed out that the WCT [ ]^{a,c} than measured and that the measured [ ]^{a,c}. There was also an ongoing discussion relative to the 'spike' in secondary to primary heat transfer shown early in time for some of the tests.

Further Discussion

Westinghouse's argument that the WCT FLECHT SEASET SG simulations provided conservative results relative to secondary to primary heat transfer was primarily based on the [ ]^{a,c}. WCAP-9724 (NUREG/CR-1534)[3] contains isometric plots which show radial secondary side temperatures vs elevation above the tube sheet for R22701. Figure 5-46 through Figure 5-48 (reproduced below) indicate that there is [ ]^{a,c} at any given time and elevation. The lack of [ ]^{a,c} can be demonstrated for R22920 and R23402 as well with

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 14, 2014 (ADAMS Accession No. ML14254A251)

[2] LTR-NRC-15-20, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," March 2015

[3] WCAP-9724 (NUREG/CR-1534), "PWR FLECHT SEASET Steam Generator Separate Effects Task Data Analysis and Evaluation Report," February 1982

information from WCAP-9621[4] (detailed data report). Figure 1 and Figure 2 show the secondary fluid temperature at 69 ft from the tube inlet (i.e. near the outlet) for radial positions 1 (close to centerline) and 4 (closest to SG shell) for R22920. The temperature profiles for radial positions 1 and 4 [ ]^{a,c}. Figure 3 and Figure 4 show the same comparison for R23402. This indicates that the SG was cooling down [ ]^{a,c}.

Regarding the secondary to primary heat transfer spike, shown most notably in WCAP-17721-P Figure 3-6 (R22701), Figure 3-12 (R23402), and Figure 3-42 (R22920), WCAP-9724 on page 5-35 provides some key information. It is stated (for the reference case, R22701) that this early peak is due to a flow transient caused by the loop flow and pressure controllers, and after the first minute, the transient decays into steady state flow. Omitting the transient data, the peak secondary to primary heat transfer rate is estimated to be approximately 144kW (137 BTU/s) on page 5-35, as compared to the 200kW (190 BTU/s) peak which occurs during the transient flow period. Figure 5-14 of WCAP-9724 (NUREG/CR-1534) indicates that the transient flow condition exists for more than 60 seconds for the R22701 test, as it does not drop to 144kW until about 125 seconds. Therefore, the initial peak in heat transfer for the FLECHT SEASET test data is attributed to transient behavior that was not modeled in the WCT simulations.

The summary data on page 22920-1 of WCAP-9621 for R22920 indicates that the temperature of the steam flow was 157°C, which was modeled in WCT; however, the plot showing the SG inlet temperature on page 22920-7 (copied below as Figure 5) shows the SG inlet temperature [ ]^{a,c} There is also a flow transient shown on page 22920-4 (copied below as Figure 6). The R22920 case was re-run with WCT accounting for the aforementioned items. The WCT calculated integral of the SG energy release is still [

]^{a,c}

Considering the transient effects in the FLECHT SEASET test data and allowing for some uncertainty in measured values (temperatures, flows, etc.) and calculated heat transfer rates, the WCT simulations demonstrate that the heat transfer is relatively well predicted compared to test data.

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[4] WCAP-9621, "PWR FLECHT SEASET Steam Generator Separate Effects Task Data Report," January 1980

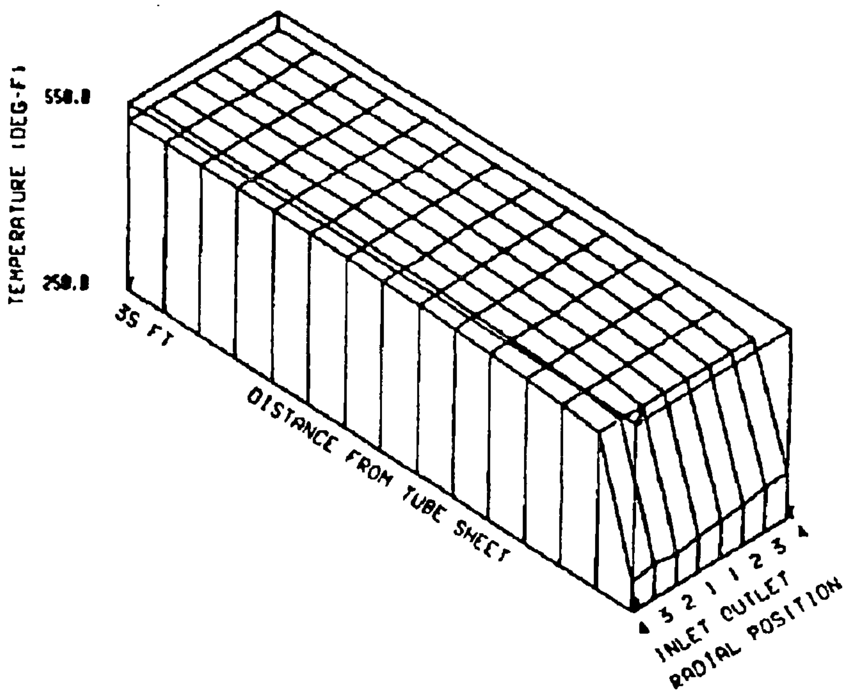

Figure 5-46. Isometric Plot of Secondary Fluid Temperatures at 3.4 Minutes Into Transient, Reference Run

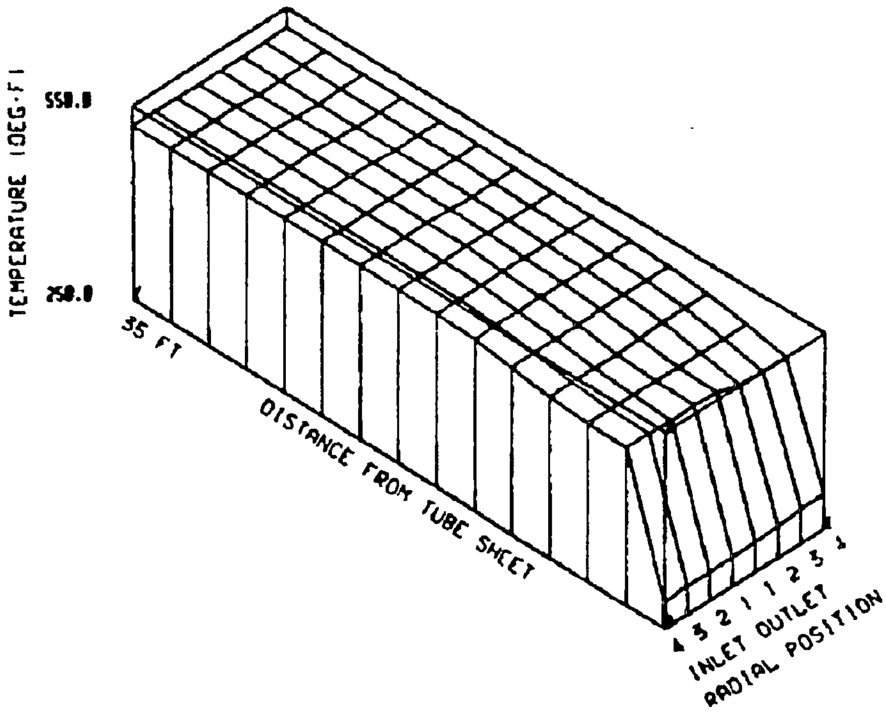

Figure 5-47. Isometric Plot of Secondary Fluid Temperatures at 6.1 Minutes Into Transient, Reference Run

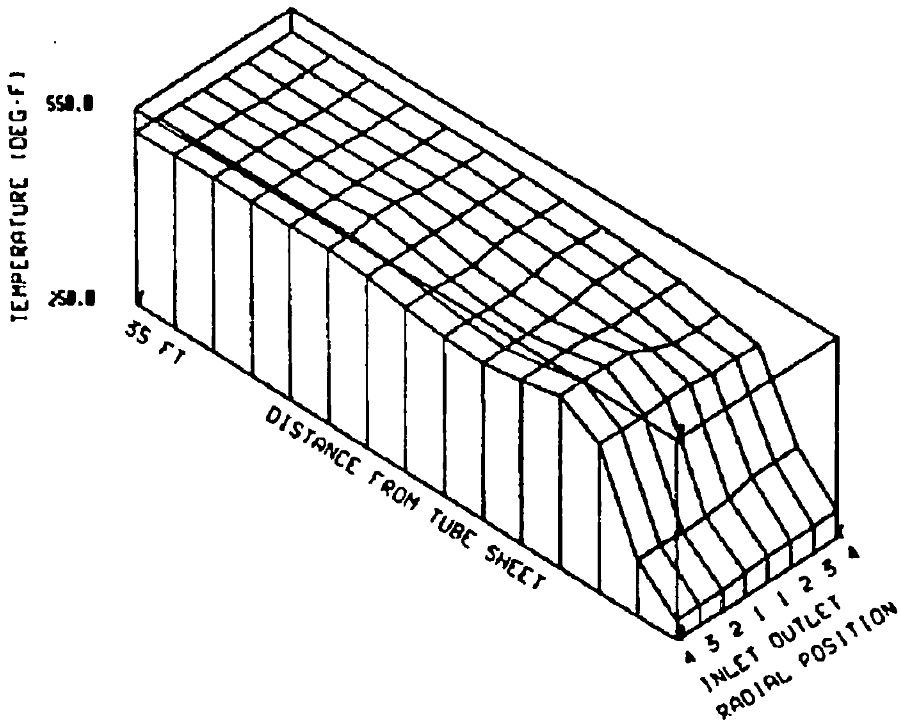

Figure 5-48. Isometric Plot of Secondary Fluid Temperatures at 12.1 Minutes Into Transient, Reference Run

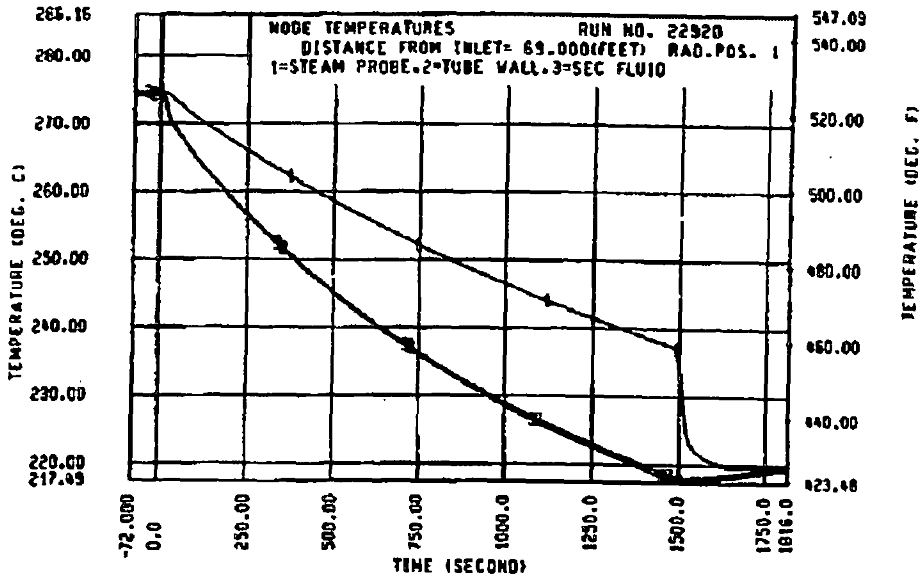

Figure 1: R22920 Steam, Tube Wall, and Secondary Temperature vs. Time for Radial Position 1

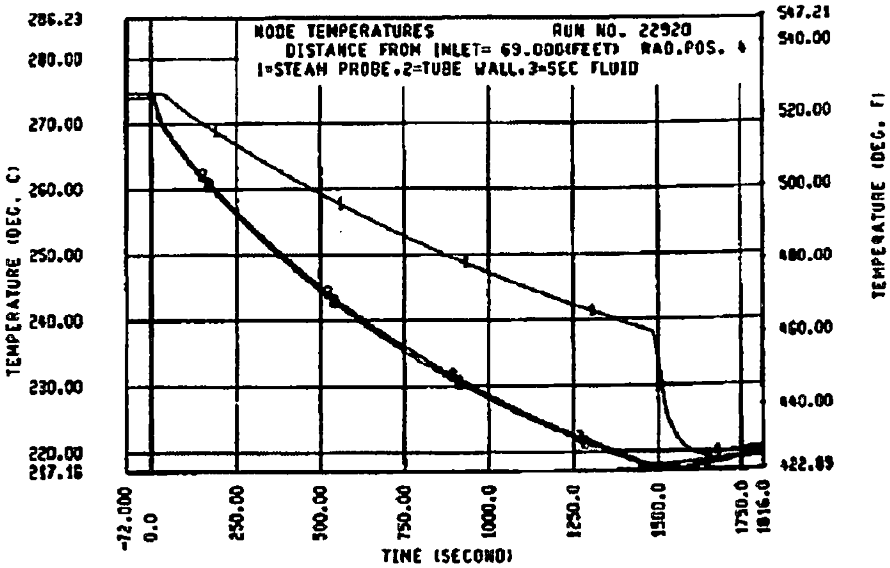

Figure 2: R22920 Steam, Tube Wall, and Secondary Temperature vs. Time for Radial Position 4

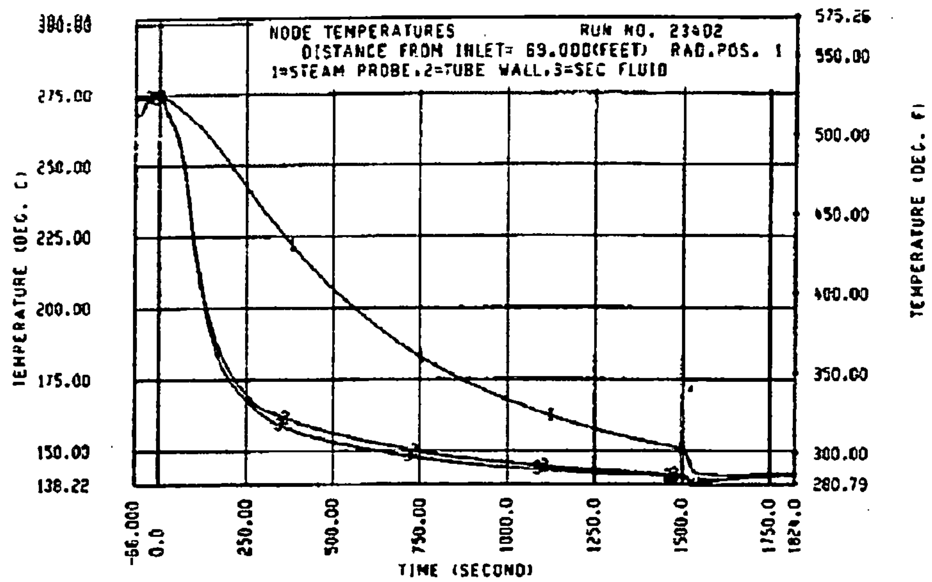

Figure 3: R23402 Steam, Tube Wall, and Secondary Temperature vs. Time for Radial Position 1

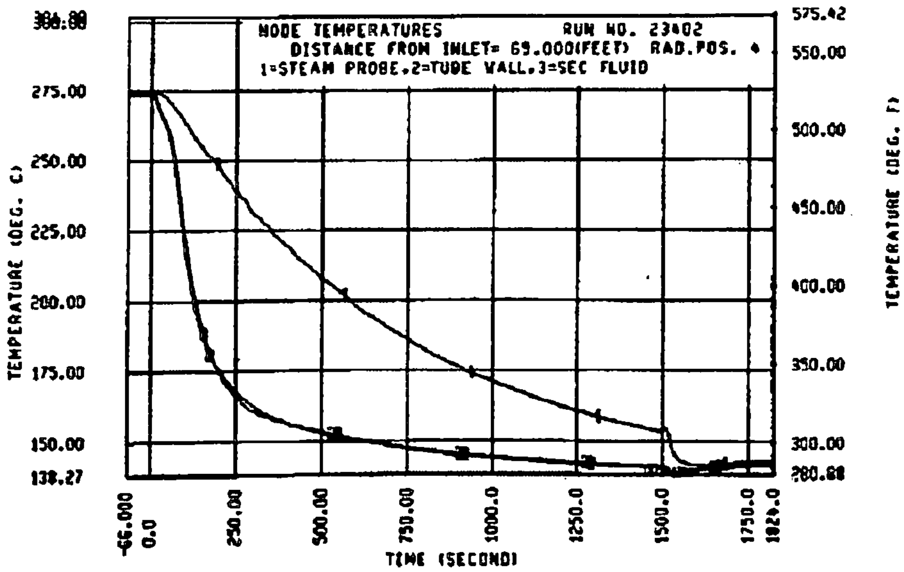

Figure 4: R23402 Steam, Tube Wall, and Secondary Temperature vs. Time for Radial Position 4

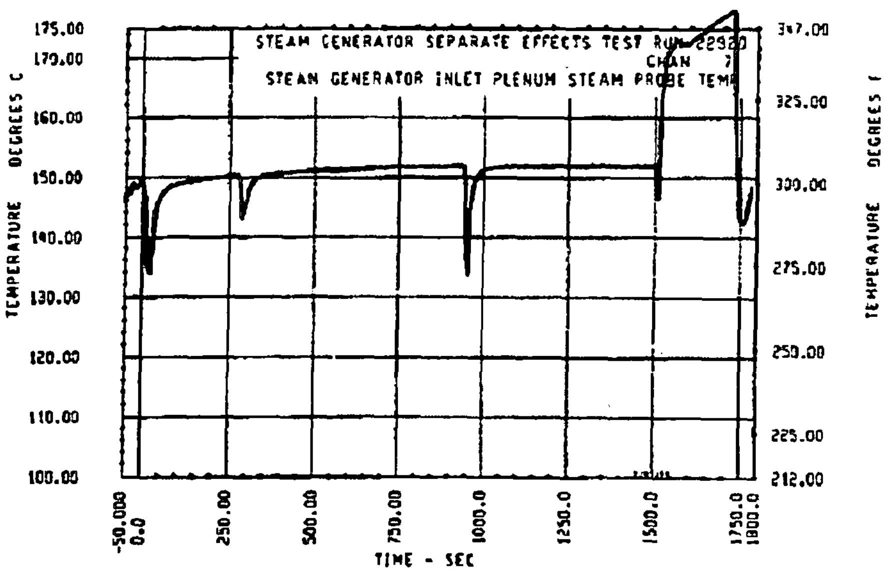

Figure 5: R22920 Primary Side Inlet Temperature

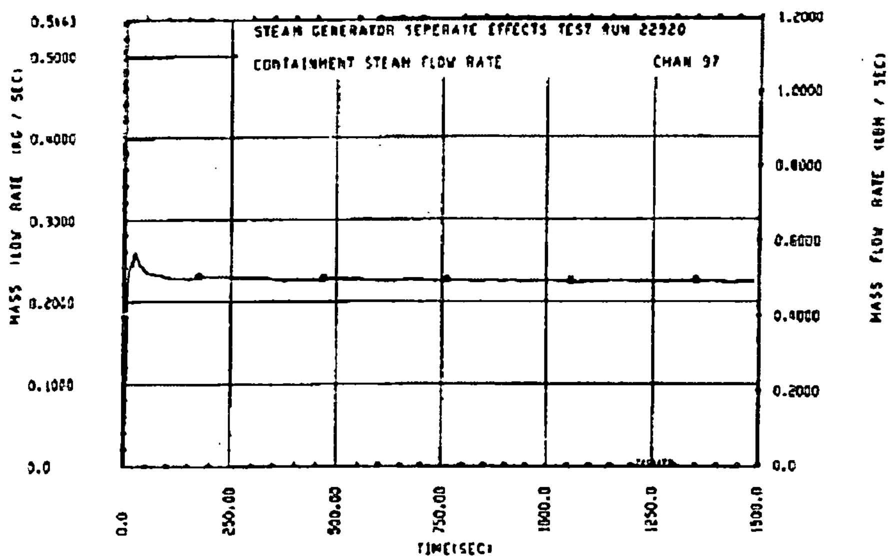

Figure 6: R22920 Primary Side Mass Flow

a,c

Figure 7: Case R22920 Integrated SG Heat Release Rate

a,c

Figure 8: Case R22920 Secondary Fluid Temperature Comparison

Westinghouse

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e-mail: greshaja@westinghouse.com

LTR-NRC-15-39

May 21, 2015

Subject: Submittal of "WCAP-17721-P RAI Response Supplements" (Proprietary/Non-Proprietary)

Enclosed are the proprietary and non-proprietary versions of a report "WCAP-17721-P RAI Response Supplements."

Also enclosed are:

1. An Application for Withholding Proprietary Information from Public Disclosure, AW-15-4191 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice
2. An Affidavit (Non-Proprietary).

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding Proprietary Information from Public Disclosure and an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference AW-15-4191 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
Dr. Joshua Kaizer (NRC)
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AW-15-4191

May 21, 2015

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-15-39 P-Attachment, "WCAP-17721-P RAI Response Supplements"

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-15-39, dated May 21, 2015

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Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

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Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

AW-15-4191
May 21, 2015

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

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I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

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(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

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 technical evaluation justifications 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.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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LTR-NRC-15-39 NP-Attachment

WCAP-17721-P RAI Response Supplements (Non-Proprietary)

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The table below summarizes the RAIs which have responses included in this attachment.

RAI #	Title
Set 2 RAI[1] 2.25	RAI-3 – GOTHIC time step sensitivity
Set 3 RAI[2] SCVB-RAI-6	GOTHIC Running In Parallel With WCOBRA/TRAC
Set 2 RAI[1] 2.30	RAI-3 – Unal's Correlation

RAI 2.25 and RAI 2.30 were previously addressed via LTR-NRC-15-20[3] and SCVB-RAI-6 was previously addressed via LTR-NRC-15-5[4]. Subsequent discussions with the NRC reviewers have led to a request for Westinghouse to supplement the previously supplied responses. This supplemental information is provided in the attachment to this letter.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 14, 2014 (ADAMS Accession No. ML14254A251)

[2] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology" - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260)

[3] LTR-NRC-15-20, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," March 26, 2015

[4] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non-Proprietary)," January 22, 2015

2.25 RAI-3 – GOTHIC time step sensitivity
and
SCVB-RAI-6: GOTHIC Running In Parallel With WCOBRA/TRAC

Background

The Nuclear Regulatory Commission (NRC) provided 2 Requests for Additional Information (RAIs) relative to the WCOBRA/TRAC (WCT) and GOTHIC coupling process. These RAIs were provided to Westinghouse as RAI 2.25[1] and SCVB-RAI-6[2]. The Westinghouse responses were provided in LTR-NRC-15-20[3] and LTR-NRC-15-5[4]. Subsequent to the submittal of the responses, an NRC/Westinghouse audit was held the week of April 5, 2015. Discussion relative to the GOTHIC/WCT coupling process, where it was recognized that there is an approximation inherent in the data transfer between WCT and GOTHIC, resulted in Westinghouse taking an action to further justify the existing coupling process.

Further Discussion

Any concerns relative to approximations in the GOTHIC/WCT coupling process can best be studied in [ ]^{a,c}. Since break flow increases rapidly in the first few tenths of a second of the transient, followed by a monotonically decreasing flow rate until the end of blowdown, the discussion on the approximation in the coupling process will be focused on [ ]^{a,c}. Figures 1 and 2 below demonstrate the [ ]^{a,c} for the [ ]^{a,c}, respectively. Figure 3 shows the total break flow rate during blowdown, and both [ ]^{a,c} are observed.

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[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 14, 2014 (ADAMS Accession No. ML14254A251)

[2] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology – PWR [Pressurized Water Reactor] LOCA [Loss-of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260)

[3] LTR-NRC-15-20, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," March 26, 2015

[4] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non-Proprietary)," January 22, 2015

In order to understand the effect that the approximation in the coupling process can have on the figure of merit (containment pressure), sensitivity studies where the [ ]^{a,c} were performed. [ ]^{a,c}. The results of these [ ]^{a,c} sensitivity studies are shown in Figure 4. [ ]^{a,c} yielded a negligible decrease in the calculated peak containment pressure as compared to the nominal case. Figure 4 also shows a containment pressure response for a coupled WCT/GOTHIC run with a [ ]^{a,c}. The result was a negligible increase in peak containment pressure relative to the nominal case. The conclusion supported by the data presented in Figure 4 is that the current coupling process, as described in WCAP-17721-P, is an acceptable approach.

a,c

Figure 1: WCT + GOTHIC Coupling [

]a,c

a,c

Figure 2: WCT + GOTHIC Coupling [

]a,c

a,c

Figure 3: DEPS MIN Total Break Flow Rate

a,c

Figure 4: Peak Containment Pressure – WCT Time Step Size Sensitivity and Modified GOTHIC

2.30 RAI-3 – Unal's correlation

Background

The Nuclear Regulatory Commission (NRC) issued a Request for Additional Information (RAI) regarding use of the Unal correlation in the Westinghouse topical Report WCAP-17721-P[1] methodology via letter dated October 14, 2014[2]. The response to the RAI is documented in Westinghouse letter LTR-NRC-15-20[3]. Subsequent to the issuance of the response, it was noted in the April 8-9, 2015 audit at Westinghouse Rockville that the mass flux through the broken loop steam generator can exceed the range of validation data presented in Table 3 of LTR-NRC-15-20. It was recognized that further justification would be required for the post critical heat flux (CHF) interfacial heat transfer treatment.

Further Discussion

Break flow is largely dictated by the boundary conditions representing the safety injection system, and the mass flux through the steam generators for the large break loss of coolant accident (LOCA) is dependent on these parameters. Therefore, Westinghouse proposes to restrict the use of the modified interfacial heat transfer logic, which invokes the Unal correlation, described in WCAP-17721-P Section 3.1.1 to plant applications where the steam generator mass flux is within the validation range (less than or equal to 20.5 lbm/ft^2-sec). Plant analyses where the steam generator tube mass flux in the post-reflood period is greater than 20.5 lbm/ft^2-sec post-reflood will use the "WCT Standard" steam generator heat transfer logic, which led to the over-prediction of steam generator energy release in the FLECHT SEASET simulations (See WCAP-17721-P Section 3.2). (It is recognized that the mass flux may be higher during the accumulator injection period, but this is short-lived and of little consequence to the integrated mass and energy releases that contribute to the second containment pressure peaks of interest.)

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[1] WCAP-17721-P, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology," April 2013

[2] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 14, 2014 (ADAMS Accession No. ML14254A251)

[3] LTR-NRC-15-20, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," March 26, 2015

The "WCT Standard" interfacial heat transfer is based on the Lee-Ryley[4] correlation, presented in WCAP-12945-P-A[5] Section 5-3-4. The use of the Lee-Ryley correlation for the interfacial heat transfer from superheated vapor to droplets has previously been approved for use in the Westinghouse realistic large break LOCA Evaluation Models (Equation 5-157 of WCAP-12945-P-A and WCAP-16009-P-A[6]). It was concluded that the prediction of steam binding was conservative (Section 25-7 in WCAP-12945-P-A), and an over-prediction of droplet vaporization in the steam generator tubes is conservative for the LOCA M&E application as well. The Lee-Ryley correlation is based on the widely accepted formulation where the Nusselt number is expressed as a function of the Reynolds and Prandtl numbers (see Equation 1). Expressing the Nusselt number in terms of Reynolds and Prandtl numbers is more mechanistic as compared to the Unal correlation, which is highly empirical.

$$Nu = 2.0 + 0.74 Re_v^{0.5} Pr_v^{0.33} \quad (1)$$

The range of data used in the development of the Lee-Ryley correlation is shown in Table 1. Regarding droplet diameter, the droplet diameter in the steam generator tubes will be [ ]^{a,c} in the annular-mist flow regime at relevant conditions according to the logic described in Section 3-4-5 of WCAP-12945-P-A. The relative velocity in the steam generator tubes ranges from very small values (in which case the drop diameter is assigned a conservatively small value) to approximately [ ]^{a,c} ft/sec for the ice condenser plants. The pressure in the steam generator tubes will generally be above the correlation development range for the large dry containment design, and the steam generator tube pressure for the ice condenser plants will generally be at the top of the validation range. Superheating in excess of the Table 1 values is known to occur in the WCOBRA/TRAC plant analysis cases in the steam generator tubes.

---

[4] Lee, K. and Ryley, D.J., "The Evaporation of Water Droplets in Superheated Steam," Trans A.S.M.E. J Heat Transfer, Vol. 90, pp. 445-451

[5] WCAP-12945-P-A Volume 1, Revision 2, "Code Qualification Document for Best Estimate LOCA Analysis Volume I: Models and Correlations," March 1998

[6] WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005

[7] [

]^{a,c}

Table 1: Data Range for the Lee-Ryley Correlation

Initial droplet diameter	230-1126 microns
Droplet Reynolds number	64-250
Degrees of superheat	5°F-61°F
Steam pressure	14.7 psia – 28.9 psia
Steam velocity	8.8-39.2 ft/sec

Although the Lee-Ryley correlation is potentially being applied outside of the original data range, the mechanistic nature of the Nusselt number as a function of the Reynolds and Prandtl numbers lends itself well to extrapolation. The RELAP5/MOD3 documentation on models and correlations (NUREG/CR-5535 Volume 4[8]) indicates that a modified Lee-Ryley correlation was used in the annular mist calculations for heat transfer from the continuous vapor phase to the dispersed liquid droplet phase. Section 4.1.1 of NUREG/CR-5535 Volume 4 indicates that the Lee-Ryley correlation, in its original format (as employed in WCT), compares well with test data over a large range of Reynolds numbers (up to 10^5) versus Nusselt numbers, based on work summarized in Kreith[9]. Under the conditions of the steam generator tubes post-LOCA, the Prandtl number of the continuous vapor phase will not deviate significantly from a value of 1.0, making the Nusselt number dependent primarily upon the Reynolds number. The large range of Reynolds numbers over which the Lee-Ryley correlation provides good agreement relative to test data (in the absence of superheat) suggests that it should be able to be applied to slightly higher pressures than the original database.

Subsequent to the work completed by Lee and Ryley, it has been demonstrated that superheating has a suppressing effect on interfacial heat transfer due to the fact that the mass efflux from a droplet in the film region has a shielding effect relative to getting energy into the droplet through the boundary layer. The correlation presented by Ban and Kim[10] is similar to the Lee-Ryley correlation in that the Nusselt number is expressed as a function of the Reynolds number and Prandtl number, but it includes the multiplicative term $x_{actual}/x_{equilibrium}$. The ratio of actual quality to equilibrium quality decreases with increasing superheat. Yuen and Chen[11] accounted for the shielding effect by incorporating the mass transfer number in another Nusselt number expression that is similar to the Lee-Ryley correlation. The effect of incorporating the mass transfer number is that a higher free stream temperature tends to suppress the Nusselt number, and thus the calculated interfacial heat transfer coefficient.

8 NUREG/CR-5535 Volume 4, "RELAP5/MOD3 Code Manual Models and Correlations," August 1995

9 Kreith, F., "Principles of Heat Transfer," Third Edition, 1973

10 Ban, H.B., and Kim, Y., "Evaporation of a Water Droplet in High-Temperature Steam," Journal of the Korean Nuclear Society, Vol. 32, pp. 521-529

11 Yuen, M.C., and Chen, L.W., "Heat Transfer Measurements of Evaporating Liquid Droplets," Int. J. Heat Mass Transfer, Vol. 21, pp. 537-542

Conclusions

The Lee-Ryley correlation has been shown to provide good agreement with test data over a large range of Reynolds numbers, and it is based on a more mechanistic model than the Unal correlation. The standard WCT steam generator heat transfer package, which uses the Lee-Ryley correlation, was shown to provide conservative calculations relative to FLECHT SEASET steam generator test energy release in WCAP-17721-P. Additionally, the Lee-Ryley correlation conservatively does not account for suppression of the Nusselt number in superheated steam environments. Therefore, when the post-reflood mass flux through the steam generators exceeds the validation range of the Unal correlation, the Lee-Ryley correlation will be used by turning off the modified interfacial heat transfer option in WCT.

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LTR-NRC-15-42

May 26, 2015

References:
1. WCAP-17721-P, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology," April 2013.

Subject: Submittal of "WCAP-17721-P - Response to Draft RAI" (Non-Proprietary).

The purpose of this letter is to transmit a response to the Nuclear Regulatory Commission's draft request for additional information (RAI) on the WCAP-17721-P [1] submittal.

The responses are presented in Attachment 1, and they contain no proprietary information.

Correspondence concerning this submittal should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

James A. Gresham, Manager
Regulatory Compliance

Enclosures
cc: Ekaterina Lenning (NRC)
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Page 2 of 2

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LTR-NRC-15-42 Attachment

WCAP-17721-P - Response to Draft RAI (Non-Proprietary)

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RAI

The Nuclear Regulatory Commission (NRC) draft Request for Additional Information (RAI) was supplied as follows:

> The NRC staff is aware of Westinghouse's InfoGram IG-14-1 which discusses material properties for LOCA M&E release analyses. However, the InfoGram does not explicitly discuss the material properties used in WCOBRA/TRAC. Are the volumetric heat capacities in the WCOBRA/TRAC M&E analysis lower than those given in the ASME Boiler and Pressure Vessel Code? If so, provide appropriate justification for the use of lower volumetric heat capacities.

Westinghouse Response

Although not explicitly stated in the document, InfoGram IG-14-1 [1] was specific to the WCAP-10325-P-A [2] methodology. The WCOBRA/TRAC (WCT) structural materials that comprise the vessel and loop components are typically limited to stainless steel, carbon steel, and Inconel®[1] alloys 600 and 690 (steam generator tubes). Good agreement is generally observed when the heat capacity[2] for these materials is compared to the values obtained from the ASME Boiler and Pressure Vessel Code 2004 edition [3], as shown in Figures 1 through 4. The only notable exception is for the lower temperature stainless steel data, as shown in Figure 1. Although the heat capacity values for the structural materials in WCT differ from those in the ASME data, the WCT data is considered to be acceptable and was obtained from credible and/or approved sources, as discussed below.

Vessel Metal Heat Capacity

The heat capacity data for stainless steel and carbon steel in the vessel were obtained from the 1967 Touloukian compilation [4]. As shown in Figure 1, there is a deviation between the ASME data and the WCT data for stainless steel at temperatures below approximately 300°F, and the carbon steel data matches very closely throughout all temperatures. It should be noted that the bulk of the vessel metal is carbon steel, as the pressure vessel itself is thick carbon steel with a thin stainless steel layer on the interior for corrosion resistance. Therefore, there is no significant impact on stored vessel metal energy due to inconsistencies in assumed material properties relative to stainless steel in the reactor vessel.

Loop Metal Heat Capacity

The largest source of metal energy in the loop components is the steam generator pressure barrier, which is comprised of carbon steel sharing the same heat capacity data as the vessel carbon steel. The next largest source of energy is the steam generator tube metal, which is

[1] Inconel is a registered trademark of the Special Metals Corporation group of companies.

[2] It is noted that the volumetric heat capacity is the product of heat capacity and density. The cold state density values for the materials in question in WCT are within +/- 1% of the ASME values.

typically Inconel 600 or Inconel 690. The heat capacity for Inconel alloys was provided in Section 10-5-2 of approved topical report WCAP-16009-P-A [5]. The smallest contributor of stored metal energy in the loops is the stainless steel loop piping. The material properties for the loop stainless steel materials (304 and 316) were also reported in Section 10-5-2 of WCAP-16009-P-A [5].

References

1. IG-14-1, "Material Properties for Loss-of-Coolant Accident Mass and Energy Release Analyses," November 5, 2014.
2. WCAP-10325-P-A, "Westinghouse LOCA Mass and Energy Release Model for Containment Design March 1979 Version," May 1983.
3. ASME Boiler and Pressure Vessel Code, Section II, Part D, "Material Properties," 2004 Edition, The American Society of Mechanical Engineers, New York, New York.
4. Touloukian, Y.S., "Thermophysical Properties of High Temperature Solid Materials Volume 3: Ferrous Alloys," Thermophysical Properties Research Center, Purdue University, The Macmillan Co., New York, New York, 1967.
5. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005.

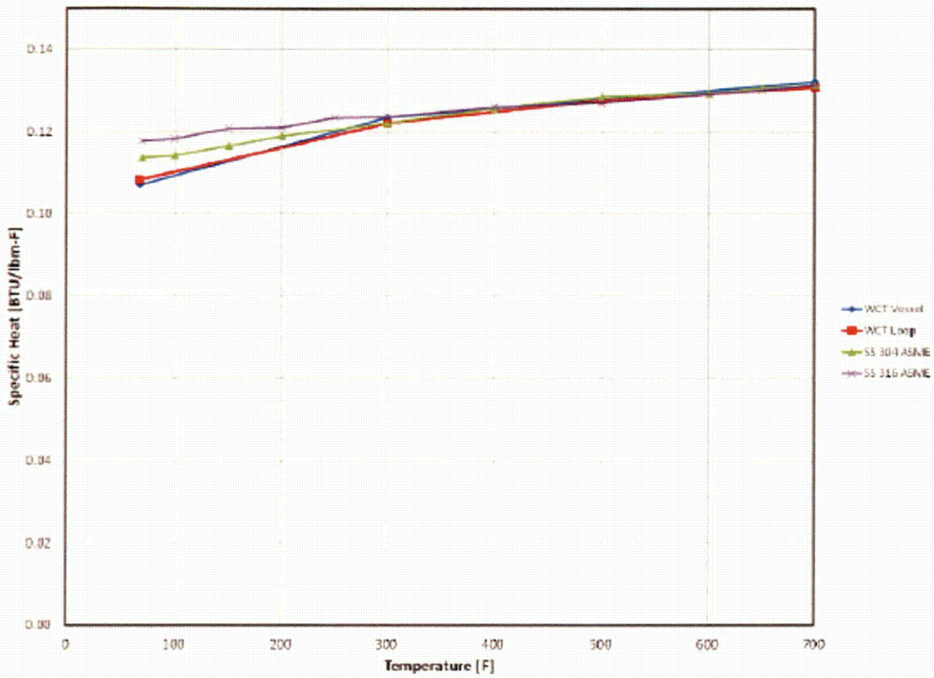

Figure 1: Stainless Steel Specific Heat Comparison

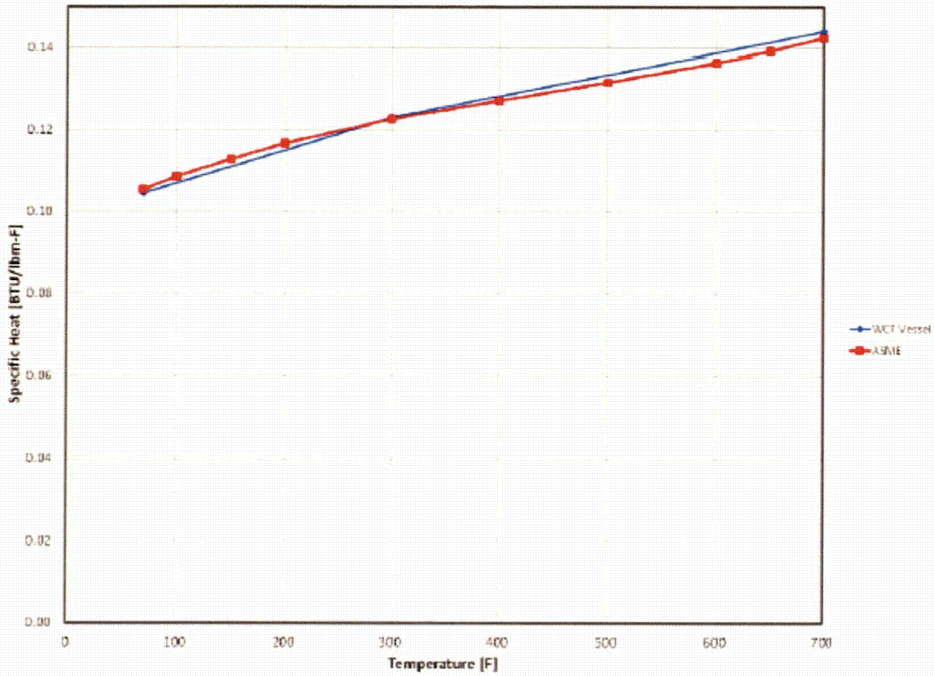

Figure 2: Carbon Steel Specific Heat Comparison

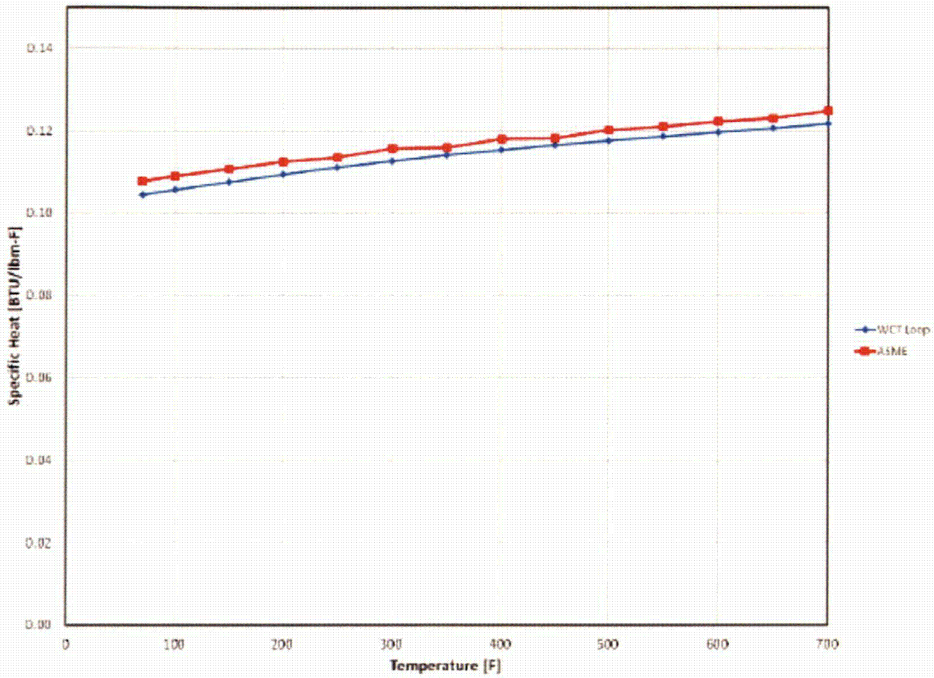

Figure 3: Inconel 600 Specific Heat Comparison

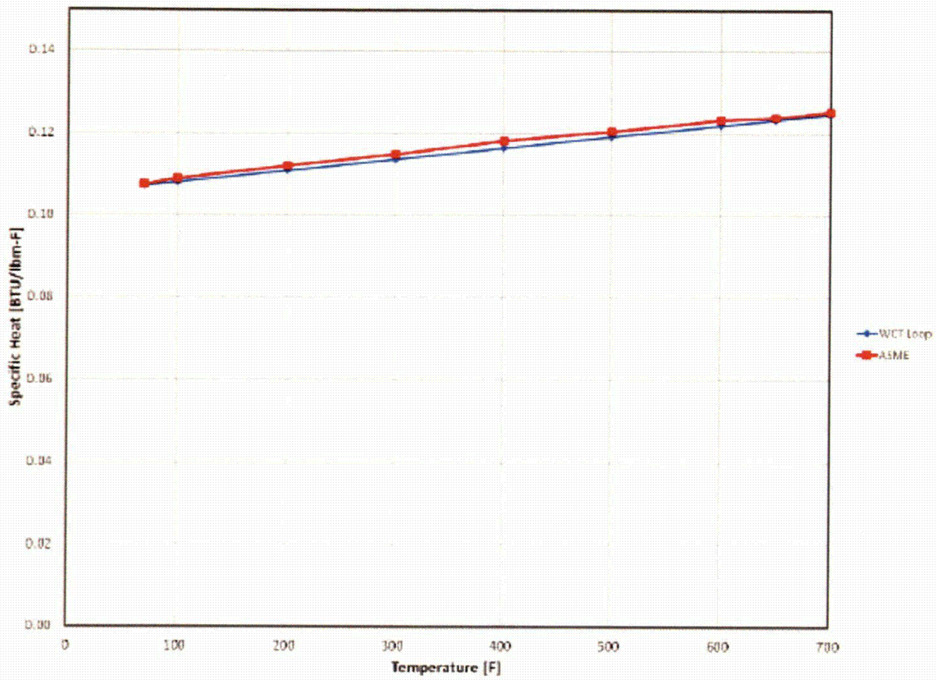

Figure 4: Inconel 690 Specific Heat Comparison