Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Direct tel: 412/374-4643
Direct fax: 412/374-4011
e-mail: greshaja@westinghouse.com
Project No.: 700
Our ref: LTR-NRC-04-33

May 28, 2004

Subject: Response to Round 3 Request for Additional Information for WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" (Proprietary)

Reference:
1. Email, S. Lu (NRC) to R. B. Sisk (Westinghouse), "Final Set of RAIs for WCAP-16078" dated May 14, 2004.
2. WCAP-16078-P, Rev. 0, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel," April 2003.

Transmitted herewith are three proprietary and two non-proprietary copies of Westinghouse Electric Company LLC (Westinghouse) responses to the Nuclear Regulatory Commission's Request for Additional Information (Reference 1) regarding WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" (Reference 2). Also transmitted are an Application for Withholding, AW-04-1842, with its associated affidavit and proprietary information notice.

This transmittal contains Westinghouse proprietary information comprising trade secrets, commercial or financial information which are considered privileged or confidential pursuant to 10 CFR 9.17(a)(4). Accordingly, Westinghouse requests that the proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for internal use by the Nuclear Regulatory Commission and may only be used for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Nuclear Regulatory Commission without the expressed prior written approval of Westinghouse. Correspondence with respect to the Application for Withholding should reference AW-04-1842 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

xc: W. A. Macon, Jr., NRC (w/ 3 proprietary copies)
F. M. Akstulewicz, NRC (w/o enclosures)
P. Clifford, NRC (w/o enclosures)

D054

Westinghouse

Westinghouse Electric Company
Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Direct tel: 412/374-4643
Direct fax: 412/374-4011
e-mail: greshaja@westinghouse.com
Project No.: 700
Our ref: AW-04-1842
May 28, 2004

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Response to Round 3 Request for Additional Information regarding WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" (Proprietary)

Reference: Letter, J. A. Gresham (Westinghouse) to USNRC Document Control Desk, "Response to Round 3 Request for Additional Information Regarding WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" (Proprietary) LTR-NRC-04-33, May 28, 2004.

This 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 that is 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-04-1842 accompanies this Application for Withholding and sets 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-04-1842 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,

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

AFFIDAVIT

STATE OF CONNECTICUT)
) ss: WINDSOR, CT
COUNTY OF HARTFORD)

Before me, the undersigned authority, personally appeared Ian C. Rickard, 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:

Ian C. Rickard,
Licensing Project Manager
Regulatory Compliance and Plant Licensing

Sworn to and subscribed before me
this 28th day of May 2004.

Notary Public

My commission expires May 31, 2008.

(1) I, Ian C. Rickard, depose and say that I am the Licensing Project Manager 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 the Westinghouse Electric Company LLC.

(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 the Westinghouse Electric Company LLC 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 10 CFR 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 for classification of proprietary information, 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.

(iv) 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 the Enclosure to "Response to Round 3 Request for Additional Information for WCAP-16078-P, Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel." This information is being transmitted to the NRC Document Control Desk by Westinghouse letter (LTR-NRC-04-33) and Application for Withholding Proprietary Information from Public Disclosure (AW-04-1842). The proprietary information as submitted for use by the Commission is expected to be applicable in other licensee submittals in response to certain NRC requirements for justification for the application of the Westinghouse BWR ECCS evaluation model.

This information is part of a model that will enable Westinghouse to evaluate the performance of BWR fuel during conditions when the emergency core cooling system is actuated, and in particular to supporting utilities in the application of Westinghouse supplied BWR fuel, that will enable Westinghouse to:

(a) Perform BWR safety analyses employing the Westinghouse safety analysis methodology for SVEA-96 Optima2 fuel to ensure regulatory limits are met,

(b) Identify important phenomena relevant to the application of the emergency core cooling model to boiling water reactor ECCS analyses including quantification of fuel performance, operational considerations and model implementation, and

(c) Support licensees in regulatory actions in which demonstration of compliance with ECCS acceptance criteria is required

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

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for licensing documentation.

(b) Westinghouse can sell the application and defense of BWR Loss of Coolant Accident Analyses.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology that 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 advanced nuclear power plant designs and to provide 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 in connection with requests for generic and/or plant-specific review and approval.

That information which is proprietary in the proprietary version is contained within brackets in order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the identification and protection of proprietary information voluntarily transmitted to the NRC. Such proprietary information has been deleted in the non-proprietary version, leaving only the brackets. The justification for claiming the information designated as proprietary is indicated in both versions by means of superscript letters (a) through (f) following the brackets enclosing each item identified as proprietary. These letters refer to the types of information Westinghouse customarily holds in confidence as identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

Enclosure to LTR-NRC-04-33

Response to Round 3 NRC Request for Additional Information Concerning WCAP-16078-P

The NRC Request for Additional Information (RAI) regarding WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" is in the form of an initial October 9, 2003 request for background material previously submitted to the NRC and twenty-eight additional RAIs. These RAIs were issued in several sets, the most recent of which was received by Westinghouse on May 14, 2004 and contained RAIs #13 through #28. Responses to RAIs 13 – 28 are provided below.

NRC Round 3 RAI 13:

The level tracking model was tested for application to lower plenum. The sensitivity study shown that the timing of key events was not sensitive to the use of the model. Therefore, please explain why this part of discussion is included in this LTR if there is no difference between USA5 and USA4. In addition, please explain what the statement on Page 16 means, "... unless warranted by the specific application.."

Westinghouse Response to RAI 13:

It is recognized that this change to the methodology has no impact on the results. However, since prior licensing topical reports (LTRs) (e.g., CENPD-283-P-A) indicated that level tracking would be used in the lower plenum, it was considered prudent to provide a formal justification for flexibility in the use of level tracking in the lower plenum in future analyses. The sensitivity study contained in WCAP-16078 provides justification for flexibility in the use of the level-tracking feature.

The statement "...unless warranted by the specific application" is included to indicate that there may be a plant-specific application where the use of level tracking in the lower plenum is necessary to maintain accuracy for a specific plant design where it is important to accurately capture the physical phenomenon associated with the location of the two-phase level interface.

NRC Round 3 RAI 14:

Please explain how was the core average channel being modeled for a mixed core; i.e., how to determine the averaged local loss coefficients, flow area, hydraulic diameter and spacer locations, if different spacer locations exist in different bundle designs?

Westinghouse Response to RAI 14:

The Westinghouse methodology is to [[

.]]^{a,c}

A comparison was presented in Section 9.3 of RPB 90-94-P-A of system response analyses performed with a full core of SVEA-64 fuel and a mixed core containing two-thirds SVEA-64 fuel and one-third 8x8 fuel. The SVEA-64 fuel is an 8x8 water-cross design and the 8x8 fuel was an open lattice design. The results showed [[

.]]^{a,c}

A similar result is expected for applications involving the introduction of SVEA-96 Optima2 fuel, which is also a 10x10-4 water-cross design with part-length fuel rods. However, Westinghouse will perform an evaluation to determine if this approach can continue to be applied during future applications of the evaluation model. This evaluation will compare a system analysis of a core containing a full core of SVEA-96 Optima2 fuel to a mixed core containing approximately one-third SVEA-96 Optima2 fuel and two-thirds legacy fuel. In the event this simplification is not justified, the mixed core model will be used for the system response analysis.

NRC Round 3 RAI 15:

Please explain how the bounding radial power distribution is developed in the average channel of GOBLIN code to maximize the sensible heat and stored energy? Is it defined on a cycle specific basis?

Westinghouse Response to RAI 15:

The normal procedure is to use the boundary conditions from the GOBLIN system analysis to drive the analysis of the hot assembly. The radial peaking used for the hot assembly is established such that [[

.]]^{a,c} As the GOBLIN system analysis usually represents the [[.]]^{a,c} Sensitivity studies have been performed using GOBLIN models with several parallel channels to represent the low power regions around the core periphery, intermediate interior power assemblies and the hot assembly. These studies showed that the [[

.]]^{a,c}

In the event a mixed core model is used to perform the GOBLIN system analysis, there would be two or more parallel channels to represent the different fuel assembly designs. The radial power factor used for each channel would be based on the core design.

The initial fuel stored energy in the GOBLIN average channel analysis is conservatively maximized by using an initial power level that includes the power measurement uncertainty and lower bound fuel rod performance conditions that minimize the cladding to pellet gap heat transfer.

<u>NRC Round 3 RAI 16:</u>
Last sentence of Page 20 seems to be incomplete. Please clarify.

<u>Westinghouse Response to RAI 16:</u>
The last sentence on page 20 continues on to page 21 where it is completed.

<u>NRC Round 3 RAI 17:</u>
Page 26 and 27 discussed seven new modeling features added from STAV7.2 code into the CHACHA-3D code. How is the ballooning effect modeled by CHACHA-3D code in terms of flow area change during the ballooning process? What is its impact on the PCT and the release of decay heat/stored energy.

<u>Westinghouse Response to RAI 17:</u>
As indicated on page 27 of WCAP-16078, only two of the fuel performance models in STAV will be installed in CHACHA-3D. These are [[

.]]^{a,c} Both of these models have been improved in STAV7.2 relative to STAV6.2. As discussed in the response to RAI #18, additional parameters supporting the temperature calculation are input from STAV as part of the LOCA analysis initialization.

The fuel cladding strain and rupture models in the CHACHA-3D code are not being changed. These models are described in Section 5.6 of CENPD-293-P-A. Section 7.2 of this report provides comparisons of predicted rupture strains with data. Although ballooning of the cladding will reduce the flow area, the evaluation model uses spray heat transfer coefficients as prescribed by Appendix K when the cladding is predicted to balloon. The effect of increased steam velocity at the ballooned locations is not modeled since these coefficients are constant throughout the 'spray cooling' interval. Although ballooning of the cladding has a beneficial effect on heat transfer by convection due to the increased outer surface area, this effect is conservatively neglected in CHACHA-3D.

With regard to the impact of ballooning on the peak cladding temperature (PCT), the overall effect of ballooning is normally to increase the PCT. Since ballooning usually develops into rod rupture for the fuel rod exhibiting the PCT, the double-sided metal-water reaction clearly increases the PCT. The ballooning of the cladding also influences the heat transfer between the fuel pellet and the cladding. The change in gap dimensions decreases the gap heat transfer coefficient, which leads to an increase of the fuel pellet temperature relative to the cladding surface temperature. [[

.]]^{a,c}

NRC Round 3 RAI 18:

Item #4 on Page 26 stated that the time scale involved with gas release is at least an order of magnitude slower. Therefore, CHACHA-3D does not model additional gas release during the transient. Only the STAV7.2 results are used as the input. Please clarify what results of STAV7.2 are used, at what stage of the LOCA.

Westinghouse Response to RAI 18:

The CHACHA-3D code is used to evaluate the performance of each lattice type for its entire burnup history. In addition to the thermal-hydraulic conditions exterior to the cladding, which are determined from the GOBLIN and DRAGON analyses, the initial conditions within the fuel rod are derived from the STAV7.2 code. These initial conditions are generated by running a STAV7.2 from beginning to end of life for a bounding power history using assumptions that produce conservative initial stored energies. In addition to the [[

.]]a,c

NRC Round 3 RAI 19:
Page 27 #5 and #4 on Page 26 seems to be duplications of the information. Please clarify.

Westinghouse Response to RAI 19:
Item 4 on page 26 describes the athermal fission gas release model. Item 5 on page 27 describes the thermal fission gas release model. The fission product gas release (FGR) model consists of an athermal and a thermal release component.

The athermal FGR model accounts for [[

.]]^{a,c}

The thermal FGR model is [[

.]]^{a,c}

NRC Round 3 RAI 20:
Page 27 item #6. Please provide a sample list of input parameters from STAV7.2 and explain any differences between the input of STAV7.2 and STAV6.2. If they are just inputs, other than outputs from STAV7.2, do they make a difference?

Westinghouse Response to RAI 20:
The list of eleven input parameters from STAV7.2 is provided in the response to RAI #18. The same parameters were provided by STAV6.2. Since the two fuel performance codes will predict a different variation of these input parameters with burnup, the [[

.]]^{a,c} These changes will affect the predicted cladding temperature response.

NRC Round 3 RAI 21:
Page 27 item #7. Please briefly summarize the revised BWR crud build-up model in STAV7.2 and explain its impact on LOCA. Please provide more details about how CHACHA-3D defines the thermal resistance of the crud layer and the oxide layer. How is the metal water reaction modeled by CHACHA-3D code with the existence of crud?

Westinghouse Response to RAI 21:
Crud model - Corrosion products released from various plant surfaces can deposit on the cladding surface. This material is referred to as crud. The previous crud correlation in STAV6.2 described the deposition of crud on the cladding surface as a [[

.]][a,c]

Oxide model - The cladding oxidation model in STAV is made up of [[

.]][a,c]

Metal-water reaction model - Section 4.4 of RPB 90-93-P-A describes how the metal-water reaction is modeled. Since the Baker-Just model is used, the rate of oxidation decreases as the thickness of the oxide increases. [[

.]][a,c]

NRC Round 3 RAI 22:
Page 27 item #8, does gap heat transfer coefficient used by CHACHA-3D subject to change during LOCA? What is the impact to PCT and other three LOCA criteria?

Westinghouse Response to RAI 22:
The information from STAV shown in the response to RAI #18 is used in CHACHA-3D to establish an initial gap heat transfer coefficient. Since the cladding balloons during the transient,

small changes in the initial gap dimensions have a small impact on the overall thermal response of the cladding.

As described in Section 5.5 of CENPD-293-P-A, the gap heat transfer coefficient in CHACHA-3D is calculated dynamically during the LOCA event to account for the change in cladding dimensions during the transient. Except for the initial condition inputs from the fuel performance code, the CHACHA-3D model is unchanged. Since the revised initial dimensional information from STAV7.2 do not change significantly, they will have a very small effect on the predicted transient gap heat transfer coefficient. Therefore, Westinghouse expects that these changes will have a small impact on the predicted cladding responses (i.e., peak temperature, maximum local oxidation and core wide oxidation).

NRC Round 3 RAI 23:
Under the title of "UO2 and Gadolinia Fuel Pellet Thermal Conductivity", it is stated that "The thermal conductivity for UO2 and Gadolinia fuel pellets are now calculated in accordance with STAV 7.2 fuel performance code." Does "in accordance with" mean that identical models and data are used?

Westinghouse Response to RAI 23:
The thermal conductivity model for the UO_2 and Gadolinia fuel pellets in the version of CHACHA-3D used for licensing applications will be identical to the corresponding correlations in the approved fuel performance code.

Westinghouse expects that the approval of WCAP-16078 will be contingent upon using initial conditions and models for fuel pellet conductivity and power distribution from an approved fuel performance code. The installation of the approved thermal conductivity and pellet power distribution models in CHACHA-3D will follow the process described in the response to RAI #25 (below). Therefore, the initial conditions for CHACHA-3D will be obtained from an approved fuel performance code and the applicable correlations from an approved fuel performance code will be installed correctly in CHACHA-3D.

NRC Round 3 RAI 24:
Page 27. Does 62 MWd/kgU set the limit of this methodology for exposure? For thermal conductivity only?

Westinghouse Response to RAI 24:
The STAV7.2 code, as described in WCAP-15836, is currently under review by the Staff as part of the Westinghouse program to obtain NRC acceptance of Westinghouse fuel assembly mechanical design methods used for BWR licensing analysis to a rod-average burnup of 62 MWd/kgU. The Westinghouse request for approval to 62 MWd/kgU is based on:

1. The understanding that the NRC is entertaining requests currently only to this burnup until additional high burnup data and support for higher burnup operation are available.
2. The Westinghouse fuel performance models, methods, and databases support fuel rod burnups in excess of 62 MWd/kgU rod-average.

The limit of 62 MWd/kgU on rod-average burnup is not based on limitations in the ECCS model. Acceptance of the fuel performance models (e.g., STAV) beyond the 62 MWd/kgU limit would be adequate justification for applying the ECCS model beyond 62 MWd/kgU.

NRC Round 3 RAI 25:
A total of eight new modeling features from STAV7.2 are implemented into CHACHA-3D code. Please provide evidence that the implemented models in CHACHA-3D can reproduce the same results as that of STAV7.2.

Westinghouse Response to RAI 25:
As indicated in Section 5.5.2.3 of WCAP-16078, only two of the new modeling features from STAV7.2 will be installed in the CHACHA-3D code. These features are the new models for [[.]]^{a,c}

Because of recent improvements to the STAV7.2 code, the [[ ]]^{a,c} have not been implemented into CHACHA-3D. However, the models that are implemented into CHACHA-3D, will be identical to the corresponding models in the approved fuel performance code. As part of the implementation process, sample calculations will be performed to verify consistency between these two codes after the final models are installed in CHACHA-3D. These calculations will be performed for a UO_2 fuel rod and a UO_2 + Gd_2O_3 as a function of nodal burnup. Similar to the validation presented in Section 7.3.2 of CENPD-293-P-A, these calculations will compare the predictions from the approved fuel performance code to the predictions by CHACHA-3D. The following quantities will be compared to ensure that the models are installed correctly:

- fuel centerline temperature,
- fuel average temperature, and
- gap heat transfer coefficient.

NRC Round 3 RAI 26:
Section 6.1.1 discussed the applicability of the spray heat transfer model to SVEA-96 OPTIMA2 fuel. It is not stated in CENPD-283-P-A about how the coefficients are used. Therefore, please explain how this coefficient is being used inside the code for different rods and channel wall. For a mixed core, does this coefficient apply to the average channel? The corner rod is a 1/3 length rod. Is it necessary to even calculate the 1/3 length rod temperature profile? In addition, do the coefficients subject to change along the axial direction? Because of the use of part length rods, the radiation heat transfer view factors change along the axial direction. Does this variation affect the spray coefficients? Why?

Westinghouse Response to RAI 26:
Application of spray heat transfer coefficients - The application of the spray heat transfer coefficients in the CHACHA-3D heat-up code is described in Section 4.5.3 of RPB 90-93-P-A. These coefficients are consistent with the 10 CFR 50.46 Appendix K requirements and are applied only in the heat-up analysis. The GOBLIN system and hot channel analyses use a different heat transfer model, which is described in Section 3.5 of RPB 90-93-P-A.

The spray heat transfer coefficients are input to the CHACHA-3D code as a table. The convective heat transfer coefficients used in the CHACHA-3D code from the beginning of the transient until the time of uncovery are taken from the [[

]][a,c] are replaced by the spray heat transfer coefficients required by Appendix K. After two-phase recovery is predicted and until the end of the transient, the heat transfer coefficients predicted by the hot assembly analysis are replaced by the 'reflood' heat transfer coefficient (25 Btu/hr-ft^2-°F) required by Appendix K.

As indicated above, the spray heat transfer coefficients are applied as a table of values. The figure below is a typical example.

a, c

Application to average channel of a mixed core - The treatment of mixed cores is described in the response to RAI #14. The spray cooling heat transfer coefficients that are required by Appendix K are applied only in the rod heat-up calculation (CHACHA-3D). The average core system response is determined using GOBLIN, which uses the heat transfer package described in Section 3.5 of RPB 90-93-P-A.

Application to the 1/3-length rods - The spray cooling heat transfer coefficients are applied at whatever axial plane is being analyzed. If the lattice being analyzed were from the lower third of the core, the 1/3-length rods would be analyzed using a spray heat transfer coefficient that is applicable to "corner" rods, as that is the location of the 1/3-length rods. [[

.]]^{a,c}

Axial variability of the spray heat transfer coefficients - Although a [[

.]]^{a,c}

Effect of radiation view factors on spray heat transfer coefficients - The radiation view factors are applied based on the actual cross-section being evaluated. The spray heat transfer coefficients are based on Appendix K requirements and are independent from the radiation view factors. As discussed above, a single set of spray heat transfer coefficients is used.

NRC Round 3 RAI 27:

Page 33 mentioned the extrapolation process to define the SVEA-96 Optima 2 spray coefficient. Please explain how the extrapolation was done. What is the independent variable to extrapolate? Diameter? Or rod layout?

Westinghouse Response to RAI 27:

The extrapolation process is based on [[

:]]^{a,c}

a, c

[[:]]^{a,c}

a, c

[[

]]^{a,c}

NRC Round 3 RAI 28:
Section 6.2 discussed the application of the radiation heat transfer model to SVEA-96 OPTIMA2 fuel. It is stated that the smallest pitch is used to perform the radiation heat transfer calculation. Please explain how are the different rod diameter and part length rods considered in the radiation heat transfer calculation.

Westinghouse Response to RAI 28:
As described in Section 4.2 of the WCAP-16078, the fuel rods in the SVEA-96 Optima2 fuel design have a single rod diameter (9.84 mm). Radiation heat transfer is modeled in the system analysis, the hot channel analysis and in the hot rod heat-up analysis.

The radiation heat transfer model for the GOBLIN system analysis and hot assembly analysis, which is described in Section 3.5 of RPB 90-93-P-A, uses [[

]]a,c

( )a, c

is used to calculate the radiative heat transfer between components at each axial node within the fuel channel. The SVEA-96 Optima2 fuel design has three axial zones (i.e., there are 24 rods in the lower zone, 23 rods in the middle zone and 21 rods in the upper zone of each sub-assembly). Each zone is surrounded on two sides by the water-cross and on the other two sides by the fuel channel. [[

.]]a,c

The radiation heat transfer model in CHACHA-3D, which is described in Section 4.5 of RPB 90-93-P-A and Section 5.4 of CENPD-293-P-A, is similar to the model in GOBLIN except that the [[

.]]a,c

Enclosure to LTR-NRC-04-33

Response to Round 3 NRC Request for Additional Information Concerning WCAP-16078-P

The NRC Request for Additional Information (RAI) regarding WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel" is in the form of an initial October 9, 2003 request for background material previously submitted to the NRC and twenty-eight additional RAIs. These RAIs were issued in several sets, the most recent of which was received by Westinghouse on May 14, 2004 and contained RAIs #13 through #28. Responses to RAIs 13 – 28 are provided below.

NRC Round 3 RAI 13:
The level tracking model was tested for application to lower plenum. The sensitivity study shown that the timing of key events was not sensitive to the use of the model. Therefore, please explain why this part of discussion is included in this LTR if there is no difference between USA5 and USA4. In addition, please explain what the statement on Page 16 means, "... unless warranted by the specific application.."

Westinghouse Response to RAI 13:
It is recognized that this change to the methodology has no impact on the results. However, since prior licensing topical reports (LTRs) (e.g., CENPD-283-P-A) indicated that level tracking would be used in the lower plenum, it was considered prudent to provide a formal justification for flexibility in the use of level tracking in the lower plenum in future analyses. The sensitivity study contained in WCAP-16078 provides justification for flexibility in the use of the level-tracking feature.

The statement "...unless warranted by the specific application" is included to indicate that there may be a plant-specific application where the use of level tracking in the lower plenum is necessary to maintain accuracy for a specific plant design where it is important to accurately capture the physical phenomenon associated with the location of the two-phase level interface.

NRC Round 3 RAI 14:
Please explain how was the core average channel being modeled for a mixed core; i.e., how to determine the averaged local loss coefficients, flow area, hydraulic diameter and spacer locations, if different spacer locations exist in different bundle designs?

Westinghouse Response to RAI 14:
The Westinghouse methodology is to [[

.]]^{a,c}

A comparison was presented in Section 9.3 of RPB 90-94-P-A of system response analyses performed with a full core of SVEA-64 fuel and a mixed core containing two-thirds SVEA-64 fuel and one-third 8x8 fuel. The SVEA-64 fuel is an 8x8 water-cross design and the 8x8 fuel was an open lattice design. The results showed [[

.]]a,c

A similar result is expected for applications involving the introduction of SVEA-96 Optima2 fuel, which is also a 10x10-4 water-cross design with part-length fuel rods. However, Westinghouse will perform an evaluation to determine if this approach can continue to be applied during future applications of the evaluation model. This evaluation will compare a system analysis of a core containing a full core of SVEA-96 Optima2 fuel to a mixed core containing approximately one-third SVEA-96 Optima2 fuel and two-thirds legacy fuel. In the event this simplification is not justified, the mixed core model will be used for the system response analysis.

NRC Round 3 RAI 15:

Please explain how the bounding radial power distribution is developed in the average channel of GOBLIN code to maximize the sensible heat and stored energy? Is it defined on a cycle specific basis?

Westinghouse Response to RAI 15:

The normal procedure is to use the boundary conditions from the GOBLIN system analysis to drive the analysis of the hot assembly. The radial peaking used for the hot assembly is established such that [[

.]]a,c As the GOBLIN system analysis usually represents the [[.]]a,c Sensitivity studies have been performed using GOBLIN models with several parallel channels to represent the low power regions around the core periphery, intermediate interior power assemblies and the hot assembly. These studies showed that the [[

.]]a,c

In the event a mixed core model is used to perform the GOBLIN system analysis, there would be two or more parallel channels to represent the different fuel assembly designs. The radial power factor used for each channel would be based on the core design.

The initial fuel stored energy in the GOBLIN average channel analysis is conservatively maximized by using an initial power level that includes the power measurement uncertainty and lower bound fuel rod performance conditions that minimize the cladding to pellet gap heat transfer.

NRC Round 3 RAI 16:
Last sentence of Page 20 seems to be incomplete. Please clarify.

Westinghouse Response to RAI 16:
The last sentence on page 20 continues on to page 21 where it is completed.

NRC Round 3 RAI 17:
Page 26 and 27 discussed seven new modeling features added from STAV7.2 code into the CHACHA-3D code. How is the ballooning effect modeled by CHACHA-3D code in terms of flow area change during the ballooning process? What is its impact on the PCT and the release of decay heat/stored energy.

Westinghouse Response to RAI 17:
As indicated on page 27 of WCAP-16078, only two of the fuel performance models in STAV will be installed in CHACHA-3D. These are [[

.]]^{a,c} Both of these models have been improved in STAV7.2 relative to STAV6.2. As discussed in the response to RAI #18, additional parameters supporting the temperature calculation are input from STAV as part of the LOCA analysis initialization.

The fuel cladding strain and rupture models in the CHACHA-3D code are not being changed. These models are described in Section 5.6 of CENPD-293-P-A. Section 7.2 of this report provides comparisons of predicted rupture strains with data. Although ballooning of the cladding will reduce the flow area, the evaluation model uses spray heat transfer coefficients as prescribed by Appendix K when the cladding is predicted to balloon. The effect of increased steam velocity at the ballooned locations is not modeled since these coefficients are constant throughout the 'spray cooling' interval. Although ballooning of the cladding has a beneficial effect on heat transfer by convection due to the increased outer surface area, this effect is conservatively neglected in CHACHA-3D.

With regard to the impact of ballooning on the peak cladding temperature (PCT), the overall effect of ballooning is normally to increase the PCT. Since ballooning usually develops into rod rupture for the fuel rod exhibiting the PCT, the double-sided metal-water reaction clearly increases the PCT. The ballooning of the cladding also influences the heat transfer between the fuel pellet and the cladding. The change in gap dimensions decreases the gap heat transfer coefficient, which leads to an increase of the fuel pellet temperature relative to the cladding surface temperature. [[

.]]^{a,c}

<u>NRC Round 3 RAI 18:</u>
Item #4 on Page 26 stated that the time scale involved with gas release is at least an order of magnitude slower. Therefore, CHACHA-3D does not model additional gas release during the transient. Only the STAV7.2 results are used as the input. Please clarify what results of STAV7.2 are used, at what stage of the LOCA.

<u>Westinghouse Response to RAI 18:</u>
The CHACHA-3D code is used to evaluate the performance of each lattice type for its entire burnup history. In addition to the thermal-hydraulic conditions exterior to the cladding, which are determined from the GOBLIN and DRAGON analyses, the initial conditions within the fuel rod are derived from the STAV7.2 code. These initial conditions are generated by running a STAV7.2 from beginning to end of life for a bounding power history using assumptions that produce conservative initial stored energies. In addition to the [[

.]][a,c]

NRC Round 3 RAI 19:
Page 27 #5 and #4 on Page 26 seems to be duplications of the information. Please clarify.

Westinghouse Response to RAI 19:
Item 4 on page 26 describes the athermal fission gas release model. Item 5 on page 27 describes the thermal fission gas release model. The fission product gas release (FGR) model consists of an athermal and a thermal release component.

The athermal FGR model accounts for [[

.]]^{a,c}

The thermal FGR model is [[

.]]^{a,c}

NRC Round 3 RAI 20:
Page 27 item #6. Please provide a sample list of input parameters from STAV7.2 and explain any differences between the input of STAV7.2 and STAV6.2. If they are just inputs, other than outputs from STAV7.2, do they make a difference?

Westinghouse Response to RAI 20:
The list of eleven input parameters from STAV7.2 is provided in the response to RAI #18. The same parameters were provided by STAV6.2. Since the two fuel performance codes will predict a different variation of these input parameters with burnup, the [[

.]]^{a,c} These changes will affect the predicted cladding temperature response.

<u>NRC Round 3 RAI 21:</u>
Page 27 item #7. Please briefly summarize the revised BWR crud build-up model in STAV7.2 and explain its impact on LOCA. Please provide more details about how CHACHA-3D defines the thermal resistance of the crud layer and the oxide layer. How is the metal water reaction modeled by CHACHA-3D code with the existence of crud?

<u>Westinghouse Response to RAI 21:</u>
Crud model - Corrosion products released from various plant surfaces can deposit on the cladding surface. This material is referred to as crud. The previous crud correlation in STAV6.2 described the deposition of crud on the cladding surface as a [[

.]][a,c]

Oxide model - The cladding oxidation model in STAV is made up of [[

.]][a,c]

Metal-water reaction model - Section 4.4 of RPB 90-93-P-A describes how the metal-water reaction is modeled. Since the Baker-Just model is used, the rate of oxidation decreases as the thickness of the oxide increases. [[

.]][a,c]

<u>NRC Round 3 RAI 22:</u>
Page 27 item #8, does gap heat transfer coefficient used by CHACHA-3D subject to change during LOCA? What is the impact to PCT and other three LOCA criteria?

<u>Westinghouse Response to RAI 22:</u>
The information from STAV shown in the response to RAI #18 is used in CHACHA-3D to establish an initial gap heat transfer coefficient. Since the cladding balloons during the transient,

small changes in the initial gap dimensions have a small impact on the overall thermal response of the cladding.

As described in Section 5.5 of CENPD-293-P-A, the gap heat transfer coefficient in CHACHA-3D is calculated dynamically during the LOCA event to account for the change in cladding dimensions during the transient. Except for the initial condition inputs from the fuel performance code, the CHACHA-3D model is unchanged. Since the revised initial dimensional information from STAV7.2 do not change significantly, they will have a very small effect on the predicted transient gap heat transfer coefficient. Therefore, Westinghouse expects that these changes will have a small impact on the predicted cladding responses (i.e., peak temperature, maximum local oxidation and core wide oxidation).

NRC Round 3 RAI 23:

Under the title of "UO2 and Gadolinia Fuel Pellet Thermal Conductivity", it is stated that "The thermal conductivity for UO2 and Gadolinia fuel pellets are now calculated in accordance with STAV 7.2 fuel performance code." Does "in accordance with" mean that identical models and data are used?

Westinghouse Response to RAI 23:

The thermal conductivity model for the UO_2 and Gadolinia fuel pellets in the version of CHACHA-3D used for licensing applications will be identical to the corresponding correlations in the approved fuel performance code.

Westinghouse expects that the approval of WCAP-16078 will be contingent upon using initial conditions and models for fuel pellet conductivity and power distribution from an approved fuel performance code. The installation of the approved thermal conductivity and pellet power distribution models in CHACHA-3D will follow the process described in the response to RAI #25 (below). Therefore, the initial conditions for CHACHA-3D will be obtained from an approved fuel performance code and the applicable correlations from an approved fuel performance code will be installed correctly in CHACHA-3D.

NRC Round 3 RAI 24:

Page 27. Does 62 MWd/kgU set the limit of this methodology for exposure? For thermal conductivity only?

Westinghouse Response to RAI 24:

The STAV7.2 code, as described in WCAP-15836, is currently under review by the Staff as part of the Westinghouse program to obtain NRC acceptance of Westinghouse fuel assembly mechanical design methods used for BWR licensing analysis to a rod-average burnup of 62 MWd/kgU. The Westinghouse request for approval to 62 MWd/kgU is based on:

1. The understanding that the NRC is entertaining requests currently only to this burnup until additional high burnup data and support for higher burnup operation are available.
2. The Westinghouse fuel performance models, methods, and databases support fuel rod burnups in excess of 62 MWd/kgU rod-average.

The limit of 62 MWd/kgU on rod-average burnup is not based on limitations in the ECCS model. Acceptance of the fuel performance models (e.g., STAV) beyond the 62 MWd/kgU limit would be adequate justification for applying the ECCS model beyond 62 MWd/kgU.

NRC Round 3 RAI 25:

A total of eight new modeling features from STAV7.2 are implemented into CHACHA-3D code. Please provide evidence that the implemented models in CHACHA-3D can reproduce the same results as that of STAV7.2.

Westinghouse Response to RAI 25:

As indicated in Section 5.5.2.3 of WCAP-16078, only two of the new modeling features from STAV7.2 will be installed in the CHACHA-3D code. These features are the new models for [[.]]^{a,c}

Because of recent improvements to the STAV7.2 code, the [[ ]]^{a,c} have not been implemented into CHACHA-3D. However, the models that are implemented into CHACHA-3D, will be identical to the corresponding models in the approved fuel performance code. As part of the implementation process, sample calculations will be performed to verify consistency between these two codes after the final models are installed in CHACHA-3D. These calculations will be performed for a UO_2 fuel rod and a UO_2 + Gd_2O_3 as a function of nodal burnup. Similar to the validation presented in Section 7.3.2 of CENPD-293-P-A, these calculations will compare the predictions from the approved fuel performance code to the predictions by CHACHA-3D. The following quantities will be compared to ensure that the models are installed correctly:

- fuel centerline temperature,
- fuel average temperature, and
- gap heat transfer coefficient.

NRC Round 3 RAI 26:

Section 6.1.1 discussed the applicability of the spray heat transfer model to SVEA-96 OPTIMA2 fuel. It is not stated in CENPD-283-P-A about how the coefficients are used. Therefore, please explain how this coefficient is being used inside the code for different rods and channel wall. For a mixed core, does this coefficient apply to the average channel? The corner rod is a 1/3 length rod. Is it necessary to even calculate the 1/3 length rod temperature profile? In addition, do the coefficients subject to change along the axial direction? Because of the use of part length rods, the radiation heat transfer view factors change along the axial direction. Does this variation affect the spray coefficients? Why?

Westinghouse Response to RAI 26:

Application of spray heat transfer coefficients - The application of the spray heat transfer coefficients in the CHACHA-3D heat-up code is described in Section 4.5.3 of RPB 90-93-P-A. These coefficients are consistent with the 10 CFR 50.46 Appendix K requirements and are applied only in the heat-up analysis. The GOBLIN system and hot channel analyses use a different heat transfer model, which is described in Section 3.5 of RPB 90-93-P-A.

The spray heat transfer coefficients are input to the CHACHA-3D code as a table. The convective heat transfer coefficients used in the CHACHA-3D code from the beginning of the transient until the time of uncovery are taken from the [[

]][a,c] are replaced by the spray heat transfer coefficients required by Appendix K. After two-phase recovery is predicted and until the end of the transient, the heat transfer coefficients predicted by the hot assembly analysis are replaced by the 'reflood' heat transfer coefficient (25 Btu/hr-ft^2-°F) required by Appendix K.

As indicated above, the spray heat transfer coefficients are applied as a table of values. The figure below is a typical example.

a, c

Application to average channel of a mixed core - The treatment of mixed cores is described in the response to RAI #14. The spray cooling heat transfer coefficients that are required by Appendix K are applied only in the rod heat-up calculation (CHACHA-3D). The average core system response is determined using GOBLIN, which uses the heat transfer package described in Section 3.5 of RPB 90-93-P-A.

Application to the 1/3-length rods - The spray cooling heat transfer coefficients are applied at whatever axial plane is being analyzed. If the lattice being analyzed were from the lower third of the core, the 1/3-length rods would be analyzed using a spray heat transfer coefficient that is applicable to "corner" rods, as that is the location of the 1/3-length rods. [[

.]]a,c

Axial variability of the spray heat transfer coefficients - Although a [[

.]]a,c

Effect of radiation view factors on spray heat transfer coefficients - The radiation view factors are applied based on the actual cross-section being evaluated. The spray heat transfer coefficients are based on Appendix K requirements and are independent from the radiation view factors. As discussed above, a single set of spray heat transfer coefficients is used.

<u>NRC Round 3 RAI 27:</u>

Page 33 mentioned the extrapolation process to define the SVEA-96 Optima 2 spray coefficient. Please explain how the extrapolation was done. What is the independent variable to extrapolate? Diameter? Or rod layout?

<u>Westinghouse Response to RAI 27:</u>

The extrapolation process is based on [[

:]]a,c

a, c

[[:]]a,c

a, c

[[

]]a,c

[[

:]]a,c

a, c

[[

.]]a,c

a, c

[[

.]]a,c

a, c

[[

.]]a,c

The same scaling procedure is used to derive heat transfer coefficients for the different SVEA designs. For the SVEA-96 Optima2 design (midplane), the comparable scaling factor is derived as follows:

a, c

As indicated in the WCAP-16078, it is proposed that [[

.]]a,c

NRC Round 3 RAI 28:
Section 6.2 discussed the application of the radiation heat transfer model to SVEA-96 OPTIMA2 fuel. It is stated that the smallest pitch is used to perform the radiation heat transfer calculation. Please explain how are the different rod diameter and part length rods considered in the radiation heat transfer calculation.

Westinghouse Response to RAI 28:
As described in Section 4.2 of the WCAP-16078, the fuel rods in the SVEA-96 Optima2 fuel design have a single rod diameter (9.84 mm). Radiation heat transfer is modeled in the system analysis, the hot channel analysis and in the hot rod heat-up analysis.

The radiation heat transfer model for the GOBLIN system analysis and hot assembly analysis, which is described in Section 3.5 of RPB 90-93-P-A, uses [[ ]]a,c

( )a, c

is used to calculate the radiative heat transfer between components at each axial node within the fuel channel. The SVEA-96 Optima2 fuel design has three axial zones (i.e., there are 24 rods in the lower zone, 23 rods in the middle zone and 21 rods in the upper zone of each sub-assembly). Each zone is surrounded on two sides by the water-cross and on the other two sides by the fuel channel. [[.]]a,c

The radiation heat transfer model in CHACHA-3D, which is described in Section 4.5 of RPB 90-93-P-A and Section 5.4 of CENPD-293-P-A, is similar to the model in GOBLIN except that the [[.]]a,c