



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

ENCLOSURE 1

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATING TO VIPRE-01 MOD 02 FOR PWR AND BWR APPLICATIONS
EPRI-NP-2511-CCM-A, REVISION 3

1.0 INTRODUCTION

By letter dated February 28, 1990 (Ref. 1), the VIPRE-01 Maintenance Group (VMG) submitted for staff review a package consisting of a summary of changes in VIPRE-01 between MOD-01 and MOD-02 and verification of VIPRE-01 for use in BWR analysis. The five-volume set of VIPRE-01 MOD-02 computer code documentation (Ref. 2) reflected changes up to Revision 3. Documentation of error corrections (Ref. 3) was later forwarded to the NRC in support of the review.

The submittal consisted of the five volume set of the VIPRE-01 MOD-02 code documentation and user's manuals. The mathematical modeling used in the code is discussed in Volume 1. Volume 2 is the user's manual and the programmer's manual is contained in Volume 3. Volume 4 documents the experimental data comparisons, sensitivity studies and plant behavior simulations. Input guidelines and capabilities and limitations of the code are presented in Volume 5. Also submitted was a summary of changes in VIPRE-01 between MOD-01 and MOD-02. For demonstration of the adequacy of VIPRE-01 for BWR analysis a series of sensitivity studies and benchmark analyses were submitted for review.

The purpose of this review was to evaluate the acceptability of new models and changes contained in the VIPRE-01 MOD-02 version for application in both PWR and BWR analysis based upon the submitted materials (Refs. 1, 3, 5 - 7). Therefore, the review was conducted in order to : (1) assure that corrections and any changes introduced in the MOD-02 version of the code do not alter the code's acceptability and applicability to PWR applications as granted under the existing SER; and (2) determine acceptability of MOD-02 for generic BWR and PWR applications. This was a generic review of the VIPRE-01 MOD-02: it

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was not a review of any specific licensing application or examination of the actual coding.

2.0 BACKGROUND

VIPRE-01 was developed by Battelle Pacific Northwest Laboratories for the Electric Power Research Institute (EPRI) for use to evaluate nuclear reactor parameters including minimum departure from nucleate boiling ratio (MDNBR), critical power ratio (CPR), fuel and clad temperatures, and reactor coolant state in normal and off-normal conditions.

VIPRE-01 MOD-01, was submitted in 1985 to the NRC for review regarding its use in PWR and BWR licensing applications. It was approved by issuance of a Safety Evaluation Report (SER) by the NRC in 1986 (Ref. 4). The SER contained certain specific restrictions and qualifications. The NRC accepted MOD-01 for PWR licensing applications for heat transfer regimes up to the point of critical heat flux (CHF), provided that (a) the CHF correlation and its limit used in the application is approved by the NRC, and (b) each organization using VIPRE for licensing calculations submit separate documentation justifying their input selection and modeling assumptions. Thus, use of VIPRE-01 MOD-01 is currently limited to PWR applications only.

VIPRE-01 MOD-02 is an improved and updated version of VIPRE-01 MOD-01 in that the code version includes 77 changes/corrections (Refs. 1, 3) from the MOD-01 version. One major modification was to include an optional drift-flux model to improve the code's ability to calculate the evolution of void fraction profiles in transients with two-phase flow conditions. Two other models, a "water tube channel model" and a "water leakage model" were also added.

3.0 STAFF EVALUATION

The review of the submittal of the VIPRE-01 MOD-02 computer code for PWR and BWR applications was performed with technical assistance from International Technical Services (ITS). The ITS review findings are contained in the

Technical Evaluation Report (TER) with its review findings attached to this report. The staff has reviewed the TER and has concurred with all its findings.

During the review of VIPRE-01 MOD-01, it was found that lack of documentation of model qualification necessitated restrictions upon use of the code for BWR applications. This was primarily because of insufficient data provided to the reviewer regarding qualification of thermal-hydraulic correlations used by the code for the computation of critical power ratio (CPR) in BWR systems, which is a measure similar to DNBR for PWR systems. The Safety Evaluation Report (SER) (Ref. 2), however, approved the code's use for PWR application, provided that the user would document and submit to the NRC for approval descriptions of how the code is to be used, including justification of all input, default parameters, selection of correlations, etc.

The MOD-02 version was developed to address, in particular, issues related to BWR applications, but it also addressed correction of errors reported to the VIPRE Maintenance Group (VMG) for MOD-01 (Refs. 3 & 4). VMG submitted the MOD-02 version of VIPRE for review of its acceptability of use for both PWR and BWR analysis.

In the performance of this work, the review included the VIPRE-01 MOD-02 code manual entitled "VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores," (Ref. 1) and supplemental information (Refs. 5 - 7). For the current review, not only were those model modifications made to the previous version of VIPRE-01 reviewed, but also reviewed were the changes to the overall documentation of the code, since new volumes of code manuals have been issued. These materials were provided by the VIPRE-01 Maintenance Group (VMG). This was a generic review of VIPRE-01 MOD-02: it was not a review of a specific application or an examination of the actual coding.

This review was conducted with respect to the following items:

1. To assure that corrections and changes introduced in the code do

not alter its acceptability and applicability for PWR applications as granted under the existing SER; and

2. To determine acceptability of MOD-02 for generic BWR applications.

Three significant major models were added to this code version specifically to assist in its application to BWR conditions:

1. Drift Flux Model
2. Water Tube Channel Model
3. Water Leakage Model

The balance of the code remains the same as previously reviewed (except for the error corrections). Therefore, the previously issued requirements placed upon the contents of the submittal to the NRC remain unchanged. Similarly, the restrictions with respect to the use of MOD-01 for PWR applications remain applicable to MOD-02.

The error corrections make the MOD-02 version of the code run better than MOD-01. However, two error corrections impact the calculations of DNBR in PWR applications. These corrections changed the thermal conductivity of Zircaloy resulting in the retention of more heat in the fuel. Its impact on a sample loss of flow transient resulted in a reduction of DNBR by roughly 2.3%, which is the trend to be expected. When PWR users switch to VIPRE-01 MOD-02, they will find that the computed DNBR will be lower for identical cases of this type. Some VIPRE PWR users are using this code to compute coefficients of response surface equations at a number of varying conditions.

4.0 SUMMARY

The staff has reviewed (1) the lists of corrections and changes to the VIPRE-01 MOD-01 code provided by the VIPRE-01 Maintenance Group, (2) the identified modeling changes implemented in the VIPRE-01 MOD-02 version, together with (3) the responses to questions provided by computer simulation analysts. Based

upon the foregoing, and subject to the limitations and restrictions contained in the original SER and set forth below with respect to correction of Zircaloy conductivity, we conclude that there are reasonable assurances that the VIPRE-01 MOD-02 computer code version is acceptable for use in PWR and BWR licensing applications.

Since there were not substantive modeling changes which would impact PWR calculations, VIPRE-01 MOD-02 is acceptable for PWR applications subject to the original SER.

With respect to PWR applications of VIPRE-01 MOD-01, the limitations on use contained in the original SER remain applicable. Because of the improved modeling capabilities in VIPRE-01 MOD-02, its use in BWR applications in computation of CPR is hereby approved subject to the conditions cited in the existing SER and the further conditions set forth below. Furthermore, the requirements regarding submittal of separate documentation of use and input selection by each organization must still be observed.

For the various models/correlations presented for use as options in the VIPRE-01 code, the code developers did not endorse any particular model/correlation for use in a particular application. Therefore, it is incumbent upon each user to choose the appropriate option for their particular application subject.

In addition, with respect to MOD-02

1. The use of this code for BWR licensing applications is contingent upon full qualification of the models described in TER Section 3.2.2.

For example, models added to the code for use specifically for BWR applications are: (1) water tube channel modeling, (2) leakage flow path connection, and (3) drift flux model. Since no model verification or qualification was provided with the submittal,

each licensee must justify the use of thermal-hydraulic models and the selected parameters related there to, on a transient-by-transient basis and over the range of two-phase flow conditions expected to be encountered.

In this respect, each user may choose to perform one of the following:

- a. perform a thorough benchmark check against plant specific data, including identification of measurement uncertainty. This approach is not acceptable if any of the key parameters or the sequence of events are not known; or
- b. benchmark against the vendors test or approved code. If any of the key parameters used by the vendor are not known for comparison, this is not acceptable.

We note that there is limited transient void fraction data available which could be compared to code results over some ranges of parameters. However, a user attempting to qualify the model for use by comparison to those data must demonstrate that the data cover the range of phenomena to be encountered in the analysis to be performed.

- c. A user may also take the approach of demonstrating that global results (such as power, pressure and core inlet-outlet temperature difference) computed with the code while using a particular drift flux formulation are conservative overall when compared to actual plant data over the range expected to be encountered during the transient being analyzed.
2. The GEXL Correlation is the only correlation currently having NRC approval for use in CPR calculations of a core containing GE

fuels. However, use of the GEXL correlation for other vendors' fuels or use of any other correlation requires a separate submittal for NRC review and approval.

3. Section 2.2 of Volume 5 of the submittal identifies a spectrum of limitations of the code. Each user, should ensure that the code is not being used in violation of these limitations.
4. By acceptance of this code version, we do not necessarily endorse procedures and uses of this code described in Volume 5 as appropriate for licensing applications. As the code developer stated in Reference 5, the materials were provided by the code developers as their non-binding advice on efficient use of the code.

Each user is advised to note that values of input recommended by the code developers are for best-estimate use only and do not necessarily incorporate the conservatism appropriate for licensing type analysis. Therefore, the user is expected to justify or qualify input selections for licensing applications.

5.0 REFERENCES

1. Letter from Y. Y. Yung, VIPRE-01 Maintenance Group, to USNRC, "Notification of Release and Request for NRC Review of VIPRE-01 MOD-02," February 28, 1990.
2. "VIPRE-01: A Thermal-Hydraulic Analysis Code for Reactor Cores," Volumes 1 - 5, EPRI-NP-2511-CCM-A, Revision 3, August 1989.
3. Letter from Y. Y. Yung, VMG, to USNRC, "VIPRE-01 Error/Change Log," February 26, 1991.
4. "Safety Evaluation Report on the VIPRE-01 Computer Code," May 1986.