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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)

Add: Jon Thompson
E-RIDS
T007
NRR

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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

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).

Copyright Notice

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

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: [

]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.

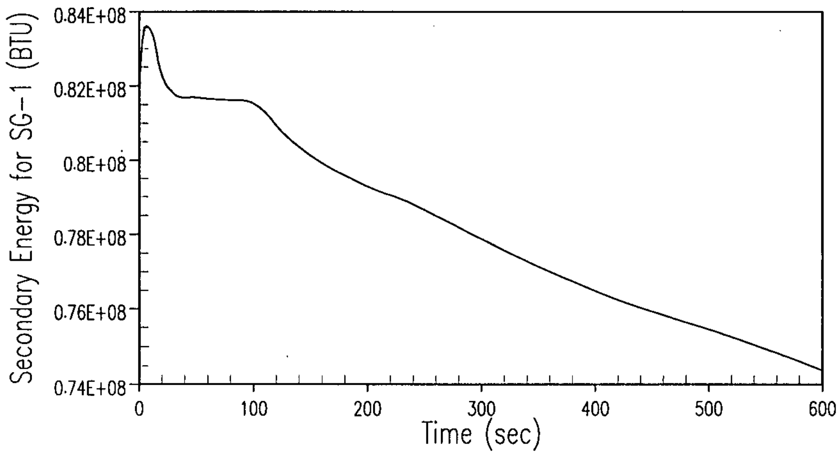

Figure 1 – Intact Loop SG Energy w/o Feedwater Coastdown

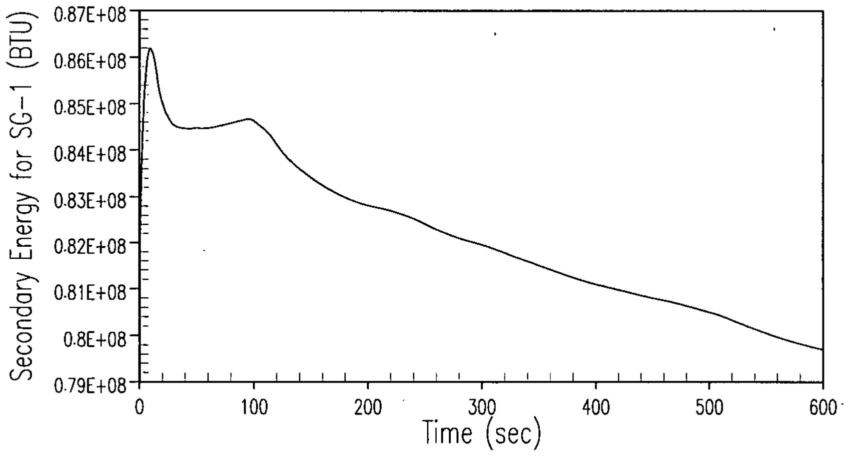

Figure 2 – Intact Loop SG Energy with Feedwater Coastdown

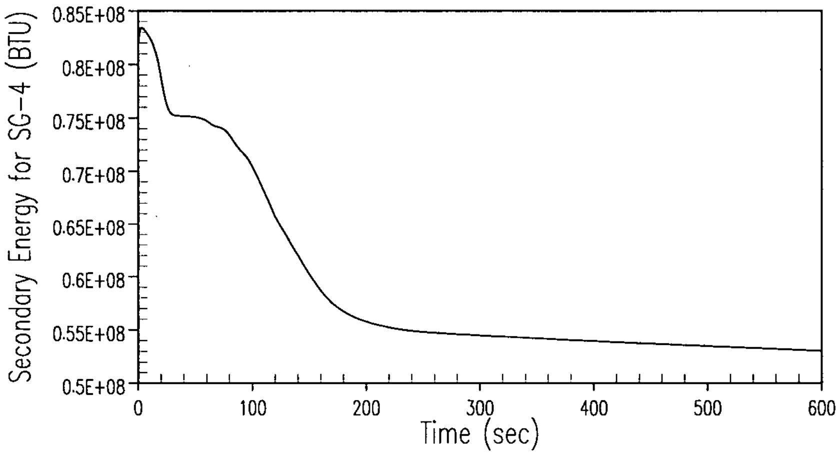

Figure 3 – Broken Loop SG Energy w/o Feedwater Coastdown

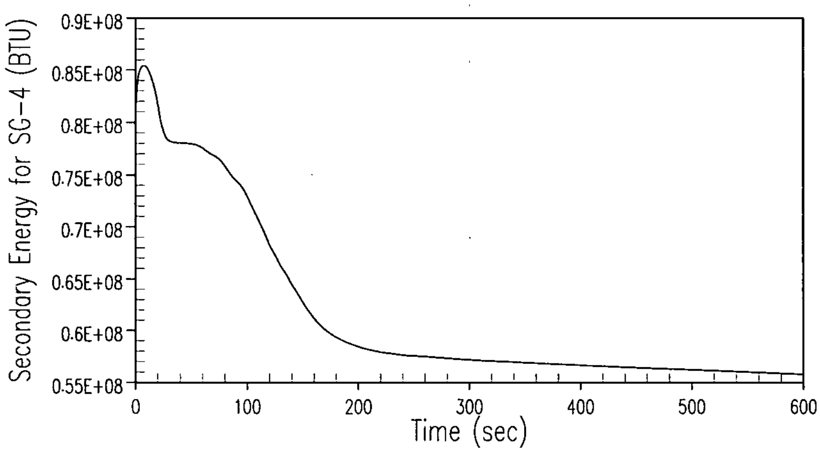

Figure 4 – Broken Loop SG Energy with Feedwater Coastdown

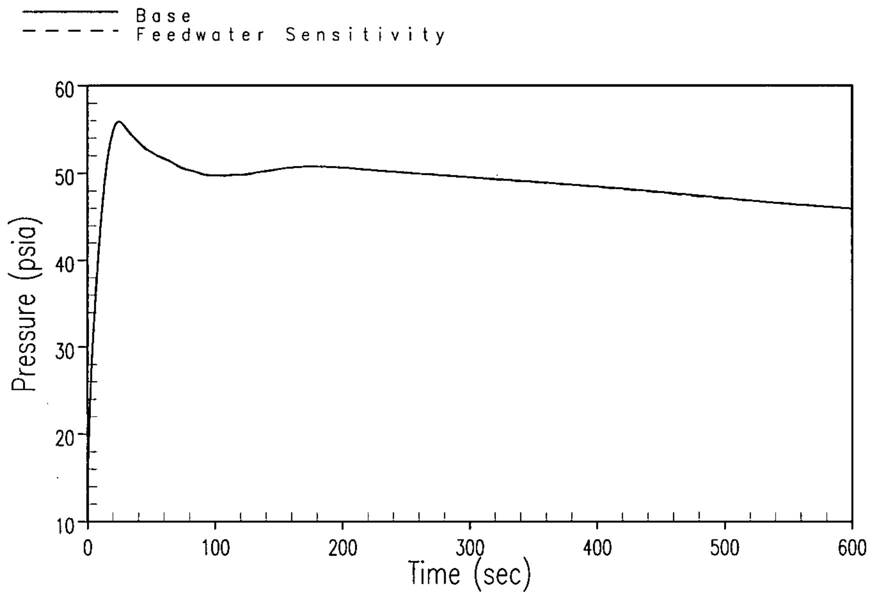

Figure 5 – Containment Pressure Comparison

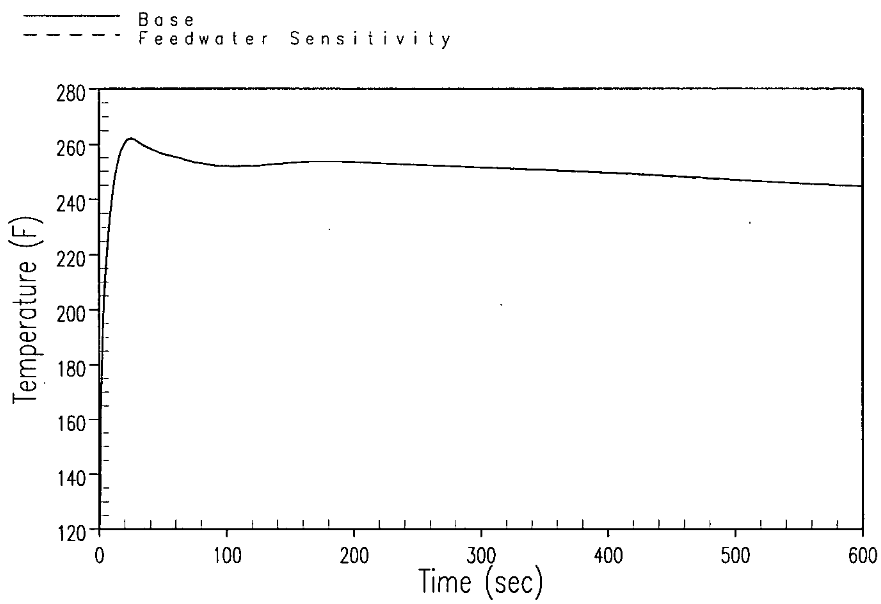

Figure 6 – Containment Temperature Comparison

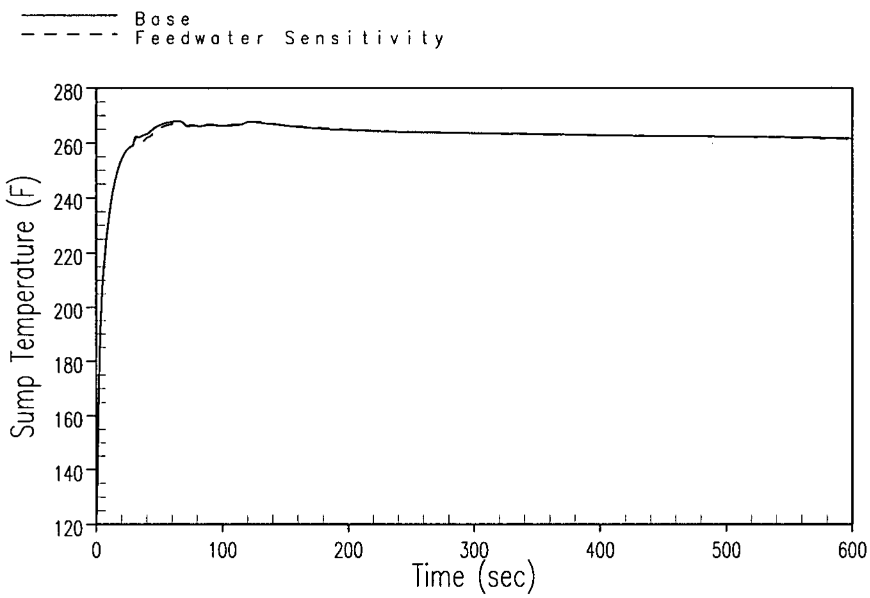

Figure 7 – Containment Sump Temperature Comparison

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 W*C/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 W*C/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 W*C/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.

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.

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: [

]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 W̲C/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 W̲C/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 W̲C/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 W̲C/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.

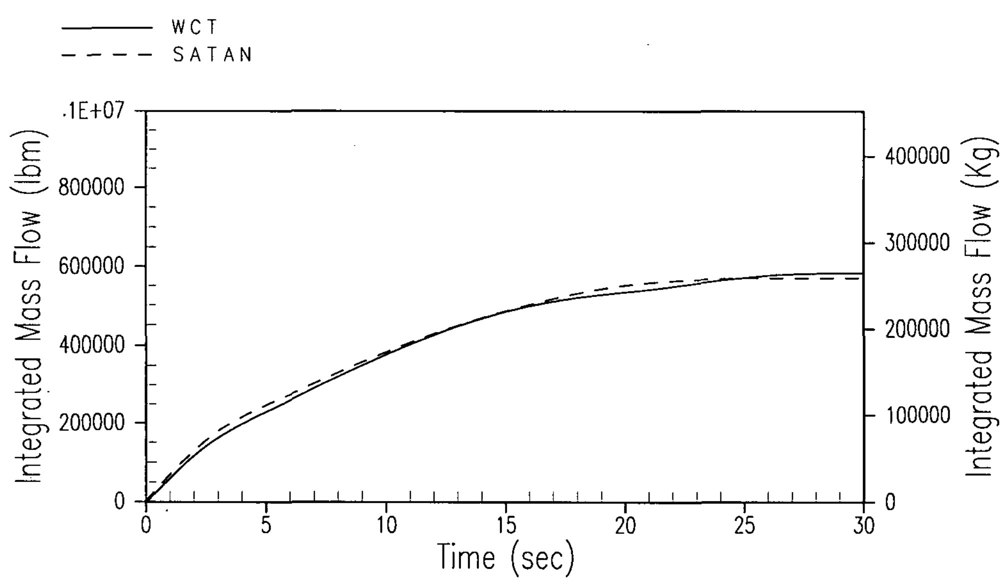

Figure 8 – Biased WCT Integrated Blowdown Mass Release Comparison

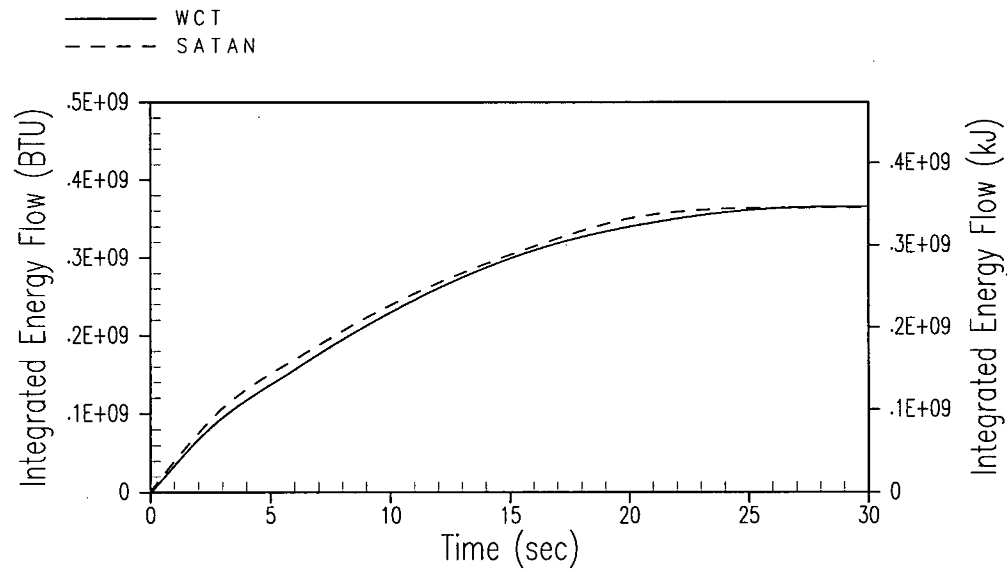

Figure 9 – Biased WCT Integrated Blowdown Energy Release Comparison

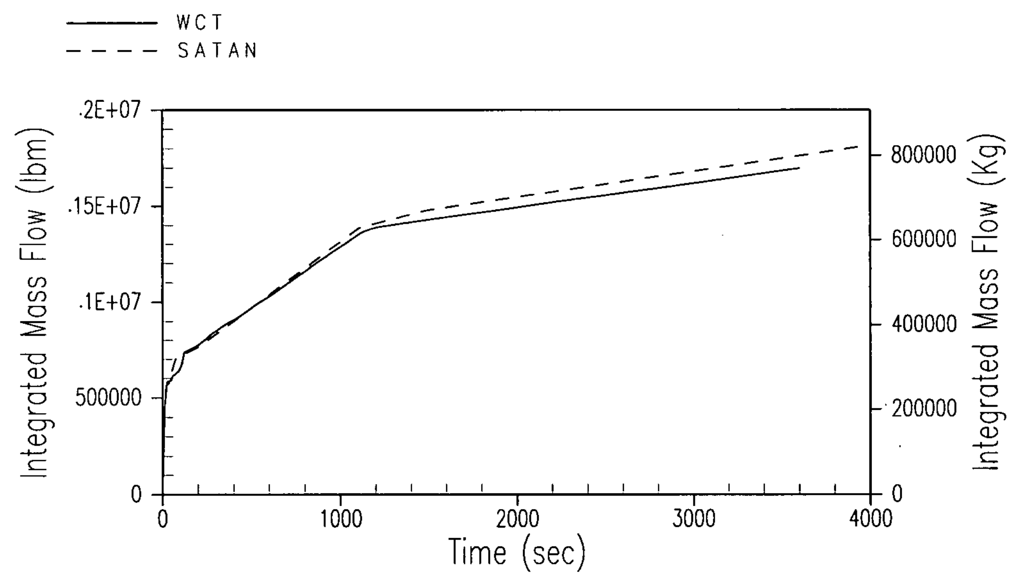

Figure 10 – Biased WCT Integrated Long-Term Mass Release Comparison

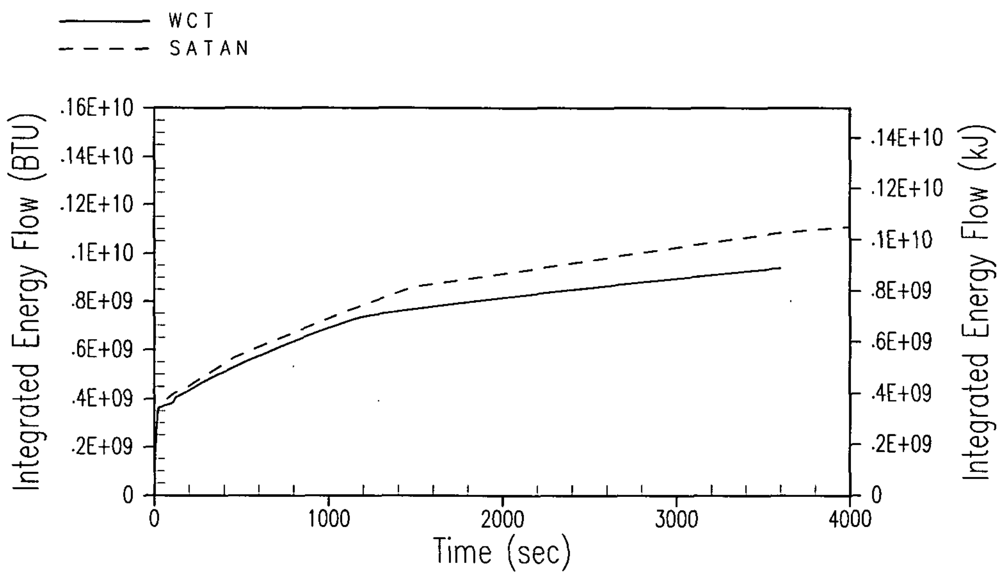

Figure 11 – Biased WCT Integrated Long-Term Energy Release Comparison

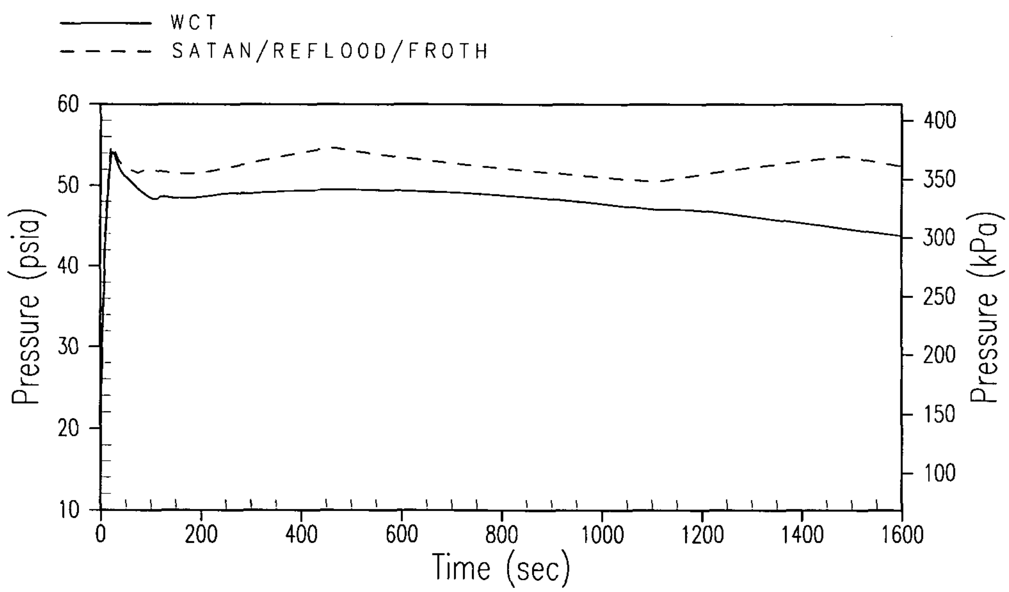

Figure 12 – Biased WCT Containment Pressure Response Comparison

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.

a,c

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.

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: [

    ]^{a,c}

    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}

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.