January 13, 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 (WESTINGHOUSE) TOPICAL REPORT (TR) WCAP-16081-P-A, ADDENDUM 1, REVISION 0, SVEA-96 OPTIMA2 CPR CORRELATION (D4): HIGH AND LOW FLOW APPLICATIONS (TAC NO. MD3959)

Dear Mr. Gresham:

By letter dated November 28, 2006, Westinghouse submitted TR WCAP-16081-P-A, Addendum 1, Revision 0, "SVEA-96 OPTIMA2 CPR [critical power ratio] Correlation (D4): High and Low Flow Applications," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated September 19, 2008, an NRC draft safety evaluation (SE) regarding our approval of TR WCAP-16081-P-A, Addendum 1, Revision 0, was provided for your review and comments. By letter dated October 10, 2008, 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-16081-P-A, Addendum 1, Revision 0, 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 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/

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:
Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355
gordon.c.bischoff@us.westinghouse.com

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/

Thomas B. Blount, Deputy Director
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Pittsburgh, PA 15230-0355
gordon.c.bischoff@us.westinghouse.com

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OFFICE	PSPB/PM	PSPB/PM	PSPB/LA	SRXB/BC*	PSPB/BC	DPR/DD
NAME	GBacuta	MHoncharik	DBaxley	GCranston	SRosenberg	TBlount
DATE	12/18/08	1/12/09	1/06/09	12/11/08	1/12/09	1/13/09

FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT (TR) WCAP-16081-P-A, ADDENDUM 1, REVISION 0

"SVEA-96 OPTIMA2 CRITICAL POWER RATIO (CPR) CORRELATION (D4):

HIGH AND LOW FLOW APPLICATIONS"

WESTINGHOUSE ELECTRIC COMPANY (WESTINGHOUSE)

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated November 28, 2006 (Reference 1), Westinghouse submitted to the U.S. Nuclear Regulatory Commission (NRC) TR WCAP-16081-P-A, Addendum 1, Revision 0, "SVEA-96 OPTIMA2 CPR Correlation (D4): High and Low Flow Applications," for NRC staff review and approval. The TR was accepted for NRC staff review by letter dated May 23, 2007 (Reference 2).

On December 9, 2004, the SVEA-96 Optima2 CPR correlation was reviewed and accepted by the NRC staff (Reference 3). The correlation is currently applied to the SVEA-96 Optima2 fuel assembly for licensing basis applications only over the applicable range for mass flux, system pressure, sub-bundle R-factor, boiling length and annular flow length as specified in Reference 3.

Westinghouse has found that under certain circumstances it may be necessary to evaluate Critical Power (CP) values outside of this approved mass flux range. The purpose of this TR (which is an addendum to Reference 3) is to describe and justify the process by which Westinghouse intends to **[**

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2.0 REGULATORY EVALUATION

Section 50.36 of Title 10 of the *Code of Federal Regulations* (10 CFR), "Technical Specifications [(TSs)]", contains a requirement that safety limits be included in plant-specific TS. The regulation at 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 10, "Reactor Design," requires, and safety limits ensure, that the reactor core and associated coolant, control, and protective system be designed with an appropriate margin to assure that specified acceptable fuel design limits are not exceeded during steady state operation, normal operational transients, and anticipated operational occurrences (AOOs).

The fuel cladding integrity safety limit is set such that no significant fuel damage is calculated to occur if the limit is maintained. Because fuel damage is not directly observable, a stepback approach is used to establish a safety limit, such that the CPR is not less than the limit specified in the TSs. A CPR greater than the specified limit represents a conservative margin relative to the conditions required to maintain fuel cladding integrity.

To ensure compliance with 10 CFR Part 50, Appendix A, GDC 10, the NRC staff will review this TR methodology to ensure that the CPR safety limit and, therefore, the specified acceptable fuel design limits are maintained, as prescribed in NUREG-0800, Standard Review Plan (SRP) Section 4, "Reactor." The subject TR provides the technical basis to support a TS amendment for CPR values.

3.0 TECHNICAL EVALUATION

Westinghouse proposed the SVEA-96 Optima2 correlation application for licensing basis analyses as follows: (1) the D4 CPR values (Reference 1) will be those predicted by D4.1.1 CPR correlation (Reference 3) for all SVEA-96 Optima2 mass flux values in the correlation range of **[ ]** kg/m^2-s; and (2) the D4 CPR values will be the D4.1.1 CPR correlation prediction for a mass value of **[ ]** kg/m^2-s for SVEA-96 Optima2 mass flux values above the correlation upper limit of **[ ]** kg/m^2-s.

The NRC staff reviewed the Westinghouse proposed approach (Reference 1) related to high and low flow applications outside of ranges specified in Section 8 of TR WCAP-16081-P-A (Reference 3) and issued a request for additional information (RAI) relating to: (1) under what circumstances low flow and high flow will occur outside approved ranges (specified in Section 8 of TR WCAP-16081-P-A) while using the SVEA-96 Optima2 CPR Correlation; (2) assessment of safety impact on the reactor operation when operating at high flow and low flow outside approved limits; (3) justification for mass flux extending beyond approved flow regions; and (4) any additional data to substantiate the reasonable ranges to be used with a sufficient safety margin. The NRC staff made several conference calls to resolve: (1) the issues identified in the RAI; and (2) insufficient information provided in the responses to the NRC staff's RAI.

3.1 Core Flow Conditions

The flow to all assemblies in a U.S. Jet Pump Boiling Water Reactor (BWR) is controlled by an orifice just below the assembly entrance. Assembly locations on the core periphery (referred to as "Peripheral Assemblies") with one side facing the water surrounding the outside of the core are equipped with an inlet orifice which provides more resistance to flow than the "Central Assemblies." The U.S. BWRs typically are equipped with two sizes of inlet orifices controlling the flow from the lower plenum to the fuel assemblies. The inlet orifices for the single layer of fuel assemblies on the core periphery have a relatively high flow resistance and are referred to as being "tightly orifice." The flow to all other assemblies in the core is controlled by less restrictive "loosely orifice" side-entry orifices. Westinghouse has found for very low flows and certain plants that the "tightly orifice" assemblies on the extreme core periphery can experience mass fluxes below the lower approved region. The "loosely orifice" assemblies adjacent to those

on the core periphery also operate at very low power due to neutron leakage and nuclear design practices which place highly burned assemblies in these locations. The very low relative power and "loose" inlet orifice for these assemblies cause them to have high assembly flows relative to the other interior "loosely orifice" assemblies operating at higher power. For some plants, and under high flow conditions, it is possible that the current approved high mass flux limit could be exceeded. For 724-assembly BWR-3 reactors such as **[**

], there are 84 peripheral assemblies and 640 central assemblies. The resistance to flow of the central assemblies is about 18 percent of the peripheral assemblies' flow resistance.

Based on predictions using the Westinghouse 3-D core simulator, POLCA7, which is used for nuclear design and reload licensing analyses, SVEA-96 Optima2 assembly mass fluxes less than the currently approved D4.1.1 lower mass flux limit could occur within the accepted plant Power/Flow map under certain plant conditions. Similarly, mass fluxes in SVEA-96 Optima2 assemblies greater than approved upper limit are predicted by POLCA7 simulations for central assemblies operating at very low powers. This behavior has been observed in central assemblies adjacent to the interior sides of the core periphery locations and for assemblies adjacent to inserted control rods.

The NRC staff reviewed the results of the POLCA7 calculations (Reference 4) and concludes that mass flux values below the approved low mass flux limit and beyond the upper approved mass flux limit can occur under specific operating conditions.

3.2 Safety Impact for Extended Flow Region

Westinghouse indicated in the response (Reference 5) that the CPR evaluation process systematically treats CPR for normal operation and AOOs outside of the approved mass flux range in a manner which assures that Operating Limit Minimum Critical Power Ratios (OLMCPRs) conservatively protect the Safety Limit Minimum Critical Power Ratio (SLMCPR) and that CPR monitoring does not over estimate margins to the OLMCPRs. The NRC staff reviewed the response and finds it acceptable because comparison of D4 CP prediction shown in Figures 3-7 through 3-11 of Reference 1 indicates that D4 predicts lower CP values in the flow region below the lower approved mass flux limit compared with available fuel test data.

3.3 SRP Section 4.4 Evaluation

Item II of SRP Section 4.4, "Thermal And Hydraulic Design, " in NUREG-0800 specifies that "At a minimum, there should be a 95-percent probability at the 95-percent confidence level that a hot fuel rod in the reactor core will not experience a departure from nucleate boiling (DNB) or a transition boiling condition during normal operation and AOO conditions." It also states that an acceptable approach to meeting this criterion is "The limiting value of departure from nucleate boiling ratio (DNBR), critical heat flux ratio (CHFR), or CPR correlations is to be established such that at least 99.9 percent of fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOOs." Westinghouse responded to the NRC staff's RAI with respect to meeting the criterion.

The NRC staff reviewed the Westinghouse responses (References 4, 5, and 7) and finds them acceptable since the D4 CPR correlation was established to systematically under-predict CPR values over the mass flux ranges above the approved upper mass flux range and below the approved low mass flux range.

3.4 Extended Mass Flux Ranges

[

], Westinghouse plans to include increased ranges of controlling parameters, including mass flux, in the FRIGG Loop CPR test in the future (Reference 5). However, these extended ranges have been incorporated into the SVEA-96 Optima3 FRIGG Loop tests which are completed (Reference 7) with the resulting trends outside of the current approved upper and lower flow limits (Reference 3) by **[ ]** kg/m^2-s below the lower limit and **[ ]** kg/m^2-s above the upper limit.

The NRC staff reviewed the new data from the SVEA Optima3 FRIGG Loop tests (Figure 1 and Figure 2 in Reference 7) in comparison with critical power (CP) prediction of D4 (Figure 3-4 through Figure 3-11 in Reference 1) and finds that the final proposed extended mass flux ranges of **[ ]** kg/m^2-s below the lower limit and **[ ]** kg/m^2-s above the upper limit are acceptable because: (1) as mass flux is decreased below the lower limit, the impact on the CP of mechanical characteristics of the assembly designs becomes less and less important and is insensitive to the assembly design, and D4 predicted CP value is lower than available test data; and (2) as mass flux is increased above the upper limit, CPR will be evaluated at upper limit mass flux without taking credit of a monotonically increasing function of mass flux.

4.0 LIMITATIONS AND CONDITIONS

Based on the results of the NRC staff evaluation described in Sections 3.1, 3.2 and 3.4, the NRC staff found that TR WCAP-16081-P-A, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications," is acceptable for the mass flux ranges of **[ ]** kg/m^2-s below the lower limit and **[ ]** kg/m^2-s above the upper mass flux limit specified in Reference 3 because: (1) the SVEA-96 Optima2 CPR correlation is an approved methodology and will be used as D4 with an extended flow region below the lower limit; (2) the mass flux range tested at FRIGG Loop for SVEA-96 Optima3 is feasible for SVEA-96 Optima2 fuel if future test is planned; (3) the trend of the CP response from SVEA-96 Optima3 test data is similar to predicted CP using D4 correlation in the flow region below the lower limit specified in Reference 3; and (4) a constant CPR value predicted at the upper limit of the mass flux specified in Reference 3 will be used for the flow region beyond the upper limit. The flow range of application for the D4 correlation (i.e., **[ ]** kg/m^2-s below the lower limit and **[ ]** kg/m^2-s above the upper limit specified in D4.1.1) is acceptable, because they are compatible to the mass flux ranges for the SVEA-96 Optima3 Loop data (i.e., **[ ]** kg/m^2-s below the lower limit in D4.1.1 and **[ ]** kg/m^2-s above the upper limit specified in D4.1.1).

The NRC staff's approval of this TR, based on the above evaluation, is subject to the following limitations and conditions:

1) The D4 CPR values for SVEA-96 Optima2 mass flux above the D4.1.1 upper limit will be the D4.1.1 CPR correlation prediction for mass flux value at the upper limit specified in D4.1.1.

2) All the limitations and conditions specified in D4.1.1 are applicable to D4 correlation and any deviation from approved methodologies stated in D4.1.1 shall be submitted for review by the NRC staff.

3) The NRC staff will ensure the implementation of the approved methodology for D4 CPR correlation specified in Reference 3. However, any new approach other than D4 or D4.1.1 will be subject to a detailed review.

5.0 CONCLUSION

The NRC staff reviewed the subject TR (Reference 1) and Westinghouse responses (References 4, 5, and 7) to the NRC staff's RAI (Reference 6) to determine acceptability of TR WCAP-16081-P-A, Addendum 1, Revision 0, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications." The NRC staff concludes that TR WCAP-16081-P-A, Addendum 1, Revision 0, is acceptable subject to limitations and conditions as described in Section 4.0.

6.0 REFERENCES

1. J. A. Gresham, Westinghouse, letter to the NRC, "Submittal of TR WCAP-16081-P-A, Addendum I/WCAP-16081-NP-A, Addendum I, 'SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications' (Proprietary/Non-Proprietary)," November 28, 2006, LTR-NRC-06-63 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML063520424).

2. S. L. Rosenberg, NRC, letter to J. A. Gresham, Westinghouse, "Acceptance for Review of Westinghouse TR WCAP-16081-P-A, Addendum 1, Revision 0, 'SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications' (TAC NO. MD3959)," May 23, 2007 (ADAMS Accession No. ML071380299).

3. H. N. Berkow, NRC, letter to J. A. Gresham, Westinghouse, "Final Safety Evaluation for Topical Report (TR) WCAP-16081-P, "10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2" (TAC No. MB9011)," dated December 9, 2004, with revised cover letter issued by B. Benney, NRC, to J. A. Gresham, Westinghouse, dated December 23, 2004. (ADAMS Accession No. ML043130235).

4. J. A. Gresham, Westinghouse, letter to the NRC, “Second Supplemental Response to NRC Request for Additional Information by the Office Of Nuclear Reactor Regulation for TR WCAP-16081-P-A Addendum 1, ‘SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications’ (TAC No. MD3959) (Proprietary/Non-proprietary)," LTR-NRC-08-32, June 24, 2008 (ADAMS Accession No. ML081820733).

5. J. A. Gresham, Westinghouse, letter to the NRC, “Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation for TR WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (134): High & Low Flow Applications " (TAC No. MD3959) (Proprietary/Non-proprietary),” LTR-NRC-07-47, September 13, 2007 (ADAMS Accession No. ML072700090).

6. J. H. Thompson, NRC, letter to J. A. Gresham, Westinghouse, “Request for Additional Information RE: Westinghouse Electric Company TR WCAP-16081-P, Addendum 1, Revision 0, “SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications” (TAC NO. MD3959),” August 16, 2007 (ADAMS Accession No. ML072180344).

7. J. A. Gresham, Westinghouse, letter to the NRC, “Supplemental Response to NRC Request for Additional Information by the Office of Nuclear Reactor Regulation for TR WCAP-16081-P-A Addendum 1, “SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications” (TAC No. MD3959) (Proprietary/Non-proprietary), LTR-NRC-08-12, March 14, 2008 (ADAMS Accession No. ML082540065).

Attachment: Resolution of Comments

Principal Contributor: T. Huang

Date: January 13, 2009

RESOLUTION OF WESTINGHOUSE ELECTRIC COMPANY (WESTINGHOUSE)

COMMENTS ON DRAFT SAFETY EVALUATION FOR TOPICAL REPORT (TR)

WCAP-16081-P-A, ADDENDUM 1, REVISION 0

"SVEA-96 OPTIMA2 CRITICAL POWER RATIO (CPR) CORRELATION (D4):

HIGH AND LOW FLOW APPLICATIONS"

(TAC NO. MD3959)

By letter dated October 10, 2008, Westinghouse provided four comments on the draft safety evaluation (SE) for TR WCAP-16081-P-A, Addendum 1, Revision 0, "SVEA-96 OPTIMA2 CPR Correlation (D4): High and Low Flow Applications," for U.S. Nuclear Regulatory Commission (NRC) staff review and approval. 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-16081-P-A, Addendum 1, Revision 0:

1. The first sentence in Section 1.0, paragraph 2, states that "On March 31, 2005, the SVEA-96 Optima2 CPR correlation was reviewed and accepted by NRC (Reference 3)."

   Reference 3 as used in the above sentence and throughout the draft SE, would normally refer to the NRC Final Safety Evaluation and approval letter, in this case, for the SVEA- 96 Optima2 CPR correlation TR WCAP-16081-P-A. In the current draft SE, however, Reference 3, instead refers to Westinghouse issued LTR-NRC-05-21, dated March 31, 2005. This letter was issued primarily to distribute the final "-A" version of the approved TR for SVEA-96 Optima2 CPR correlation topical WCAP-16081-P-A.

   As such, it is recommended that Reference 3 of the draft SE be revised to refer to the "Final Safety Evaluation for Topical Report (TR) WCAP-16081-P, "10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," (TAC No. MB9011)" by letter from H. N. Berkow, NRC, to J. A. Gresham, Westinghouse, dated December 9, 2004, with revised cover letter issued by B. Benney, NRC, to J. A. Gresham, Westinghouse, dated December 23, 2004.

   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 first sentence in Section 1.0, paragraph 2, is changed to read "On December 9, 2004, the SVEA-96 Optima2 CPR correlation was reviewed and accepted by the NRC staff (Reference 3)."

ATTACHMENT

Reference number 3 of the SE is revised to read:

"3. H. N. Berkow, NRC, letter to J. A. Gresham, Westinghouse, "Final Safety Evaluation for Topical Report (TR) WCAP-16081-P, "10x10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," (TAC No. MB9011)," dated December 9, 2004, with revised cover letter issued by B. Benney, NRC, to J. A. Gresham, Westinghouse, dated December 23, 2004 (ADAMS Accession No. ML043130235)."

2. The first sentence of Section 3.1, paragraph 2, appears to be missing several words. To address this, it is suggested that the following text be added which is based on the related information previously provided in supplemental response LTR-NRC-08-12 dated March 14, 2008:

> The Westinghouse 3-D core simulator, POLCA7, used for nuclear design and reload licensing analyses predicts that SVEA-96 Optima2 assembly mass fluxes less than the D4.1.1 lower mass flux limit of **[ ]** kg/m^2-s can occur for realistic **[ ]** conditions.

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:

> "Based on predictions using the Westinghouse 3-D core simulator, POLCA7, which is used for nuclear design and reload licensing analyses, SVEA-96 Optima2 assembly mass fluxes less than the currently approved D4.1.1 lower mass flux limit could occur within the accepted plant Power/Flow map under certain plant conditions...."

3. For additional clarification, please add the following sentence to the beginning of the first paragraph in Section 3.4.

> **[**
>
> **].**

This proposed sentence would add potentially relevant information regarding the context and intent of the opening statement provided by this paragraph. Also, the suggested sentence is taken directly from Reference 5, which refers to the Westinghouse Response to RAI 4 provided by LTR-NRC-07-47, dated September 13, 2007.

NRC Resolution for Comment 3 on Draft SE:

The NRC staff reviewed the Westinghouse's comment 3 and found it acceptable because the statement is made in the supplemental response (Reference 5).

The following sentence is added to the beginning of the first paragraph in Section 3.4.: "**[**
]."

4. Request for consideration of additional information not presently addressed in Section 4.0, Limitations and Conditions.

In addition to those limitations and conditions currently addressed by the draft SE, Westinghouse (in its Response to Request 4 provided in LTR-NRC-08-32, June 24, 2008) also proposed to include a method for conservatively calculating CP below **[ ]** that would utilize **[ ].** This provision is needed because increasing the D4 lower mass flux range above the minimum value of **[ ]** would increase the probability of a D4 CPR mass flux range violation during plant operation (see the Response to RAI 2 provided in LTRNRC-08-12, March 14, 2008). This method was proposed in order to address the NRC staff concerns about the lack of measured data for mass flux below **[ ].** **[ ].**

NRC Resolution for Comment 4 on Draft SE:

The NRC staff has reviewed Comment 4 and found it not acceptable generically because the proposed **[ ]** will be applied to the region beyond the approved correlation range (see Reference 5 and this SE).