Westinghouse

Westinghouse Electric Co., LLC
2000 Day Hill Road
Windsor, CT 06095

LTR-ESI-02-030
February 8, 2002

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

Subject: **Improved Application of Westinghouse Boiling Length CPR Correlations (Contains Proprietary Information)**

Reference:
1. CENPD-392-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlations: SVEA-96, September 2000.
2. CENPD-389-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlations: SVEA-96+, September 1999.
3. Telecommunication, J. Cushing (NRC) to W. Harris (WEC), November 7, 2001.

References 1 and 2 describe the ABBD1.0 and ABBD2.0 Critical Power Ratio (CPR) correlations used for Westinghouse SVEA-96 and SVEA-96+ (BWR) fuel. The purpose of this letter is to document improvements in the application of these correlations to ensure conservative CPR predictions for double-peaked axial power distributions and to improve the treatment of CPR predictions for the four sub-bundles in a SVEA (or water cross) assembly.

Westinghouse will implement the sub-bundle model described in Enclosure 2 for predicting CPR in all future SVEA fuel applications involving core supervision and to support licensing analyses. Implementing this model does not change the approved ABBD1.0 and ABBD2.0 CPR correlations described in References 1 and 2. Therefore, this information on the manner in which the CPR correlations are applied is provided solely in response to an NRC request, Reference 3; formal staff review and approval is not requested. A non-proprietary version of this information is provided in Enclosure 3.

The information contained in Enclosure 2 has been determined by Westinghouse to be proprietary in nature. It is requested that this information be withheld from public disclosure in accordance with the provisions of 10 CFR 2.790 and be appropriately safeguarded. The reasons for the classification of this information as proprietary are delineated in the attached affidavit, Enclosure 1.

Please feel free to contact Virgil Paggen of my staff at 860-731-6287 or me if you have any questions.

Sincerely,

Philip W. Richardson
Licensing Project Manager

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Enclosure: As Stated
cc: A. C. Attard (OWFN, 8E-23)
J. S. Cushing (OWFN, 4D-7)

Enclosure 1

Proprietary Affidavit

I, Philip W. Richardson, depose and say that I am the Licensing Project Manager of Westinghouse Electric Company LLC (WEC), duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and described below.

I am submitting this affidavit in conformance with the provisions of 10 CFR 2.790 of the Commission's regulations for withholding this information. I have personal knowledge of the criteria and procedures utilized by WEC in designating information as a trade secret, privileged, or as confidential commercial or financial information.

The information for which proprietary treatment is sought, and which documents have been appropriately designated as proprietary, is contained in the following:

- *Improved Application of Westinghouse Boiling-Length CPR Correlations, Enclosure 2 to letter LTR-ESI-02-030, dated February 8, 2002*

Pursuant to the provisions of Section 2.790(b)(4) of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information included in the documents listed above should be withheld from public disclosure.

1. The information sought to be withheld from public disclosure is owned and has been held in confidence by WEC. It consists of details of the methodology for predicting Critical Power Ratios.
2. The information consists of analyses or other similar data concerning a process, method or component, the application of which results in substantial competitive advantage to WEC.
3. The information is of a type customarily held in confidence by WEC and not customarily disclosed to the public.
4. The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.790 with the understanding that it is to be received in confidence by the Commission.
5. The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements that provide for maintenance of the information in confidence.
6. Public disclosure of the information is likely to cause substantial harm to the competitive position of WEC because:
   a. A similar product or service is provided by major competitors of Westinghouse.
   b. WEC has invested substantial funds and engineering resources in the development of this information. A competitor would have to undergo similar expense in generating equivalent information.
   c. The information consists of methodology and application of critical power ratio correlations to Westinghouse SVEA-type BWR fuel, the use of which provides a competitive economic advantage. The availability of such information to competitors

would enable them to design their product or service to better compete with WEC, take marketing or other actions to improve their product's position or impair the position of WEC's product, and avoid developing similar technical analysis in support of their processes, methods or apparatus.

d. Significant research, development, engineering, analytical, manufacturing, licensing, quality assurance and other costs and expenses must be included in pricing WEC's products and services. The ability of WEC's competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

e. Use of the information by competitors in the international marketplace would increase their ability to market comparable products or services by reducing the costs associated with their technology development. In addition, disclosure would have an adverse economic impact on WEC's potential for obtaining or maintaining foreign licenses.

Philip W. Richardson
Licensing Project Manager
Westinghouse Electric Company LLC

Sworn to before me this
8th day of February 2002

Carol L. Veilleux
Notary Public

CAROL L. VEILLEUX
NOTARY PUBLIC
My commission expires: MY COMMISSION EXPIRES AUG. 31, 2006

Enclosure 3

Improved Application of Westinghouse Boiling-Length CPR Correlations

[Contains Non-Proprietary Information]

1.0 Introduction

The ABBD1.0 and ABBD2.0 Critical Power Ratio (CPR) correlations, References 1 and 2, are used in the USA for SVEA-96 and SVEA-96+ fuel CPR determinations for core supervision and licensing analyses. These critical-quality/boiling-length CPR correlations are based on top-peaked, bottom-peaked, and cosine shaped axial power distributions. Derivation of these CPR correlations is based primarily on 24-rod sub-bundle measurements. The method for applying these CPR correlations to a full assembly is also discussed in References 1 and 2 and involves correction of the sub-bundle results by an analytical function of relative sub-bundle power referred to in this document as the "mismatch factor."

Recent critical power measurements for a single heated rod in a heated annulus conducted at the Royal Institute of Technology (KTH) in Stockholm, Sweden indicated that the Westinghouse boiling length CPR correlations may over-predict the assembly CPR for certain types of axial power distributions generally characterized as double-peaked shapes. Westinghouse has carefully reviewed this KTH data and developed a method of conservatively correcting the predictions of the ABBD1.0/2.0 Boiling Length CPR correlations for this type of axial power distribution to avoid CPR over-predictions.

Recent experience with high energy cycles with relatively large feed fuel batches has demonstrated that the mismatch factor approach described in References 1 and 2 can lead to underestimates in CPR that are sufficient to cause relatively highly-controlled assemblies to be predicted to be limiting. To account for this, Westinghouse will improve the manner in which CPR calculated as described in References 1 and 2 is applied to SVEA-96 and SVEA-96+ assemblies. This improvement represents a more exact calculation of CPR for SVEA-type assemblies, which more accurately treats the sub-bundle configuration of the assembly.

2.0 Axial Power Shape Correction Factor

The ABBD1.0 and ABBD2.0 CPR correlations documented in References 1 and 2 are based on top-peaked, bottom-peaked, and cosine shaped axial power distributions. These correlations are based upon and exhibit a very good fit to the extensive FRIGG Loop database. Experience to date has confirmed that these correlations accurately capture the databases from which they were derived. The assumption implicit in basing the CPR correlation on these axial power shapes is that intermediate power shapes and combinations of these shapes will be adequately captured provided that the cosine, top-peaked, and bottom-peaked shapes are captured. Current BWR industry practice is to base critical power tests on these three axial power shapes. However, the recent KTH test data indicates that the ABBD1.0/2.0 correlations may over-predict the CPR for double-peaked axial power shapes.

The postulate that the Westinghouse boiling length CPR correlations may over-predict the assembly CPR for double-peaked axial power shapes is based on critical power measurements for a single heated rod in a heated annulus conducted recently at the Royal Institute of Technology (KTH) in Stockholm, Sweden. A description of some of these KTH measurements is provided in Reference 3. The tests described in Reference 3 involved an annular geometry consisting of one heated central test rod within a concentric heated outer tube. The benefit of this relatively simple KTH geometry is that it facilitates testing of a relatively broad spectrum of axial power shapes. However, the tube data upon which the information is based may not represent the CPR performance of the current SVEA-type Westinghouse BWR fuel assemblies, since the annular test configuration is believed to be more conducive to dryout than are fuel rods in the SVEA-96/96+ assembly geometry.

While the KTH geometry is not entirely representative of the SVEA-96/96+ geometry, the possibility exists that the non-conservative trends implied by the tube data could occur for SVEA-96/96+ fuel designs. Accordingly, detailed comparisons of the ABBD1.0/2.0 CPR predictions with the trends in the KTH database were performed to establish a means to correct the CPR predictions to accommodate the KTH trends. The result was a correction factor which avoids non-conservative predictions when compared with the KTH data while still predicting the relative CPR performance of the FRIGG Loop top-peaked, bottom-peaked, and cosine shaped axial power distributions. The correction factor is applied to the CPR predicted by ABBD1.0/2.0 for SVEA-type fuel.

3.0 Sub-bundle CPR Calculation Model for SVEA Fuel

A special consideration in calculating the R-factor for the SVEA-type assemblies has to do with the fact that the SVEA-96 assembly consists of four sub-channels separated by a water cross with flow communication slots between the sub-channels along the channel length. Since the CPR correlation is applied to full 96-rod SVEA-type assemblies in design and licensing applications as well as for CPR monitoring in the plant Core Monitoring System, the impact on critical power caused by a mismatch in the power between the sub-bundles and the flow mismatch caused by this power mismatch must be taken into account. As described in References 1 and 2, this power mismatch is currently accounted for in the boiling length-critical quality CPR correlations for SVEA-type fuel by an adjustment to the CPR calculation by a factor referred to as the "mismatch factor."

A further consideration is that the mismatch factor approach is more acceptable when applied to relatively small reload fuel batches since inserting fresh fuel adjacent to control blades can more easily be avoided. Recent industry trends toward more efficient operation with higher energy cycles have increased the probability of control rod insertion adjacent to relative fresh assemblies. Furthermore, an important source of double-peaked axial power distributions is the partial insertion of a control rod. Consequently, the combination of the conservative double-peaked axial power shape correction and the mismatch factor can lead to CPR under-prediction and significantly increase the probability that highly controlled assemblies will be predicted to be limiting. Therefore, the incentive to adopt the more accurate sub-bundle model for CPR evaluation of SVEA-type fuel is more important today than in the past.

Accordingly, Westinghouse has developed an improved method of accommodating sub-bundle power mismatch in the treatment the sub-bundles in SVEA-type fuel. The improved method is referred to as the "sub-bundle model." The more exact sub-bundle model approach of calculating the CPR eliminates the need for the mismatch factor.

Furthermore, CPR evaluation of SVEA-type fuel using the sub-bundle model is performed in a manner which can be supported by three dimensional core simulators typically used in U.S. plant core supervision systems.

4.0 Licensing Applications

Although the annular tube configuration upon which the KTH test information is based does not represent the configuration of SVEA-type Westinghouse BWR fuel assemblies, Westinghouse has found that CPR calculated by ABBD1.0/2.0 with the improved sub-bundle models and corrected for double-peaked axial power distributions encompasses conservatively both the FRIGG loop and the KTH data. The ABBD1.0 and ABBD2.0 CPR correlations will continue to be calculated as described in References 1 and 2, however, the CPR calculation will be performed in a more precise manner with the improved sub-bundle model and the resulting CPR will be corrected by a conservative multiplier to assure that the CPR predicted for double-peaked type axial power shapes is not over-estimated. Westinghouse believes that these improvements in the manner in which the ABBD1.0/2.0 correlations are applied ensure that margins to dryout will be conservatively predicted.

5.0 References

1. CENPD-392-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlations: SVEA-96, September 2000.

2. CENPD-389-P-A, 10x10 SVEA Fuel Critical Power Experiments and CPR Correlations: SVEA-96+, September 1999.

3. Paper presented at the Second Japanese-European Two-Phase Flow Group Meeting, University of Tsukuba, Japan, "Loop Studies Simulating - in Annular Geometry - the influence of the Axial Power Distribution and the number of Spacers on Dryout in 8x8 BWR Assemblies, 25-29 September, 2000.