Westinghouse Non-Proprietary Class 3

WCAP-16081-NP-A
Addendum 1-A
Revision 0

March 2009

SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications

WCAP-16081-NP-A
Addendum 1-A
Revision 0

SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications

Original Version: November 2006
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*Electronically approved records are authenticated in the electronic document management system.

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Section A

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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,

Thomas B. Blount

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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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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 [

].

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).

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Section B

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Westinghouse

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

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Our ref: LTR-NRC-06-63

November 28, 2006

Subject: Submittal of WCAP-16081-P-A, Addendum 1/WCAP-16081-NP-A, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications" (Proprietary/Non-Proprietary)

Enclosed are 5 Proprietary and 3 Non-Proprietary copies of WCAP-16081-P-A, Addendum 1 / WCAP-16081-NP-A, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications" submitted to the NRC for Review and Approval. It is requested that the above topical be approved by March 2008. It is also requested that the NRC provide an estimate on the man-power resources required for the review and a tentative date for an acceptance meeting.

WCAP-16081-P-A, Addendum 1/WCAP-16081-NP-A, Addendum 1 will extend the mass flux range of the SVEA-96 Optima2 Critical Power Ratio (CPR) for correlation both low and high flow applications.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-06-2213 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit, AW-06-2213.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR Section 2.390. Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

Correspondence with respect to this Application for Withholding should reference AW-06-2213 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

Enclosures

cc: G. V. Cranston, NRR
A. C. Attard, NRR
J. H. Thompson, NRR
S. E. Peters, NRR
H. D. Cruz, NRR

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Our ref: AW-06-2213

November 28, 2006

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Submittal of WCAP-16081-P-A, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications" (Proprietary)

Reference: Letter from J. A. Gresham to Document Control Desk, LTR-NRC-06-63, dated November 13, 2006

The Application for Withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-06-2213 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-06-2213 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse) and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

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

Sworn to and subscribed
before me this 29th day
of November, 2006

Notary Public

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
Member, Pennsylvania Association Of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse) and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WCAP-16081-P-A, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-06-63) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is that associated with extension of capabilities in the BISON code. This submittal is for NRC review and approval.

This information is part of that which will enable Westinghouse to:

(a) Extend the SVEA-96 Optima2 Critical Power Ratio (CPR) for both high and low flow applications.

Further this information has substantial commercial value as follows:

(a) Westinghouse can use its methodology capability to further enhance their licensing position over their competitors.

(b) Assist customers to obtain license changes.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and non-proprietary versions of documents furnished to the NRC. In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

Copyright Notice

The documents transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies for the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection not withstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond these necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

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1 INTRODUCTION AND SUMMARY

The SVEA-96 Optima2 Critical Power Ratio (CPR) correlation was reviewed and accepted by the NRC as described in Reference 1. 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 Section 8 of Reference 1 and the NRC Safety Evaluation (SE). This range is defined by the range of parameters in the correlation database described in Reference 1.

As noted in Section 8 of Reference 1, the mass flux range of the CPR correlation is [ ]^{a,c} kg/m^2-s. Westinghouse has found that under certain circumstances it may be necessary to evaluate Critical Power values outside of this mass flux range. For example, for some plant applications, Critical Power evaluation may be needed at very low core flows for which assemblies on the core periphery could have the potential for experiencing mass flux values less than [ ]^{a,c} kg/m^2-s. Therefore, it may be necessary to conservatively estimate SVEA-96 Optima2 Critical Power values for mass fluxes outside of the approved correlation range. The CPR estimates outside of the correlation range from [ ]^{a,c} kg/m^2-s must be conservative since CPR data for SVEA-96 Optima2 are not available outside of this range.

This addendum to Reference 1 describes and justifies the process by which Westinghouse intends to conservatively estimate SVEA-96 Optima2 CPR values for which the mass flux is outside of the data base range of [ ]^{a,c} kg/m^2-s.

For all SVEA fuel designs, CPR has been found to be [

]^{a,c} For example, this trend is illustrated for SVEA-96 Optima2 fuel in Figures 4.9 and 4.10 of Reference 1. Accordingly, should it be necessary to evaluate CPR for mass flux values greater than [

]^{a,c} as input. This approach assures that CPR is not overestimated above for mass flux values above [ ]^{a,c} kg/m^2-s.

Since Critical Power is [

]^{a,c} would not provide a conservatively low CPR. Therefore, as discussed in Section 3, the D4.1.1 CPR correlation described in Section 5 of Reference 1 was originally established to predict conservatively low CPR values at mass flux levels below [ ]^{a,c} kg/m^2-s. This was accomplished by extrapolating Critical Power from the lowest measured Critical Power at [ ]^{a,c} kg/m^2-s to zero mass flux as follows:

1. Dryout was assumed to occur for zero heat flux at zero mass flux. Physically, a non-zero, positive heat flux (i.e. core power) is required to achieve dryout at zero mass flux. Therefore, requiring zero heat flux at zero mass flux provides a conservative intercept at zero mass flux supporting conservative CPRs at low flows.

2. Critical Quality is a decreasing function of mass flux. Critical power tests demonstrate that Critical Quality increases with decreasing mass flux. Therefore, the D4 .1.1 correlation was constrained to predict conservative Critical Powers at all mass fluxes between [ ]^{a,c} kg/m^2-s

and zero mass flux by requiring Critical Qualities to be constant or decreasing in this low flow range. Requiring Dryout to occur at qualities less than the actual Critical Quality assures that the Critical Powers are conservatively predicted. Constant or decreasing Critical Qualities were accomplished by requiring that predicted Critical Powers decrease at least as rapidly as a linear decrease in Critical Power as a function mass flux.

SVEA-96 Optima2 Critical Power data below a mass flux of [ ]^{a,c} kg/m^2-s are not available. The demonstration of the conservative nature of the SVEA-96 Optima2 CPR correlation below a mass flux of [ ]^{a,c} kg/m^2-s in Section 3 is based on comparisons with measured Critical Quality values of the early 7×7 assembly described in Reference 3 whose Critical Power performance at normal operating flow conditions is about [ ]^{a,c} than that of the SVEA-96 Optima2 assembly. Use of these data to confirm that SVEA-96 Optima2 CPRs predicted at mass fluxes less than [ ]^{a,c} kg/m^2-s is acceptable since, as mass flow is decreased, the impact on Critical Power of mechanical characteristics of the assembly designs becomes less and less important going to a non-zero value at zero mass flow in which the critical heat flux depends on the fluid characteristics (e.g., liquid density, steam density, void fraction, and heat of vaporization) and is insensitive to the assembly design. Consequently, available low-flow Critical Power data for assembly designs other than SVEA-96 Optima2 can be used to support the establishment of a conservative CPR dependence on mass flux for low mass fluxes. Using these Critical Power measurements, encompassing a broad range of conditions, the evaluation in Section 3 confirms that the D4.1.1 CPR correlation without any modifications provides conservative predictions below [ ]^{a,c} kg/m^2-s as intended.

The SVEA-96 Optima2 CPR correlation is named D4.1.1 in Reference 1. In this Addendum to the topical report, the use of the correlation outside of the approved range is justified, but the correlation itself is not changed below [ ]^{a,c} kg/m^2-s. The same values for the critical power would be obtained by applying the correlation as it is described in Reference 1, as well as in this report, up to a mass flux of [ ]^{a,c} kg/m^2-s. As described above, for mass fluxes above [ ]^{a,c} kg/m^2-s , a lower Critical Power value is predicted by the correlation as described in this Addendum than that given by the D4.1.1 correlation in Reference 1. Specifically, for mass fluxes greater than [ ]^{a,c} kg/m^2-s [

]^{a,c} kg/m^2-s. The name of the SVEA-96 Optima2 CPR correlation with this [ ]^{a,c} revision is "D4." Therefore, the D4 correlation provides [

]^{a,c}.

2 SVEA-96 OPTIMA2 CORRELATION APPLICATION FOR LICENSING BASIS ANALYSES

The manner in which the D4 SVEA-96 Optima2 dryout correlation will be applied to licensing basis analyses is summarized as follows:

For all SVEA-96 Optima2 mass flux values in the correlation range of [

]^{a,c}

For SVEA-96 Optima2 mass flux values above the correlation upper limit of [

]^{a,c}

3 DISCUSSION

The evaluation of SVEA-96 Optima2 Critical Power below [ ]^{a,c} kg/m^2-s using the D4 CPR correlation summarized in Section 2 is discussed in this section. As shown below, the conservative nature of the D4 CPR correlation predictions below a mass flux of [ ]^{a,c} kg/m^2-s is confirmed by comparisons with available measured Critical Power data for the 7×7 assembly described in Reference 3. The 7×7 data selected for comparison with the low flow D4 predictions are discussed in Section 3.1, and the actual data comparisons with D4 predictions and evaluations are contained in Section 3.2.

3.1 7×7 AND SVEA-96 OPTIMA2 DATA FOR LOW FLOW D4 EVALUATION

D4 correlation cosine axial power shape predictions were compared with available SVEA-96 Optima2 and 7×7 cosine shape Critical Power data over ranges of mass flux, inlet subcooling, and exit pressures. In order to capture trends with decreasing flow in the low-flow region for the available SVEA-96 Optima2 and 7×7 data it was necessary to consider a similar range of exit pressures. In order to support comparison of the D4 correlation predictions with a relatively large data base, calculated D4 predictions were compared with 7x7 measurements from Reference 3 over a broad range of inlet subcooling. The cosine axial power shape data base from Reference 3 used in the comparison is the 49-rod 7×7 Atlas Test Assemblies 24A, 24B and 25A in the ranges shown in Table 3-1. These test bundles were selected since their data bases included relatively low-flow measurements.

Accordingly, the ranges of inlet sub-cooling and exit pressures in the data comparisons in Section 3.2 are shown in Table 3-1.

Table 3-1 Conditions for Comparisons in Section 3.2

Data Base or Calculation	Axial Shape	Subcooling Range at 70 bar (kJ/kg)	Pressure Range (bar)	Reference
SVEA-96 Optima2	Cosine	38-68	70-71	Reference 1
7×7	Cosine	2.4 -311.4	67.6 – 71.4	Reference 3
Calculated D4 predictions	Cosine	20 -240	70	

The comparisons shown in Section 3.2 are based on the entire SVEA-96 Optima2 cosine data base in Reference 1 for the ranges shown in Table 3-1.

3.2 HIGH AND LOW FLOW APPLICATION OF THE D4 CPR CORRELATION

While the SVEA-96 Optima2 D4 CPR correlation has not yet been used to evaluate CPR in licensing analysis applications below the low mass flux limit of [ ]^{a,c} kg/m^2-s, the correlation was originally established to predict conservatively low CPR values below [ ]^{a,c} kg/m^2-s. This was accomplished by requiring predicted Critical Powers in this range to be less than or equal to a linear extrapolation from the Critical Power prediction at [ ]^{a,c} kg/m^2-s to a zero value of Critical Power at zero mass flux. The assumption of a zero value of Critical Power at zero mass flux is conservative since a non-zero finite heat flux (or assembly power) is required to achieve dryout at zero mass flux. The conclusion that an

extrapolation providing Critical Power values less than or equal to a linear extrapolation from the CPR prediction at [ ]^{a,c} kg/m^2-s to a zero value of Critical Power at zero mass flux is conservative was based on the observation that this linear extrapolation corresponds to a constant Critical Quality and a review of available data providing the behavior of Critical Quality as a function of mass flux at low flows.

Figure 3-1 shows Critical Qualities established from the SVEA-96 Optima2 testing described in Reference 1 and illustrates the increasing tendency of Critical Qualities with decreasing mass flux for SVEA-96 Optima2 mass fluxes less than 1200 kg/m^2-s. Figure 3-2 shows that the critical qualities established from a subset of the 7x7 testing described in Reference 3 show a similar increasing trend in Critical Quality with decreasing mass flux. The Critical Qualities calculated with the D4 correlation shown in Figure 3-3 are reasonably constant for the top-peaked axial power shape and decrease or are approximately constant for the bottom-peaked and cosine-shaped axial power shapes below [ ]^{a,c} kg/m^2-s. Figure 3-3 illustrates, therefore, that Critical Qualities (and, therefore, Critical Powers) are underestimated in the mass flux region below [ ]^{a,c} kg/m^2-s. It should be noted that the decreases in Critical Quality in the bottom-shaped and cosine-shaped Critical Qualities in Figure 3-3 are at mass fluxes for which the Critical Powers are decreasing with a slope which is less (more negative) than a linear slope.

The conclusion that data obtained at low mass fluxes with other assembly designs can be used to establish conservative Critical Power predictions for SVEA-96 Optima2 is based on the fact that as mass flow is decreased, the impact of mechanical characteristics of different assembly designs becomes less and less important converging to a positive, non-zero Critical Heat Flux at zero mass flow where the Critical Heat Flux depends only on the fluid characteristics and is independent of the assembly design. Consequently, available Critical Power data for assembly designs other than SVEA-96 Optima2 can be used at low mass flux to support the establishment of a conservative CPR dependence on mass flux for low mass fluxes.

The D4 predictions for the top-peaked, bottom-peaked, and cosine-shaped axial power distributions for mass fluxes above 1000 kg/m^2-s are shown in Figure 3-4 for an assembly exit pressure of 70 bar and an inlet subcooling of 54 kJ/kg (10° K). The axial power shapes are the same as those used in the SVEA-96 Optima2 testing documented in Reference 1. As shown in Figure 3-4, the Critical Power above a mass flux of [ ]^{a,c} kg/m^2-s is conservatively set equal to the value evaluated by the D4 CPR correlation at [ ]^{a,c} kg/m^2-s as required.

The D4 predictions for the top-peaked, bottom-peaked, and cosine-shaped axial power distributions are shown in Figure 3-5 in the low-flow region. As shown in Figure 3-5, the predicted Critical Power for a top-peaked axial power shape below a mass flux of [ ]^{a,c} kg/m^2-s is very close to a linear extrapolation from its value at [ ]^{a,c} kg/m^2-s to zero at zero mass flux. The Critical Powers predicted by D4 for the cosine-shaped and bottom-peaked axial power distributions are generally slightly less than that given by a linear extrapolation from their values at [ ]^{a,c} kg/m^2-s to zero at zero mass flux.

Figure 3-6 is a comparison of SVEA-96 Optima2 and 7×7 data with D4 predictions at a pressure of 70 bar and an inlet subcooling of 54 kJ/kg for a cosine axial power shape over the entire mass flux range. Figure 3-6 illustrates the following:

1. At normal operating flow rates (about 1300 kg/m^2-s), the Critical Power performance of the 7×7 fuel is about [ ]^{a,c} than that of the SVEA-96 Optima2 assemblies.

2. The Critical Power data shown in Figure 3-6 reflect the trend that as flow rate is decreased, differences in measured Critical Power performance for different assembly designs also decrease.

Figure 3-7 is the same comparison of SVEA-96 Optima2 and 7×7 data with D4 predictions at a pressure of 70 bar and an inlet subcooling of 54 kJ/kg as shown in Figure 3-6 but in the low flow range. In light of the difference between SVEA-96 Optima2 and 7×7 Critical Power performance at normal operating flow rates of about [ ]^{a,c}, the similarity of the SVEA-96 Optima2 and 7×7 Critical Power values below 500 kg/m^2-s clearly demonstrates the relative insensitivity of assembly design to Critical Power performance at low flow rates and justifies the conclusion that the 7×7 Critical Power values in the low flow range can be used to estimate the CPR performance of the SVEA-96 Optima2 assembly in this range. Figure 3-7 demonstrates that the D4 Critical Power prediction in this low flow regime is conservative. Note that the D4 prediction for a cosine shape at a pressure of 70 bar and an inlet subcooling of 54 kJ/kg becomes increasingly conservative relative to the 7x7 data base shown for mass fluxes below 250 kg/m^2-s. Therefore, these comparisons provide confirmation that the D4 CPR correlation conservatively predicts critical power below the mass flux lower limit in Reference 1 down to a value of zero mass flux.

Further insight into the conservativism in the D4 predictions at low mass flux is provided by the predictions of D4 at a given inlet subcooling with the 7x7 data base for ranges of inlet subcoolings enveloping the inlet subcooling at which the D4 predictions were performed. These comparisons are shown in Figures 3.8 through 3.11. Note that dryout measurements for SVEA-96 Optima2 with subcooling values below that for which the calculation was performed would be expected to be less than the calculated correlation predictions. In general, the 7x7 data are greater than the D4 predictions for the entire subcooling range of measured values further demonstrating the level of conservatism of the D4 correlation. The only exceptions to this general conclusion are the three points at about 235 kg/m^2-s which lie below the D4 prediction in Figure 3.10. These three points are subcooled by about 135 kJ/kg which is significantly below the calculated value of 150 kJ/kg. In light of the substantially lower Critical Power capability of the 7x7 fuel at normal operating conditions, the general trend of D4 low-flow Critical Powers to lie below the 7x7 data points in Figures 3.8 to 3.11 confirms the conservative nature of the D4 correlation at low flows.

Therefore, it is concluded that the D4 correlation applied as summarized in Section 2.0 will provide sufficiently conservative estimates of SVEA-96 Optima2 Critical Power for licensing applications.

a,b,c

Figure 3-1 Exit quality at dryout for SVEA-96 Optima2 measurements at approximately 70 bar, with a sub-cooling of 54 kJ/kg, and an R-factor of 0.93

a,b,c

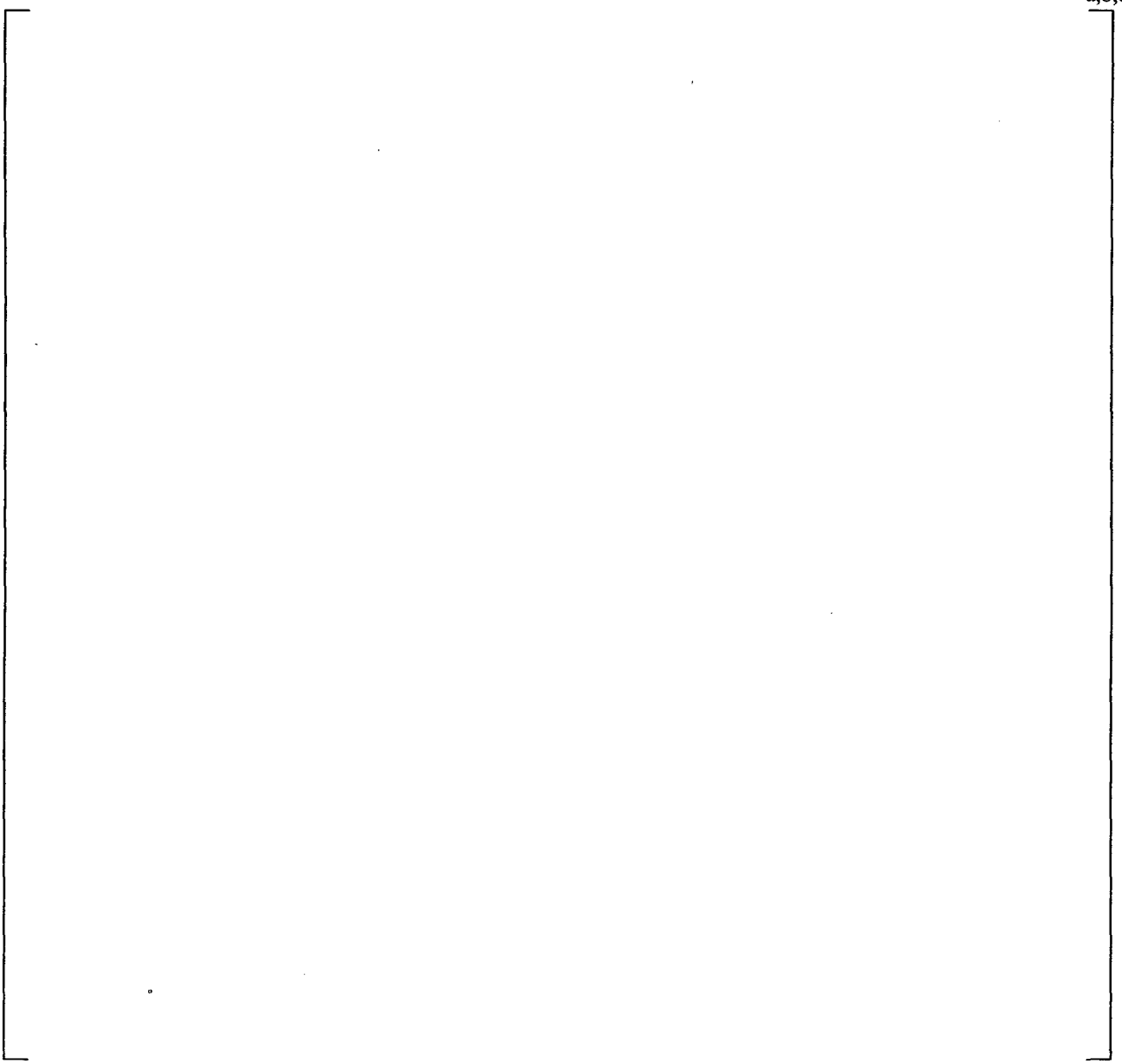

Figure 3-2 Exit quality at dryout for 7X7 fuel measurements at approximately 70 bar and a sub-cooling of 54 kJ/kg

a,c

Figure 3-3 Critical Quality Prediction of D4 for Cosine, Top Peak, and Bottom Peak Axial Power Shapes

a,c

Figure 3-4 Prediction of D4 for Cosine, Top Peak, and Bottom Peak Axial Power Shapes at Medium and High Flow

a,c

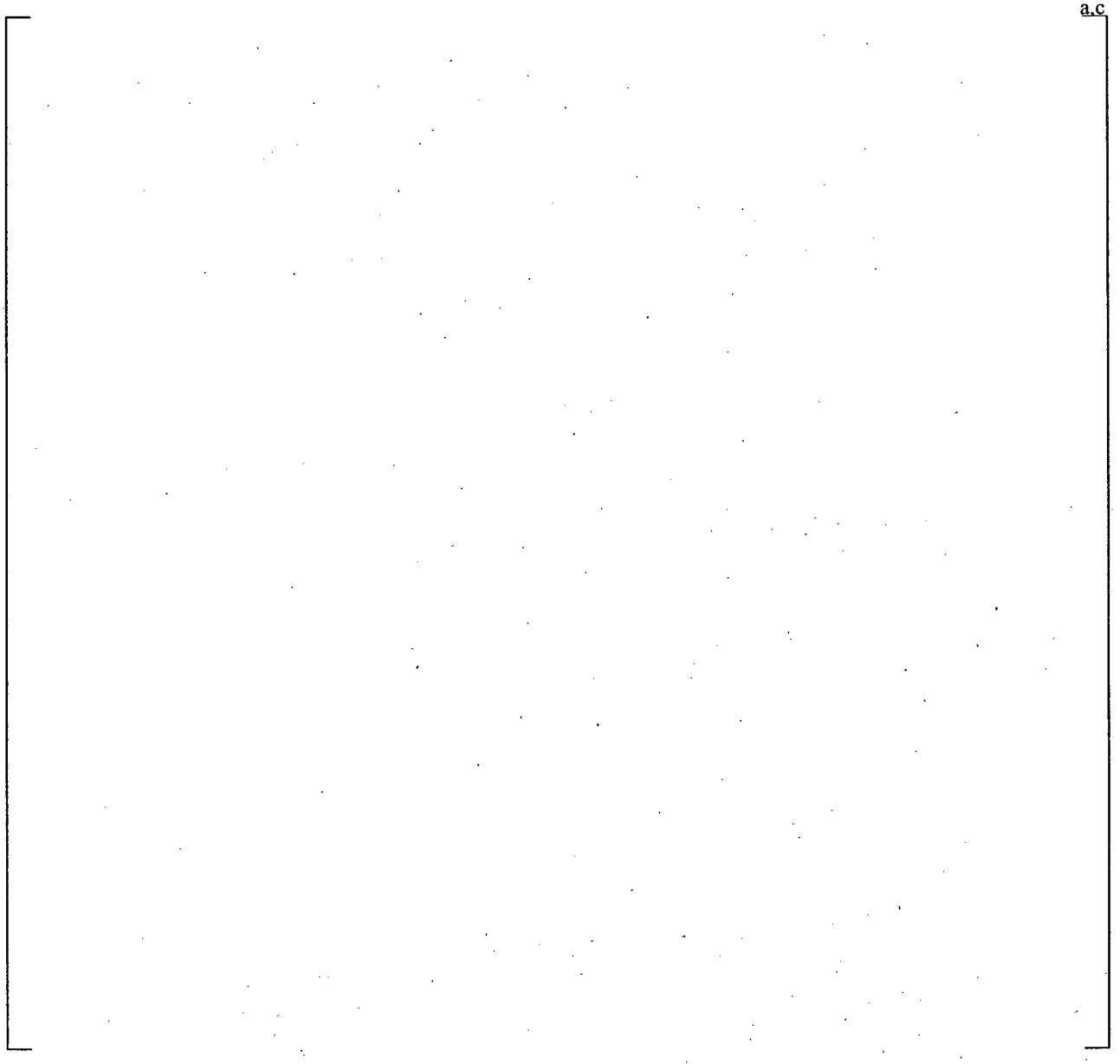

Figure 3-5 Prediction of D4 for Cosine, Top Peak, and Bottom Peak Axial Power Shapes at Low Flow

a,b,c

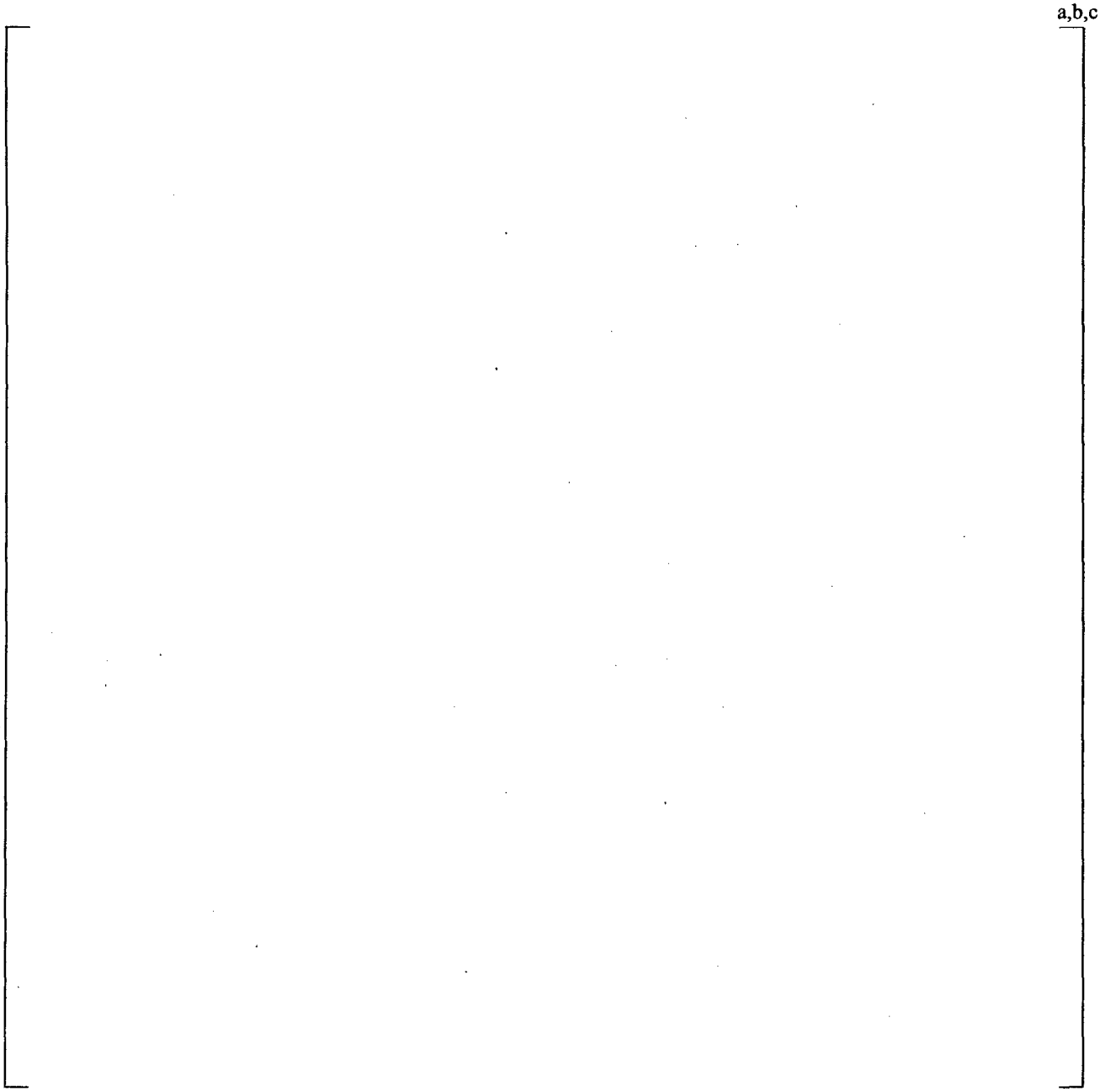

Figure 3-6 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape

a,b,c

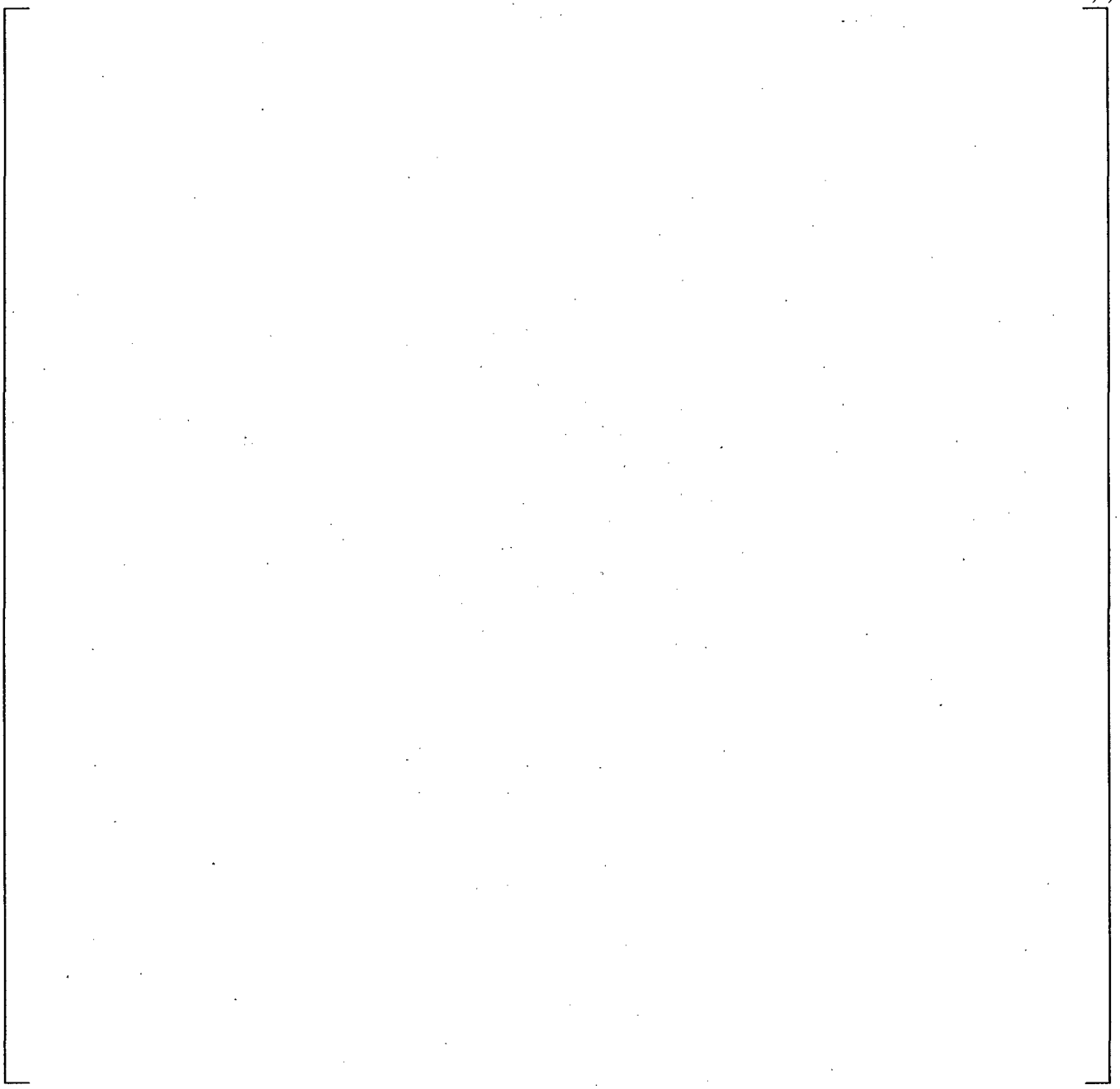

Figure 3-7 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape at Low Flow with 7x7 Data at all Subcoolings

a,b,c

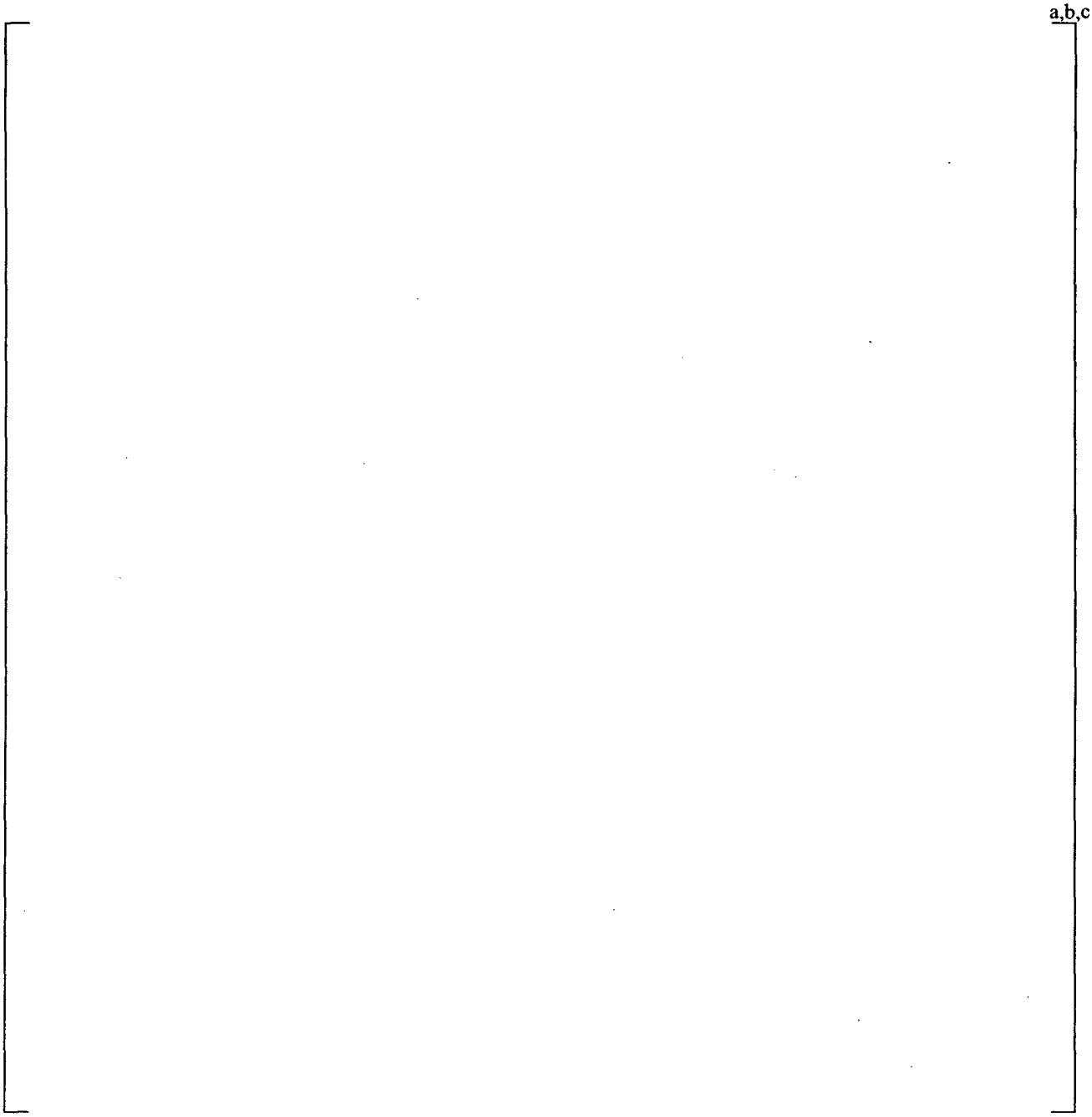

Figure 3-8 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape at Low Flow and a Subcooling of about 20 kJ/kg

a,b,c

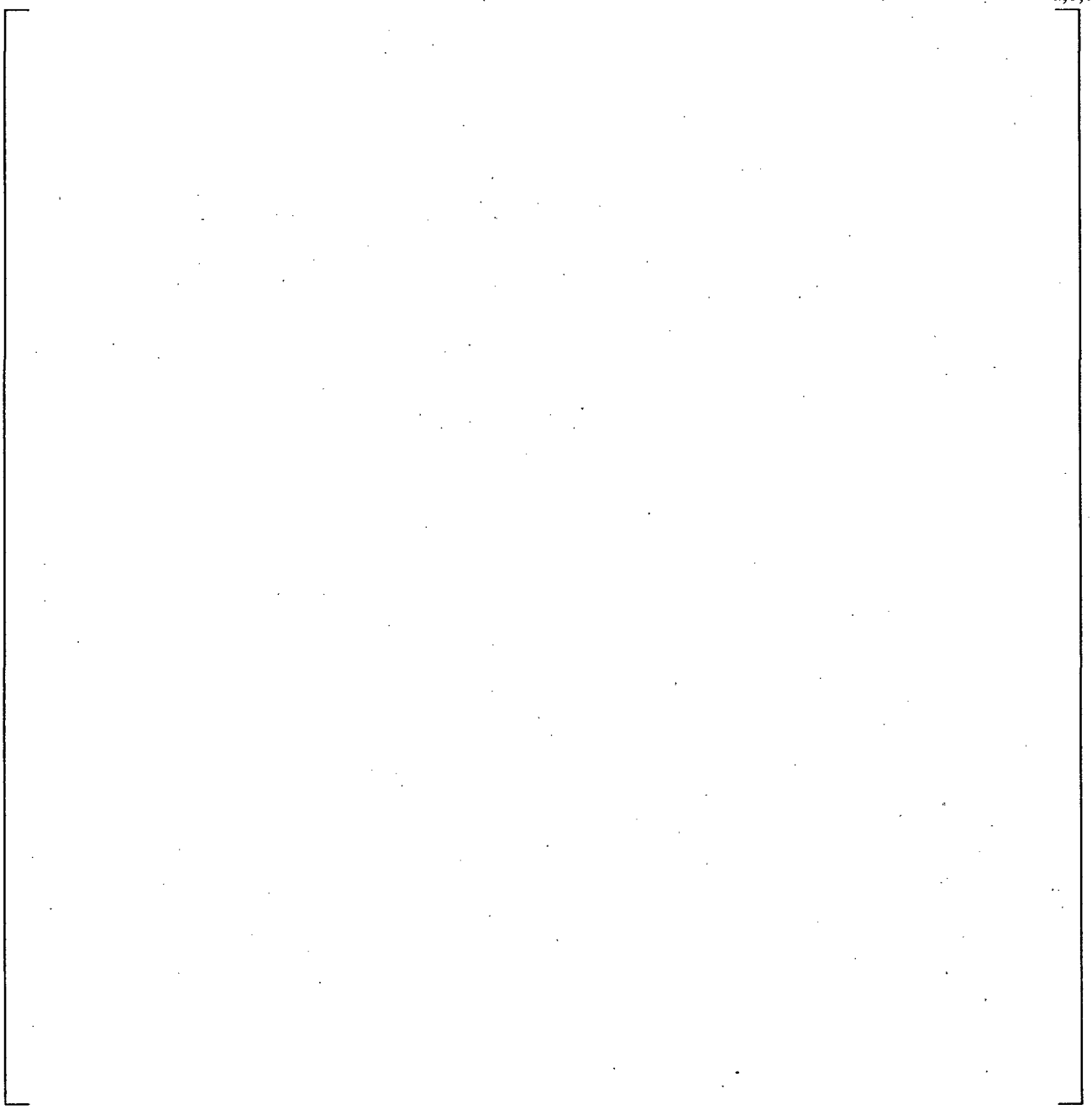

Figure 3-9 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape at Low Flow and a Subcooling of about 54 kJ/kg

a,b,c

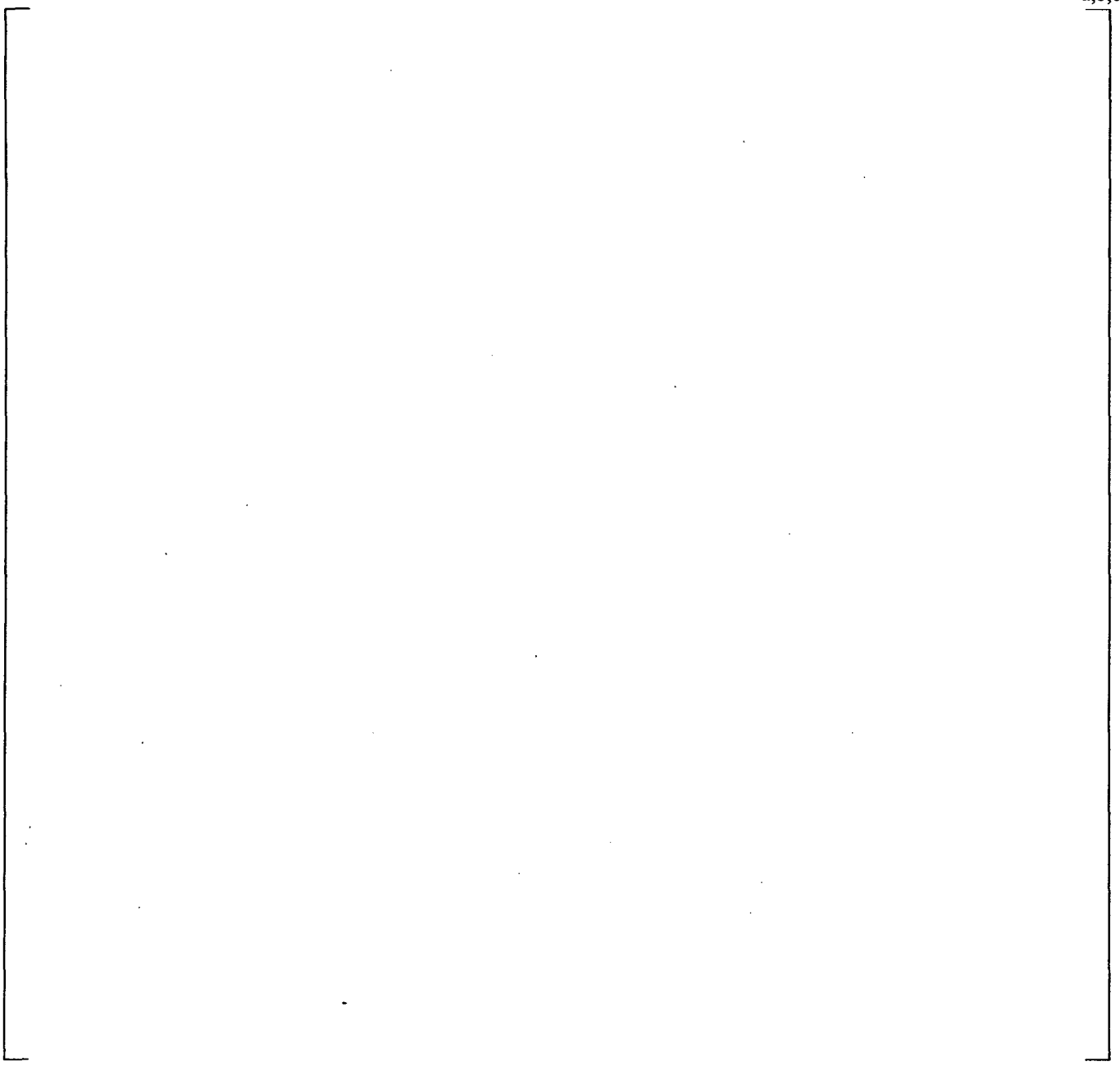

Figure 3-10 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape at Low Flow and a Subcooling of about 150 kJ/kg

a,b,c

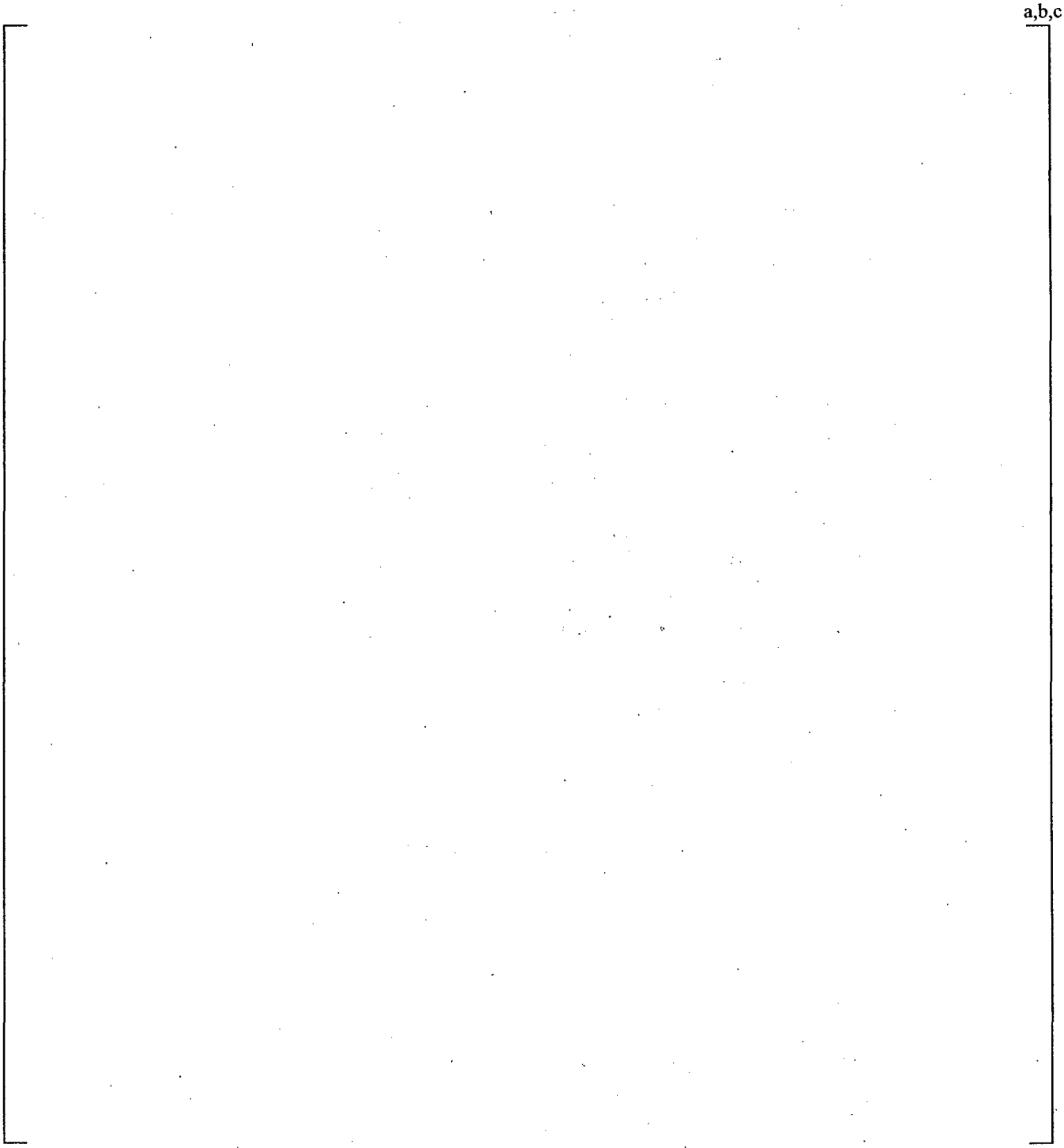

Figure 3-11 Comparison of SVEA-96 Optima2 and 7×7 Data with D4 Predictions for Cosine Axial Power Shape at Low Flow and a Subcooling of about 240 kJ/kg

4 REFERENCES

1. WCAP-16081-P-A, "10×10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," March 2005.

2. WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors, Supplement 1 to CENPD-287-P-A," May 2006.

3. NEDE-10958, "General Electric BWER Thermal Analysis Basis, Data, Correlation, and Design Application," November 1973.

Section C

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Our ref: LTR-NRC-07-47
September 13, 2007

Subject: Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications " (TAC No. MD3959) (Proprietary/Non-proprietary)

Enclosed are copies of the Proprietary and Non-Proprietary response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications."

Also enclosed is:

1. One (1) copy of the Application for Withholding, AW-07-2329 (Non-proprietary) with Proprietary Information Notice.
2. One (1) copy of Affidavit (Non-proprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the affidavit or Application for Withholding should reference AW-07-2329 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

Enclosures
cc: A. Mendiola, NRR
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Our ref: AW-07-2329
September 13, 2007

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Proprietary)

Reference: Letter from J. A. Gresham to Document Control Desk, LTR-NRC-07-47, dated September 13, 2007

The application for withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-07-2329 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-07-2329 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

Cc: A. Mendiola, NRR
J. Thompson, NRR

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse) and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

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

Sworn to and subscribed
before me this 13th day
of September, 2007.

Sharon L. Markle
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Sharon L. Markle, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 29, 2011
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse) and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked "Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, 'SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications' (TAC No. MD3959) (Proprietary)," for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-07-47) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is that associated with response to NRC's Request for Additional Information for WCAP-16081-P-A Addendum 1.

This information is part of that which will enable Westinghouse to:

(a) Obtain generic NRC licensed approval for the SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications.

(b) Assist customers in improving their fuel performance (zero defects).

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to continue to implement improvements to ensure the highest quality of fuel and analyses in order to meet the customer needs.

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Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

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Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Non-Proprietary)

September 2007

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

Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Non-Proprietary)

NRC RAI 1

Please describe under what circumstances low flow and high flow will occur outside approved ranges (in Section 8 of WCAP-16081-P-A) while using the SVEA-96 Optima2 CPR Correlation.

Westinghouse Response to RAI 1

As noted in Reference 1, Westinghouse has identified certain circumstances in which it may be necessary to evaluate Critical Power values outside of the mass flux range specified in Section 8 of Reference 2 of [ ]^{a,c} kg/m^2-s. Examples of circumstances for which we anticipate that CPR evaluation could be required outside of the [ ]^{a,c} kg/m^2-s range are as follows:

1. 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 orificed". The flow to all other assemblies in the core is controlled by less restrictive "loosely orificed" side-entry orifices. We have found for very low core flows and certain plants that the tightly orificed assemblies on the extreme core periphery can experience mass fluxes below [ ]^{a,c} kg/m^2-s. It should be noted that due to core leakage and nuclear design practices which place highly burned assemblies on the core periphery, these assemblies operate at very low powers with very wide margins to CPR limits. [

   ]^{a,c}.

2. The "loosely orificed" assemblies adjacent to those on the core periphery also operate at very low powers 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 orificed" assemblies operating at higher power. For some plants, and under high flow conditions, it is possible that the current high mass flux limit of [ ]^{a,c} kg/m^2-s could be exceeded. These assemblies also operate at relatively low powers which, in conjunction with the high flow rates, experience very wide margins to thermal limits, and [

   ]^{a,c} kg/m^2-s.

3. If the Sub-bundle Model described in Section 5.4.2 of Reference 2 is used to calculate CPR [

   ]^{a,c}. As a consequence of the resulting reduction in two-phase pressure drop, this will cause a higher mass flow which may exceed [ ]^{a,c} kg/m^2-s. Analogous with the

peripheral assembly case described above, when the flow is increased as a result of low power, the margins to CPR limits tend to be very wide.

4. We have concluded that it is possible that assembly mass flux values less than the [ ] [a,c] kg/m^2-s lower limit could be encountered in certain conservative dynamic analyses used in the establishment of CPR limits. [

] [a,c].

Consequently, in an anticipatory mode, Reference 1 requests approval of the extended mass flux range in a manner which assures that CPR is conservatively treated.

NRC RAI 2

Describe safety impact on the reactor operation when operating at high flow and low flow outside approved limits. Provide and justify the method used to determine that high and low flow operation outside approved limits is acceptable and that the method is proper for any BWR applications. Identify the proposed limits to be used up to or beyond approved flow ranges.

Westinghouse Response to RAI 2

As discussed in Reference 1 and the response to RAI 1, the process for monitoring CPR outside of the [ ] [a,c] kg/m^2-s range assures that [

] [a,c].

[

] [a,c].

Therefore, the D4 CPR values described in Reference 1 will not be used to establish the maximum CPR used to establish a ΔCPR during an AOO if this maximum CPR occurs when flow is outside the mass flux values of the [ ] [a,c] kg/m^2-s range. A conservatively high CPR value which will provide a conservatively large change in CPR during the event can be used to establish a ΔCPR during an AOO if the maximum CPR occurs when flow is outside of the [ ] [a,c] kg/m^2-s range.

In summary, the CPR evaluation process described in Reference 1 and clarified in this document systematically treats CPR for normal operation and AOO's outside of the [ ] [a,c] kg/m^2-s range in a manner which assures that OLMCPRs conservatively protect the Safety Limit Minimum CPR (SLMCPR) and that CPR monitoring does not over estimate margins to the OLMCPRs. Consequently, operation at high flow and low flow outside of the mass flux limits provided in Section 8 of Reference 2 ([ ] [a,c] kg/m^2-s) will not have an adverse impact on the safe operation of the reactor.

The process for CPR evaluation below the lower mass flux limit of [ ] [a,c] kg/m^2-s will be applied from [ ] [a,c]. As discussed in Reference 1, the [ ] [a,c].

As noted in Reference 1, CPR has been found to be [ ] [a,c].

Therefore, our experience indicates that application of the CPR established at a mass flux of [ ] [a,c]. However, we do not anticipate the need for SVEA-96 Optima2 CPR evaluation above a mass flux of [ ] [a,c] kg/m^2-s. Therefore, based on the evaluation in Reference 1 and clarified in these RAI's, we intend to adopt a mass flux range of [ ] [a,c] kg/m^2-s for the D4 CPR correlation.

NRC RAI 3

Please show that the critical power predictions obtained with D4 correlation in the low flow region (below the range of D4.1.1 correlation's database) satisfy the thermal margin protection specified in SRP 4.4.

Westinghouse Response to RAI 3

Section II of Reference 4 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 DNB or a transition condition during normal operation and AOO conditions". The transition condition referred to is transition to a film boiling regime. Reference 4 also states that an acceptable approach to meeting this criterion is "The limiting (minimum) value of DNBR, CHFR, or CPR correlations is to be established such that at least 99.9 percent of the fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOO's."

Westinghouse satisfies this requirement for BWR applications with the Safety Limit Minimum Critical Power Ratio (SLMCPR) and AOO evaluation methodologies originally described in Reference 5. As described in Reference 1 and the responses to RAI's 1 and 2 in this document, the D4 CPR correlation systematically treats CPR for normal operation and AOO's outside of the [ ] [a,c] kg/m^2-s range in a manner which assures that OLMCPR's are conservatively established and that margins to the OLMCPR's are not over estimated thereby protecting the SLMCPR. Therefore, the SRP requirement "that at least 99.9 percent of the fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOO's" is satisfied.

NRC RAI 4

Are there any future tests planned to collect information for the proposed low flow and high flow ranges that are outside of approved ranges to justify the validity of the proposed method to extend the approved flow ranges?

Westinghouse Response to RAI 4

It is recognized that further testing is the most desirable method of extending the D4 CPR correlation range to mass fluxes above and below the [ ] ^{a,c} kg/m^2-s range from a purely technical standpoint which deals only with SVEA-96 Optima2. This option would allow the treatment of CPR outside of the [ ] ^{a,c} kg/m^2-s range on a best estimate basis rather than the conservative basis described in this document and in Reference 1. [

] ^{a,c}.

It should be noted that we plan to include increased ranges of controlling parameters, including mass flux, in FRIGG Loop CPR tests in the future. For example, these extended ranges have been incorporated into the SVEA-96 Optima3 FRIGG Loop tests which are currently in progress.

References

1. WCAP-16081-P-A Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications," November 2006.

2. WCAP-16081-P-A, "10×10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," March 2005.

3. OG04-0153-260, "BWROG Plant-Specific Regional Mode DIVOM Procedure Guideline," June 14, 2004.

4. NUREG-0800, U.S. Nuclear Regulatory Commission "Standard Review Plan, Section 4.4 Thermal and Hydraulic Design, Revision 2," March 2007.

5. CENPD-300-P-A, "Reference Safety Report for ABB BWR Fuel," July 1996.

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Section D

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USA

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

Direct tel: (412) 374-4643
Direct fax: (412) 374-4011
e-mail: greshaja@westinghouse.com

Our ref: LTR-NRC-08-12
March 14,2008

Subject: Supplemental Response to NRC Request for Additional Information by the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications " (TAC No. MD3959) (Proprietary/Non-proprietary)

Enclosed are copies of the Proprietary and Non-Proprietary supplements to the prior Westinghouse response to the NRC Request for Additional Information by the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications."

Also enclosed is:

1. One (1) copy of the Application for Withholding, AW-08-2399 (Non-proprietary) with Proprietary Information Notice.
2. One (1) copy of Affidavit (Non-proprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the affidavit or Application for Withholding should reference AW-08-2399 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

Enclosures
cc: A. Mendiola, NRR
P. Clifford, NRR

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

U.S. Nuclear Regulatory Commission
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Washington, DC 20555

Direct tel: 412/374-4643
Direct fax: 412/374-4011
e-mail: greshaja@westinghouse.com

Our ref: AW-08-2399
March 14,2008

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Supplemental Response to NRC Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Proprietary)

Reference: Letter from J. A. Gresham to Document Control Desk, LTR-NRC-08-12, dated March 14,2008

The application for withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-08-2399 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-08-2399 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

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

Cc: A. Mendiola, NRR
J. Thompson, NRR

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse) and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief

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

Sworn to and subscribed
before me this 14th day
of March, 2008.

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Sharon L Markle, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 29, 2011
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(1) I am Manager, Regulatory Compliance and Plant Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse) and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

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Supplemental Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Non-Proprietary)

March 2008

Westinghouse Electric Company
P.O. Box 355
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Supplemental Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Non-Proprietary)

The following is in response to the information requested by NRC reviewer Tai Huang during the February 15, 2008 teleconference on topical report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications."

NRC telecon participants: Jon Thompson and Tai Huang
Westinghouse participants: Bill Harris, Gunilla Norbäck, Mike Riggs, Arnaldo Mingo

This information is intended to supplement the RAI responses provided in letter LTR-NRC-07-47, dated September 13, 2007 (Reference 5).

NRC Request 1 Expand the response to RAI 1 to address the following:

a. Provide more detail about the nature of the Central and Peripheral orifices including the number of each type, their location relative to the fuel, and some description of their physical characteristics.
b. Expand response to RAI 1 to include more detail about how we know we have or will have a problem with the current ranges. Mention our POLCA7 simulations which predict low flow violations on the periphery as well as existing conditions were we exceed the high flow limit.
c. provide a description of the SVEA-96 Optima3 sub-bundle flow communication slots.

Westinghouse Response to Request 1 The following supplements the Westinghouse response to RAI 1 provided in Reference 5:

a. The flow to all assemblies in a U.S. Jet Pump 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 Central Assemblies occupy all core locations not occupied by Peripheral Assemblies. For 724-assembly BWR/3's reactors such as the Dresden and Quad Cities units there are 84 Peripheral Assemblies and 640 Central assemblies. The resistance to flow of the central assemblies is about 18 % of the Peripheral Assembly's flow resistance.

   Since Peripheral Assemblies are located on the core periphery, the neutron leakage is substantially greater than that for the Central Assemblies. Consequently, to optimize neutron efficiency, highly burned assemblies are loaded on the core periphery. Consequently, these assemblies operate at very low powers justifying the reduced flow associated with a high flow resistance at the inlet and allowing greater flow to the potentially limiting assemblies in the core interior.

b. The Westinghouse 3-D Core simulator, POLCA7 used for nuclear design and reload licensing analyses predicts SVEA-96 Optima2 assembly mass fluxes [
   ]^{a,c} during realistic Dresden and Quad Cities steady-state simulations. This expectation concerns future cycles. [
   ]^{a,c} As more and more SVEA-96 Optima2 assemblies are loaded in these

plants and the Legacy fuel is discharged, the SVEA-96 Optima2 population of Peripheral core locations will increase.

Similarly, mass fluxes in SVEA-96 Optima2 assemblies [
]^{a,c} are predicted by POLCA7 simulations for Central Assemblies operating at very low powers. This behavior has, for example, been observed in Central Assemblies adjacent to the interior sides of the core periphery locations and for assemblies adjacent to inserted control rods. It should be noted that margins to thermal limits are very high for these assemblies since they operate at very low powers and, therefore, high relative flow.

c. All SVEA assembly designs (e.g. SVEA-96, SVEA-96+, SVEA-96 Optima, SVEA-96 Optima2, and SVEA-96 Optima3) are equipped with [

]^{a,c}

NRC Request 2 Expand the response to RAI 2 to identify a non-zero lower mass flux limit since it is not physically realistic to reach zero flow.

Westinghouse Response to Request 2 The following text supplements the Westinghouse response to RAI 2 provided in Reference 5:

Our sensitivity studies indicate that the need to evaluate CPR below a mass flux of [

]^{a,c}

NRC Request 3 Expand the response to RAI 3 to add additional text to explain how we assure that SRP 4.4 is satisfied.

Westinghouse Response to Request 3 The following text supplements the Westinghouse response to RAI 3 provided in Reference 5:

Based on the discussions in the responses to RAIs 2 and 3 in Reference 5, assurance of compliance with SRP 4.4 can be summarized as follows:

1. Section II of Reference 3 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 DNB or a transition condition during normal operation and AOO conditions". The transition condition referred to is transition to a film boiling regime. Reference 3 also states that an acceptable approach to meeting this criterion is "The limiting (minimum) value of DNBR, CHFR, or CPR correlations is to be established such that at least 99.9 percent of the fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOO's."

   As discussed in Reference 4, Westinghouse satisfies this requirement by establishing an Operating Limit Minimum Critical Power Ratio (OLMCPR) such that at least 99.9 percent of the fuel rods in the

core will not experience a DNB or boiling transition during normal operation or Anticipated Operating Occurrences (AOO's).

2. The OLMCPR is the sum of the SLMCPR and the maximum change in CPR during any licensing basis AOO. The SLMCPR conservatively demonstrates that at least 99.9 percent of the fuel rods in the core will not experience boiling transition during steady-state operation. Therefore, operation with CPR's greater than the OLMCPR assures that 99.9 percent of the fuel rods in the core will not experience a DNB or boiling transition during normal operation or AOO's.

3. As discussed in the Westinghouse Response to RAI 3 in Reference 5, the D4 CPR correlation was established to systematically under-predict CPR values above [
]^{a,c} This will assure that margins to the OLMCPR will be conservatively under-estimated above [

]^{a,c}

NRC Request 4 Expand the response to RAI 4 to include high mass flux and low mass flux SVEA-96 Optima3 data outside of the currently approved SVEA-96 Optima2 range to justify conservatism of proposed treatment of SVEA-96 Optima2 CPR in the expanded mass flux range.

Westinghouse Response to NRC Request 4 The following text supplements the Westinghouse response to RAI 4 provided in Reference 5:

At the time the response to RAI 4 was issued, the SVEA-96 Optima3 FRIGG loop CPR tests were still in progress. They are now completed, and the resulting trends outside of the current upper and lower flow limits in Reference 1 can be seen in Figure 1 and 2 below. [
]^{a,c}

In the figures, XT, XB and XC identify the top-peaked, bottom-peaked, and cosine-shaped axial power Optima3 measurements respectively. The notation RAx, RHx, and RFx denote different relative radial assembly power distributions.

The low flow results for SVEA-96 Optima3 in Figure 1 confirm that it is conservative to [
]^{a,c}. The high flow results in Figure 2 confirm the general trend cited in Reference 2 that critical power is a monotonically increasing function of flow and justify the conclusion that [
]^{a,c}

References

1. WCAP-16081-P-A, "10×10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," March 2005.

2. WCAP-16081-P-A Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications," November 2006.

3. NUREG-0800, U.S. Nuclear Regulatory Commission "Standard Review Plan, Section 4.4 Thermal and Hydraulic Design, Revision 2," March 2007.

4. CENPD-300-P-A, "Reference Safety Report for ABB BWR Fuel," July 1996.

5. Westinghouse LTR-NRC-07-47, "Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications"," September 13, 2007.

Figures

[a,b,c]

Figure 1 SVEA-96 Optima3 flow series with minimum flow below 320 kg/m^2-s

[a,b,c]

Figure 2 SVEA-96 Optima3 flow series with maximum flow exceeding 2040 kg/m^2-s

Section E

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Our ref: LTR-NRC-08-32
June 24, 2008

Subject: Second Supplemental Response to NRC Request for Additional Information by the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications " (TAC No. MD3959) (Proprietary/Non-proprietary)

Enclosed are copies of the Proprietary and Non-Proprietary supplements to the prior Westinghouse response to the NRC Request for Additional Information by the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications."

Also enclosed is:

1. One (1) copy of the Application for Withholding, AW-08-2450 (Non-proprietary) with Proprietary Information Notice.
2. One (1) copy of Affidavit (Non-proprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the affidavit or Application for Withholding should reference AW-08-2450 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

R. M. Gresham /for

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

Enclosures
cc: A. Mendiola, NRR
Jon Thompson, NRR
George Bacuta, NRR

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Our ref: AW-08-2450
June 24, 2008

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Second Supplemental Response to NRC Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Proprietary)

Reference: Letter from J. A. Gresham to Document Control Desk, LTR-NRC-08-32, dated June 24, 2008

The application for withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-08-2450 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-08-2450 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

R. M. Gresham/for

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

Cc: A. Mendiola, NRR
J. Thompson, NRR

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared T. Rodack, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse) and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

T. Rodack, Director

Quality Licensing Programs

Sworn to and subscribed
before me this 25th day
of June, 2008.

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Sharon L. Markle, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Jan. 29, 2011
Member, Pennsylvania Association of Notaries

(1). I am Director, Quality Licensing Programs, in Nuclear Fuel, Westinghouse Electric Company LLC (Westinghouse) and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked "Second Supplemental Response to NRC Request for Additional Information By the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, 'SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications' (TAC No. MD3959) (Proprietary)," for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-08-32) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is that associated with the supplemental response to NRC Request for Additional Information for WCAP-16081-P-A Addendum 1.

This information is part of that which will enable Westinghouse to:

(a) Obtain generic NRC licensed approval for the SVEA-96 Optima2 CPR Correlation (D4): High & Low Flow Applications.

(b) Assist customers in improving their fuel performance (zero defects).

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to continue to implement improvements to ensure the highest quality of fuel and analyses in order to meet the customer needs.

(b) Assist customers to obtain license changes.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for developing the enclosed improved core thermal performance methodology.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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Second Supplemental Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation For Topical Report WCAP-16081-P-A Addendum 1, "SVEA-96 OPTIMA2 CPR Correlation (D4): High & Low Flow Applications" (TAC No. MD3959) (Non-Proprietary)

June 2008

Westinghouse Electric Company
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Second Supplemental Response to NRC Request for Additional information by the Office Of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, WCAP-16081, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications" in a telephone call on April 2, 2001 {*sic. April 2, 2008*}

The following is a response containing the information requested by NRC reviewer Tai Huang during the April 2, 2008 and June 2, 2008 teleconferences regarding topical report WCAP-16081, Addendum 1, SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications.

NRC telecon participants: John Thompson, Tai Huang
Westinghouse participants: George Roberts, Gunilla Norback, Mike Riggs, Bill Harris, Tom Rodack (6/2/08 call only)
This information is intended to supplement the RAI responses provided in LTR-NRC-07-47 and LTR-NRC-08-12 (References 3 and 4).

Background:
Reference 1 describes the D4.1.1 CPR correlation for SVEA-96 Optima2 fuel and provides justification for the correlation based on a large FRIGG Loop Critical Power data base for SVEA-96 Optima2. Reference 1 identified upper and lower mass flux limits for the D4 CPR correlation of [ ]^{a,c}, respectively. Reference 1 was reviewed and accepted by the NRC as described in Reference 1.

Reference 2 described, justified, and requested NRC acceptance of the process by which Westinghouse intends to conservatively estimate SVEA-96 Optima2 CPR values for which the mass flux is outside of the data base range of [ ]^{a,c}.

Reference 3 is a response to the NRC's request for information in addition to that provided in References 1 and 2 further justifying the conservative process Westinghouse intends to use for calculating CPR outside of the mass flux range from [ ]^{a,c}. RAI 2 of Reference 3 identified the Westinghouse intention to adopt an expanded mass flux range of [ ]^{a,c} for the D4 CPR correlation.

Reference 4 is a supplemental response to information requested by the NRC during the February 15, 2008, teleconference regarding References 2 and 3. NRC Request 2 of Reference 3 requested that Westinghouse provide a non-zero lower mass flux limit based on the conclusion that it is not physically realistic to reach zero flow. Westinghouse responded with the intention to adopt a low mass flux limit of [ ]^{a,c} and noted that the D4 correlation prediction below [ ]^{a,c} becomes increasingly conservative as mass flux is reduced.

In April 2, 2008 and June 2, 2008 teleconferences, the NRC requested further information regarding the range of conditions outside of the currently approved range of [ ]^{a,c}.
The NRC request can be summarized as follows:

NRC Request 1: Please provide the results of POLCA calculations indicating the range of mass fluxes expected during steady-state operation and Anticipated Operational Occurrences.

NRC Request 2: Please provide the D4.1.1 CPR predictions for the cases discussed in Request 1.

NRC Request 3: Are there any more SVEA-96 Optima3 Critical Power data in the low mass flux region in addition to that shown in the Westinghouse Response to NRC Request 4 in Reference 4 which can be used to support operation at low mass fluxes?

NRC Request 4: Please address the impact of adopting a D4 mass flux range within the SVEA-96 Optima3 mass flux test data range of [ ]^{a,c}.

Westinghouse Response to Request 1:

A systematic evaluation of the mass flux range for which CPR evaluation might be required was performed based on Westinghouse core simulator (POLCA7) calculations on the periphery of Dresden and Quad Cities conditions. Conclusions regarding the conservative extrapolation process for CPR evaluation for mass flux values outside of the D4 data base based on Dresden and Quad Cities described herein as well as in References 1 through 4 are applicable to other U.S. BWRs as well.

This evaluation was performed for a Quad Cities 2 equilibrium SVEA-96 Optima2 core. Specifically, calculations were performed for the following cases:

1. Possibly limiting conditions on the boundary of the composite Dresden/Quad Cities Power-to-Flow map for anticipated operation are shown in Figure 1. Specifically, Points B, C, D, E, and G were considered. In addition, a point at 10 % power and 30 % flow simulating start-up on the Two-pump Minimum Pump speed trajectory in Figure 1 was considered.

2. While commercial reactors are not operated in the natural circulation condition, two limiting points on the natural circulation trajectory in Figure 1 were evaluated: Specifically, the point labeled "A" in Figure 1 and a point at 22 % power and 20 % flow were considered. It is judged that these points indicate a conservative bound on conditions at which low mass fluxes could be encountered.

3. The Recirculation Flow Run-Up (RFRU) Anticipated Operational Occurrence (AOO) can be evaluated with steady-state methods using POLCA7. Therefore, operation at a typical initial condition of 50 % power and 40 % flow as well as two final conditions simulating the final state of a non-pressurization RFRU transient (RFRU-nonpressurize) at 110 % power and 110 % flow and a bounding pressurization final state at 125 % power and 110 % flow (RFRU-pressurize) were considered.

4. While U.S. commercial BWR's can not be critical without at least one recirculation pump operating, startup in Single Loop Operation (SLO) is generally acceptable. For example, start-up in the SLO mode is permitted for the Dresden and Quad Cities plants. 25 % core power is the threshold for requiring CPR monitoring in U.S. BWRs in general including Dresden and Quad Cities. It is estimated that the minimum SLO core flow at this power would be about 29 %. Consequently, a case at 25 % core power and 29 % core flow was evaluated.

The results are summarized in Table 1. The following conclusions are based on the results in Table 1.

1. Low mass flux values (< [ ]^{a,c}) typically, but not always, occur in tightly-orificed peripheral assemblies. The data in Table 1 indicate a lowest mass flux of [ ]^{a,c} for operating conditions for the SLO startup up point in Table 1. However, the very bounding points on the Natural Circulation (NC) line in Figure 1 indicate that very low mass fluxes are possible. While these two NC cases are unrealistic, these sensitivity studies indicate that mass flux points somewhat lower than [ ]^{a,c} might occur for allowed conditions. Therefore, [ ]^{a,c} is considered to be a prudent choice, and was recommended in Reference 4 for the low mass flux limit line.

2. High mass flux values (> [ ]^{a,c}) typically occur in the sub-bundle immediately adjacent to the control rod in a fully or highly controlled assembly. As shown in Table 1,

exceeding the D4 upper mass flux limit of [ ]^{a,c} can occur for steady-state points at and near rated conditions and approach the [ ]^{a,c} range in the final condition of the RFRU pressurization AOO. Therefore, an upper limit greater than or equal to [ ]^{a,c} would be a prudent choice for the high mass flux limit.

Westinghouse Response to Request 2:

D4 CPR predictions for each of the SVEA-96 Optima2 minimum and maximum mass flows in Table 1 are provided in Table 1. Table 1 also shows the core Minimum Critical Power Ratio (MCPR) for each case for comparison. A comparison of the CPR in the minimum or maximum mass flux assembly with the core MCPR demonstrates that, even with the conservative CPR treatment outside of the [ ]^{a,c} range by the D4 CPR correlation discussed in References 2, 3, and 4, the margin to CPR limits is relatively large for the assemblies above and below the data base range of [ ]^{a,c}.

Westinghouse Response to Request 3:

Westinghouse does not have additional SVEA-96 Optima3 Critical Power FRIGG Loop data below [ ]^{a,c} which can be used to help justify a D4 mass flux limit below [ ]^{a,c}.

Westinghouse Response to Request 4:

The proposed D4 mass flux upper limit of [ ]^{a,c} specified in response to RAI question #2 (Ref. 3) is below the mass flux of the SVEA-96 Optima3 data base range of [ ]^{a,c}, and would be acceptable provided that mass fluxes above [ ]^{a,c} would be conservatively evaluated using a mass flux of [ ]^{a,c}. [ ]^{a,c} is the upper mass flux limit of the D4 Critical Power measurements. This is consistent with Reference 2, which established that D4 CPR evaluations for all mass flux values above [ ]^{a,c} would be performed using a mass flux of value of [ ]^{a,c}.

Increasing the D4 lower mass flux range minimum value from [ ]^{a,c}, which was proposed in the supplemental response provided in Reference 4, to [ ]^{a,c} would increase the probability of a D4 CPR mass flux range violation during plant operation. Therefore, an acceptable method for conservatively calculating critical power below [ ]^{a,c} is needed. In order to address NRC concerns about the lack of measured data for mass flux below [ ]^{a,c}, it is proposed that [

]^{a,c}, be used to conservatively calculate Critical Power for mass velocity below [ ]^{a,c}. [ ]^{a,c}

Conclusion

[ ]^{a,c} will be adopted for the SVEA-96 Optima2 D4 CPR correlation with the following conditions:

1. [

]^{a,c}

2. [

]^{a,c}

a,c

Figure 1 [ ]^{a,c} and [ ]^{a,c} Composite Power-to-Flow Map

a,c

[ ]

References

1 WCAP-16081-P-A, "10×10 SVEA Fuel Critical Power Experiments and CPR Correlation: SVEA-96 Optima2," March 2005.
2 WCAP-16081, Addendum 1, SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications, November 2006.
3 LTR-NRC-07-47, Response to NRC's Request for Additional Information By the Office of Nuclear Reactor Regulation for Topical Report WCAP-16081-P-A Addendum 1, SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications, 9/13/2007.
4 LTR-NRC-08-12, Supplemental Response to NRC Request for Additional Information by the Office of Nuclear Reactor Regulation for Topical Report WCAP-16081, Addendum 1, "SVEA-96 Optima2 CPR Correlation (D4): High and Low Flow Applications", March 14, 2008.
5 N.Zuber, M. Tribus, J.W. Westwater, The Hydrodynamic Crises in Pool Boiling of Saturated and Subcooled Liquids, International Developments in Heat Transfer Part II, 1961, pg. 230-236.
6 P. Griffith, K.T. Avedisian, J.F. Walkush, Countercurrent Flow Critical Heat Flux, National Heat Transfer Conference San Francisco, Aug. 1975.
7 WCAP-16081, Addendum 2, SVEA-96 Optima2 CPR Correlation (D4): Modified R-factors for Part-Length Rods, July 2007.

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