October 15, 2004

Mr. James A. Gresham, Manager
Regulatory and Licensing Engineering
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT WCAP-16078-P, "WESTINGHOUSE BWR ECCS EVALUATION MODEL: SUPPLEMENT 3 TO CODE DESCRIPTION, QUALIFICATION AND APPLICATION TO SVEA-96 OPTIMA2 FUEL" (TAC NO. MB8908)

Dear Mr. Gresham:

On April 30, 2003, Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel," to the staff for review. On September 13, 2004, an NRC draft safety evaluation (SE) regarding our approval of the TR was provided for your review and comments. By letter dated September 23, 2004, Westinghouse commented on the draft SE. The staff's disposition of Westinghouse's comments on the draft SE are discussed in the attachment to the final SE enclosed with this letter. The proprietary information contained in the proprietary SE is indicated in bold type.

The staff has found that WCAP-16078-P is acceptable for referencing in licensing applications for boiling water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed SE between the title page and the abstract. They must be well indexed such that information is readily located. Also, they must contain historical review information, such as questions and accepted responses, draft SE comments, and original TR pages that were replaced. The accepted versions shall include a "-A" (designating accepted) following the TR identification symbol.

Enclosure 1 transmitted herewith contains sensitive unclassified information. When separated from Enclosure 1, this document is decontrolled.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, Westinghouse and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

/RA/
Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 700

Enclosures: 1. Proprietary Safety Evaluation
2. Non-proprietary Safety Evaluation

cc w/encl 2:
Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16078-P, "WESTINGHOUSE BWR ECCS EVALUATION

MODEL: SUPPLEMENT 3 TO CODE DESCRIPTION, QUALIFICATION AND

APPLICATION TO SVEA-96 OPTIMA2 FUEL"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated April 30, 2003 (Reference 1), Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 To Code Description, Qualification and Application to SVEA-96 OPTIMA2 Fuel," to the staff for review. By letters dated June 30 (Reference 2) and December 12, 2003 (Reference 3), April 22 (Reference 4), May 28 (Reference 5), June 23 (Reference 6), and August 28, 2004 (Reference 7), Westinghouse responded to the staff's requests for additional information (RAIs). The objective of this TR is to introduce the modified counter-current flow limit correlation, a fuel rod plenum model that is applicable to part-length fuel rods, the applicable features of the improved STAV7.2 fuel performance model and the basis of applying this version of the model to the SVEA-96 Optima2 fuel design.

WCAP-16078-P describes changes to the Westinghouse emergency core cooling system (ECCS) evaluation model (EM) for boiling water reactors (BWRs). This version of the EM is identified as USA5. The differences between the USA5 and the previously approved USA4 version are:

- A change to the counter-current flow limit (CCFL) correlation to apply a conservative bias such that it bounds all the scatter in the correlation database,
- Addition of a fuel rod plenum model applicable to part-length fuel rods,
- Incorporation of the applicable features of the improved STAV7.2 fuel performance model, and
- Provides the analytical basis for applying USA5 to the SVEA-96 Optima2 fuel design.

The original Westinghouse ECCS EM (Reference 8) and version USA4 (Reference 9) were previously submitted, reviewed, and approved by the staff. This safety evaluation documents the staff's review of the modifications to the GOBLIN/CHACHA-3D series of codes supplementing the approved methods described and qualified in Reference 8. In addition, the staff reviewed the application of this methodology to the mixed core reload analysis. The staff's evaluation of these changes and the mixed core application methodology is discussed below.

2.0 REGULATORY EVALUATION

10 CFR 50.46

A loss-of-coolant accident (LOCA), as defined in Title 10 of the *Code of Federal Regulations,* Section 50.46 (10 CFR 50.46), "Acceptance criteria for emergency core cooling systems for light-water nuclear reactors," is a postulated accident to determine the design acceptance criteria for a plant's ECCS. There are five specific design acceptance criteria for the plant defined in 10 CFR 50.46:

- Peak Cladding Temperature - "The calculated maximum fuel element cladding temperature shall not exceed 2200°F."
- Maximum Cladding Oxidation - "The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation."
- Maximum Hydrogen Generation - "The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react."
- Coolable Geometry - "Calculated changes in core geometry shall be such that the core remains amenable to cooling."
- Long-term Cooling - "After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core."

10 CFR Part 50, Appendix K

Section A.1 of 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," notes:

> *1. The Initial Stored Energy in the Fuel:*
>
> The steady-state temperature distribution and stored energy in the fuel before the hypothetical accident shall be calculated for the burn-up that yields the highest calculated cladding temperature (or, optionally, the highest calculated stored energy.)

Section D.6 and D.7 of 10 CFR 50, Appendix K, notes:

> *D.6 Convective Heat Transfer Coefficients for Boiling Water Reactor Fuel Rods Under Spray Cooling*
>
> Following the blowdown period, convective heat transfer shall be calculated using coefficients based on appropriate experimental data.
>
> *D.7 The Boiling Water Reactor Channel Box Under Spray Cooling*
>
> Following the blowdown period, heat transfer from, and wetting of, the channel box shall be based on appropriate experimental data.

3.0 TECHNICAL EVALUATION

3.1 General LOCA ECCS Model Features

ECCS Model Framework

The Westinghouse BWR ECCS LOCA method consists of two computer codes, GOBLIN/DRAGON and CHACHA-3D. The GOBLIN and DRAGON computer codes are essentially the same code. The GOBLIN code is used to analyze the response of the reactor system to a LOCA. It models the break flow, and the actuation of automatic features such as main steam isolation valve (MSIV) closure, reactor scram, and the ECCS. GOBLIN would also determine the boundary conditions that are applied to the hot channel analysis. Based on the GOBLIN analysis results (i.e., the plenum to plenum flow boundary conditions), the GOBLIN code is used to analyze the response of hot channel/assembly in a mode referred to as DRAGON. The hot channel analysis determines the response of the hot channel to the LOCA event (e.g., boiling transition, dryout, and refill). These results and the calculated thermal hydraulic conditions in the hot assembly are used to establish the heat transfer coefficients and boundary conditions that are applied to the limiting hot bundle cross section. The response of the limiting cross section of the hot assembly is then calculated using the CHACHA-3D computer code. CHACHA-3D determines the detailed temperature distribution for all components at the limiting cross section. It includes the effects of cladding oxidation and fuel rod swell and rupture.

When applying this methodology to a new fuel bundle design, new CPR models are needed for the GOBLIN/DRAGON code. The nodalization needs to capture the geometrical characteristics of the fuel design that are important to the key phenomena of a LOCA event. The critical power ratio (CPR) correlation for the new fuel bundle design needs to be developed and approved by the NRC. Both the CCFL correlation and the ECCS spray cooling heat transfer coefficient need to demonstrate that the new bundle expected responses are conservatively bounded. Otherwise, new correlations are needed.

The framework of this method and the generic application procedures remain the same as version USA4 and previous versions approved by the NRC. The staff found that the new changes implemented into the code package do not have an impact on the general framework and the application procedures; therefore, the overall methodology structure is acceptable. The evaluation of detailed physics model changes and their applications to SVEA-96 Optima2 fuel are provided below.

CPR Correlation And General Implementation Procedures

Following the same approach as USA4, the USA5 version uses a CPR correlation to conservatively predict boiling transition in the hot assembly. Specifically, the CPR correlation is used to determine the initial power of the hot assembly and verify whether the core is operating at or outside the boundary for acceptable operating conditions. For a LOCA analysis, it determines the time to switch to boiling transition during the blowdown phase of the LOCA. Several CPR correlations have been implemented into the GOBLIN code. The user has the option to choose the NRC-approved CPR correlations applicable to either SVEA-96 or SVEA-96+.

A new fuel design normally requires a specific CPR correlation approved by the NRC. The implementation of a new CPR correlation into GOBLIN has become a routine code update process, which includes the source code development, new CPR correlation validation and non-Westinghouse fuel justifications. Westinghouse requested that this process be evaluated through the 10 CFR 50.46 annual report process. Therefore, the staff does not necessarily review the details of the implementation process. The staff has previously reviewed the proposed process from Reference 8 and determined that the requested process is acceptable as long as the new CPR correlation has been approved by the NRC and the change to the LOCA method is reported to the NRC through the 10 CFR 50.46 reporting process. For version USA5, the currently approved CPR correlations (i.e., XL-S96, ABBD1.0 and ABBD2.0) can still be used within the approved ranges of applicability. However, the new CPR correlation for SVEA-96 Optima2 fuel has not yet been approved by the NRC. Therefore, the current version of the SVEA-96 Optima2 fuel CPR correlation in USA5 cannot be used until it has received the approval of the staff.

Level Tracking Model

[

] The level tracking model was part of the physics model package of USA4 which was approved by the staff. Extending the USA4 version, Westinghouse performed the sensitivity studies in this TR to explore the application of the level tracking model **[**

] Therefore, the use of the model **[** **]** does not alter the analysis results or the conclusions.

The staff reviewed the results of the sensitivity cases listed in Table 5-1 of Reference 1 and found that both the use or non-use of level tracking **[ ]** are acceptable.

3.2 SVEA96 Optima 2 Fuel Design and Modeling Features

3.2.1 General Design Features

The introduction of the Optima2 fuel design in the SVEA-96 fuel family was driven by the need for improved nuclear performance, particularly in the shutdown margin. This resulted in the use of part-length rods. In addition, the new fuel design has improved the CPR performance, stability performance, and reduced two-phase pressure drop. Evolving from the SVEA-96+ fuel design, the Optima2 design employs two 2/3-length part-length rods and one 1/3-length rod for each of the four sub-assemblies. The two 2/3-length part-length rods are placed adjacent to the central channel, while the one 1/3-length rod is placed in the outer corner of the sub-assembly.

The Optima2 and SVEA-96+ fuel assembly designs use the same handle with spring and transition piece. The fuel channels have the same outer dimensions. All four sub-assemblies have the same general structural design. Each sub-bundle of the Optima2 fuel is constructed as a separate unit with its own bottom tie plate and is equipped with two tie rods. Spacers are used to hold the rods in the radial positions. **[ ]** The Zircaloy channel consists of an outer channel with a square cross-section and an internal double-walled, cruciform structure (water-cross) that forms gaps containing non-boiling water. The water-cross has a square central water channel and smaller water channels in each of the four wings.

Table 4-1 of Reference 1 compares various parameters for the 10x10 SVEA fuel designs and shows that the fuel rod outer diameter is **[ ]**, while the pellet diameter is **[ ]**. Instead of using a uniform pitch, the Optima2 design employs **[ ]**. The hydraulic diameter varies **[ ]**. Overall, the Optima2 design evolves from the SVEA-96+ design with the use of part-length rods, small fuel rod dimension changes and radial layout changes.

The new features of the Optima2 fuel design requires updating the ECCS LOCA methodology. Westinghouse applied the qualification process for new fuel designs as described in RPB 90-94-P-A and CENPD-283-P-A (References 10 and 11) which were approved by the NRC and identified the following necessary modifications:

- Plenum model for part-length rod
- New GOBLIN and DRAGON input models
- New CPR correlation

In addition, Westinghouse reviewed the applicability of their existing codes.

The staff reviewed the qualification process and found the new model updates identified by Westinghouse to be acceptable.

3.2.2 CCFL Correlation Change

One of the essential aspects of the Westinghouse BWR ECCS EM is the modeling of the performance of the core spray system. Following a LOCA, cooling water is injected into the upper plenum of a BWR via the core spray header above the core. The path that this cooling water takes is affected by the CCFL, which represents the maximum rate at which water can flow downward for a given upward steam flow. The CCFL correlation, therefore, is a limiting curve defining the operating region where a counter-current flow can exist. As such, the axial transport of energy along the fuel bundle and the occurrences of key LOCA events, such as fuel bundle midplane dryout and midplane reflood, can be accurately predicted.

The CCFL correlation presently used by Westinghouse in its approved EM has a restriction. In the qualification of the CCFL correlation (Reference 12) for use in EM version USA2, it was predicted that plant system responses were shown to be insensitive to the CCFL in analyses with resulting peak cladding temperatures (PCTs) in the 1500–1600°F temperature range. However, in demonstrating the acceptability of the CCFL for instances when the PCT approached the 10 CFR 50.46 limit (2200°F), Westinghouse submitted data showing that as the peak linear heat generation rate approached 36 KW/m, there existed a 100°F temperature difference between the plant-specific sensitivity case and the base case. Therefore, in the SE relating to CENPD-283-P-A (Reference 11), Westinghouse is required to include a conservative bias in the CCFL correlation when the calculated PCT is close to the 10 CFR 50.46 limit. This bias was to conservatively bound the database predictions of all fuel assembly components that were used to derive the basic CCFL correlation, thereby diminishing the probability of non-conservative predictions due to plant-specific influences.

The present CCFL correlation contains **[**

] The more restrictive effective diameter relation would better represent the observed data and would eliminate the restriction placed on earlier versions of the EM.

To qualify the validity of the CCFL correlation change, Westinghouse presented a comparison between the CCFL correlation prediction and the experimental data. **[**

] The curve generated by Westinghouse using the modified CCFL correlation for the SVEA-64 fuel design bounds all of the relevant experimental data points, and therefore, performs in the same manner as the imposed restriction. To confirm this assertion, the staff duplicated the curve and found that the effective diameter modification to the [ ] regime is acceptable. The staff also found, given that the modified CCFL correlation acts in the same manner as the imposed restriction, that there is no justification for the continued use of a separate conservative bias when the calculated PCT approaches the 10 CFR 50.46 limit.

To qualify the applicability of the modified CCFL model to SVEA-96 Optima2 fuel, Westinghouse performed a sensitivity study demonstrating the effect of the new fuel design and the modified CCFL correlation on the overall LOCA response. In the study, LOCA analyses were conducted using a base case, where the modified correlation and SVEA-96 Optima2 fuel were incorporated, and a sensitivity case, where the effective diameter of the fuel's upper tie plate was reduced by over 10 percent. The occurrences of key events following the LOCA were compared. The results showed negligible changes in the limiting occurrence of midplane boiling transition, midplane dryout, lower plenum refill, and midplane reflood. The staff reviewed the results of this sensitivity study, the sensitivity study conducted in CENPD-283-P-A, and the thermal hydraulic parameter differences between SVEA-64, SVEA-96, and SVEA-96 Optima2 fuel assembly design parameters. The staff found that the CCFL model with appropriate geometric parameters is acceptable for applications involving SVEA-96, SVEA-96+, and SVEA-96 Optima2 fuel.

3.2.3 <u>Gas Plenum Model for Part-length Fuel Rods</u>

The use of the part-length rods in the SVEA-96 Optima2 design results in the part-length rod gas plenum being located inside the reactor core. Unlike the gas plenum of a full length fuel rod, the part-length rod gas plenum will receive radiation heat transfer from adjacent fuel rods during the heat-up process. Therefore, the previous version of the CHACHA-3D code cannot be directly applied to Optima2 fuel.

Westinghouse applied a simple two step conservative approach to calculate the part-length rod gas plenum temperature. [

] In this way, the development of a sophisticated part-length rod plenum model was not necessary. In order to demonstrate that the acceptability of the two-step approach, Westinghouse applied the approach to the Optima2 fuel and found that the part-length rod plenum pressure and temperature were higher than that of the hot rod. This approach is judged to be conservative.

The staff reviewed the simplified conservative approach and found that the part-length rod plenum model is acceptable.

3.2.4 Application to SVEA-96 Optima2 Fuel

Nodalization

Applying the USA5 version EM to the SVEA-96 Optima2 fuel design requires input model changes for both the GOBLIN and DRAGON codes. Westinghouse also developed specific input models for the SVEA-96 Optima2 fuel. The previous SVEA-96 GOBLIN system input model was used to model the Optima2 fuel with changes in the core region. The core model of SVEA-96 Optima2 fuel has very similar nodalization to the SVEA-96+ fuel, which was reviewed previously by the staff. **[**

]

[

] A minor nodalization change was made by Westinghouse for modeling the Optima2 fuel design due to the existence of part-length rod gas plenum.

The CHACHA-3D code is used to perform a detailed fuel rod mechanical and thermal response calculation at a specified axial level of the hot assembly or sub-assembly. Because of the similarity between the SVEA-96/96+ design and the SVEA-96 Optima2 design, Westinghouse did not change the nodalization to model the Optima2 fuel design.

The staff reviewed the nodalization changes of the SVEA-96/96+ input models for the GOBLIN and DRAGON codes and found that the changes are acceptable to model the Optima2 fuel.

Applicability of Core Spray Cooling Convective Heat Transfer Coefficient

Core spray cooling convective heat transfer coefficients are used by the CHACHA-3D code to calculate the fuel rod heat-up at the limiting plane starting from the time the spray pump reaches the rated flow to the time of two-phase recovery in the core. **[**

] The staff questioned the validity of these spray coefficients for the Optima2 fuel part-length rods. In response (Reference 5), Westinghouse indicated that the spray cooling heat transfer coefficients required by 10 CFR Part 50, Appendix K, are applied only in the rod heat-up calculation. The same set of spray cooling heat transfer coefficients are applied to the axial plane being analyzed. If the lattice being analyzed was in the lower third of the core, the 1/3-length rods would be analyzed using the spray heat transfer coefficient for the corner rods.

Comparing the hydraulic diameters of three zones of Optima2 fuel, Westinghouse found that the Optima2 fuel hydraulic diameters for Zone 2 and 3 are greater than the hydraulic diameter of the SVEA-96/96+ fuel but less than that of the SVEA-64 fuel type. Therefore, the spray cooling coefficients should be between the coefficients of these two fuel types. Conservatively, Westinghouse decided to use the coefficients of the SVEA-64 fuel design. Although the Zone 1 hydraulic diameter is slightly less than that of SVEA-96/96+ by about 1.3 percent, it is considered reasonable to apply the coefficients for the SVEA-64 fuel design.

Because of the similarity of the lattice layout to the SVEA-96/96+ fuel design, the staff finds applying SVEA-64 spray coefficients to the Optima2 fuel to be conservative and acceptable.

Radiation Heat Transfer Model

Correctly modeling the radiation heat transfer phenomenon is essential for a LOCA ECCS evaluation model. The phenomenon is analyzed by both codes, GOBLIN/DRAGON and CHACHA-3D. The impact of radiation heat transfer on the system response, hot channel analysis and hot plane was evaluated. Westinghouse applied the same methodology to the SVEA-96 Optima2 fuel without modifications. The SVEA-96 Optima2 fuel design has three axial zones, 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. Applying the radiation model to Optima2 fuel, Westinghouse calculated the radiation heat transfer between each rod and its surrounding components. In order to be conservative, the smallest pitch of three radial zones is used to calculate the view factors.

The staff reviewed the application of the radiation model to the Optima2 fuel and found the approach to be conservative and acceptable.

3.3 Transition Core Application

When a utility changes fuel vendors, the reactor core can be loaded with different types of fuel bundles. These reload cycles are referred to as mixed, or transition cores. The presence of non-Westinghouse fuel invalidates the approach proposed by version USA5, which assumes the entire core is loaded with the same type of Westinghouse fuel; e.g., SVEA-96 Optima2 fuel, no matter what the legacy fuels are. The staff questioned the applicability of version USA5 in the following two aspects:

- Different fuel designs can have different mass and thermal hydraulic characteristics. These differences, coupled with different initial power distribution profiles, can cause different initial stored energy and LOCA event timing. If the dryout or the reflood occur at different times due to these differences, the uniform fuel loading approach may not be bounding or conservative.

- One of the major trends of the latest fuel designs from different fuel vendors is the use of burnable poisons. Depending on the burnable poison concentrations, some of the fuel/core design may result in hot assemblies that are twice-burned. Therefore, a non-Westinghouse fuel bundle may become the limiting bundle for a transition core. This may require other vendors to recalculate the maximum average planar linear heat generation rate (MAPLHGR) limit based on the new core design configuration.

In response to these two issues (References 5, 6, and 7), Westinghouse indicated that comparisons were made between a full core of GE 8x8 fuel, a full core of QUAD+, and a mixed core comprised of QUAD+ and GE 8x8 fuel for the limiting break using the GOBLIN code (Section 9 of RPB 90-94-P-A). The key phenomenon examined were the core inlet flow rate during blowdown, the vessel depressurization rate, and the time of core reflood. **[**

] Westinghouse also cited the experimental results of Dix (Reference 12) which showed that water pooling exists above the core for all BWR designs. This ensures an even distribution of ECCS spray water between all fuel assemblies because the QUAD+ fuel was designed to have similar upper assembly and bail handle to that of GE 8x8 fuel.

Based on the analyses performed for QUAD+ and GE 8x8 fuel during the limiting LOCA, Westinghouse concluded that the introduction of QUAD+ fuel in a transition core with GE 8x8 fuel would not adversely impact the specific fuel type LOCA MAPLHGR limits based on a full core of the respective fuel type. Extrapolating from this conclusion, Westinghouse has been assuming that all other Westinghouse fuel designs would be similar to other vendor fuel designs so that a full core of a given Westinghouse fuel would bound a transition core.

The staff found this approach does not have a sufficient basis and considered it a deficiency of the methodology for two reasons. First, the fuel designs from different vendors have changed significantly from the time of the QUAD+ and GE 8x8 fuel design. The introduction of the water rods, the part-length fuel rods, and other improvements among fuel designs have altered the fuel thermal-hydraulic and neutronic characteristics. The justification of a full core QUAD+ as the bounding fuel loading is no longer valid without specific analysis for a transition core. Second, it is questionable to assume that the fuel type specific LOCA MAPLHGR cannot be adversely affected during the mixed core operation, because the MAPLHGR limits might be subject to change during the transition core operation and other vendors may need to determine cycle specific MAPLHGR for their fuel designs. In response to the staff's concerns, Westinghouse agrees that an evaluation will be performed to determine applicability of this approach. Specifically, Westinghouse will compare a system analysis of a core containing a full load of SVEA-96 Optima2 fuel to a mixed core containing approximately one-third SVEA-96 Optima2 fuel and two-thirds legacy fuel. If this simplification is not justified, the mixed core model will be used for the system response analysis to determine the MAPLHGR limits for the Westinghouse fuel. For another vendor's legacy fuel, Westinghouse will obtain the MAPLHGR limits from the other vendor regardless whether these limits are cycle dependent or not.

Considering that version USA5 can be applied to other previously approved Westinghouse fuel designs, the staff believes the following requirements need to be satisfied when the method is applied to a first transition cycle with the introduction of Westinghouse fuel:

- A multi-channel mixed core analysis is needed to determine the system response and examine the applicability of the full core Westinghouse fuel model. Proper nodalizations are needed for modeling the legacy fuel.

- The Westinghouse USA5 version cannot be used to determine MAPLHGR limits of other vendors' fuel, since these limits may be cycle-specific.

3.4 Fuel Performance Model Modification

As part of the version USA5 submittal, the heat-up computer code (CHACHA-3D) has been modified to use a consistent set of inputs and models from the STAV7.2 fuel performance code. The following is a brief list of these modeling features added to the code:

- The STAV7.2 pellet conductivity model, which considers the burn-up-induced degradation, has been implemented into the CHACHA-3D code to replace the STAV6.2 fuel pellet conductivity model.

- The pellet radial power distribution model has been modified to take into account power generation by plutonium isotopes and treat the pellet rim region.

- CHACHA-3D uses the oxidation and crud thickness from STAV7.2 as input to account for the thermal resistance of the crud layer and the oxide layer.

- CHACHA-3D is enabled to receive STAV7.2 gap size and gas composition information at the beginning of the transient to determine the gap heat transfer coefficient.

However, STAV7.2 is currently under review by the NRC and has not yet been approved. Prior to the approval of STAV7.2, the applicability of any modeling features implemented into the CHACHA-3D code from STAV7.2 cannot be determined. Therefore, USA5 can only be used with modeling features from the currently approved STAV6.2 while the staff completes its review of STAV7.2.

Although the CHACHA-3D code has the STAV6.2 type of models, which was approved as part of the USA4 version, the STAV6.2 code has not been demonstrated to be applicable to the SVEA-96 Optima2 fuel design as a stand-alone fuel performance code. Westinghouse evaluated the differences between the SVEA-96 and the Optima2 fuel design and concluded in Reference 7 that the CHACHA-3D code with the STAV6.2 type of models is applicable to Optima2 fuel. The only limitation identified is that the rod average burnup is less than 50 MWd/kgU. The staff reviewed the Westinghouse evaluation and concluded that it is acceptable to apply the CHACHA-3D code with STAV6.2 type of models to the Optima2 fuel LOCA analysis.

4.0 CONDITIONS AND LIMITATIONS

The staff finds that Westinghouse has adequately demonstrated the reasonably conservative nature of its modified ECCS methodology except for the implementation of STAV 7.2 modeling features which are currently under review by the staff. Therefore, the approval of the entire USA5 package and the use of it are subject to the following limitations:

1. All of the STAV7.2 features cannot be used pending completion of the staff review and approval of the STAV7.2 code. The previously approved STAV 6.2 model in the CHACHA-3D code can continue to be used for LOCA analysis. Upon receipt of staff approval of STAV7.2, Westinghouse shall provide written notification that STAV7.2 models are now being used in their ECCS methods and shall submit a revision to WCAP-10678-P, if it is determined necessary by the NRC staff, to document any changes in the STAV7.2 models, methods, or implementation currently described in this TR.

2. A mixed core GOBLIN model shall be developed during the first reload analysis of a transition core to verify the validity of the full core Westinghouse fuel approach. If it is confirmed that the analysis with a full core of Westinghouse fuel is bounding, then the LOCA ECCS evaluation can be performed using the full core Westinghouse fuel approach. Otherwise, the mixed core model shall be used.

3. The USA5 EM cannot be used to calculate the MAPLHGR limits for non-Westinghouse fuel for a mixed core analysis. If the transition core analysis indicates that the system performance of the mixed core is more limiting than the full core analysis of legacy fuel, Westinghouse will request the utility to contact the legacy fuel vendor for an evaluation of the impact of the mixed core on the MAPLHGR limits for their fuel.

4. The methodology cannot be used until the SVEA-96 Optima 2 fuel CPR correlation is approved by NRC.

5. The overall acceptability of the Westinghouse BWR ECCS methodology remains subject to the restrictions and limitations of all other governing SEs of relevant computer codes, models, and fuel designs, as previously approved.

5.0 CONCLUSION

The staff reviewed the incremental changes from the previously approved USA4 version to USA5 and found that the differences between these two versions do not alter the major framework of the EM. The currently approved capability for analyzing BWR LOCA events in accordance with the requirements of 10 CFR 50.46 is improved by the proposed changes with respect to applying the EM to the SVEA-96 Optima2 fuel design, and the staff finds these changes are acceptable. The staff also reviewed the USA4 CCFL model change, the spray cooling model, and their applications to SVEA-96 Optima2 fuel according to the 10 CFR Part 50, Appendix K, requirements and finds these changes are acceptable. The staff finds that the overall conservatism and the framework of the original USA4 version are preserved through this set of proposed changes for USA5. The evaluation results for each of the specific model changes are summarized below:

1. The SVEA-96 Optima2 CPR correlation is currently being reviewed by the staff. After it is approved, Westinghouse may implement it into the USA5 EM model and report to the NRC through the 10 CFR 50.46 annual report process.

2. Use of the optional level tracking model **[ ]** of the GOBLIN vessel model is acceptable.

3. The CCFL correlation with appropriate geometric parameters is qualified for applications involving SVEA-96 Optima2 fuel.

4. The plenum model for part-length rods reflects the physical locations of the gas plenum and was found to be conservative and acceptable for calculating plenum gas temperature and pressure.

5. The SVEA-96 Optima2 GOBLIN/DRAGON/CHACHA-3D models have been evaluated. The models evolved from the SVEA-96+ model with specific changes for the Optima2 fuel. These model changes and the extension of the core spray cooling model and the radiation heat transfer model to Optima2 fuel are considered to be acceptable.

6.0 <u>REFERENCES</u>

1. Letter from H.A. Sepp (Westinghouse) to NRC, "Submittal of WCAP-16078-P, Revision 0 and WCAP-16078-NP, Revision 0, 'Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel' (Proprietary/Non-proprietary)," LTR-NRC-03-17, dated April 30, 2003. (Accession No. ML031220211)

2. Letter from H.A. Sepp (Westinghouse) to B.J. Benney (NRC), "Requested Information in Support of the NRC Review of WCAP-16078-P 'Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel' (Proprietary)," LTR-NRC-03-33, dated June 30, 2003.

3. Letter from B.F. Maurer (Westinghouse) to J.S. Wermiel (NRC), "Response to Round 1 Request for Additional Information Regarding WCAP-16078-P & -NP, 'Westinghouse BWR ECCS Evaluation Model: Supplement 3 to Code Description, Qualification and Application to SVEA-96 Optima2 Fuel' (Proprietary/Non-proprietary)," LTR-NRC-03-74, dated December 19, 2003. (Accession No. ML033600246)

4. Letter from J.A. Gresham (Westinghouse) to NRC, "Response to Round 2 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/Non-proprietary)," LTR-NRC-04-24, dated April 22, 2004. (Accession No. ML041170286)

5. Letter from J.A. Gresham (Westinghouse) to NRC, "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/Non-proprietary)," LTR-NRC-04-33, dated May 28, 2004. (Accession No. ML042510098)

6. Letter from J.A. Gresham (Westinghouse) to NRC, "Response to Round 4 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/Non-proprietary)," LTR-NRC-04-39, dated June 23, 2004. (Accession No. ML042510042)

7. Letter from J.A. Gresham (Westinghouse) to NRC, "Revision 1 to the Responses to Round 4 NRC 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/Non-proprietary)," LTR-NRC-04-51, dated August 24, 2004. (Accession No. ML042400336)

8. Westinghouse Report RPB-90-93-P-A (Proprietary) and RPB-90-91-NP-A (Nonproprietary), "Boiling Water Reactor Emergency Core Cooling System Evaluation Model: Code Description and Qualification," dated October 1991.

9. Letter from H.A. Sepp (Westinghouse) to NRC, "Submittal of WCAP-15682-P-A, Rev. 0 and WCAP-15682-NP-A, Rev. 0, 'Westinghouse BWR ECCS Evaluation Model: Supplement 2 to Code Description, Qualification and Application' (Proprietary/Non-proprietary)," dated May 30, 2003. (Accession No. ML031540688)

10. Westinghouse Report RPB 90-94-A, "Boiling Water Reactor Emergency Core Cooling System Evaluation Model: Code Sensitivity," dated October 1991.

11. Westinghouse Report CENPD-283-P-A, "Boiling Water Reactor Emergency Core Cooling System Evaluation Model: Code Sensitivity for SVEA-96 Fuel," dated July 1996.

12. G. Dix, "BWR Loss of Coolant Technology Review," International Topical Meeting on Nuclear Reactor Thermal-hydraulic (ANS), Santa Barbara, CA, USA, January 11, 1983.

Attachment: Resolution of Comments

Principal Contributor: S. Lu, NRR

Date: October 15, 2004

RESOLUTION OF COMMENTS

DRAFT SAFETY EVALUATION FOR TOPICAL REPORT WCAP-16078-P,

"WESTINGHOUSE BWR ECCS EVALUATION MODEL: SUPPLEMENT 3 TO CODE

DESCRIPTION, QUALIFICATION AND APPLICATION TO SVEA-96 OPTIMA2 FUEL"

By letter dated September 23, 2004, Westinghouse provided comments on the draft safety evaluation (SE) for WCAP-16078-P, "Westinghouse BWR ECCS Evaluation Model: Supplement 3 To Code Description, Qualification and Application to SVEA-96 OPTIMA2 Fuel." The following is the staff's resolution of those comments.

1. Westinghouse Comment: Section 1.0, "INTRODUCTION," indicates that the change to the counter-current flow correlation is to accommodate the implementation of SVEA-96 fuel.

   Westinghouse Proposed Resolution: "A change to the counter-current flow limit (CCFL) correlation to apply a conservative bias such that it bounds all the scatter in the correlation database."

   NRC Action: The comment was fully adopted into the final SE.

2. Westinghouse Comment: Item D.7 in Section 2.0 should be revised.

   Westinghouse Proposed Resolution: "D.7 The Boiling Water Reactor Channel Box Under Spray Cooling."

   NRC Action: The comment was fully adopted into the final SE.

3. Westinghouse Comment: The first sentence of the second paragraph of Section 3.1, "General LOCA ECCS Model Features," should be revised.

   Westinghouse Proposed Resolution: "When applying this methodology to a new fuel bundle design, new CPR models are needed for the GOBLIN/DRAGON code."

   NRC Action: The comment was fully adopted into the final SE.

4. Westinghouse Comment: The next to last sentence in the last paragraph of Section 3.1, "General LOCA ECCS Model Features," should be revised.

   Westinghouse Proposed Resolution: "The staff reviewed the results of the sensitivity cases listed in Table 5-1 of Reference 1 and found that both the use or non-use of level tracking in **[ ]** are acceptable."

   NRC Action: The comment was fully adopted into the final SE.

5. Westinghouse Comment: The word "assembly" in the third sentence of the second paragraph of Section 3.2.1, "General Design Features," be replaced.

   Westinghouse Proposed Resolution: Replace "assembly" with "sub-bundle."

   NRC Action: The comment was adopted into the final SE.

6. Westinghouse Comment: The fifth sentence of the second paragraph of Section 3.2.1, "General Design Features," be replaced.

   Westinghouse Proposed Resolution: **[**

   ]

   NRC Action: The comment was fully adopted into the final SE.

7. Westinghouse Comment: The last sentence in the third paragraph of Section 3.2.1, "General Design Features," should be revised.

   Westinghouse Proposed Resolution: Delete the word "Thus."

   NRC Action: The comment was fully adopted into the final SE.

8. Westinghouse Comment: Section 3.2.1, "General Design Features," regarding the CCFL correlation changes should be revised.

   Westinghouse Proposed Resolution: Delete the first bullet item.

   NRC Action: The comment was fully adopted into the final SE.

9. Westinghouse Comment: The word "to" should be replaced with the word "for" in the third sentence of the first paragraph of Section 3.2.2, "CCFL Correlation Change".

   Westinghouse Proposed Resolution: "... flow downward for a given upward stream flow."

   NRC Action: The comment was fully adopted into the final SE.

10. Westinghouse Comment: The last sentence of the last paragraph of Section 3.2.2, "CCFL Correlation Change," should be modified.

    Westinghouse Proposed Resolution: "The staff found that the CCFL model with appropriate geometric parameters is acceptable for applications involving SVEA-96, SVEA-96+ and SVEA-96 Optima2 fuel."

    NRC Action: The comment was fully adopted into the final SE.

11. Westinghouse Comment: The next to last sentence in the first paragraph of Section 3.2.4, "Application to SVEA-96 Optima2 Fuel," should be revised.

    Westinghouse Proposed Resolution: **[**

    ]

    NRC Action: The comment was fully adopted into the final SE.

12. Westinghouse Comment: The first sentence of the third paragraph in Section 3.2.4, "Application to SVEA-96 Optima2 Fuel," should be revised.

    Westinghouse Proposed Resolution: "The CHACHA-3D code is used to perform a detailed fuel rod mechanical and thermal response calculation at a specified axial level of the hot assembly or sub-assembly."

    NRC Action: The comment was fully adopted into the final SE.

13. Westinghouse Comment: The last sentence of the next to last paragraph in Section 3.2.4, "Application to SVEA-96 Optima2 Fuel," should be revised.

    Westinghouse Proposed Resolution: Delete the word "ratio."

    NRC Action: The comment was fully adopted into the final SE.

14. Westinghouse Comment: The second sentence of the third item in the number list of Section 4.0, "CONDITIONS AND LIMITATIONS," should be revised.

    Westinghouse Proposed Resolution: "If the transition core analysis indicates that the system performance of the mixed-core is more limiting than the full-core analysis of legacy fuel, Westinghouse will request the utility to contact the legacy fuel vendor for an evaluation of the impact of the mixed core on the MAPLHGR limits for their fuel.

    NRC Action: The comment was fully adopted into the final SE.

15. Westinghouse Comment: The name of the fuel design indicated in the first item in the number list of Section 5.0, "CONCLUSION," should be corrected.

    Westinghouse Proposed Resolution: Replace "SVEA-96+" with "SVEA-96 Optima2."

    NRC Action: The comment was fully adopted into the final SE.

16. Westinghouse Comment: The second item in the number list of Section 5.0, "CONCLUSION," should be modified.

    Westinghouse Proposed Resolution: "Use of the level-tracking model **[** **]** of the GOBLIN vessel model is optional."

NRC Action: The comment was adopted into the final SE with minor wording change. Proprietary information was marked consistent with comment 4 above.

17. Westinghouse Comment: The description of the CCFL correlation in paragraph 3 of Section 3.2.2, "CCFL Correlation Change," should be marked proprietary.

    Westinghouse Proposed Resolution: Westinghouse provided a markup.

    NRC Action: The comment was fully adopted into the final SE.

18. Westinghouse Comment: The description of the CCFL correlation in paragraph 4 of Section 3.2.2, "CCFL Correlation Change," should be marked proprietary.

    Westinghouse Proposed Resolution: Westinghouse provided a markup.

    NRC Action: The comment was fully adopted into the final SE.