

WCAP-15306-NP-A  
Addendum 1-A  
Revision 0

August 2004

# **Addendum 1 to WCAP-15306-NP-A Qualification of ABB Critical Heat Flux Correlations with VIPRE-01 Code**



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Westinghouse Non-Proprietary Class 3

WCAP-15306-NP-A

Addendum 1-A

**Addendum 1 to WCAP-15306-NP-A**  
**Qualification of ABB Critical Heat Flux Correlations**  
**with VIPRE-01 Code**

Original Version: May 2003  
Approved Version: August 2004

Prepared by:

W. H. Slagle

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**Section A**

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

April 14, 2004

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

**SUBJECT: FINAL SAFETY EVALUATION FOR WCAP-14565-P-A, ADDENDUM 1, AND  
WCAP-15306-NP-A, ADDENDUM 1, "QUALIFICATION OF ABB CRITICAL HEAT  
FLUX CORRELATION WITH VIPRE-01 CODE" (TAC NO. MB9509)**

Dear Mr. Gresham:

By letter dated June 4, 2003, the Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-14565-P-A, Addendum 1 and WCAP-15306-NP-A, Addendum 1, "Qualification of ABB Critical Heat Flux Correlations with VIPRE-01 Code," to the staff for review. On March 23, 2004, an NRC draft safety evaluation (SE) regarding our approval of the TR was provided for your review and comments. By e-mail dated April 5, 2004, Westinghouse agreed with the content of the SE.

The staff has found that the TR is acceptable for referencing as an approved methodology in plant licensing applications. The enclosed SE documents the staff's evaluation of Westinghouse's justification for the improved methodology.

Our acceptance applies only to the 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.

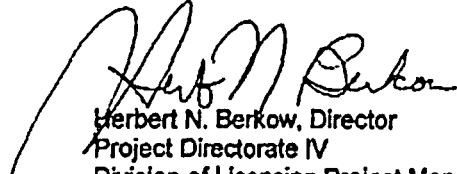
In accordance with the guidance provided on the NRC's TR website, we request that Westinghouse publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE between the title page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

J. Gresham

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If the NRC's criteria or regulations change so that its conclusions in this letter, that the TR is acceptable, is invalidated, Westinghouse and/or the licensees referencing the TR will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

Sincerely,

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

Project No. 700

Enclosure: Safety Evaluation

cc w/encl:  
Mr. Gordon Bischoff, Project Manager  
Westinghouse Owners Group  
Westinghouse Electric Company  
Mail Stop ECE 5-16  
P.O. Box 355  
Pittsburgh, PA 15230-0355



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-14565-P-A, ADDENDUM 1, AND WCAP-15306-NP-A,

ADDENDUM 1, "QUALIFICATION OF ABB CRITICAL HEAT FLUX

CORRELATION WITH VIPRE-01 CODE"

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION

By letter dated June 4, 2003, Westinghouse Electric Company LLC (Westinghouse) submitted topical reports (TRs) WCAP-14565-P, Addendum 1, and WCAP-15306-NP, Addendum 1, "Qualification of ABB Critical Heat Flux Correlations with VIPRE-01 Code," to the NRC for review and approval. The objective of this addendum to the approved TRs was to provide the information and data necessary to license the VIPRE-01 code incorporating the ABB critical heat flux (CHF) correlations (ABB-NV and ABB-TV) that have been previously licensed in CENPD-387-P-A for use with the TORC thermal-hydraulic code (CENPD-206-P-A). Thus, the ABB critical heat flux correlations are not new, but are being incorporated into the approved VIPRE-01 code with the same 95/95 correlation limit as licensed in TORC. The VIPRE-01 code was licensed by the NRC with the Westinghouse correlations WRB-1 and WRB-2. In WCAP-15025-P-A, the WRB-2M correlation was licensed and incorporated into VIPRE-01. The addition of the ABB CHF correlations into VIPRE-01 falls under the guidelines of Generic Letter (GL) 83-11, Supplement 1, "Licensee Qualification for Performing Safety Analyses," since neither the form of the correlation nor the 95/95 correlation limit are being changed.

2.0 REGULATORY EVALUATION

Section 34 of Title 10 of the Code of Federal Regulations (CFR) Chapter 50, "Contents of Applications; Technical Information," requires that Safety Analysis Reports be submitted that analyze the design and performance of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. As part of the core reload design process, licensees (or vendors) perform reload safety evaluations to ensure that their safety analyses remain bounding for the design cycle. To confirm that the analyses remain bounding, licensees confirm that key inputs to the safety analyses (such as the CHF) are conservative with respect to the current design cycle. If key safety analysis parameters are not bounded, a re-analysis or a reevaluation of the affected transients or accidents is performed to ensure that the applicable acceptance criteria are satisfied.

There are no specific regulatory requirements for the review of TR revisions, supplements, or addendums. Guidance for TR reviews is provided in NRR Office Instruction LIC-500,

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"Processing Requests for Reviews of Topical Reports" and in LIC-101, "License Amendment Review Process." The staff's review was based on the evaluation of the technical merit of the submittal and compliance with any applicable regulations associated with the TRs.

### 3.0 TECHNICAL EVALUATION

VIPRE-01 is a subchannel thermal-hydraulic computer code developed by Battelle Pacific Northwest Laboratories (PNL) under the sponsorship of the Electric Power Research Institute (EPRI). The basic computational model of VIPRE-01 comes from the PNL COBRA-IIIC code.

VIPRE-01 is typically used to describe the reactor core of a nuclear power plant in order to evaluate the thermal-hydraulic safety margin. The code requires that users enter the boundary conditions describing the coolant entering the core, the power generation, and the dimensional and material properties of the nuclear fuel. The boundary conditions for the coolant entering the core include either the inlet flow rate, enthalpy and pressure, or the pressure, inlet enthalpy and differential pressure from which the inlet flow rate can be derived. The core power generation input includes spatial as well as temporal variations. The code input is versatile and flexible, providing the user with numerous options. These include choices among correlations for heat and mass transfer that are built into the code. Multiple channels can be described and cross flow is calculated based on user supplied input.

The VIPRE-01 code was initially submitted for NRC staff review by the Utility Group for Regulatory Applications (UGRA) and was accepted for referencing in license applications to the extent specified and under the limitations delineated in the safety evaluation.

#### 3.1 Use of VIPRE-01 by Westinghouse

Westinghouse intends to use the VIPRE-01 code as a replacement for the TORC code for departure from nucleate boiling (DNB) analyses of the Combustion Engineering (CE) pressurized-water reactor (PWR) fuels using the current NRC-approved methodology. The ABB CHF correlations will be used with the VIPRE-01 code for calculating the DNB ratio (DNBR), similar to the current applications with the TORC code. The DNB analyses include defining safety limits that provide the basis for reactor protection system setpoints and predicting minimum DNBR in non-LOCA transient analyses.

Westinghouse will apply the VIPRE-01 code with the ABB CHF correlations under the following conditions consistent with the requirements in the CENPD-387-P safety evaluation:

1. The 95/95 DNBR limits of the ABB-NV and ABB-TV correlations are not lower than the current NRC-approved limit of 1.13 for the CE-PWR fuels.
2. The ABB-NV and ABB-TV correlations are used with the VIPRE-01 code, in addition to the TORC and CETOP-D codes currently used for CE-PWRs. This addendum demonstrates the VIPRE-01 equivalency to TORC for DNBR calculations.
3. The ABB-NV and ABB-TV correlations are used with the optimized  $F_c$  shape factor to account for the effects of non-uniform axial power shapes.

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4. The current range of applicability for the ABB-NV and ABB-TV correlations as shown in Table 2-1 of the TR remains applicable.
5. The ABB-NV and ABB-TV correlations are used only for CE-PWR fuel designs with NRC-approved methodology for PWR safety analysis.
6. Technology transfer is accomplished through a process that meets the guidance of GL 83-11, Supplement 1.

The events analyzed using VIPRE-01 will be the same as those presently analyzed using the TORC code, which have been approved by the NRC staff. The TORC code performs thermal-hydraulic calculations within the fuel channels, including DNBR evaluation at the fuel pin surface. For calculations in which transient heat conduction within the fuel pins is important, this calculation is performed by other codes.

### 3.2 VIPRE-01 Models

#### 3.2.1 Modeling the ABB-NV and ABB-TV Correlations

Westinghouse performed VIPRE-01 calculations with the entire ABB-NV and ABB-TV experimental databases, consisting of test data for the correlation development and validation. Similar to the TORC code, VIPRE-01 was used for predicting local fluid condition at each axial node in each subchannel of a CHF test section. Local mass velocity and local quality are inputs to the ABB-NV and ABB-TV correlations for a CHF calculation. A VIPRE-01 model for each correlation was prepared in the same way as originally prepared in the TORC model for each test section based on the geometry and power distribution of the rod bundle. Representative VIPRE-01 geometric models for the CE 14x14 and 16x16 fuel designs are presented in the TR. The VIPRE-01 turbulent mixing correlation is the same as that performed by the TORC correlation model.

The VIPRE-01 two-phase flow and crossflow correlations are kept the same as that for Westinghouse PWR applications in WCAP-14565-P-A. The VIPRE-01 versus TORC modeling results are summarized in tabular form in the TR. The VIPRE-01 calculations used the same measured values of pressure, inlet temperature, bundle average mass velocity and bundle average heat flux from the CHF tests as those used in the TORC calculations. The VIPRE/ABB-NV and VIPRE/ABB-TV results for both entire databases are listed in Appendix A and Appendix B, respectively of WCAP-14565-P-A.

#### 3.2.2 Comparison of VIPRE-01 Results with TORC Results

The accuracy of CHF predictions is measured as the ratio of the measured CHF to the predicted CHF (M/P). Comparison results provided in the TR show mean and standard deviations of VIPRE/ABB-NV and VIPRE/ABB-TV M/P values for each test section for each of the points in the correlation database, the validation database, and the entire database, as compared to the TORC/ABB-NV and TORC/ABB-TV results. The VIPRE-01 based M/P value for each data point was determined at the same location in the hot subchannel as the TORC-based value in the TR. The comparisons show that the VIPRE/ABB-NV and VIPRE/ABB-TV M/P results are in good agreement with the original TORC values. A plot of

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measured CHF versus VIPRE/ABB-NV and VIPRE/ABB-TV predicted CHF results are also included in the TR. Plotted results show no particular bias in the CHF predictions for either the VIPRE/ABB-NV or the VIPRE/ABB-TV M/P for pressure, local mass velocity and local quality.

The number of VIPRE/ABB-NV data points within the correlation range for several test sections is slightly different from the TORC-based database due to differences in local fluid conditions predicted by the two codes. The overall VIPRE/ABB-NV database contained 718 data points, including an additional three data points that are within the applicable range of the ABB-NV correlation, as compared to 715 data points in the TORC/ABB-NV database. On the other hand, the overall VIPRE/ABB-TV database contained the same number of data points, 296, as the TORC/ABB-TV database in the applicable range of the ABB-TV correlation. The statistical tests described in Section 6.0 of the TR were applied to both VIPRE/ABB-NV and VIPRE/ABB-TV databases to determine the 95/95 DNBR limit for application of the ABB-NV and ABB-TV correlations with the VIPRE-01 code.

Based upon this analysis, the current 95/95 DNBR limit of 1.13 remains unchanged for both ABB-NV and ABB-TV application with the VIPRE-01 code. The overall M/P is slightly higher for the VIPRE/ABB-NV compared to the TORC/ABB-NV, resulting in an improvement in CHF performance. However, the standard deviation is slightly higher. The difference in the M/P statistics has a negligible impact on the 95/95 DNBR limit. The M/P CHF ratio corresponding to the 1.13 DNBR limit is 0.885 for both ABB-NV and ABB-TV correlations. For the entire VIPRE/ABB-NV database only nineteen data points fall below the value of 0.885, similar to the number of data points (18) in the TORC/ABB-NV database below the limiting value. Similarly, for the entire VIPRE/ABB-TV database, only 5 data points fall below the value of 0.885, the same as the number of data points in the TORC/ABB-TV database below the limiting value. These similar comparisons of the number of points below the limiting M/P value provides additional technical basis for using the same 95/95 DNBR limit of 1.13.

#### 4.0 CONDITIONS AND LIMITATIONS

The NRC-approved ABB CHF correlations were developed based on the TORC code. The Westinghouse VIPRE-01 code and model have been approved by the NRC for PWR licensing applications. Coupling the ABB correlations with the VIPRE-01 code does not result in any change to the current NRC-approved methodology. This addendum demonstrates that VIPRE-01 is equivalent to TORC for ABB-NV and ABB-TV DNBR calculations under the following conditions:

1. Addendum 1 to the WCAP-14565-P-A VIPRE-01 model must remain consistent with that for the DNB data analysis described in WCAP-14565-P-A VIPRE-01;
2. The current 95/95 DNBR limit of 1.13 remains unchanged; and
3. DNBR calculations for CE-PWR fuels are within the current applicable range defined in Table 2-1 of the TR.

As such, the NRC staff finds the application of the ABB correlations within the VIPRE-01 code to be acceptable.

5.0 CONCLUSION

Based on the foregoing considerations, the NRC staff concludes that the implementation of the ABB-NV and ABB-TV correlations into the VIPRE-01 code as described in WCAP-14565-P-A, Addendum 1, and WCAP-15306-NP-A, Addendum 1, is acceptable for licensing calculations and may be used to replace the TORC computer code in the Westinghouse-approved refueling methodology.

Principal Contributor: A. Attard

Date: April 14, 2004

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Section B

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Nuclear Services  
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e-mail: sepl1ha@westinghouse.com

Attention: J. S. Wermiel, Chief  
Reactor Systems Branch  
Division of Systems Safety and Analysis

Our ref: LTR-NRC-03-25

June 4, 2003

Subject: Submittal of WCAP-14565-P-A, Addendum 1 / WCAP-15306-NP-A, Addendum 1, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code," for NRC Review and Approval (Proprietary/Non-proprietary)

Dear Mr. Wermiel:

Enclosed are copies of WCAP-14565-P-A, Addendum 1 / WCAP-15306-NP-A, Addendum 1, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code," submitted to NRC for Review and Approval (Proprietary/Non-proprietary). It is requested that the above topical be approved by May 2004, in support of the St. Lucie Unit 2 Transition to WCAP-9272-P-A Reload Methodology for Cycle 15. It is also requested that the NRC provide an estimate on the man-power resources required for the review.

The ABB Critical Heat Flux (CHF) Correlations (ABB-NV and ABB-TV) have been previously licensed in CENPD-387-P-A for use with the TORC thermal-hydraulic code (CENPD-206-P-A). Thus, the ABB Critical Heat Flux Correlations are not new, but are being incorporated into VIPRE-01 (WCAP-14565-P-A) with the same 95/95 correlation limit as licensed in TORC. The VIPRE-01 code was licensed by the NRC with the Westinghouse Correlations WRB-1 and WRB-2. In WCAP-15025-P-A, the WRB-2M correlation was licensed and incorporated into VIPRE-01. The addition of the ABB CHF Correlations into VIPRE-01 falls under the guidelines of Generic Letter 83-11, Supplement 1 since neither the form of the correlation nor the 95/95 correlation limit are being changed.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-03-1655 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit, AW-03-1655.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.17(a)(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Page 2 of 2  
LTR-NRC-03-25  
June 4, 2003

Correspondence with respect to this Application for Withholding should reference AW-03-1655 and should be addressed to H. A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,



Henry A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

Enclosure

Copy to:  
F. Akstulewicz, NRR  
D. Holland, NRR  
U. Shoop, NRR  
S. L. Wu, NRR



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Attention: J. S. Wermiel, Chief  
Reactor Systems Branch  
Division of Systems Safety and Analysis

Our ref: AW-03-1655

June 4, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY  
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Submittal of WCAP-14565-P-A, Addendum 1 / WCAP-15306-NP-A, Addendum 1, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code," for NRC Review and Approval (Proprietary/Non-proprietary)

Reference: Letter from H. A. Sepp to J. S. Wermiel, LTR-NRC-03-25, dated June 4, 2003

Dear Mr. Wermiel:

The application for withholding is submitted by Westinghouse Electric Company LLC, a Delaware limited liability company ("Westinghouse"), pursuant to the provisions of paragraph (b)(1) of Section 2.790 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 2.790, Affidavit AW-03-1655 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 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-03-1655 and should be addressed to the undersigned.

Very truly yours,

A handwritten signature in cursive script, appearing to read 'H. A. Sepp'.

Henry A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

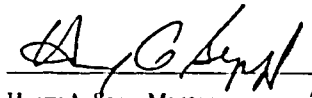
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COMMONWEALTH OF PENNSYLVANIA:

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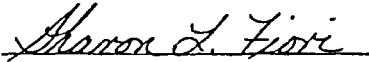
COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared Henry A. Sepp, 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, a Delaware limited liability company ("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.

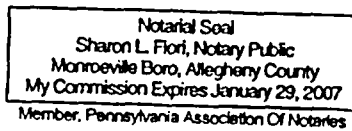
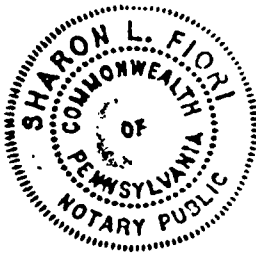


Henry A. Sepp, Manager  
Regulatory Compliance and Plant Licensing

Sworn to and subscribed  
before me this 4th day  
of June, 2003.



Notary Public



- (1) I am Manager, Regulatory Compliance and Plant Licensing, in the Nuclear Services, of the Westinghouse Electric Company LLC, a Delaware limited liability company ("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 the Westinghouse Electric Company.
- (2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 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 the Westinghouse Electric Company 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 2.790 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 2.790, 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, "Submittal of WCAP-14565-P-A, Addendum 1 / WCAP-15306-NP-A, Addendum 1, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code," for NRC Review and Approval (Proprietary/Non-proprietary)", June 4, 2003, for submittal to the Commission, being transmitted by Westinghouse Electric Company (W) letter (LTR-NRC-03-25) and Application for Withholding Proprietary Information from Public Disclosure, Henry A. Sepp, Westinghouse, Manager Regulatory Compliance and Plant Licensing to the attention of J. S. Wermiel, Chief, Reactor Systems Branch, Division of Systems Safety and Analysis. The proprietary information as submitted by Westinghouse Electric Company is that associated with a request for NRC review and approval.

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

- (a) Obtain generic NRC licensed approval for the use of VIPRE-01 with ABB-NV Critical Heat Flux Correlation for CE-PWR 14x14 and 16x16 fuels with non-mixing vane grids and ABB-TV Critical Heat Flux Correlation for CE-PWR 14x14 Turbo fuel with mixing vane grids.
- (b) This addition of the ABB-NV and ABB-TV Critical Heat Flux Correlations to VIPRE-01 will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

- (a) Westinghouse can use modeling 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.

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Further the deponent sayeth not.

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**Addendum 1 to WCAP-15306-NP-A**

**Qualification of ABB Critical Heat Flux Correlations with VIPRE-01 Code**

**1.0 Introduction**

ABB Critical Heat Flux (CHF) correlations (Ref. 1) were developed for 14x14 and 16x16 fuels of Pressurized Water Reactors (PWR) designed by the former Combustion Engineering (CE). The ABB-NV correlation is for CE-PWR 14x14 and 16x16 fuels with non-mixing vane grids, and ABB-TV is for the 14x14 Turbo fuel with mixing vane grids. The correlations were developed based on CHF data obtained from the Heat Transfer Research Facility of Columbia University. A CHF correlation is also commonly referred to as a Departure from Nucleate Boiling (DNB) correlation in PWR safety analyses.

Westinghouse VIPRE-01 (VIPRE) modeling and qualification for PWR non-LOCA thermal-hydraulic (T/H) safety analysis are described in WCAP-15306-NP-A (Ref. 2). Westinghouse has installed ABB-NV and ABB-TV CHF correlations into its version of the VIPRE code. The correlation coding addition does not alter the fundamental VIPRE computational methods and functional capabilities. In the Safety Evaluation Reports (SER) on the VIPRE code (Ref. 3, 4) and Westinghouse VIPRE model (Ref. 5), the NRC staff required additional justification on the use of a new CHF correlation not currently included in the VIPRE code. The SER on the ABB CHF correlations (Ref. 6) also states that a submittal is required for use of ABB-NV and ABB-TV with a computer code other than TORC.

This addendum provides justification on use of the ABB CHF correlations with the VIPRE code in compliance with the SER conditions (Ref. 3, 4, 5). It is organized into six sections. Section 2 describes intended applications of the VIPRE code with the ABB CHF correlations. Section 3 provides a description of VIPRE modeling of the ABB-NV database and comparison of VIPRE results with the original TORC values. A similar description on VIPRE modeling of the ABB-TV database and comparisons between VIPRE and TORC is provided in Section 4. Conclusions and references are presented in succeeding sections.

## 2.0 Intended Applications

Westinghouse intends to use the VIPRE code in replacement of the TORC code for DNB analyses of the CE-PWR fuels using the current NRC-approved methodology. The ABB CHF correlations will be used with the VIPRE code for calculating DNB Ratio (DNBR) similar to the current applications with the TORC code. The DNB analyses include defining safety limits that provide the basis for reactor protection system setpoints and predicting minimum DNBR in non-LOCA transient analyses. Westinghouse will apply the VIPRE code with the ABB CHF correlations under the following conditions consistent with the requirements in the SER (Ref. 6):

1. The 95/95 DNBR limits of the ABB-NV and ABB-TV correlations are not lower than the current NRC-approved limit of 1.13 for the CE-PWR fuels.
2. The ABB-NV and ABB-TV correlations are used with the VIPRE code, in addition to the TORC and CETOP-D codes currently used for CE-PWR. This addendum demonstrates VIPRE equivalency to TORC for DNBR calculations.
3. The ABB-NV and ABB-TV correlations are used with the optimized  $F_C$  shape factor (Ref. 1) to account for effects of non-uniform axial power shapes.
4. The current range of applicability for the ABB-NV and ABB-TV correlations as shown in Table 2-1 remains applicable.
5. The ABB-NV and ABB-TV correlations are used only for CE-PWR fuel designs with NRC-approved methodology for PWR safety analysis.
6. Technology transfer is accomplished through a process that meets the requirements specified in Generic Letter (GL) 83-11 Supplement 1, "Licensee Qualification for Performing Safety Analyses" (Ref. 7).

**Table 2-1**  
**Applicable Range of ABB CHF Correlations**

<b>Parameter</b>	<b>ABB-NV Range</b>	<b>ABB-TV Range</b>
Pressure (psia)	1750 to 2415	1500 to 2415
Local Mass Velocity (Mlbm/hr-ft <sup>2</sup> )	0.8 to 3.16	0.9 to 3.40
Local Quality (Fraction)	-0.14 to 0.22	-0.10 to 0.225
Heated Length, Inlet to CHF Location (in)	48 to 150	48 to 136.7
Grid Spacing (in)	8 to 18.86	8 to 18.86
Heated Hydraulic Diameter Ratio, $\Delta h_m/\Delta h$	0.679 to 1.08	0.679 to 1.00

### 3.0 Qualification of ABB-NV Correlation

#### 3.1 ABB-NV Database

The ABB-NV database used for the correlation development consists of approximately 530 CHF data points from twelve test sections in a 5x5 array simulating CE 14x14 and 16x16 fuel designs with non-mixing vane grids. The ABB-NV validation database consists of approximately 190 data points from additional four test sections. The test sections cover a range of heated lengths from 48 to 150 inches with different grid spacings, with uniform and non-uniform axial power shapes, with and without guide thimble tubes. The geometric characteristic of each test section is summarized in Table 3-1. A more detailed description of the test sections can be found in Reference 1.

#### 3.2 ABB-NV Correlation

The ABB-NV correlation is based on a linear relationship between CHF and local quality. The correlation includes the following variables: pressure, local mass velocity, local equilibrium quality, distance from grid to CHF location, heated length from inlet to CHF location, and heated hydraulic diameter of the subchannel. Special geometry terms are used in the correlation to correct CHF calculations for grid, heated length, heated diameter (cold wall effect) and guide tube effects. A modified Tong factor is applied to the ABB-NV CHF predictions to account for effects of non-uniform axial power distribution. The ABB-NV correlation has been used with the TORC code (Ref. 8) for CE-PWR licensing applications. The NRC-approved DNBR limit is 1.13 (Ref. 1) at a 95% probability and a 95% confidence level (95/95). A more detailed description of the ABB-NV correlation can be found in Reference 1.

#### 3.3 VIPRE Model

VIPRE calculations were performed with the entire ABB-NV database consisting of test data for the correlation development and validation. Similar to the TORC code, VIPRE was used for predicting local fluid condition at each axial node in each subchannel of a CHF test section. Local mass velocity and local quality are input to ABB-NV for a CHF calculation. A VIPRE model was prepared in the same way as the TORC model for each test section based on the geometry and power distribution of the rod bundle. Representative VIPRE geometric models for the 14x14 and 16x16 fuel designs are shown in Figures 3-1 through 3-4. The VIPRE turbulent mixing correlation is the same as the TORC correlation:





Based upon this analysis, the current 95/95 DNBR limit of 1.13 remains unchanged for ABB-NV application with the VIPRE code based on small differences observed in overall statistics given in Table 3-3. The overall M/P is slightly higher for VIPRE/ABB-NV compared to TORC/ABB-NV resulting in an improvement in CHF performance; however the standard deviation is slightly higher. The difference in the M/P statistics has a negligible impact on the 95/95 DNBR limit. The M/P CHF ratio corresponding to the 1.13 DNBR limit is 0.885. For the entire VIPRE/ABB-NV database only nineteen data points fall below the value of 0.885, similar to the number of data points (eighteen) in the TORC/ABB-NV database below the limiting value. The similar comparison of the number of points below the limiting M/P value provides further support for using the same 95/95 DNBR limit.

**Table 3-1**  
**Geometric Characteristics of ABB-NV Correlation and Validation Tests**

Test No.	Bundle Array	Rod Diameter (in.)	Rod Pitch (in.)	Heated Length (in.)	Grid Spacing (in.)	Guide Tube	GT Diameter (in.)	Axial Shape	Grid/Type	Grid Material
<b>Correlation Data</b>										
<b>Validation Data</b>										

a, b, c

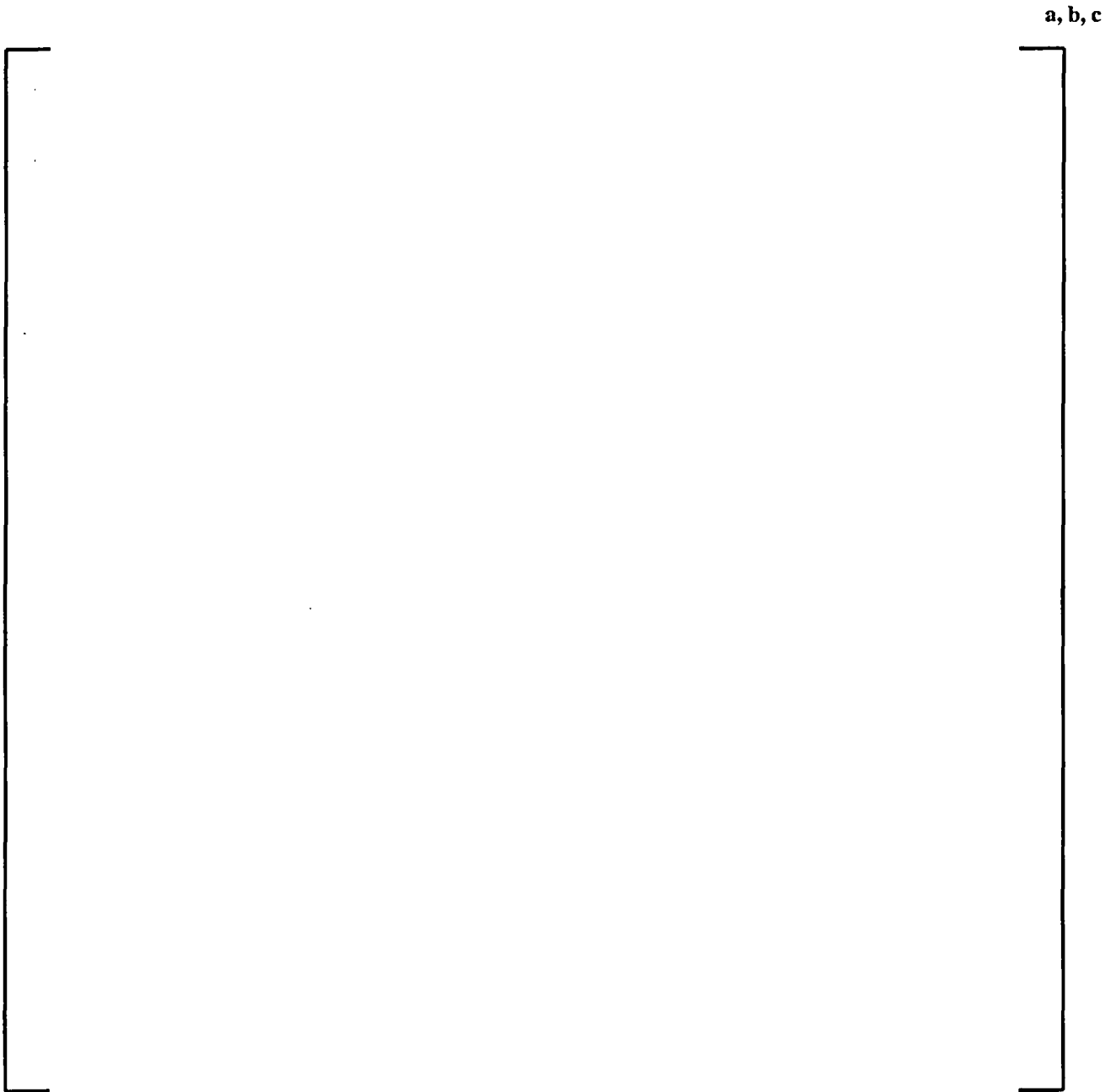
a, b, c

Table 3-2

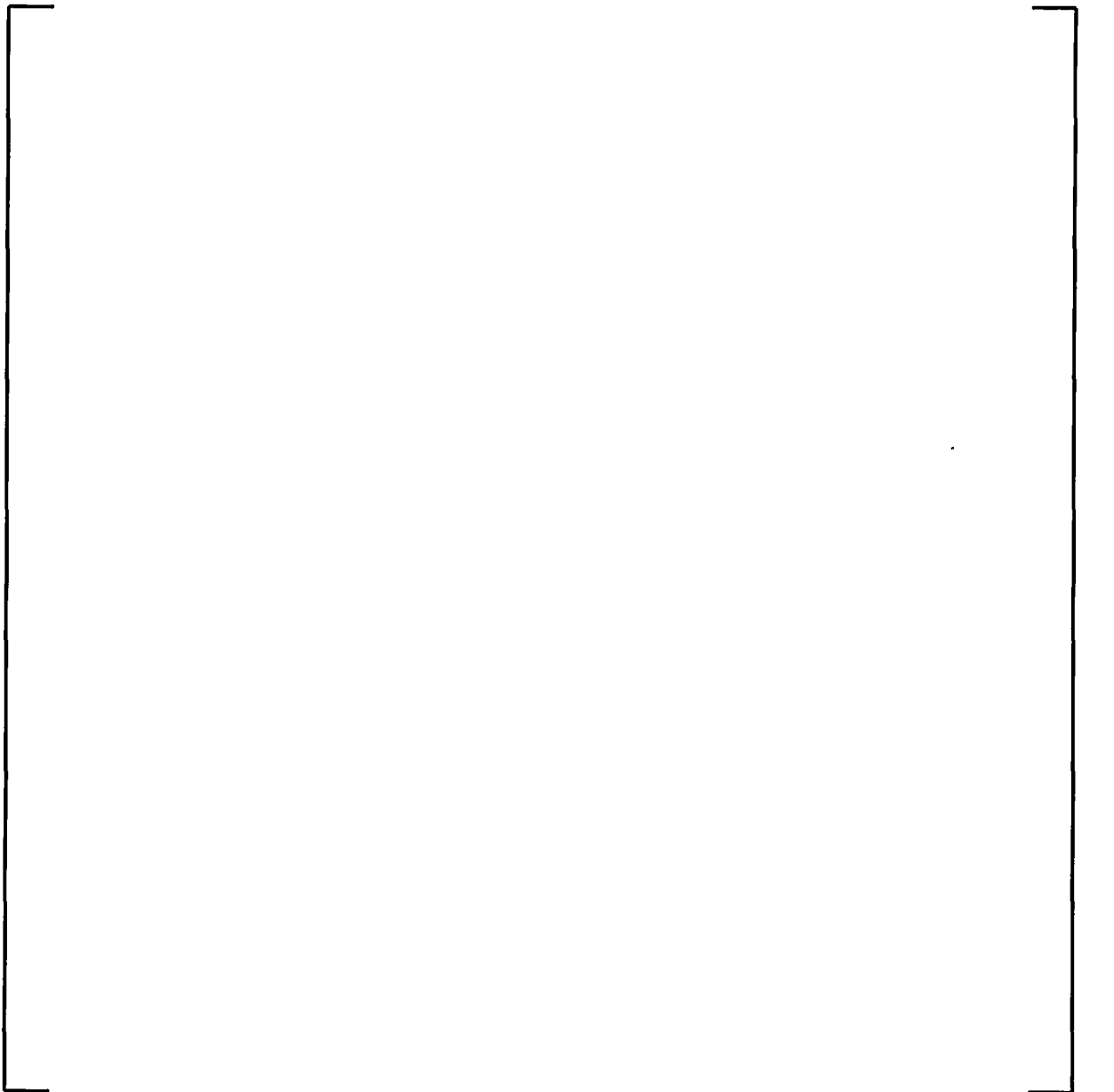
Summary of VIPRE Model with ABB-NV in Comparison with TORC Model

Input Parameter	VIPRE	TORC (Ref. 1)
Radial Channels	Fig. 3-1 through 3-4	Fig. 3-1 through 3-4
Number of Axial Nodes	[ ] <sup>a, b, c</sup> for HL = 48" [ ] <sup>a, b, c</sup> for HL = 84" [ ] <sup>a, b, c</sup> for HL = 150"	[ ] <sup>a, b, c</sup> for HL < 150" [ ] <sup>a, b, c</sup> for HL = 150"
[ ] <sup>a, c</sup> for Turbulent Mixing	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Turbulent Momentum Factor	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Axial Friction Factor, f	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Crossflow Momentum Parameter	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Crossflow Resistance Factor, K	[ ] <sup>a, b, c</sup> [ ] <sup>a, b, c</sup> [ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Average Grid Loss Coefficient, K	[ ] <sup>a, b, c</sup> [ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup> [ ] <sup>a, b, c</sup>
Two-Phase Flow	[ ] <sup>a, c</sup>	[ ] <sup>a, c</sup>
Two-Phase Flow Friction Multiplier	[ ] <sup>a, c</sup>	[ ] <sup>a, c</sup>

**Figure 3-1**  
**Typical Radial Geometry, ABB-NV Test**  
**for 21 Rods, 14x14 Geometry**



**Figure 3-2**  
**Typical Radial Geometry, ABB-NV Test**  
**for 25 Rods, 14x14 Geometry**



**Figure 3-3**  
**Typical Radial Geometry, ABB-NV Test**  
**for 21 Rods, 16x16 Geometry**

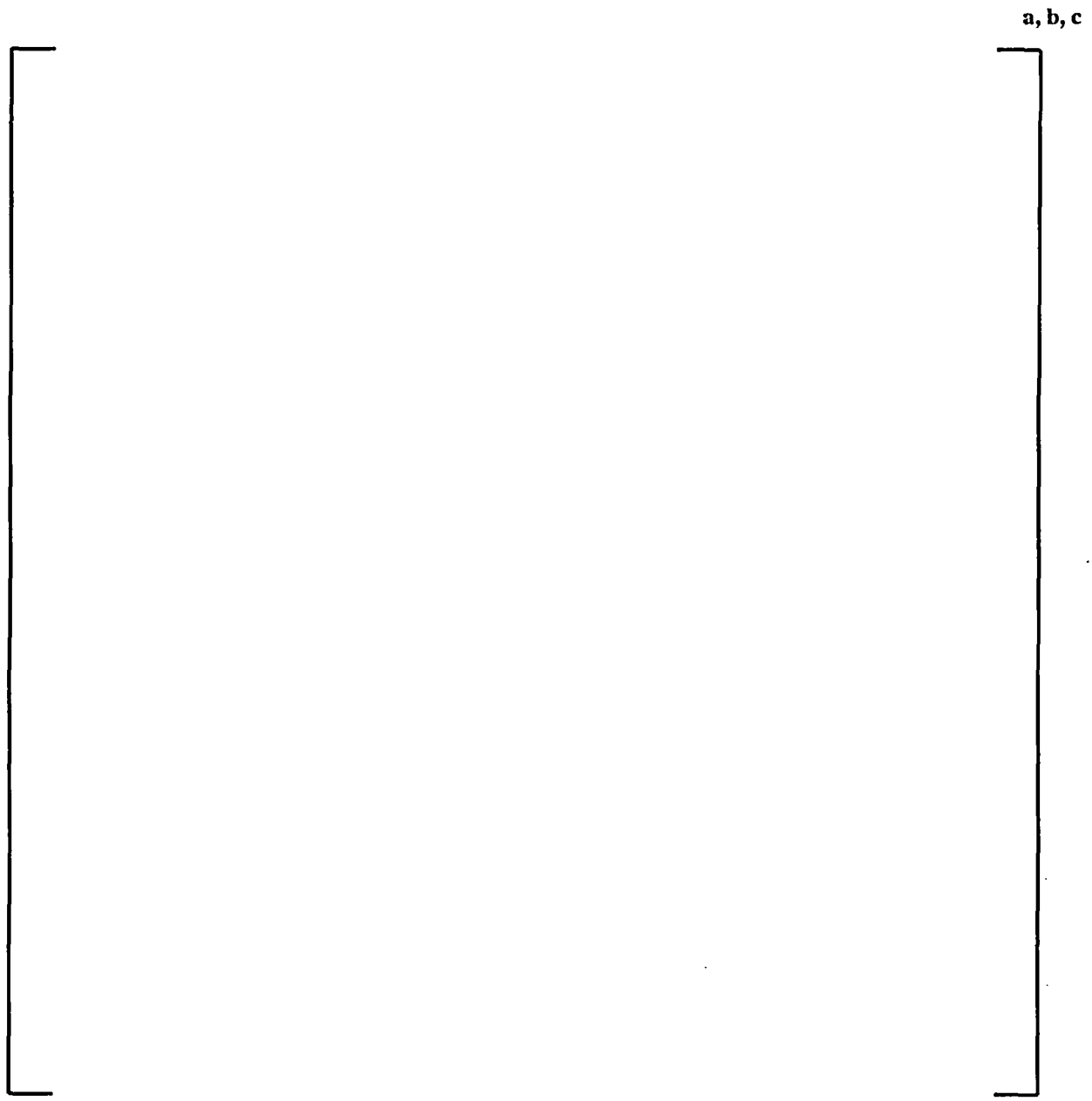


Figure 3-4  
Typical Radial Geometry, ABB-NV Test  
for 25 Rods, 16x16 Geometry

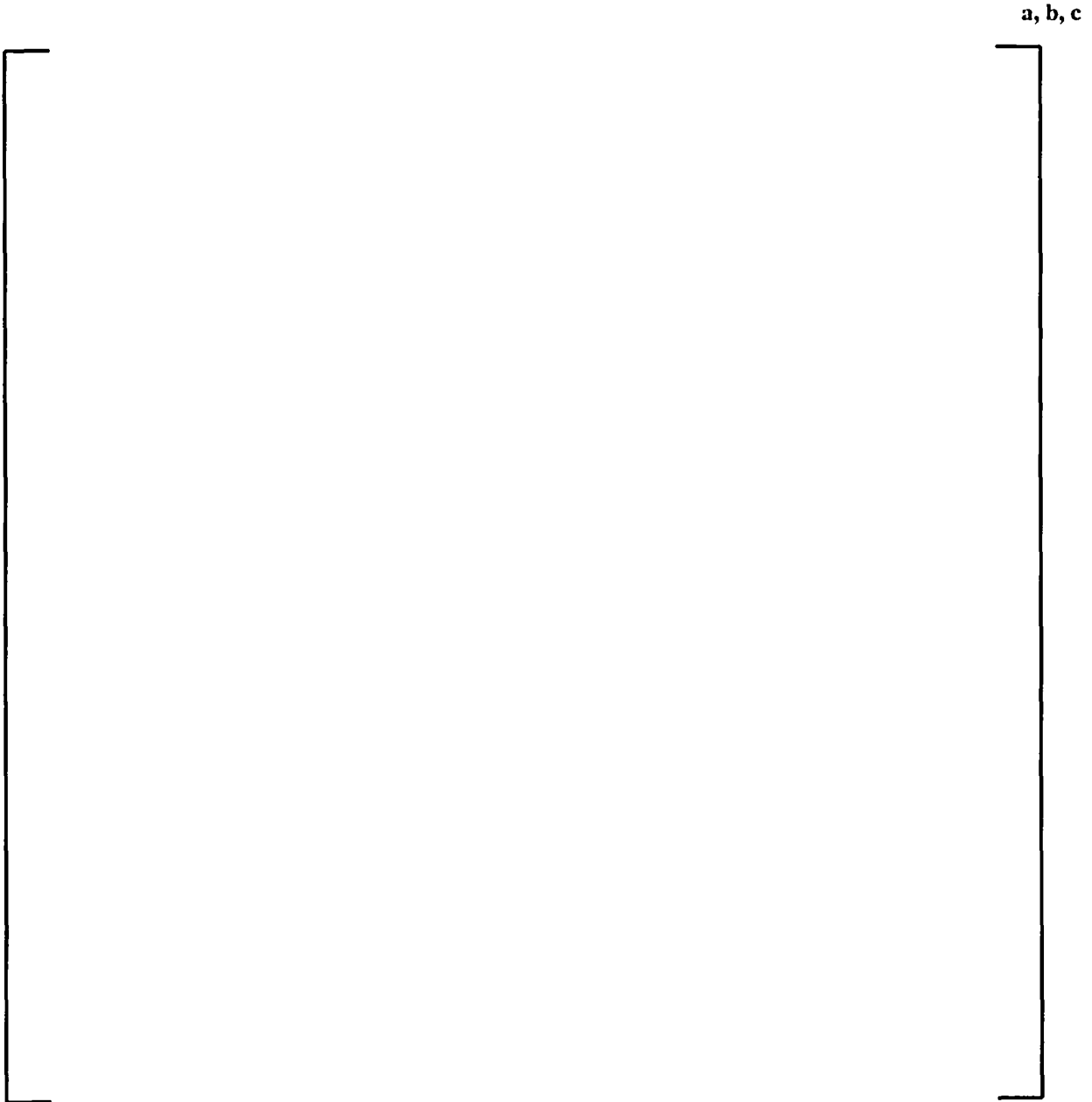




Table 3-3  
VIPRE and TORC M/P Comparison for ABB-NV Database

Test Number	VIPRE/ABB-NV			TORC/ABB-NV (Ref.1)			a, b, c
	N	M/P Mean	Std. Dev.	N	M/P Mean	Std. Dev.	
							a, b, c
Entire Database	718	1.0105	0.0650	715	1.0044	0.0603	a, b, c
							a, b, c

<sup>1</sup> Similar to the TORC database (Ref.1), [  
] a, b, c

Figure 3-5  
Measured CHF vs. VIPRE/ABB-NV Predicted CHF

Measured and Predicted CHF for the ABB-NV Correlation  
Based on VIPRE Code

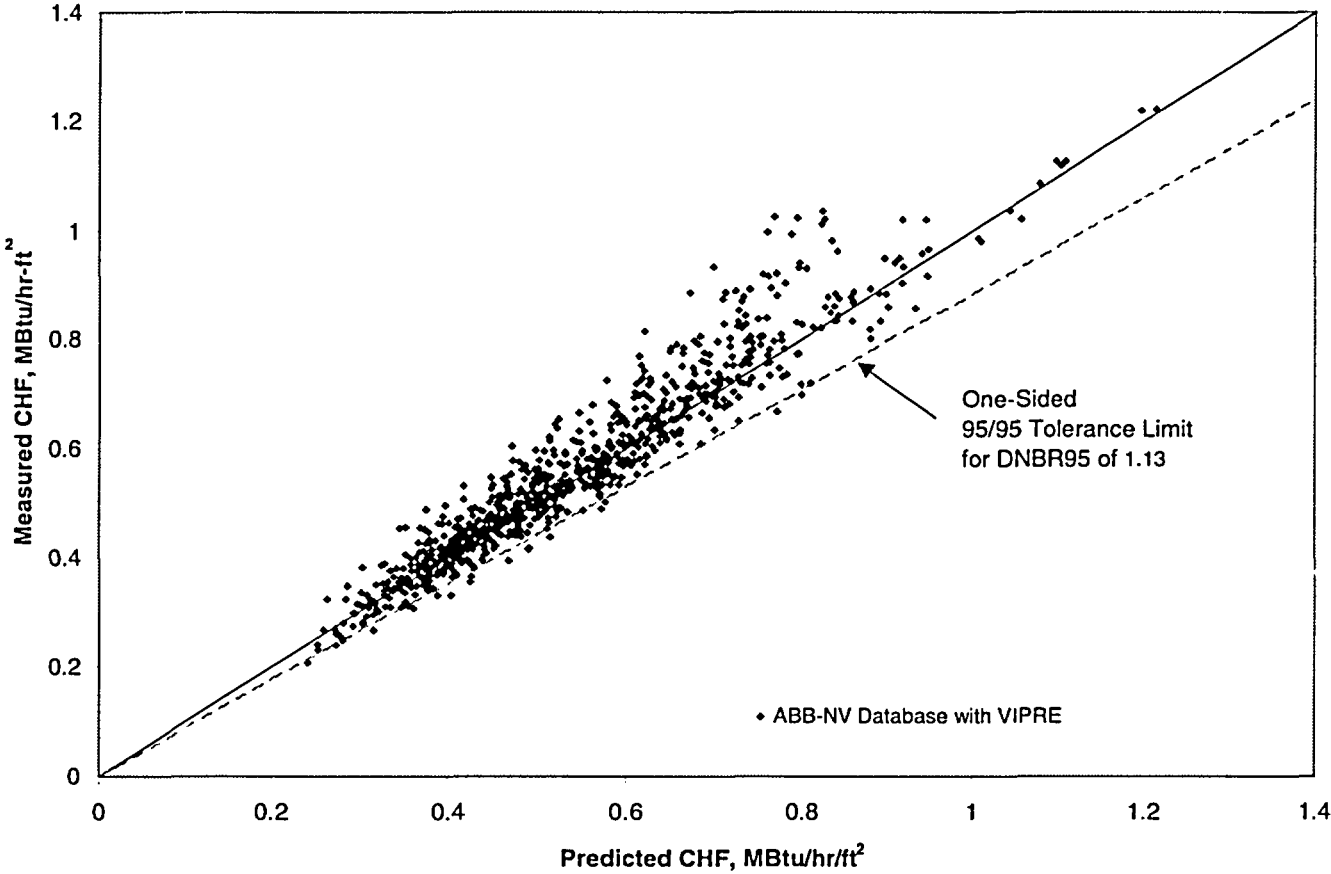


Figure 3-6  
VIPRE/ABB-NV M/P vs. Pressure

Variation of the Ratio of Measured and Predicted CHF with Pressure  
for the ABB-NV Correlation Using VIPRE Code

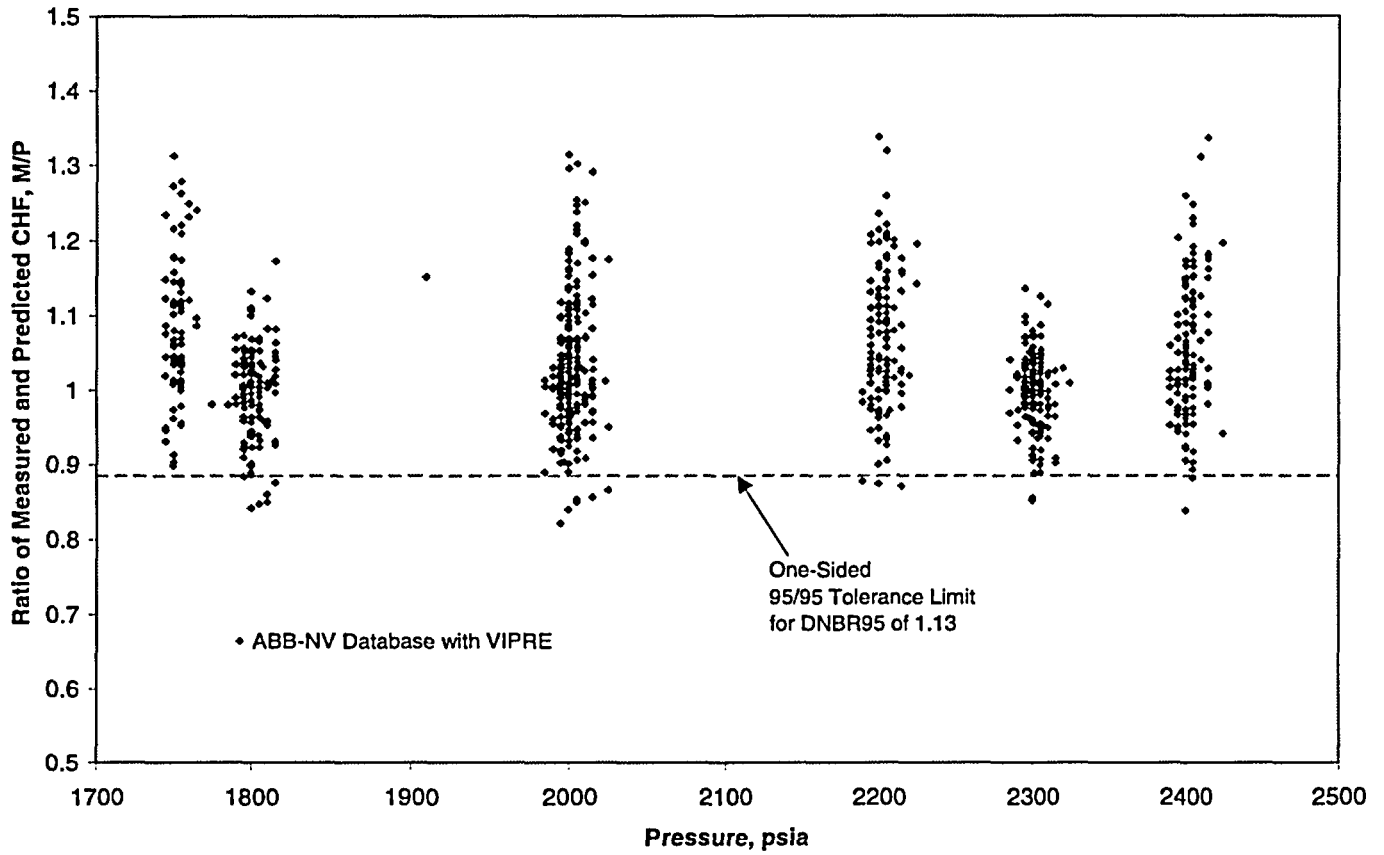


Figure 3-7  
VIPRE/ABB-NV M/P vs. Local Mass Velocity

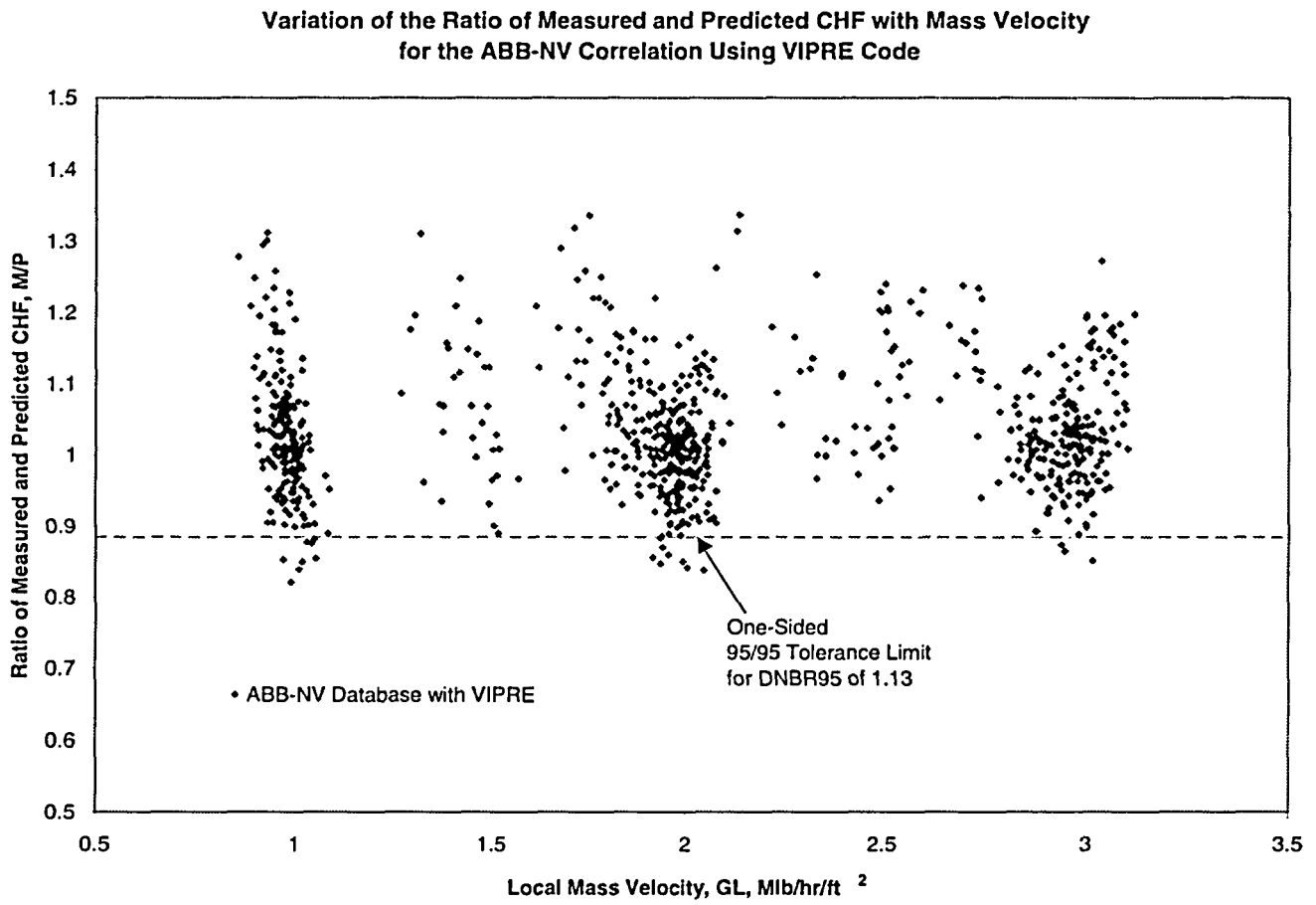
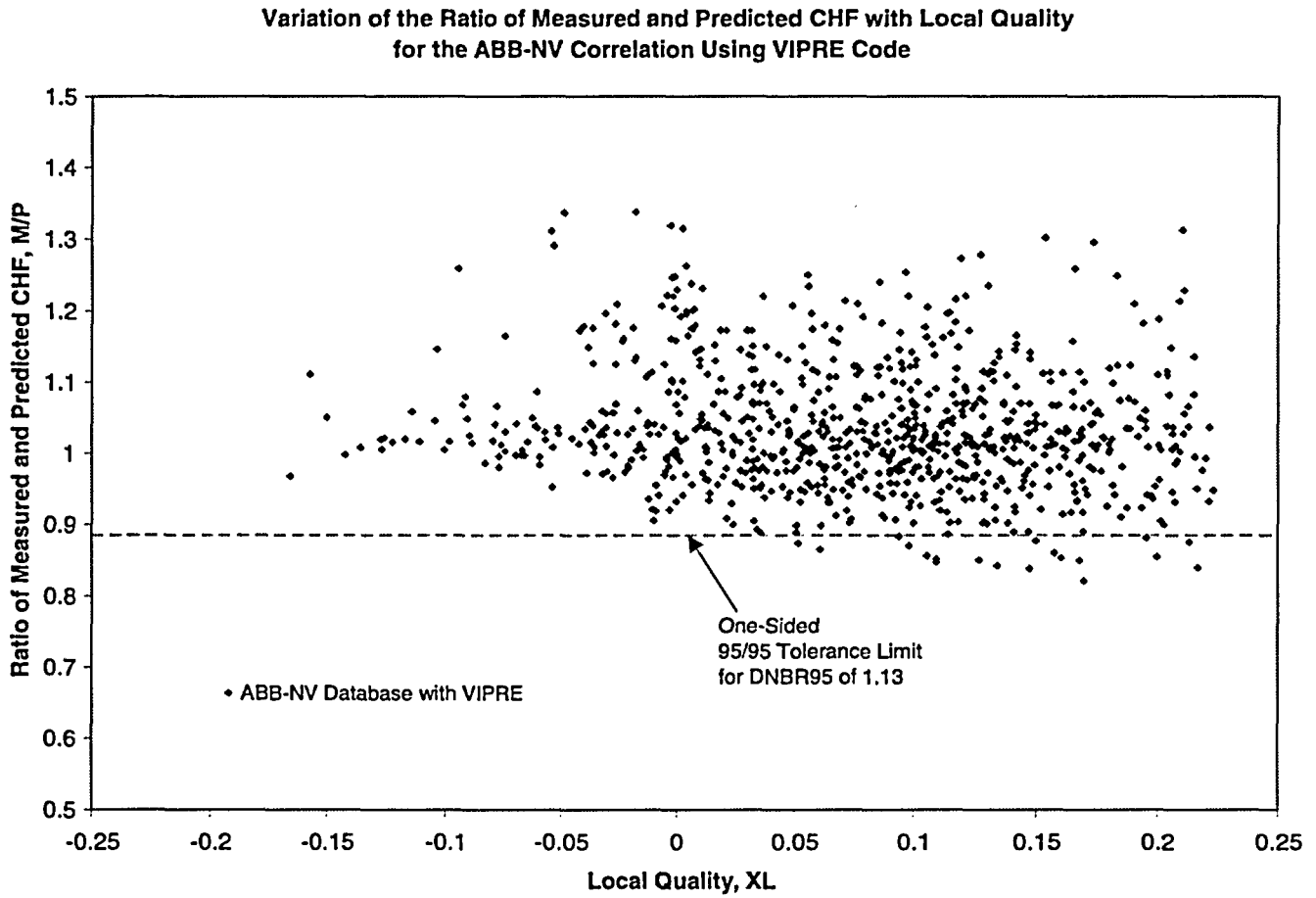


Figure 3-8  
VIPRE/ABB-NV M/P vs. Local Quality



## 4.0 Qualification of ABB-TV Correlation

### 4.1 ABB-TV Database

The ABB-TV database used for the correlation development consists of approximately 230 CHF data points from three test sections in a 6x6 array simulating CE 14x14 Turbo fuel design with mixing vane grids. The ABB-TV validation database consists of approximately 60 additional data points from the three test sections. The test sections contain heated rods with an outside diameter (OD) of 0.440 inch and a rod pitch of 0.580 inch, with uniform and non-uniform axial power shapes, with and without guide thimble tube. The geometric characteristic of each test section is summarized in Table 4-1. A more detailed description of the test sections can be found in Reference 1.

### 4.2 ABB-TV Correlation

The ABB-TV correlation has the identical functional form as ABB-NV but with different coefficients for a portion of the correlation. It is also based on a linear relationship between CHF and local quality, similar to other Westinghouse correlations for fuel designs with mixing vane grids such as WRB-1 (Ref. 9). The same modified Tong factor for ABB-NV is applied to the ABB-TV CHF predictions to account for effects of non-uniform axial power distribution. The NRC-approved 95/95 DNBR limit is 1.13 (Ref. 1) for use with the TORC code. A more detailed description of the ABB-TV correlation can be found in Reference 1.

### 4.3 VIPRE Model

VIPRE calculations were performed with the entire ABB-TV database consisting of test data for the correlation development and validation. A VIPRE model was prepared in the same way as the TORC model for each test section based on the geometry and power distribution of the rod bundle. Representative VIPRE geometric models for the 14x14 Turbo fuel are shown in Figures 4-1 and 4-2. The VIPRE turbulent mixing correlation is the same as the TORC model. The VIPRE two-phase flow and crossflow correlations are the same as that for Westinghouse PWR applications as described in Reference 2. The VIPRE model is summarized in Table 4-2 in comparison to the TORC model. The VIPRE calculations used the same measured values of pressure, inlet temperature, bundle average mass velocity and bundle average heat flux from the CHF test as those used in the TORC calculations.

**Table 4-1**  
**Geometric Characteristics of ABB-TV Correlation and Validation Tests**

Test No.	Bundle Array	Rod Diameter (in.)	Rod Pitch (in.)	Heated Length (in.)	Grid Spacing (in.)	Guide Tube	GT Diameter (in.)	Axial Shape	Grid/Type	Grid Material

a, b, c

\* Turbo Mixing Vane Grid

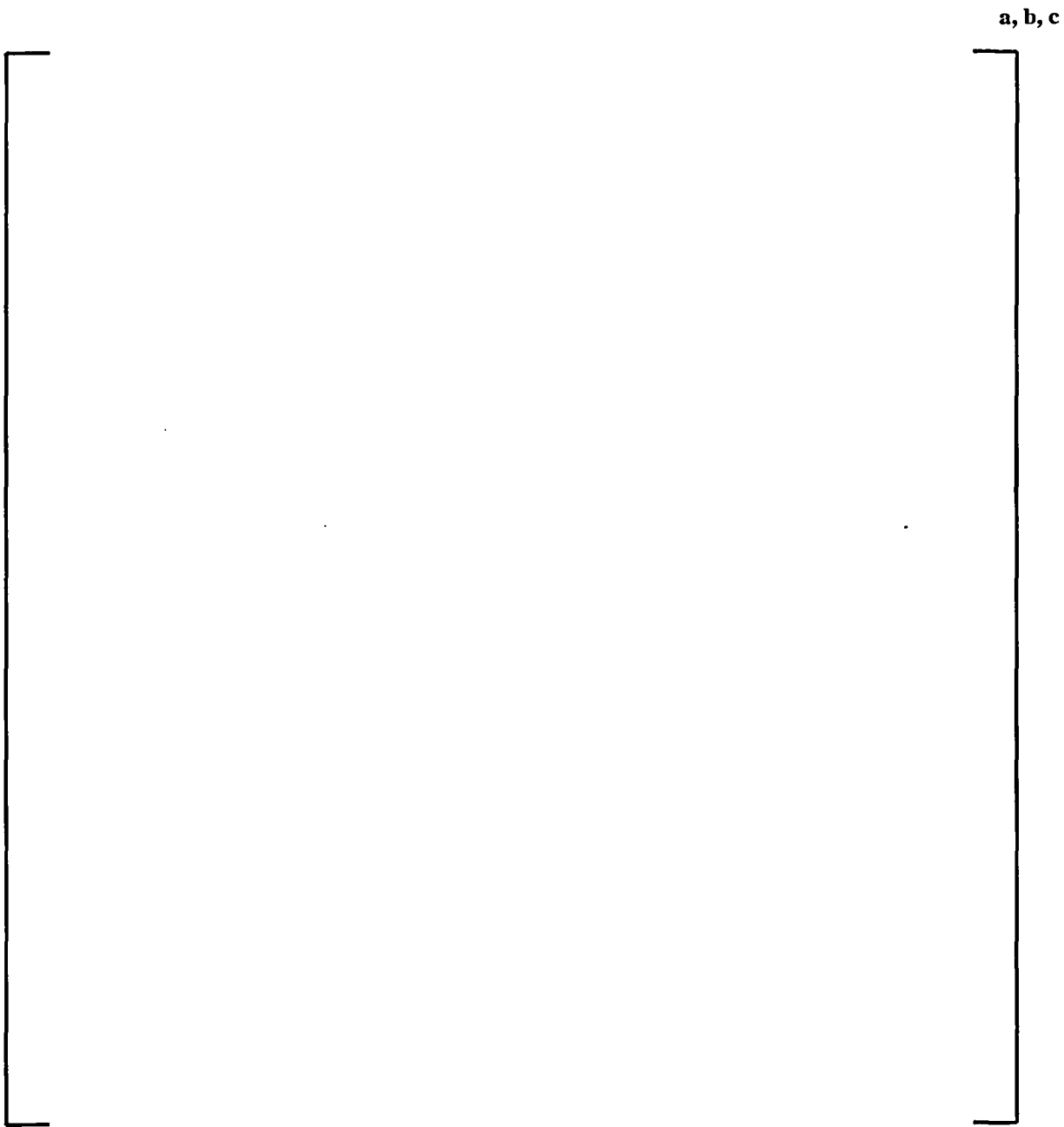
Table 4-2

Summary of VIPRE Model with ABB-TV in Comparison with TORC Model

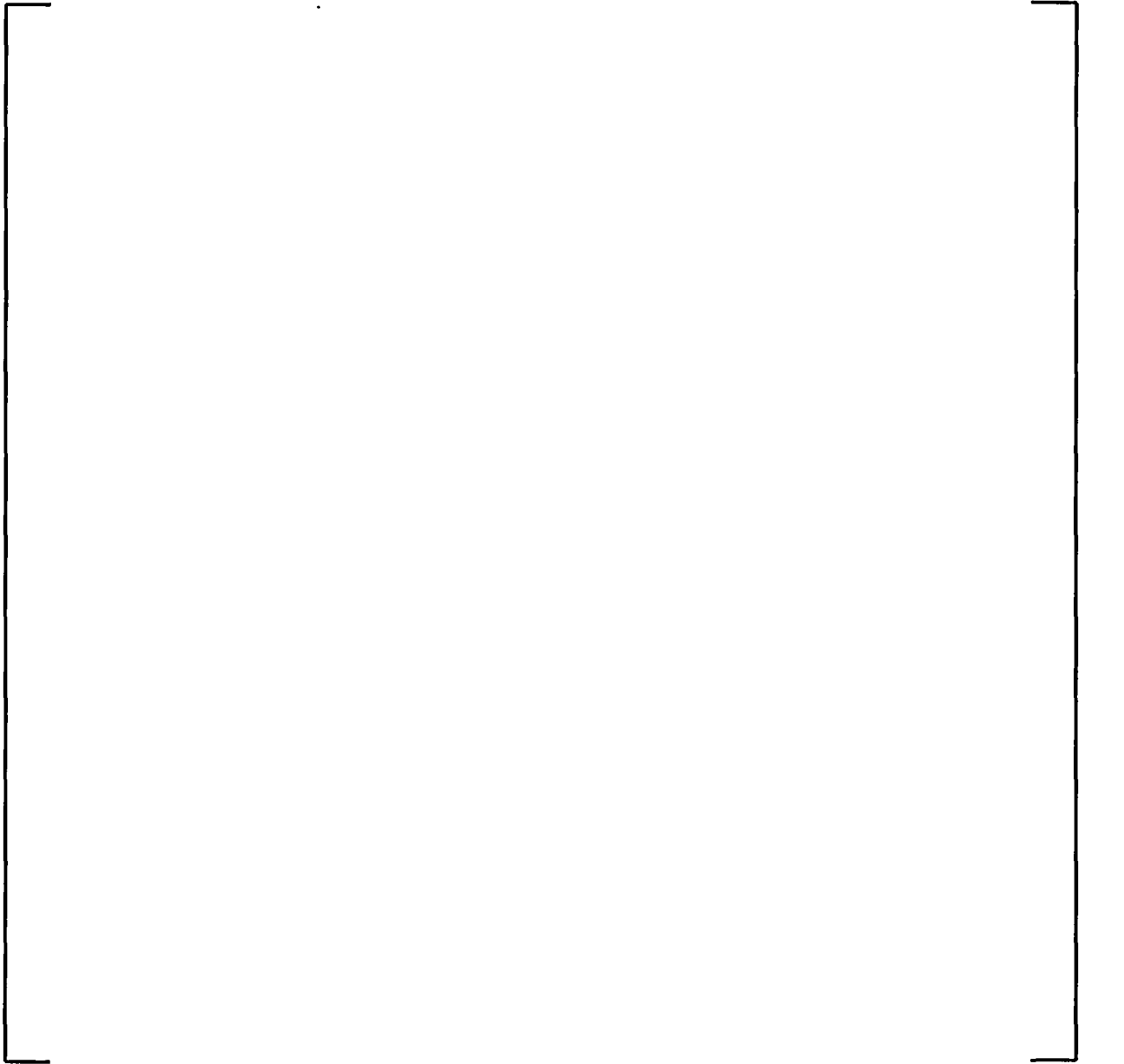
Input Parameter	VIPRE	TORC (Ref. 1)
Radial Channels	Fig. 4-1 through 4-2	Fig. 4-1 through 4-2
Number of Axial Nodes	[ ] <sup>a, b, c</sup> for Tests 91 & 92 [ ] <sup>a, b, c</sup> for Test 93	[ ] <sup>a, b, c</sup>
[ ] <sup>a, c</sup> for Turbulent Mixing	[ ] <sup>a, b, c</sup> (Test 91) [ ] <sup>a, b, c</sup> (Tests 92 & 93)	[ ] <sup>a, b, c</sup> (Test 91) [ ] <sup>a, b, c</sup> (Tests 92 & 93)
Turbulent Momentum Factor	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Axial Friction Factor, f	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Crossflow Momentum Parameter	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Crossflow Resistance Factor, K	[ ] <sup>a, b, c</sup>	[ ] <sup>a, b, c</sup>
Average Grid Loss Coefficient, K	[ ] <sup>a, b, c</sup> for Test 91 (Vane Grids) [ ] <sup>a, b, c</sup> for Tests 92 & 93 (Vane Grids with Guide Thimble Tube) [ ] <sup>a, b, c</sup> for Test 93 (Grid without vane)	[ ] <sup>a, b, c</sup> for Test 91 (Vane Grids) [ ] <sup>a, b, c</sup> for Tests 92 & 93 (Vane Grids with Guide Thimble Tube) [ ] <sup>a, b, c</sup> for Test 93 (Grid without vane)
Two-Phase Flow	[ ] <sup>a, c</sup>	[ ] <sup>a, c</sup>
Two-Phase Flow Friction Multiplier	[ ] <sup>a, c</sup>	[ ] <sup>a, c</sup>



**Figure 4-1**  
**Typical Radial Geometry, ABB-TV Test**  
**for 32 Rods, 14x14 Geometry**



**Figure 4-2**  
**Typical Radial Geometry, ABB-TV Test**  
**for 36 Rods, 14x14 Geometry**



#### 4.4 Comparison with TORC Results

ABB-TV CHF predictions are based on the local fluid conditions calculated by the VIPRE code. Table 4-3 shows means and standard deviations of VIPRE/ABB-TV M/P values for each test section, for the combined correlation and validation database, as compared to the TORC/ABB-TV results from Reference 1. The VIPRE-based M/P value for each data point was determined at the same location in the hot subchannel as the TORC-based value in Reference 1. The comparisons show that the VIPRE/ABB-TV M/P results are in good agreement with the original TORC values. A plot of measured CHF versus VIPRE/ABB-TV predicted CHF is also shown in Figure 4-3. There is no bias in the CHF predictions observed in the scatter plots of VIPRE/ABB-TV M/P versus pressure, local mass velocity and local quality in Figures 4-4 through 4-6.

The overall VIPRE/ABB-TV database contains the same number of data points, 296, as the TORC/ABB-TV database in the applicable range of the ABB-TV correlation. The statistical tests described in section 6.0 of Reference 1 were applied to the VIPRE/ABB-TV database to determine the 95/95 DNBR limit for application of the ABB-TV correlation with the VIPRE code. Similar to the results with TORC, documented in Reference 1, the calculated 95/95 DNBR limit for ABB-TV correlation is lower than 1.13 based on the VIPRE results. As stated in Reference 1, the coefficients for the heated length, HL, and distance from grid, DG, exponential terms are based upon the data in the ABB-NV database. In addition, the optimization of the constants in the coefficient C of the non-uniform axial shape factor,  $F_C$ , was performed with non-uniform data from both the ABB-NV database and ABB-TV database. Since the form and results for the ABB-TV correlation rely heavily on the ABB-NV database, the 95/95 DNBR limit for the ABB-TV correlation is set to 1.13 (Ref. 1), the value determined for the ABB-NV correlation. The M/P CHF ratio is 0.885, corresponding to the DNBR limit of 1.13. For the entire VIPRE/ABB-TV database only five data points fall below the value of 0.885, same as the number of data points in the TORC/ABB-TV database below the limiting value. Therefore, the current 95/95 DNBR limit of 1.13 is conservative and remains unchanged for ABB-TV application with the VIPRE code.

Table 4-3  
 VIPRE and TORC M/P Comparison for ABB-TV Database

Test Number	VIPRE/ABB-TV			TORC/ABB-TV (Ref.1)		
	N	M/P Mean	Std. Dev.	N	M/P Mean	Std. Dev.
Entire Database	296	1.0099	0.0499	296	0.9996	0.0483

a, b, c

Figure 4-3  
Measured CHF versus VIPRE/ABB-TV Predicted CHF

Measured and Predicted CHF for the ABB-TV Correlation  
Using on VIPRE Code

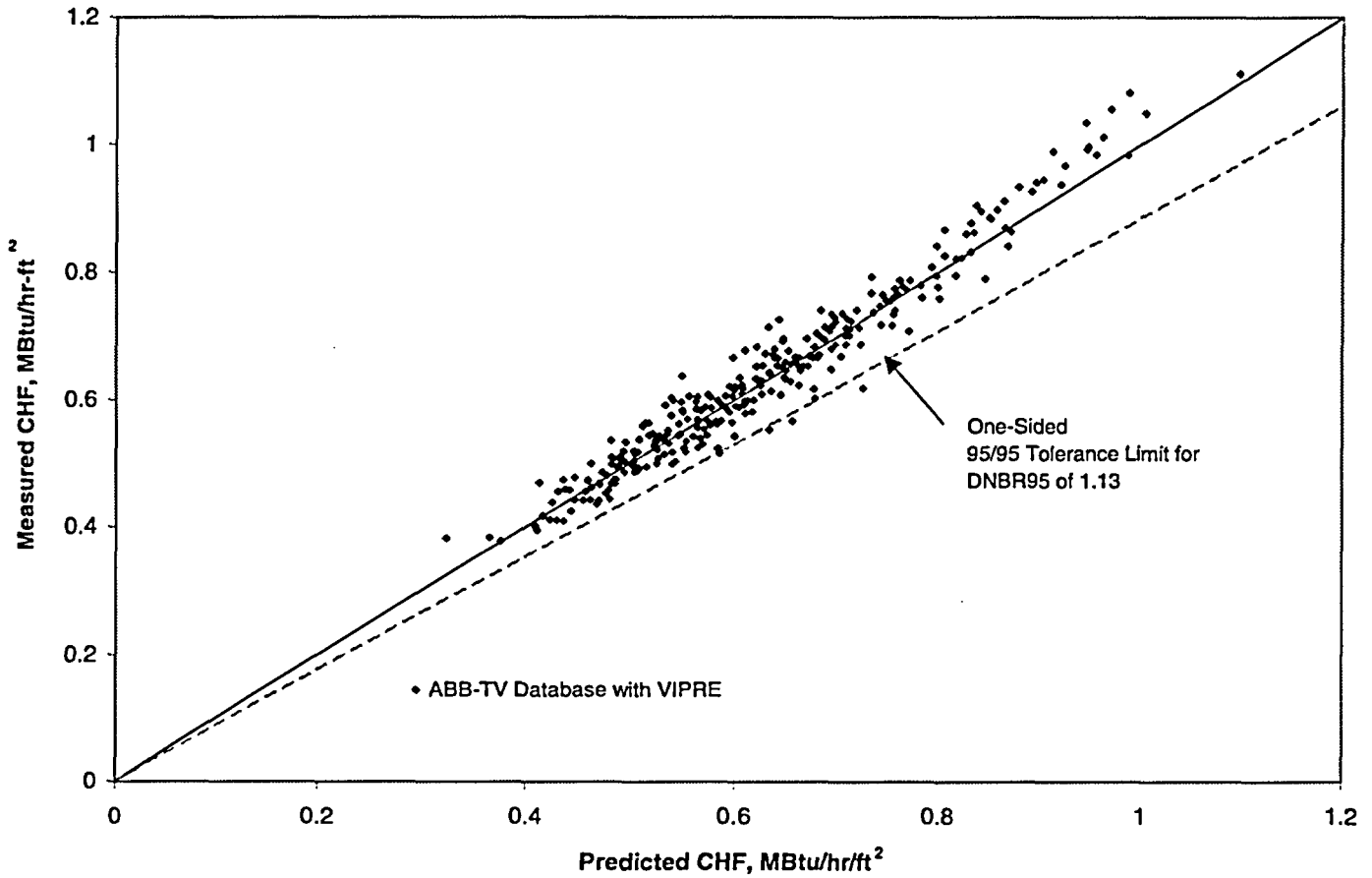


Figure 4-4  
VIPRE/ABB-TV M/P versus Pressure

Variation of the Ratio of Measured and Predicted CHF with Pressure  
for the ABB-TV Correlation Using VIPRE Code

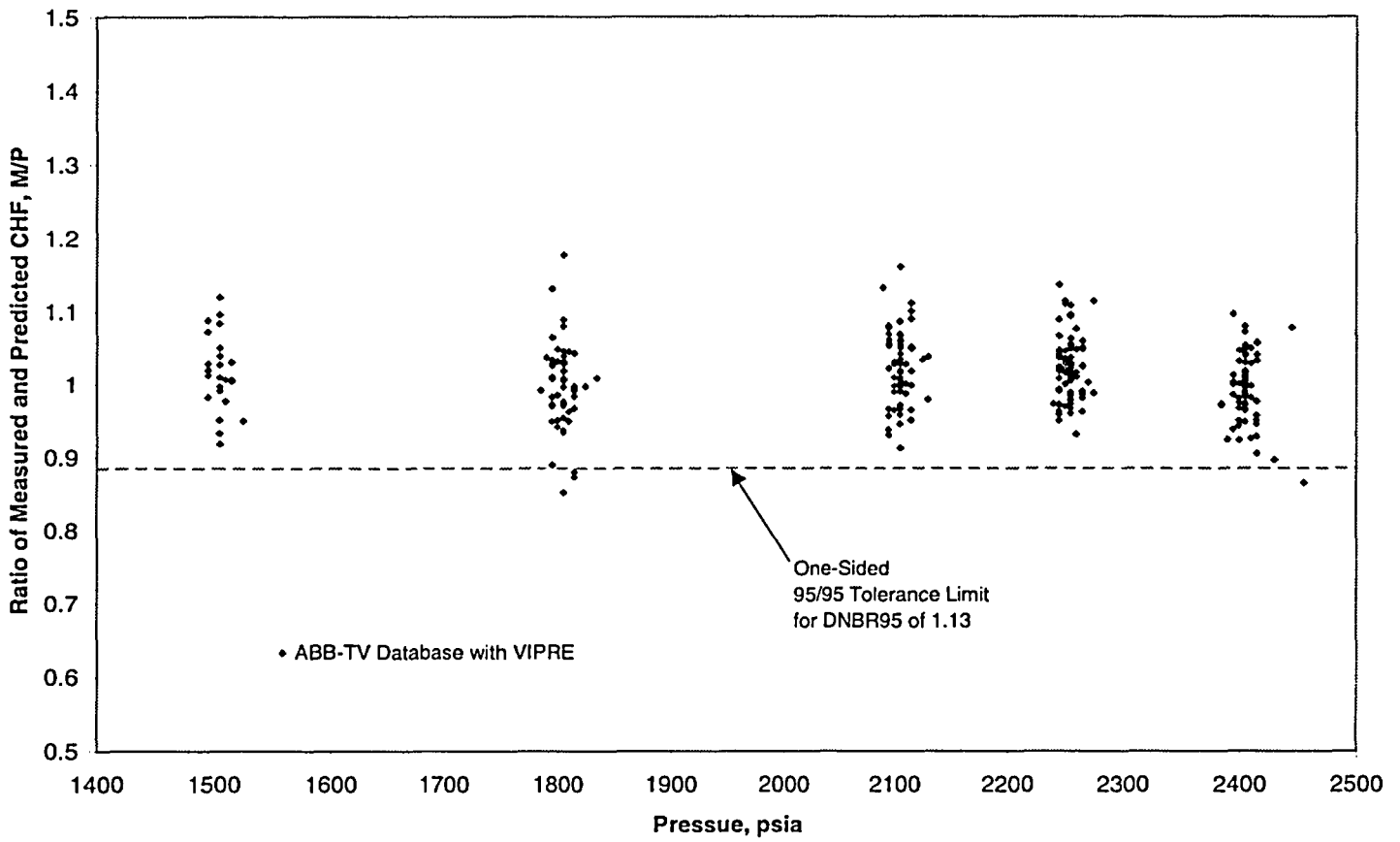


Figure 4-5  
VIPRE/ABB-TV M/P versus Local Mass Velocity

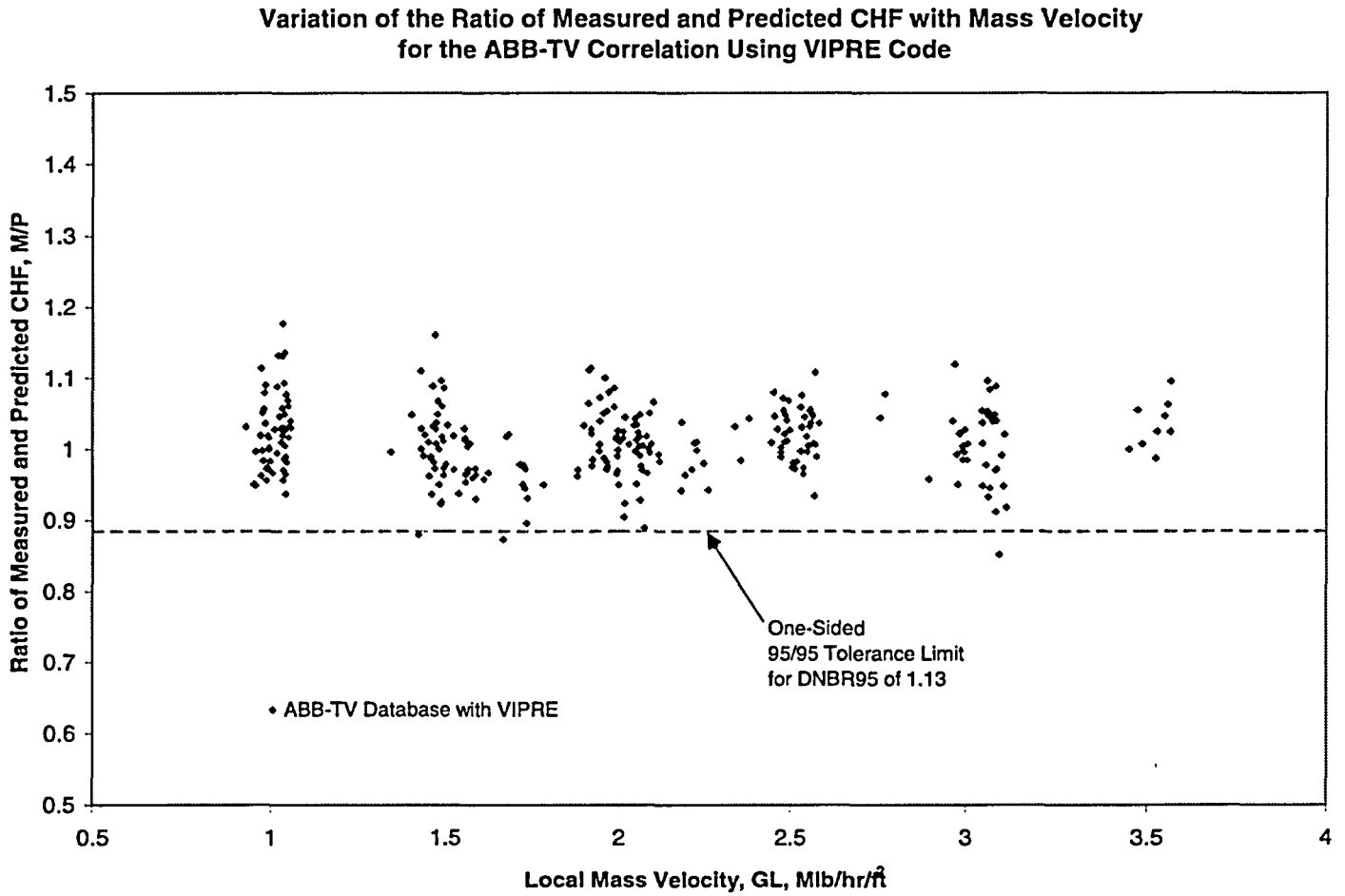
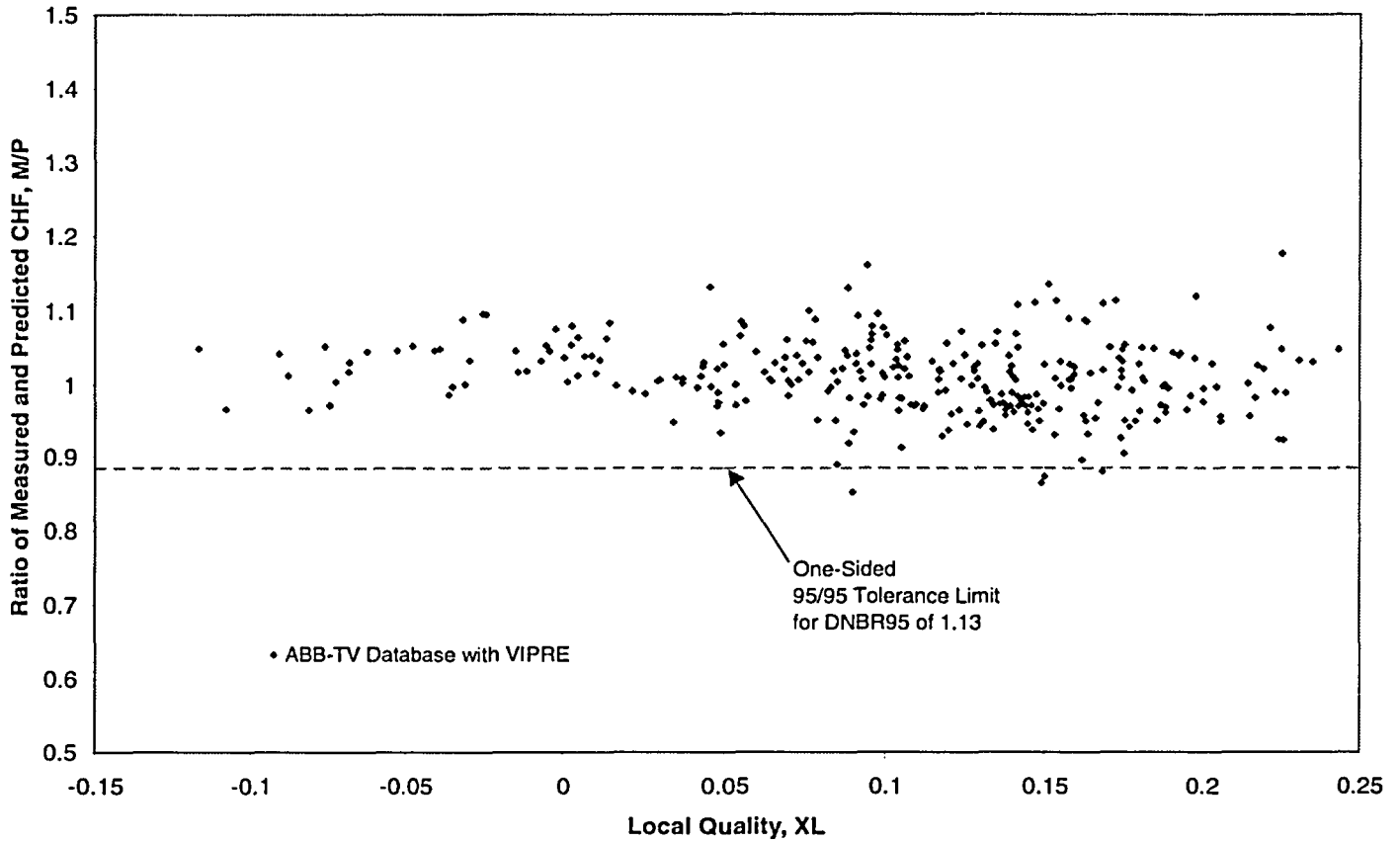


Figure 4-6  
VIPRE/ABB-TV M/P versus Local Quality

Variation of the Ratio of Measured and Predicted CHF with Local Quality  
for the ABB-TV Correlation Using VIPRE Code





## 5.0 Conclusions

The NRC-approved ABB CHF correlations were developed based on the TORC code. Westinghouse VIPRE code and model have been approved by the NRC for PWR licensing applications. Coupling the ABB correlations with the VIPRE code does not result in any change to the current NRC-approved methodology. This addendum demonstrates that VIPRE is equivalent to TORC for ABB-NV and ABB-TV DNBR calculations under the following conditions:

- 1) VIPRE model is consistent with that for the DNB data analysis described in this submittal;
- 2) The current 95/95 DNBR limit of 1.13 remains unchanged;
- 3) DNBR calculations for CE-PWR fuels are within the current applicable range defined in Table 2-1.

## 6.0 References

1. "ABB Critical Heat Flux Correlations for PWR Fuel," CENPD-387-P-A, Rev.000, May 2000.
2. Sung. Y. X., et al., "VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis," WCAP-15306-NP-A, October 1999.
3. Letter from C. E. Rossi (NRC) to J. A. Blaisdell (UGRA Executive Committee), "Acceptance for Referencing of Licensing Topical Report, EPRI NP-2511-CCM, 'VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores,' Volumes 1, 2, 3, and 4," May 1986.
4. Letter from A. C. Thadani (NRC) to Y. Y. Yung (VIPRE-01 Maintenance Group), "Acceptance for Referencing of Licensing Topical Report, EPRI NP-2511-CCM, Revision 3 'VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores,' (TAC No. M79498)," October 1993.
5. Letter from T. H. Essig (NRC) to H. Sepp (Westinghouse), "Acceptance for Referencing of Licensing Topical Report WCAP-14565, 'VIPRE-01 Modeling and Qualification for Pressurized Water Reactor Non-LOCA Thermal-Hydraulic Safety Analysis,' (TAC No. M98666)," January 1999.
6. Letter from S. A. Richards (NRC) to I. C. Rickard (ABB-CE), "Acceptance for Referencing of CENPD-387-P, 'ABB Critical Heat Flux Correlations for PWR Fuel,' (TAC No. MA6109)," March 2000.
7. United States Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, "NRC Generic Letter 83-11, Supplement 1, 'Licensee Qualification for Performing Safety Analysis'," June 24, 1999.
8. "TORC Code, Verification and Simplified Modeling Methods," CENPD-206-P-A, June 1981.
9. Motley, et al., "New Westinghouse Correlation WRB-1 for Predicting Critical Heat Flux in Rod Bundles with Mixing Vane Grids," WCAP-8762-P-A (Proprietary) & WCAP-8763-A (Non-Proprietary), July 1984.

**Appendix A**  
**VIPRE/ABB-NV Database**

A summary of the VIPRE/ABB-NV database is shown in Table A-1. Nomenclature for heading abbreviations is defined below:

TS TD = Test Section, Test Section Type

RUN = Test Run Number

Pr = Pressure (psia)

GL = Local Mass Velocity in CHF Channel (Mlbm/hr-ft<sup>2</sup>)

XL = Local Quality in CHF Channel (Fraction)

GS = Nominal Grid Spacing (inches)

HL = Heated Length to CHF Site (inches)

DG = Distance from last grid to CHF site (inches)

Dh = Heated Hydraulic Diameter of CHF Channel (inches)

Dhm = Heated Hydraulic Diameter of Matrix Channel (inches)

CHFM = Measured CHF (Mbtu/hr-ft<sup>2</sup>)

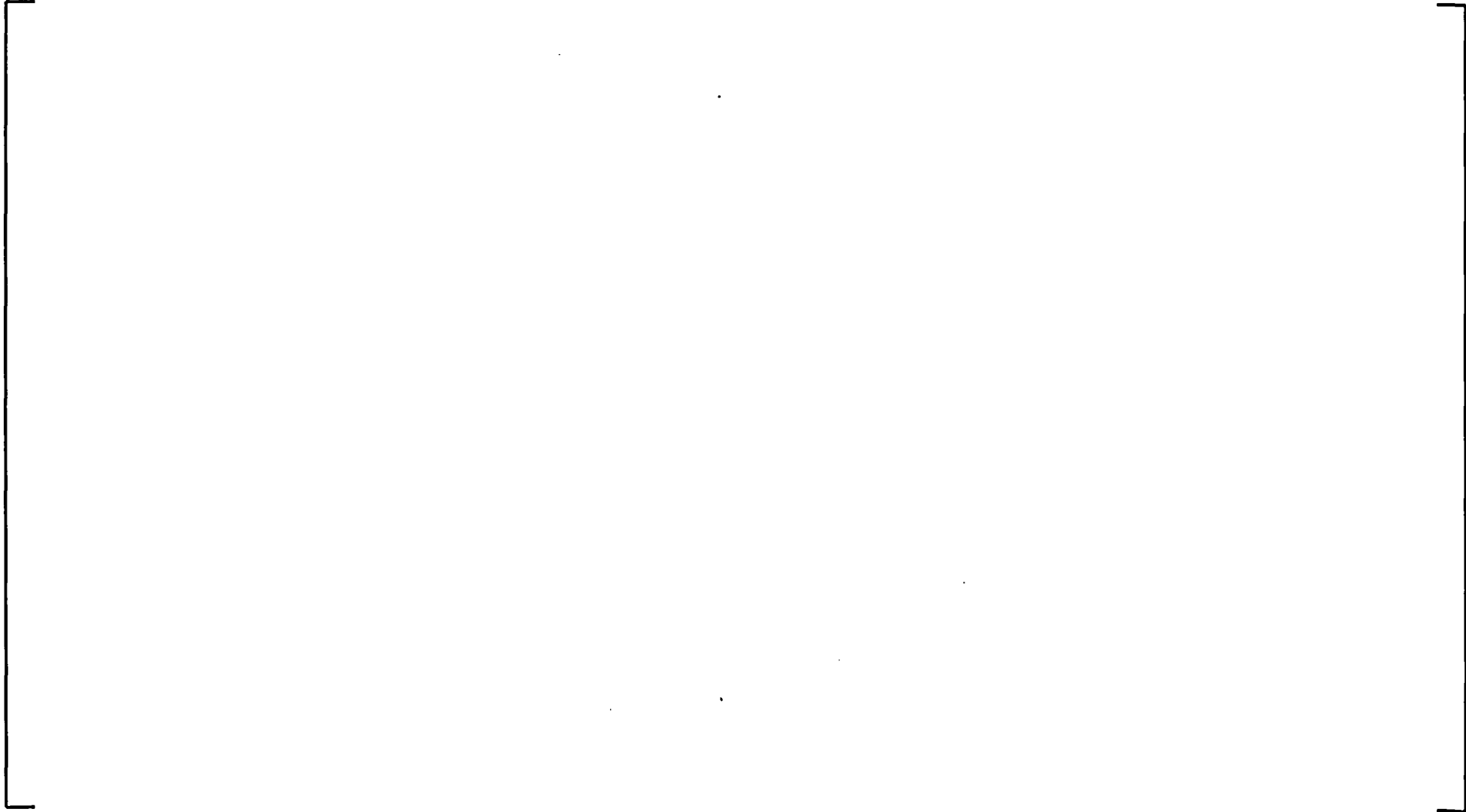
CHFP = Predicted CHF (Mbtu/hr-ft<sup>2</sup>)

M/P = Ratio of Measured CHF to Predicted CHF.

Table A-1  
VIPRE/ABB-NV Database

TS TD	Run	Pr	GL	XL	GS	HL	DG	Dh	Dhm	CHFM	CHFP	M/P-1	M/P	a, b, c
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**TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c**



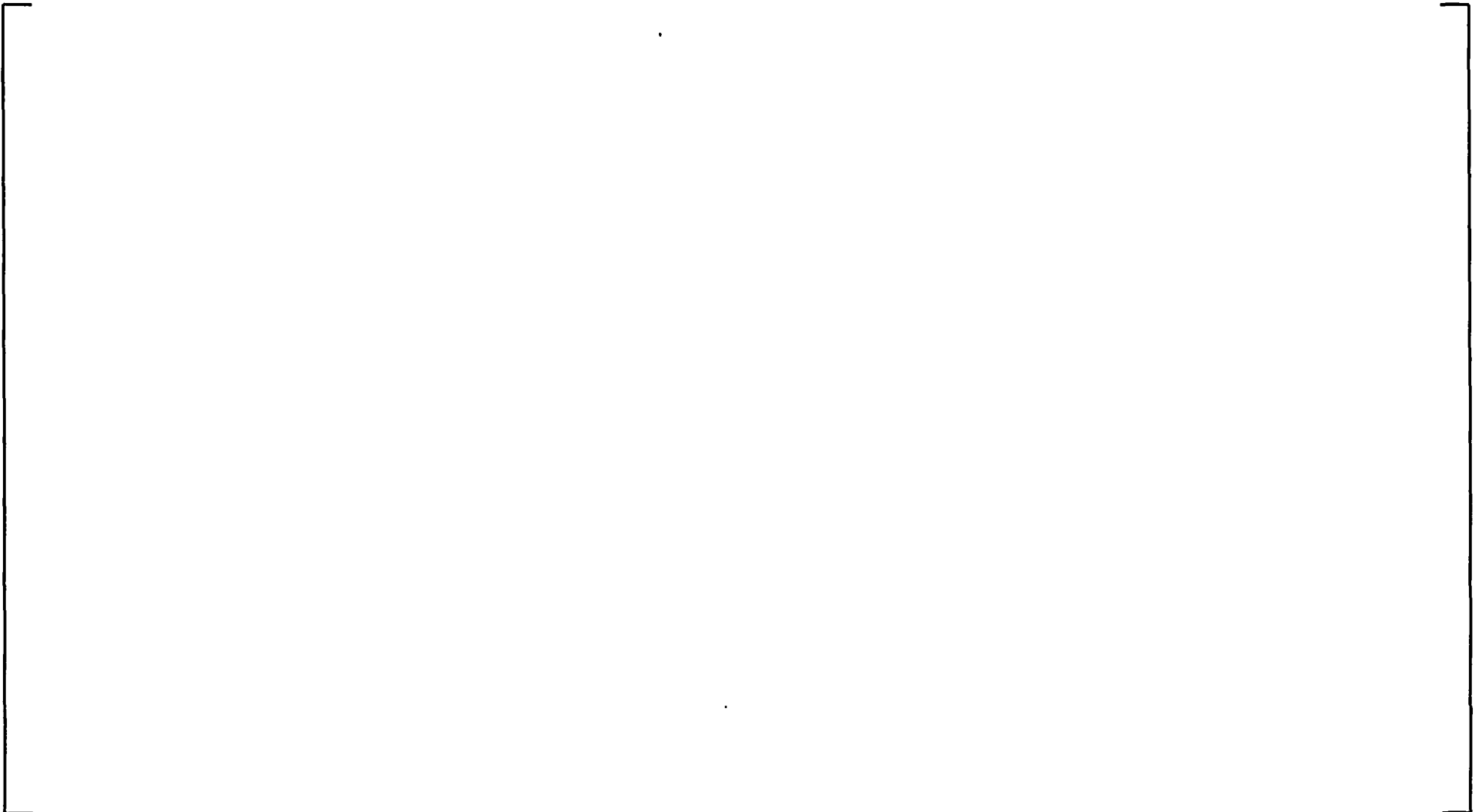
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TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c





TS TD Run Pr GL XL GS HL DG Dh DhM CHEM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c



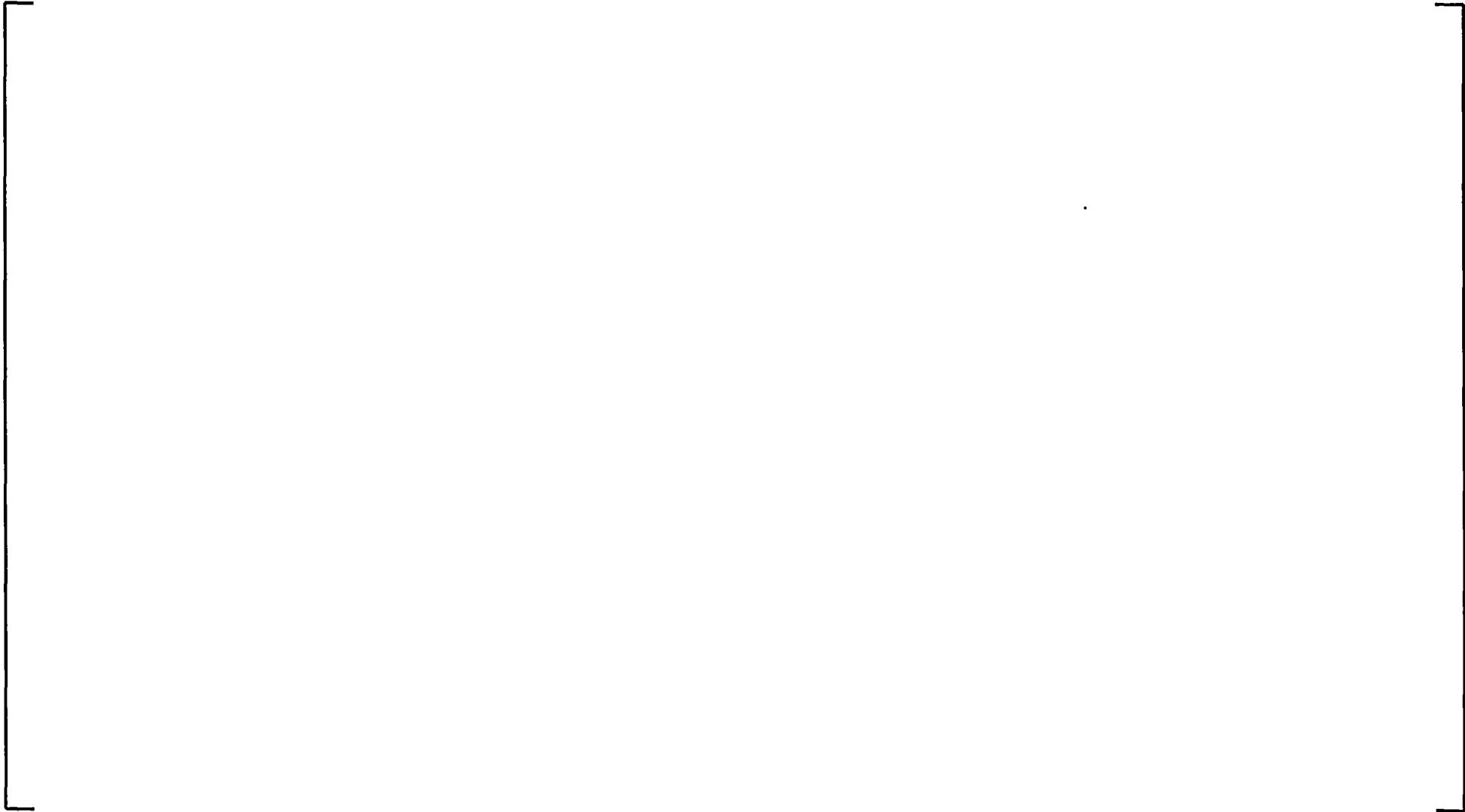
**TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c**



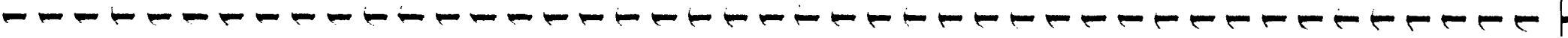
TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c



**TS TD Run Pr GL XL GS HL DG Dh DhM CHEM CHFP M/P-1 M/P a, b, c**



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c





<u>TS TD</u>	<u>Run</u>	<u>Pr</u>	<u>GL</u>	<u>XL</u>	<u>GS</u>	<u>HL</u>	<u>DG</u>	<u>Dh</u>	<u>Dhm</u>	<u>CHFM</u>	<u>CHFP</u>	<u>M/P-1</u>	<u>M/P</u>	a, b, c
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TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c



**TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c**



TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c



**TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c**




TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c





TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh Dhm CHFM CHFP M/P-1 M/P a, b, c

**Appendix B**  
**VIPRE/ABB-TV Database**

A summary of the VIPRE/ABB-TV database is shown in Table B-1. Nomenclature for heading abbreviations is defined below:

TS TD = Test Section, Test Section Type

RUN = Test Run Number

Pr = Pressure (psia)

GL = Local Mass Velocity in CHF Channel (Mlbm/hr-ft<sup>2</sup>)

XL = Local Quality in CHF Channel (Fraction)

GS = Nominal Grid Spacing (inches)

HL = Heated Length to CHF Site (inches)

DG = Distance from last grid to CHF site (inches)

Dh = Heated Hydraulic Diameter of CHF Channel (inches)

Dhm = Heated Hydraulic Diameter of Matrix Channel (inches)

CHFM = Measured CHF (Mbtu/hr-ft<sup>2</sup>)

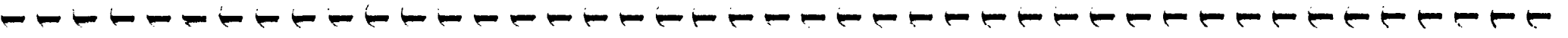
CHFP = Predicted CHF (Mbtu/hr-ft<sup>2</sup>)

M/P = Ratio of Measured CHF to Predicted CHF.

**Table B-1**  
**VIPRE/ABB-TV Database**

TS TD	Run	Pr	GL	XL	GS	HL	DG	Dh	Dhm	CHEM	CHFP	M/P-1	M/P	a, b, c
-------	-----	----	----	----	----	----	----	----	-----	------	------	-------	-----	---------

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

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TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

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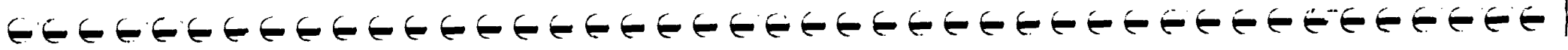
TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c

TS TD Run Pr GL XL GS HL DG Dh DhM CHFM CHFP M/P-1 M/P a, b, c



**Section C**

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

Direct tel: (412) 374-5036  
Direct fax: (412) 374-4011  
e-mail: galem1js@westinghouse.com

Attn: J. S. Wermiel, Chief  
Reactor Systems Branch  
Division of Systems Safety and Analysis

Our ref: LTR-NRC-03-64

November 10, 2003

- References:
1. Fax dated October 28, 2003 from Mr. B. Benney (NRC) to Mr. R. Sisk (Westinghouse); Subject – Request for Additional Information (RAIs) for WCAP-14565-P; ABB-NV/TV Fuel
  2. WCAP-14565-P / WCAP-15306-NP, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code"

Subject: Response to Request for Additional Information (RAI) Regarding WCAP-14565-P / WCAP-15306-NP, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code"

Dear Mr. Wermiel:

Enclosed are copies of Westinghouse Electric Company LLC (Westinghouse) responses to the Nuclear Regulatory Commission (NRC) Request for Additional Information (Reference 1) regarding WCAP-14565-P / WCAP-15306-NP, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code" (Reference 2). This information is being submitted by Westinghouse Electric Company LLC to obtain Nuclear Regulatory Commission approval.

Also enclosed are:

1. One (1) copy of the Application for Withholding, AW-03-1734 with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of Affidavit AW-03-1734.

This submittal contains proprietary information of Westinghouse Electric Company LLC. In conformance with the requirements of 10 CFR Section 2.790, 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.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Correspondence with respect to this affidavit or Application for Withholding should reference AW-03-1734 and should be addressed to J. S. Galembush, Acting Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,



J. S. Galembush, Acting Manager  
Regulatory Compliance and Plant Licensing

Enclosures

cc: F. M. Akstulewicz/NRR  
B. J. Benney/NRR  
U. Shoop/NRR  
S. L. Wu/NRR  
E. S. Peyton/NRR



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e-mail: galem1js@westinghouse.com

Our ref: AW-03-1734

November 10, 2003

APPLICATION FOR WITHHOLDING PROPRIETARY  
INFORMATION FROM PUBLIC DISCLOSURE

Subject: Response to Request for Additional Information for WCAP-14565-P, "Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code" (Proprietary)

Reference: Letter from J. S. Galembush to J. S. Wermiel, LTR-NRC-03-64, dated November 10, 2003

The Application for Withholding is submitted by Westinghouse Electric Company LLC (Westinghouse), pursuant to the provisions of Paragraph (b)(1) of Section 2.790 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 enclosure to the referenced letter. In conformance with 10 CFR Section 2.790, Affidavit AW-03-1734 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 2.790 of the Commission's regulations.

Correspondence with respect to this Application for Withholding or the accompanying affidavit should reference AW-03-1734 and should be addressed to J. S. Galembush, Acting Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

A handwritten signature in black ink, appearing to read 'J. S. Galembush'.

J. S. Galembush, Acting Manager  
Regulatory Compliance and Plant Licensing

Enclosures

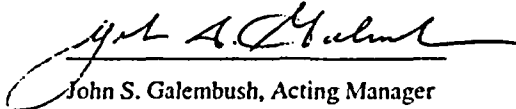
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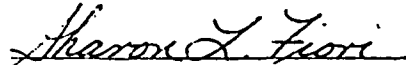
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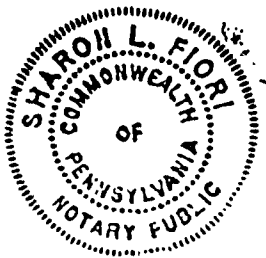
COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared John S. Galembush, 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:

  
John S. Galembush, Acting Manager  
Regulatory Compliance and Plant Licensing

Sworn to and subscribed  
before me this 10<sup>th</sup> day  
of November, 2003

  
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 Acting 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 rule making proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company LLC.
- (2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 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 the Westinghouse Electric Company LLC 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 2.790 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 that 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 2.790, 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 as "Response to Request for Additional Information (RAI) Regarding WCAP-14565-P 'Qualification of ABB Critical Heat Flux Correlation with VIPRE-01 Code'", being transmitted by Westinghouse Electric Company letter (LTR-NRC-03-64) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk, Attention Mr. J. S. Wermiel. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC review and approval.

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

- (a) Obtain generic NRC licensed approval for the use of VIPRE-01 with ABB-NV Critical Heat Flux Correlation for CE-PWR 14x14 and 16x16 fuels with non-mixing vane grids and ABB-TV Critical Heat Flux Correlation for CE-PWR 14x14 Turbo fuel with mixing vane grids.
- (b) This addition of the ABB-NV and ABB-TV Critical Heat Flux Correlations to VIPRE-01 will promote convergence between Westinghouse business units.

Further this information has substantial commercial value as follows:

- (a) Westinghouse can use modeling 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 manufacturing processes 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.

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 2.790 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 2.790(b)(1).

**COPYRIGHT NOTICE**

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of 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 2.790 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those 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.

Response to Request for Additional Information (RAIs)  
for WCAP-15306-NP "Qualification of Critical Heat Flux Correlation  
with VIPRE-01 Code"

1. *Table 2-1, page 3 of the topical report, provides the applicable Range of ABB-NV/TV CHF Correlations. The staff presumes that these ranges are less than or equal to those specified in the safety evaluation (SER) for these correlations. Is that indeed the case? If not, please provide a qualitative and quantitative technical justification for operating outside these ranges.*

Response:

The applicable ranges of ABB-NV/TV CHF correlations with the VIPRE code remain the same as those specified in the Safety Evaluation Report (SER) on CENPD-387-P-A, "ABB Critical Heat Flux Correlations for PWR Fuel."

2. *The first paragraph of Section 4.3 states that the VIPRE calculations were performed using the entire data base upon which the ABB-NV/TV correlation was developed and validated.*

*(a) Does this include out-liars that were part of the original data base?*

Response:

As stated on page 6-2 of CENPD-387-P-A, [ ]<sup>a,c</sup> as outliers in the ABB-NV database and [ ]<sup>a,c</sup> from the ABB-TV database. The [ ]<sup>a,c</sup> from the ABB-NV database had values of measured to predicted (M/P) CHF ratio above the mean by [ ]<sup>a,c</sup>. These same points were [ ]<sup>a,c</sup> using the VIPRE code. Therefore, the final database used for the VIPRE calculations is the same database used for the development of the correlation documented in CENPD-387-P-A.

*(b) Does Westinghouse intend applying VIPRE to fuel types that were not included in the original data base?*

Response:

As stated in Section 2.0 of the submittal, Westinghouse intends to use the VIPRE code for DNB analyses of the CE-PWR fuels using the current NRC-approved methodology. Westinghouse will apply the VIPRE code with the ABB-NV and ABB-TV correlations, in addition to the TORC and CETOP-D codes, under the conditions consistent with the requirements in the SER on CENPD-387-P-A.

3. *The last paragraph of Section 4.4, on page 23, states that the M/P CHF ratio is 0.885, corresponding to the DNBR limit of 1.13. Please provide the derivation of both these numbers.*

Response:

The 95/95 DNBR limit of the ABB-TV correlation with the VIPRE code, based on the M/P statistics of the ABB-TV database in Table 4-3 of the submittal, would be less than 1.13. As stated on page 6-28 of CENPD-387-P-A, [

],<sup>a,c</sup> the 95/95 DNBR limit for the ABB-TV correlation is set to the more conservative 95/95 DNBR limit for the ABB-NV correlation, 1.13, section 3.4. As stated in section 3.4, page 6, the M/P CHF ratio corresponding to the 1.13 DNBR limit is 0.885.