PROJ. 702

FRAMATOME ANP

March 23, 2001
NRC:01:014

Document Control Desk
ATTN: Chief, Planning, Program and Management Support Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Request for Additional Information – Framatome ANP Richland, Inc. Topical Report EMF-2361(P) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*, (TAC NO. MB0574)

Ref.: 1. Letter, N. Kalyanam (NRC) to J. F. Mallay (FRA-ANP), "Request for Additional Information - Framatome ANP Richland Inc., Topical Report EMF-2361(P) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*, (TAC NO. MB0574)," March 5, 2001.

In Reference 1, the NRC requested additional information to facilitate the completion of its review of the Framatome ANP Richland, Inc. topical report EMF-2361(P) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*. Responses to this request are provided in two attachments: one proprietary and one nonproprietary.

The last request in Reference 1 expressed the desire to obtain the computer codes used for this methodology. FRA-ANP has provided these codes along with detailed instructions for their use. Because the NRC does not have access to the appropriate computer operating system, it may not be possible to run these codes. FRA-ANP has committed to assist the NRC in determining how to apply these codes to its operating system. If a suitable approach is not identified in a reasonable time period, FRA-ANP requests that the NRC waive its request to operate these computer codes.

Framatome ANP Richland, Inc. considers some of the information contained in Attachment 1 to this letter to be proprietary. This information has been noted by enclosing it within brackets. The affidavit provided with the original submittal of the reference topical report satisfies the requirements of 10 CFR 2.790(b) to support the withholding of this information from public disclosure.

Very truly yours,

James F. Mallay, Director
Regulatory Affairs

cc: R. Caruso
N. Kalyanam (w/Attachments)
J. S. Wermiel
Project No. 702 (w/Attachments)

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Request for Additional Information on Topical Report EMF-2361(P) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*

Question 1.

It was stated in the report that RELAX00 is an one-dimensional homogeneous equilibrium code, which over predicts the amount of condensation in volumes where large amounts of subcooled liquid are injected. This results in a non-realistic pressure suppression in that volume. It was further stated that a so called "enthaply injection model" has been added to RELAX to manage this aspect of a one-dimensional homogeneous equilibrium model. The staff requests the applicant to provide an assurance based on physical reasoning and test validations that this modification, which has been arbitrarily added to RELAX in order to compensate for a code limitation,

a) *will consistently predict conservative results, and*

b) *under no permissible reactor operating condition, a non-conservative result will be predicted.*

Question 1. Response:

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] When the spray is initially injected, the upper plenum is filled with steam. The large interfacial area of the spray droplets in contact with the steam environment promotes rapid heat and mass transfer between the liquid and gas phases. It is assumed in the RELAX code that the spray droplets and steam environment are in thermal equilibrium.

In a single channel model, CCFL limits downflow of liquid into the core, and a two-phase mixture is calculated to develop at the top of the core in the upper plenum. This mixture rises and eventually covers the core spray sparger. When this happens, there is a significant change in the upper plenum phenomena. Injection of the spray is now directly into the two-phase mixture, and there is no direct contact and little interaction with the gas phase above the mixture.

The Compendium of ECCS Research for Realistic LOCA Analysis (NUREG-1230) describes the phenomena observed in experiments under these conditions. The experimental results demonstrate that when the spray sparger becomes covered, the upper plenum conditions depart from thermal equilibrium. The steam above the mixture remains saturated at a pressure determined by the remaining system depressurization behavior, while the mixture is composed of regions of saturated liquid and local regions beneath the sparger which contain significantly subcooled liquid. The experiments show that the effect of this subcooled liquid is to quickly break down the CCFL behavior directly below this region and allow the upper plenum mixture to rapidly flow into the lower plenum.

[

] The core heat transfer during this time is being computed by the HUXY code using conservative empirical spray coefficients. The only data used from the RELAX code during the refill and reflood periods is the time of core reflood.

This model was developed to preclude the calculation of unrealistic, non-physical behavior, and will always calculate a conservatively late time of reflood. This calculation of reflood time is conservative because the refill model conservatively ignores multiple channel effects, and because the beneficial effects of the subcooled liquid observed in the large scale tests is conservatively ignored in the calculation.

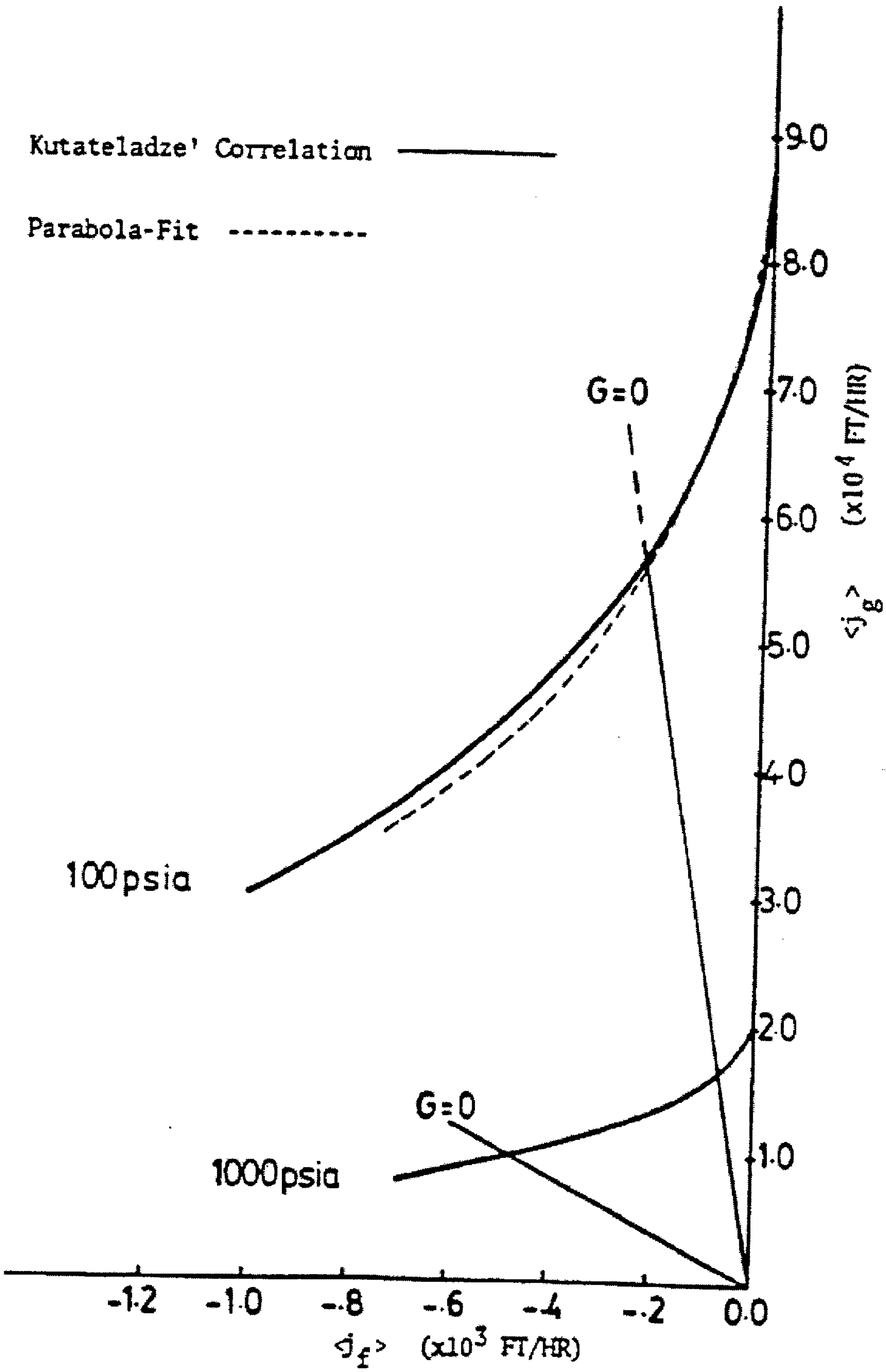
Question 2.

In Figure 3.1 of the report, the effect of drift flux models on void fraction was presented for steady state conditions. The staff requests the applicant to submit comparisons of void fraction distribution predicted by EXEM BWR-2000 with other approved code and test results at intermediate and low pressures also. The pressure should include values typically encountered during refill/reflood phase.

Question 2 Response:

The document NES-486, "The Analysis of Proposed BWR Inlet Flow Blockage Experiments in PBF," describes the analytical development of the Ohkawa-Lahey drift flux model and shows that the drift flux model was designed to provide a smooth and continuous representation for a wide range of pressures (on the order of 100 to 2000 psia) and that it is applicable over the parametric space that is encountered in the RELAX calculations. The following figures from NES-486 show that the correlation is designed to provide a smooth representation of the drift flux from low to high pressure.

The first figure shows a parabolic fit to the data compared to the Ohkawa-Lahey drift flux model and its implementation in the Kutateladze form. This figure demonstrates that the Ohkawa-Lahey drift flux model adequately represents data taken at lower pressures. The second and third figures show the representations of void fraction versus slip velocity and C_o (where C_o is the parameter used in the Zuber-Findley drift flux formulation). These two figures show the behavior of the Ohkawa-Lahey drift flux correlation for both 100 and 1000 psia, for which it was designed. The calculation of C_o and slip velocity are well behaved and have no specific flow regime dependence; they are continuous and stable throughout the operating space to which they are applied.


Kutateladze' Correlation
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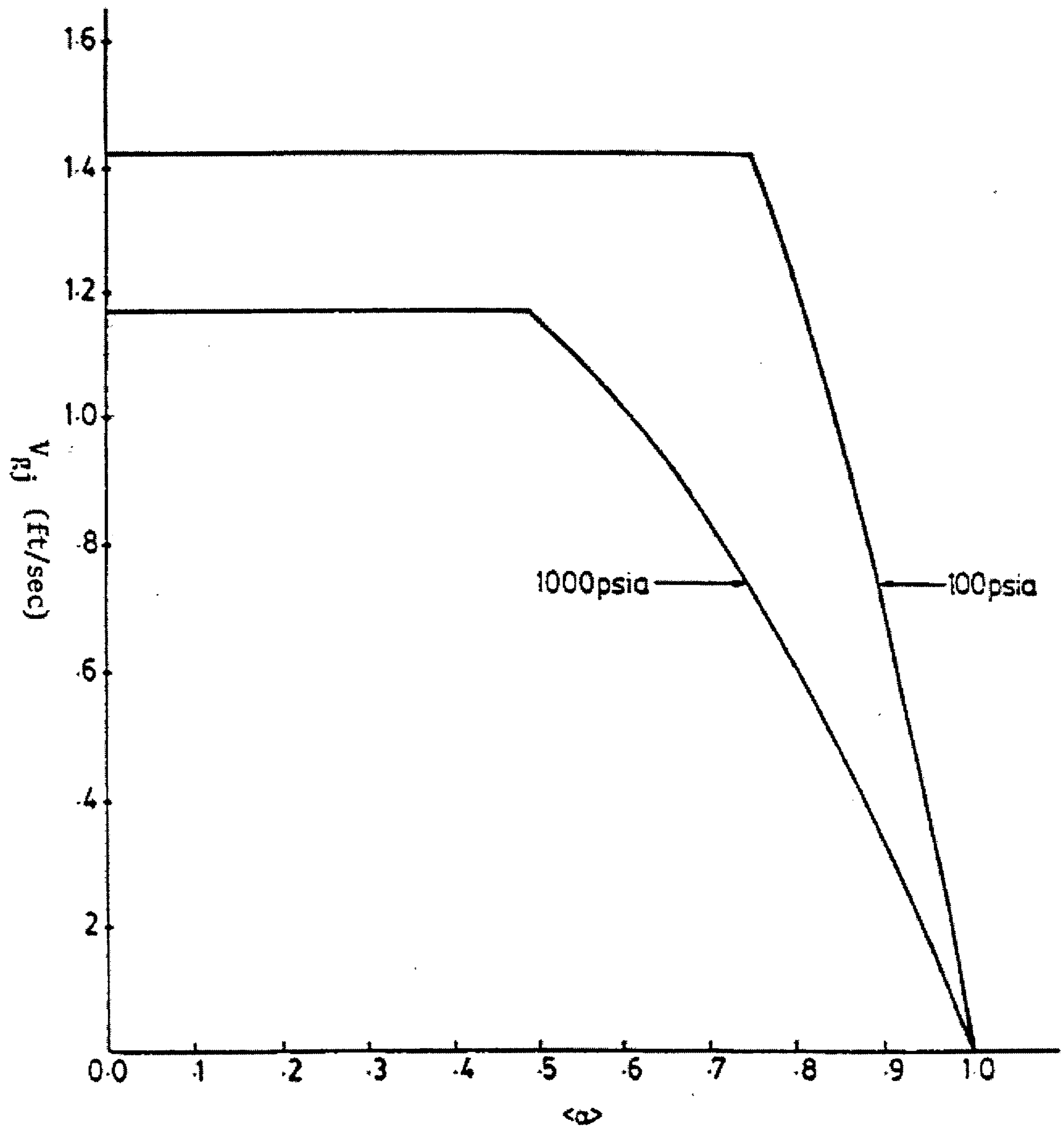
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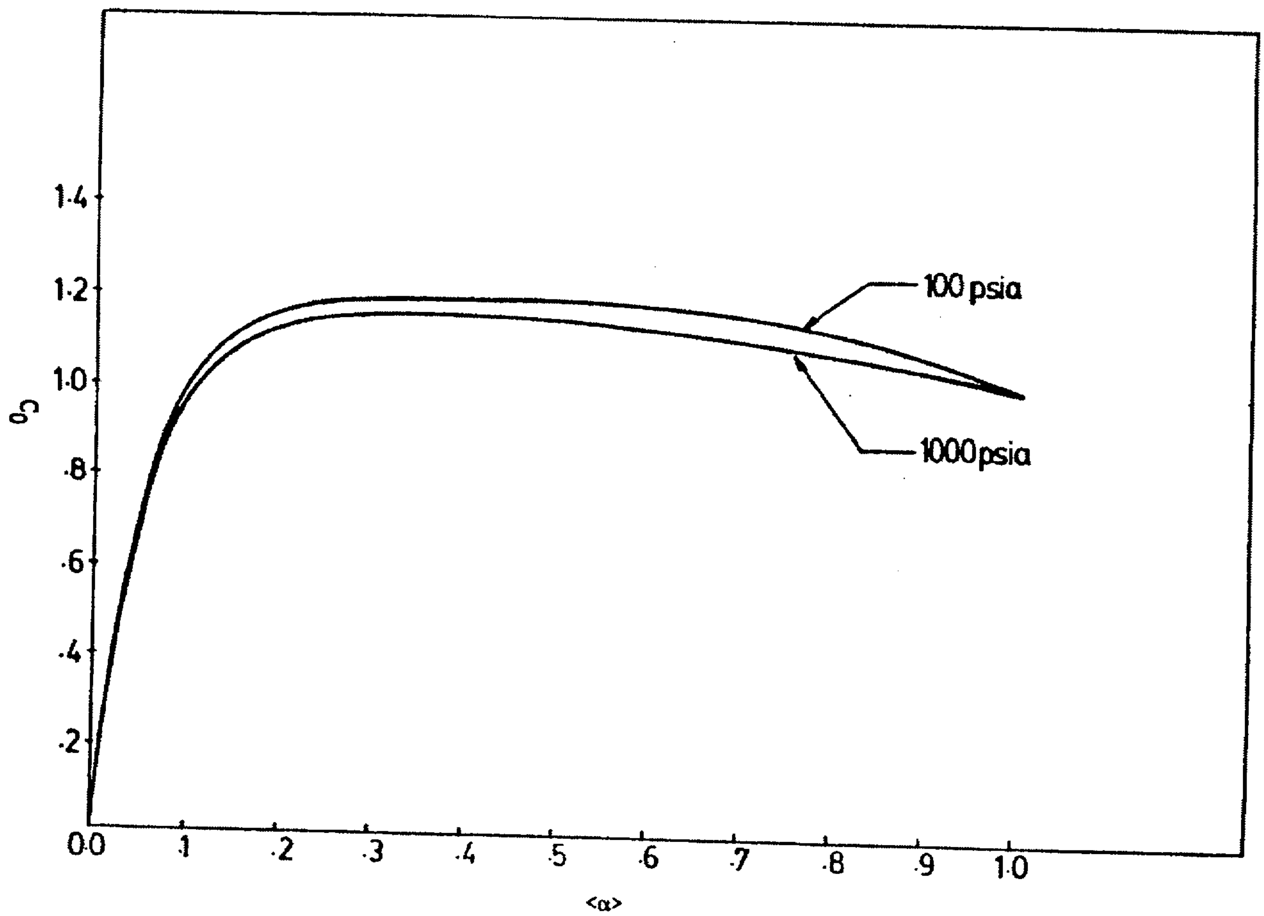

The Appendix K features of the methodology and the transient conditions encountered during the event obscure the effects of the drift flux model for comparisons of the RELAX calculations against the large break FIST cases. The small break case provides a better basis to judge the adequacy of the drift flux model. The topical report, EMF-2361(P), contains a plot (Figure 5.46) that compares the calculated and measured bundle mass versus time (at low pressure) for the small break case and shows reasonable agreement.

Question 3.

Is there any potential for introducing human error while transferring data from RELAX to FLEX in the current evaluation model EXEM/BWR? If there is, then does the proposed model EXEM BWR-2000 completely eliminates this potential source of error while using the code?

Question 3. Response:

The current evaluation model, EXEM/BWR, has a small potential for introducing human error in the specification of the files to be transferred between FLEX and RELAX. The EXEM BWR-2000 model does not use the FLEX code, and no data transfer is necessary. Thus, the potential for human error in this data transfer has been eliminated.

Question 4.

It was stated in the report that results from the EXEM BWR-2000 code, and FIST and TLTA tests, which are single channel results, will always give conservative PCT compared to large tests with multiple parallel channels of varying power; or the actual BWR behavior during LOCA. This is because spray coolant can easily bypass hot assemblies and reach lower plenum through colder peripheral assemblies resulting faster refill and reflood. It was further stated that single channel test and code results do not reflect this phenomenon. The staff requests the applicant to provide an estimated value of PCT reduction due to this phenomenon.

Question 4. Response:

An estimate of the PCT impact of the use of a single channel versus the use of multiple channels is provided below. The following assumptions were made to calculate the estimate of the PCT reduction.

- The upper plenum includes both of the volumes below the steam dome that are employed in the methodology.
- The lower plenum includes both lower plenums employed in the methodology as well as the guide tube volume.
- All of the mass that is injected into the upper plenum goes straight to the lower plenum.
- All of the mass in the bypass goes straight to the lower plenum.
- The time of reflood is directly related to the time the mixture level in the lower plenum fills that volume. That is, the mass in the lower plenum at the time of reflood for the actual calculation is the mass which is required to cover the lower tie plate for the adjusted calculation. This mass is called the reflood threshold. The new time of reflood is determined when the adjusted mass exceeds the reflood threshold.
- [ ]

The mass in the lower plenum was adjusted by adding the masses in the upper plenum and the bypass. The following plots show the differences in the time of reflood for the two cases for both large and small breaks.

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A more detailed calculation would show some holdup in the bypass volume as well as some changes in the swelling calculation of the lower plenum. These effects would reduce this PCT estimate.

Question 5.

In page 2-10 of the report, it was stated that, "A minor change was made to the critical flow model in RELAX." Please elaborate.

Question 5. Response:

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Question 6.

In order to verify the code performance and to be able to reproduce some of the results presented in the subject topical report, the staff requests the applicant to supply the following items: source code, executable, user code document, and specific input decks that should include one large-break and one small-break LOCA decks.

Question 6. Response:

This information was provided in the letter NRC:01:012, J. F. Mallay (FRA-ANP) to Document Control Desk (NRC), "NRC Review of EMF-2361(P) Revision 0, *EXEM BWR-2000 ECCS Evaluation Model*," March 1, 2001.