December 28, 2009

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

SUBJECT: FINAL SAFETY EVALUATION FOR WESTINGHOUSE ELECTRIC COMPANY TOPICAL REPORT WCAP-16500-P, SUPPLEMENT 1, REVISION 1, "APPLICATION OF CE SETPOINT METHODOLOGY FOR CE 16x16 NEXT GENERATION FUEL (NGF)" (TAC NO. ME0143)

Dear Mr. Gresham:

By letter dated October 24, 2008, Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-16500-P, Supplement 1, Revision 1, "Application of CE Setpoint Methodology for CE 16x16 Next Generation Fuel (NGF)", to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated October 26, 2009, an NRC draft safety evaluation (SE) regarding our approval of TR WCAP-16500-P, Supplement 1, Revision 1, was provided for your review and comments. By letter dated November 4, 2009, Westinghouse commented on the draft SE. The NRC 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 NRC staff has found that TR WCAP-16500-P, Supplement 1, Revision 1, is acceptable for referencing in licensing applications for pressurized water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for our 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 final SE after the title page. Also, they must contain historical review information, including NRC requests for additional information and your responses. The accepted versions shall include an "-A" (designating accepted) following the TR identification symbol.

NOTICE: Enclosure 2 transmitted herewith contains proprietary information. When separated form Enclosure 2, 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/ by TQuay for

Thomas B. Blount, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 700

Enclosures: 1. Final SE (non-proprietary version)
2. Final SE (proprietary version)

cc w/encl 1 only:

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J. Gresham

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DATE	11/27/09	12/14/09	12/1/09	9/30/09	12/22/09	12/28/09

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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16500-P, SUPPLEMENT 1, REVISION 1

"APPLICATION OF CE SETPOINT METHODOLOGY FOR CE 16x16

NEXT GENERATION FUEL (NGF)"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated October 24, 2008 (Reference 1), as supplemented by letter dated August 21, 2009 (Reference 2), Westinghouse Electric Company (Westinghouse) submitted for U.S. Nuclear Regulatory Commission (NRC) staff review Topical Report (TR) WCAP-16500-P, Supplement 1, Revision 1, "Application of CE [Combustion Engineering] Setpoint Methodology for CE 16x16 Next Generation Fuel (NGF)." This TR describes a revised analytical process for calculating COLSS and CPCS addressable constants and database constants for plant reloads with CE 16x16 NGF (CE16NGF) assemblies.

2.0 REGULATORY EVALUATION

Regulatory guidance for the review of fuel system designs and adherence to General Design Criteria (GDC) - 10, GDC-27, and GDC-35 is provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design" (Reference 3). In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

a. The fuel system is not damaged as a result of normal operation and anticipated operational occurrences,

b. Fuel system damage is never so severe as to prevent control rod insertion when it is required,

c. The number of fuel rod failures is not underestimated for postulated accidents, and coolability is always maintained.

In addition to licensed reload methodologies, an approved mechanical design methodology is utilized to demonstrate compliance to SRP 4.2 fuel design criteria. The NRC staff's prior review of WCAP-16500-P, Revision 0 (Reference 4), was to ensure that the approved reload and fuel mechanical design methodologies (1) remain applicable to the CE16NGF design and (2)

adequately addresses the applicable regulatory requirements identified in SRP 4.2. In addition, based upon Lead Test Assemblies, post-irradiation examinations, mechanical testing, past operating experience of similar designs and materials, and fuel performance model predictions, the NRC staff reviewed expected performance of the CE16NGF assembly to ensure it satisfied these requirements.

Supplement 1, Revision 1, addresses deficiencies in the CE digital setpoint methodology identified during review of WCAP-16500-P. Hence, the NRC staff's review builds on its prior review of the CE setpoint methodology described in WCAP-16500-P Supplement 1 as supplemented by request for additional information (RAI) responses (Reference 4).

3.0 TECHNICAL EVALUATION

During its review of WCAP-16500-P (Reference 4), the NRC staff identified potential problems with the application of the CE digital setpoints process, known as Modified Statistical Combination of Uncertainties (MSCU), to reload cores containing CE16NGF assemblies. Specifically, the application of MSCU methods to reloads where the critical heat flux (CHF) correlation within core operating limit supervisory system (COLSS) (i.e., plant monitoring system) and core protection calculator system (CPCS) (i.e., plant protection system) were inconsistent with the axial-dependent CHF correlations of the CE16NGF design. In this application, the two NGF CHF correlations each have the potential to introduce separate temperature-dependent, pressure-dependent, flow-dependent and axial shape index (ASI)-dependent biases.

In response to NRC staff concerns, Westinghouse submitted Supplement 1-P, which detailed the application of CE digital setpoint methodology for CE16NGF assemblies. Section 3.7 of the NRC staff's safety evaluation (Reference 4) documents the NRC staff's review of Supplement 1 along with several subsequent RAIs and an audit. In the end, the NRC staff was unable to reach a safety finding, concluding:

> Based upon these concerns, the NRC staff is unable to conclude that the proposed digital setpoints methodology is (1) consistent with the currently approved methods and (2) will preserve the required 95/95 protection level when applied to the NGF assemblies.

To support batch implementation of CE16NGF assemblies (which offer many advanced features designed to benefit fuel performance), the NRC staff developed an interim departure from nucleate boiling (DNB) margin penalty which was included as a condition on the staff's approval of WCAP-16500-P.

> WCAP-16500-P-A Condition #5:
> To compensate for NRC staff concerns related to the digital setpoints process, an interim margin penalty of 6 percent must be applied to the final addressable constants (e.g., BERR1* 1.06, [(1+EPOL2)*1.06 - 1.0]) calculated following the 1/64 hypercube setpoints process (Response No. 6 of Reference 6). Removal of this interim margin penalty will be considered after the digital setpoints methods have

been formalized, documented (e.g., revision to TR WCAP-16500-P), and approved by the NRC (SE Section 3.7).

Revision 1 of WCAP-16500-P-A, Supplement 1 (Reference 1), documents a revised analytical procedure for performing the MSCU digital setpoint process which accounts for inconsistent CHF correlations in an attempt to remove the above interim DNB penalty. The proposed analytical procedure does not change the underlying MSCU methodology (depicted in Figure 1 of Reference 1) previously approved by the NRC.

In addition to reviewing the material presented in Supplement 1, Revision 1, and in response to RAIs, the NRC staff conducted an audit of the supporting Westinghouse engineering calculations on August 12, 2009, at the Westinghouse Rockville office.

3.1 Revised MSCU Setpoints Process

Section 2 of WCAP-16500-P, Supplement 1, Revision 1, describes the revised MSCU setpoints process for application to core reloads with a full core of CE16NGF. A detailed description of each analytical step is documented in Section 2.4 of WCAP-16500-P, Supplement 1, Revision 1. This revised analytical process is intended to address NRC staff concerns documented in Reference 4.

The two CE16NGF CHF correlations (i.e., above and below elevation of first mixing grid) each have the potential to introduce separate temperature-dependent, pressure-dependent, flow-dependent and ASI-dependent biases. Analytical steps #1 - #3 describe the process for separately evaluating these potential biases and defining the limiting operating space within the $1/64^{th}$ hypercube. In response to an RAI regarding the **[ ]** acceptance criterion on DNB power operating limit (POL) used to assess whether to perform the MSCU within a limited range of temperature, pressure, and mass flux (i.e., 1/64 hypercube) (RAI #2, Reference 2), Westinghouse stated that **[**

] The NRC staff finds this acceptance criterion acceptable.

Westinghouse states that the hypercube "divide operating space into sufficiently small regions such that any correlation in DNBR [departure from nucleate boiling ratio] uncertainty within the hypercube is insignificant" (Section 2.3 of WCAP-16500-P, Supplement 1, Revision 1). Based upon an evaluation of the sample **[ ]** reload analyses documented in Section 2.5 of WCAP-16500-P, Supplement 1, Revision 1, and the **[ ]** reload analyses reviewed during the NRC staff audit (Reference 5), the NRC staff finds the level of division in the $1/64^{th}$ hypercube methodology acceptable.

Analytical step #4 is used to investigate the axial power distribution (referred to as axial shape index (ASI)) dependence of the DNB POL error in both the COLSS range (narrow) and CPCS range (wide) of operating space. Examination of Figure 20 of WCAP-16500-P, Supplement 1, Revision 1, reveals this evaluation for the sample **[ ]** reload analysis and

illustrates two distinct, non-poolable data sets. These distinct regions result from the placement of mixing vanes in the top 2/3 of the CE16NGF assembly and differences between the WSSV-T and critical heat flux correlation for non-vaned fuel (ABB-NV) CHF correlations (relative to CE-1 CHF correlation). It is expected that these differences will always result in two distinct, non-poolable data sets. Nevertheless, the revised set point process includes a statistical test to assess poolability (see analytical step #6). The result of analytical step #4 is a set of ASI ranges defining the breakpoints and transition zone for these two regions.

Analytical step #5 runs the core protection calculators (CPC) MSCU using the limiting 1/64th hypercube of step #3 over the entire ASI range and **[**

] In analytical step #7, the three raw BERR1 values are used to calculate ASI-dependent COLSS and CPCS database constants which will act as heat flux penalties in the on-line DNBR calculations in the transition region and more positive ASI range (lower portion of the core below 1st mixing vane). Incorporating ASI-dependent database penalties allows the use of the more benign BERR1 values (and EPOL2 in COLSS) associated with the top portion of the core. This strategy promotes more DNB margin benefit since the BERR1/EPOL2 values associated with the WSSV-T CHF are employed during normal operating conditions.

Analytical step #8 performs the final COLSS and CPC MSCU analyses incorporating the limiting 1/64th hypercube of step #3 **[**

] defined in step #4 at each time in cycle applying the COLSS and CPC database ASI-dependent adjustment factors from step #7. **[**

]

In the proposed setpoint methodology, **[**

]
(RAI #1, Reference 2). These modified codes would subsequently be utilized to calculate new addressable constants and provide a thermal margin benchmark. In response to RAI #1, Westinghouse proposed an alternative approach which **[**

] Note that this approach is different from just replacing the CE-1 correlation with the NGF correlations in that it **[**

] Further, Westinghouse stated that this work scope would not be complete until March 2010. In the interim, the NRC staff recommends that a 3 percent margin penalty be applied to the final addressable constants (e.g., BERR1* 1.03, [(1+EPOL2)*1.03 - 1.0]) calculated in accordance with the revised analytical steps until such time as Westinghouse provides an acceptable written response to RAI #1. This 3 percent margin penalty supersedes

the previous 6 percent interim margin penalty (condition specified in Reference 4) and provides reasonable assurance that the COLSS and CPCS DNBR calculations remain conservative (given the revised analytical steps which address the NRC staff's earlier concerns).

In response to an RAI regarding treatment of CETOP-D/TORC correction factors within the revised setpoint process (RAI #3, Reference 2), Westinghouse stated that the **[**

] The NRC staff finds this approach acceptable.

In response to an RAI regarding the historical basis for the values of CPC constants E1 and E2 (RAI #4, Reference 2), Westinghouse described the use of these CPC constants in the new process as well as their historic values. While the values may be changing, the functional basis of E1 and E2 remain consistent with the approved methodology.

In response to an RAI regarding the DNB POL error in the ASI transition region (RAI #5, Reference 2), Westinghouse stated that the revised process will compensate for any points where the ASI dependent functions are non-conservative due to unexpected non-linearity. **[**

] This assures that the combination of the addressable values and ASI-dependent database adjustments yield conservative results over the entire ASI range.

In response to an RAI regarding a minimum number of MSCU cases to ensure a statistically significant population (RAI #6, Reference 2), Westinghouse described the different sets of cases used in COLSS analyses relative to CPC analyses as well as time in cycle specific case sets. This approach ensures a large number of cases in the statistical analyses. Westinghouse further stated that the process has the capability of detecting a significant misdistribution of cases versus ASI. This ensures that each respective case set evenly and thoroughly encompasses the allowable ASI range.

On August 12, 2009, the NRC staff conducted an audit of Westinghouse engineering calculations supporting the **[** **]** core reload. This reload is the first application of the revised analytical procedures described within WCAP-16500-P, Supplement 1, Revision 1. The audit report (Reference 5) captures the NRC staff's assessment of the modified MSCU process.

Based upon a review of the material presented in WCAP-16500-P, Supplement 1, Revision 1, and in response to RAIs, as well as the audit of **[** **]** core reload calculations, the NRC staff finds that the revised MSCU analytical process adequately addresses earlier concerns with the application of the CE MSCU set points methodology to reload cores containing CE16NGF assemblies. As such, the interim DNB margin penalty (6 percent) dictated via WCAP-16500-P, SE Condition #5 (Reference 4) is no longer required.

4.0 LIMITATIONS AND CONDITIONS

Licensees referencing WCAP-16500-P, Supplement 1, Revision 1, must ensure compliance with the following conditions and limitations:

> Until Westinghouse provides an acceptable written response to RAI #1, an interim margin penalty of 3.0 percent must be applied to the final addressable constants (e.g., BERR1* 1.03, [(1+EPOL2)*1.03 - 1.0]) calculated following the analytical steps defined in WCAP-16500-P, Supplement 1, Revision 1.

5.0 CONCLUSION

Based upon a review of the material presented in WCAP-16500-P, Supplement 1, Revision 1, and in response to RAIs, as well as the audit of **[ ]** core reload calculations, the NRC staff finds that the revised MSCU analytical process adequately addresses earlier concerns with the application of the CE MSCU set points methodology to reload cores containing CE16NGF assemblies. As such, the interim DNB margin penalty (6 percent) dictated via WCAP-16500-P, SE Condition #5 (Reference 4) is no longer required. Licensees referencing this TR will need to comply with the conditions listed in Section 4.0 of this SE.

6.0 REFERENCES

1. Letter from J. A. Gresham (W) to U.S. Nuclear Regulatory Commission, “Submittal of WCAP-16500-P Supplement 1 Revision 1 / WCAP-16500-NP, Supplement 1, Revision 1, "Application of CE Setpoint Methodology for CE 16x16 Next Generation Fuel (NGF)," LTR-NRC-08-52, October 24, 2008.
2. Letter from J. A. Gresham (W) to U.S. Nuclear Regulatory Commission, “Response to the NRC’s Request for Additional Information by the Office of Nuclear Reactor Regulation for Topical Report (TR) WCAP-16500-P, Supplement 1, Revision 1, ‘Application of CE Setpoint Methodology for CE 16x16 Next Generation Fuel (NGF)’," LTR-NRC-09-44, August 21, 2009.
3. NUREG-0800, Standard Review Plan, Section 4.2, “Fuel System Design,” Revision 3, March 2007.
4. Letter from U.S. Nuclear Regulatory Commission to J. A. Gresham (W), “Final Safety Evaluation for Westinghouse Electric Company (Westinghouse) Topical Report (TR) WCAP-16500-P, Revision 0, ‘CE [Combustion Engineering] 16X16 Next Generation Fuel [(NGF)] Core Reference Report’,” July 30, 2007.
5. NRC Memorandum, “Audit Report for WCAP-16500-P, Supplement 1, Revision 1, ‘Application of CE Setpoint Methodology for CE 16x16 Next Generation Fuel’,” August 24, 2009.

Attachment: Resolution of Comments

Principle Contributor: Paul Clifford (NRR/DSS)

Date:

RESOLUTION OF WESTINGHOUSE ELECTRIC COMPANY

COMMENTS ON DRAFT SAFETY EVALUATION FOR

TOPICAL REPORT WCAP-16500-P, SUPPLEMENT 1, REVISION 1

"APPLICATION OF CE SETPOINT METHODOLOGY FOR

CE 16X16 NEXT GENERATION FUEL (NGF)"

WESTINGHOUSE ELECTRIC COMPANY

(TAC NO. ME0143)

By letter dated November 4, 2009, Westinghouse Electric Company (Westinghouse) provided four comments on the draft safety evaluation (SE) for Topical Report (TR) WCAP-16500-P-, Supplement 1, Revision 1, "Application of CE Setpoint Methodology for CE 16X16 Next Generation Fuel (NGF)". Some information in the draft SE for this TR was identified as proprietary; therefore, the draft of this SE will not be made publicly available. The following are the NRC staff's resolution of these comments:

Draft SE comments for TR WCAP-16500-P, Supplement 1, Revision 1:

1. The last sentence in Section 3.0, paragraph 1, states that "...separate temperature-dependent, pressure-dependent, and flow-dependent biases as a function of axial power shape." Westinghouse proposed the following change:

   "…separate temperature-dependent, pressure-dependent, flow-dependent and axial shape index (ASI)-dependent biases."

   NRC Resolution for Comment 1 on Draft SE:

   The NRC staff reviewed the Westinghouse recommendation and found it acceptable because the change is editorial in nature.

   The last sentence in Section 3.0, paragraph 1, is changed to read:

   "In this application, the two NGF CHF correlations each have the potential to introduce separate temperature-dependent, pressure-dependent, flow-dependent and axial shape index (ASI)-dependent biases."

ATTACHMENT

2. The first sentence of Section 3.1, paragraph 2, states that "…separate temperature-dependent, pressure-dependent, and flow-dependent biases as a function of axial power shape." Westinghouse proposed the following change:

> "…separate temperature-dependent, pressure-dependent, flow-dependent and axial shape index (ASI)-dependent biases."

NRC Resolution for Comment 2 on Draft SE:

The NRC staff has reviewed the Westinghouse suggestion, and found it acceptable to reword as follows:

The first sentence of Section 3.1, paragraph 2, is changed to read:

> "The two CE16NGF CHF correlations (i.e., above and below elevation of first mixing grid) each have the potential to introduce separate temperature-dependent, pressure-dependent, flow-dependent and ASI-dependent biases."

3. The second sentence of Section 3.1, paragraph 7, states that states that "**[ ]**" Westinghouse proposed the following change:

"**[ ]**."

NRC Resolution for Comment 3 on Draft SE:

The NRC staff has reviewed the Westinghouse suggestion, and found it acceptable to reword as follows.

The second sentence of Section 3.1, paragraph 7, is changed to read:

[

]

4. The fifth sentence of Section 3.1, paragraph 7, states that "**[** **]**" Westinghouse proposed the following change:

"**[** **]**."

NRC Resolution for Comment 4 on Draft SE:

The NRC staff has reviewed the Westinghouse suggestion, and found it acceptable to reword as follows.

The fifth sentence of Section 3.1, paragraph 7, is changed to read:

In response to RAI #1, Westinghouse proposed an alternative approach **[**

]