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August 16, 1982
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Office of Nuclear Reactor Regulations
Attn: Harold R. Denton, Director
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Resolution of NUREG 0737 Item II.K.3.20, SB LOCA Methods

On July 20, 1982, the B&W Owners met with the Staff to culminate the continuing dialogue on the scope of the program for resolution of NUREG 0737, Item II.K.3.30, "Revised Small Break LOCA Methods to Show Compliance with 10CFR50, Appendix K." This letter formalizes the proposals made at that meeting.

We will resolve the two separate areas identified by the Staff in the April 16, 1982 meeting. The first, assurance of core cooling (10CFR50, Appendix K), is being evaluated under an ongoing SB LOCA Methods program approved by the Staff. The B&W Owners will continue to address the NUREG 0737, II.K.3.30 staff issues in the SB LOCA Methods program as identified in Attachment #1. The B&W Owners Group has also prepared a number of reports as a result of the recent joint test evaluation with the Staff which are identified in Attachment #2.

The second area deals with the analytical basis for recovery of natural circulation, long term cooling, and operator guidelines and training for these events. B&W Owners propose to benchmark our best estimate codes with Integral System Test (IST) data from the GERDA SB LOCA test facility and a modified test loop of SRI, which is a two loop EPRI scaled test facility of TMI-2. The GERDA facility was designed to provide better understanding of the longer term response of the B&W system. It will also provide data which will validate ATOG assumptions for these transient periods. The SRI facility will be used to supplement the GERDA facility when investigating two loop effects. The inclusion of GERDA and SRI-II test data should also resolve the Staff's desire for improved understanding of the B&W design as expressed by the Staff in our meetings. GERDA will also provide test data for natural circulation, interruption of natural circulation, the transition to boiler-condenser mode of cooling and the long term cooldown of the system. This additional data will provide sufficient confidence in the validity of B&W best estimate codes to accept the Owner's program as resolution of II.K.3.30.

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From prior meetings, we understand the Staff desire for a large Integrated System Test. GPUNC (and, we understand, the other B&W Owners) is not willing to commit to an undefined and open-ended test program, but does recognize that issues may be identified as data are developed from GERDA/SRI which require further evaluation. We propose to evaluate any issues which arise and to take appropriate action for their resolution.

The following is a detailed explanation for this position.

Background:

Following the accident at TMI-2, the NRC required that further small break LOCA analyses be performed and that operator guidelines for managing small break loss of coolant transients be developed. The results of this work were documented by B&W in the May 7, 1979, "Blue Books." In their review, documented in NUREG 0565, the NRC concluded that while there was not a safety concern, certain features of the B&W SB LOCA Evaluation Model required more extensive verification. In general, the recommendations were that:

1. Additional code model predictions of Semiscale and LOFT experiments should be performed.

2. The SB LOCA methods should be revised to address their specific concerns. In addition, the licensees should verify the analysis models with appropriate integral system data.

These recommendations were implemented as requirements in NUREG 0737, Item II.K.3.30 and the following describes our actions toward resolution of this item.

Discussion:

The B&W Owners have taken several actions in responding to these recommendations. In response to recommendation 1, computer code simulations of LOFT tests L3-1[1] and L3-6[2] and Semiscale test S-07-10D[3] were submitted. The B&W simulation results compared well with the test data and the simulations presented by other Vendors. Nevertheless, the Staff still desires a benchmark to a geometry more closely resembling a B&W plant.

Prior to any action to respond to the SB LOCA issues in NUREG 0565, the B&W Owners Group met with the Staff on December 16, 1980, to obtain a better quantification of the Staff's issues relative to NUREG 0737, Item II.K.3.30. The Staff's issues were specified in the Staff minutes of that meeting.

On May 12, 1981, the Owners Group again met with the Staff to present their program designed to address the issues of reference 4. The Staff concluded that eight of the nine issues would be resolved by the implementation of the program presented but that IST data would be required before II.K.3.30 could be signed off by the Staff. Attachment #1 details the response to each of the nine items in reference 4. During the May 12 meeting, the Staff raised a number of issues over and above those originally quantified as II.K.3.30 issues. Following this meeting and for several months thereafter, a continuing technical dialogue was held between the Owners and the Staff in an effort to obtain and understand a complete list of specific issues.

Finally, in a meeting with B&W Utility Executives on October 23, 1981, the Staff identified the issues as uncertainties regarding hot leg "bubble dynamics" during the transition from natural circulation to the boiler-condenser mode.

From that October 23 meeting, the Staff agreed to participate in an in-depth review of the then current Babcock & Wilcox Small Break LOCA Methods Program, including the verification base. At the same time, the Owners agreed to participate in a joint effort with the Staff to assure that current Small Break LOCA methods and Anticipated Transient Operating Guidelines (ATOG) programs are fully understood. The program was to include the following:

- Code parameters, models, assumptions, etc., which are important in controlling dynamics of interest will be identified. Available experimental data substantiating their validity will be reviewed using results of the improved evaluation model in order that the most accurate dynamic response characteristics are reviewed.

- Additional existing experimental data, from separate effects or integral tests, will be identified which address specific technical gaps, if any.

- Identify where and how additional experimental data may be obtained, if any is required.

The Owners Group Analysis Subcommittee set a meeting with the Staff for December 16 and 17 to implement this commitment. The Owners came to that meeting prepared to address "bubble dynamics" and the CRAFT code. The Staff expected to be presented with a test program and the meeting ended in an impasse. In a letter to the Staff on February 5, 1982, the Subcommittee again set a meeting to discuss:

- Phenomena of bubble dynamics

- Sensitivity of the system to decay heat, number of HPI pumps, phase slip, and interphase heat transfer

- Discussion of benchmarks

On April 9, 1982, six reports were hand delivered to the Staff for review prior to the April 16 meeting with the Owners Group. Attachment #2 to this letter provides a brief description of these reports.

In the period between February and April, the Staff again expanded issues (for example, OTSG tube rupture, and cold leg thermal shock) outside of II.K.3.30 (reference 5). Since the Owners were involved in an intensive effort to produce documents in response to the identified focused issue of "bubble dynamics", it was not possible to address the items in reference 5 specifically in the April 16 meeting. The presentations in the April 16 meeting were well received and to date the Staff has made no negative comments on the information presented at that meeting. We have since addressed these issues (Attachment #3).

At the conclusion of the April 16 meeting, the issues could clearly be separated into two parts. One part deals with the assurance of core cooling (10CFR50, Appendix K) and the other deals with the analytical basis for recovery of natural circulation, long term cooling, and operator guidelines and training for these events. At this time, the Owners began to develop the program described above for acquiring IST data to benchmark best estimate codes to be used in calculating operator oriented phenomena for ATOG.

Summary:

The B&W Utility Owners are continuing their work to address II.K.3.30 with the SB LOCA Methods Program described to the Staff and with the six reports described in Attachment #2. We will (in cooperation with the other B&W Owners) benchmark best estimate codes with GERDA/SRI-II test data to provide better Staff understanding of the concerns in reference 5 which are outside of II.K.3.30. We believe that GERDA is a technically acceptable test facility to address the phenomena associated with recovery from a small break and offers a unique way to benchmark several of these phenomenon as they interrelate - that is, GERDA is an integral system facility designed to test the longer term natural circulation phenomena of the B&W design. We provided the Staff with technical presentations on the design of GERDA at the Alliance Research Center on July 7 and followed with a tour of the facility.

The majority of Staff comments were favorable during and immediately following the presentation. However, a very negative comment was made by the Staff in the July 20 meeting with the Executives. We would be happy to address any technical questions the Staff or their consultants might have regarding GERDA, SRI-II and the test programs at each facility. B&W will be sending you, under separate cover, a description of the GERDA and SRI-II test programs.

We view our IST test program as the final element in addressing issues raised by the Staff during their review of the II.K.3.30 SB LOCA program and as a source of useful data to address other issues. These tests will be used to determine if there is any residual need for additional or modified test facilities. We, therefore, invite the Staff to consider our test program as the means to maximize Owner and Staff resources on the highest priority programs while enhancing the knowledge of the B&W system.

We intend to provide a follow-up letter within the next several weeks which will provide additional details and milestones which we intend to pursue.

Very truly yours,

R. F. Wilson
Vice President
Technical Functions

RFW/al
ATT
cc: R. Jacobs
R. C. Haynes
R. Mattson
B. Sheron

## References


1. "B&W's Post Test Evaluation of LOFT Test L3-1", Document No. 51-1125988-00, May 1981.

2. "B&W's Best Estimate Prediction of the LOFT L3-6 Nuclear Small Break Test Using the CRAFT 2 Computer Code", Document No. 12-1124993-01, March, 1981.

3. "B&W's Post Test Analysis for Semiscale Test S-07-10D", Document No. 86-1125888-00, May, 1981.

4. Summary of Meeting with the B&W Owners Group Concernig the Abnormal Transient Operating Guidelines (ATOG) Program and TMI Action Item II.K.3.30 Small Break Loss of Coolant Accident Models (December 16, 1980).

5. Letter from Eisenhut to Mattimoe, March 25, 1982, Docket No. 50-312, Subject: Need for Model Verification.

ATTACHMENT #1

Nine areas of concern for II.K.3.30 were identified in the meeting of December 16, 1980 between the Staff and B&W Owners. These concerns are repeated below as found in the minutes of that meeting prepared by Mr. Throm of the Reactor Systems Branch. Owner responses to each concern are also included.

1. NEED TO VERIFY THE CURRENT NON-CONDENSIBLE MODEL AND THE CONSERVATISM OF THE CONDENSATION HEAT TRANSFER RATE IN THE STEAM GENERATOR.

   a) Report has been prepared describing a method to predict the amount of non-condensible gases in the primary system, including gas produced via radiolytic decomposition which may be released during a SBLOCA. This report will be submitted to the NRC in August 1982.

   b) A non-condensible gas heat removal model has been prepared and incorporated into the CRAFT code. This model is described in the revision to the CRAFT Topical Report scheduled for submittal to the Staff in September 1982.

2. NEED TO VERIFY THE NON-EQUILIBRIUM MODEL AND TO JUSTIFY THAT THE AMOUNT OF ECCS WATER INJECTED IS CONSERVATIVE.

   a) Report has been prepared and will be submitted to the Staff in August which justifies the current B&W ECCS evaluation model which utilizes CFT injection into the lower downcomer region.

   b) This work was discussed with the Staff in the technical presentations on December 16, 1981.

3. NEED TO DISCUSS THE PRESSURIZER MODEL AND THE EFFECTS OF A NON-EQUILIBRIUM MODEL.

   a) A non-equilibrium pressurizer model has been incorporated into the CRAFT code. This model will be addressed in the revised CRAFT Topical Report to be submitted to the Staff in September 1982. This model was discussed with the Staff on December 16, 1981.

   b) The surge line model was discussed with the Staff on December 16. The open question from the Staff will be addressed in a written response in September 1982.

4. NEED TO ADDRESS THE FORMATION OF A STEAM BUBBLE IN THE HOT LEG "CANDY CANE". (IS IT A REAL OR CALCULATED PHENOMENON?) EXPERIMENTAL VERIFICATION BELIEVED NECESSARY.

   a) This is addressed in several parts of the SBLOCA Methods Program:

      - System modeling study (steam generator, hot leg, and reactor vessel head)
      - Steam generator and pressurizer model changes

b) The joint NRC/Owners testing evaluation task concentrated on this issue. Documents described in Attachment #2 support the evaluation of this concern, and the report on "Bubble Dynamics" specifically addresses this concern.

5. THE STAFF INDICATED THAT A MECHANISTIC MODEL OF THE STEAM GENERATOR HEAT TRANSFER SHOULD BE DEVELOPED. A BEST ESTIMATE OR VERIFIED CONSERVATIVE MODEL WOULD BE ACCEPTABLE.

   a) The steam generator model has been upgraded and will be described in the revision of the CRAFT Topical Report to be issued to the Staff in September 1982.

   b) Steam generator model was presented to the Staff in the December 16, 1981 meeting.

6. AS PART OF THE ADDITIONAL SYSTEMS VERIFICATION NEEDED, THE FOLLOWING SEMISCALE AND LOFT TESTS SHOULD BE CONSIDERED: SEMISCALE S-07-10D, LOFT L3-1, L3-5, AND L3-6.

   a) The Owners considered the above tests and provided the Staff post test evaluations of L3-1, L3-6, and S-07-10D (References 1, 2, and 3 to this letter).

7. THE OVERALL THERMAL-HYDRAULIC BEHAVIOR OF THE CORE DURING UNCOVERY SHOULD BE VERIFIED AGAINST APPLICABLE EXPERIMENTAL DATA, PARTICULARLY THE RECENT ORNL DATA.

   a) ORNL data has been used to show that the current application of the Ditters-Boelter correlation is conservative. Data was discussed with the Staff on December 16, 1981, and a report will be provided to the Staff in August 1982.

8. THE INFLUENCE OF METAL HEAT ON THE SYSTEM PRESSURE RESPONSE, PARTICULARLY ON THE TIME OF ECCS INJECTION, WAS IDENTIFIED AS AN AREA OF CONCERN AND SHOULD BE SHOWN TO BE PROPERLY CONSIDERED IN THE ANALYSIS MODELS.

   a) The B&W ECCS Evaluation Model currently accounts for metal heat and no change needs to be made.

9. THE BREAK FLOW MODEL NEEDS TO BE CONFIRMED. THE USE OF COMBINED MODELS WITH VARIOUS DISCHARGE COEFFICIENTS APPLIED TO THEM NEEDS TO BE COMPARED TO A BEST ESTIMATE MODEL TO DEMONSTRATE CONSERVATISMS.

   a) The existing leak discharge model has been found to produce results which are similar to yet still conservative with respect to those obtained with the best estimate model.

   b) The work was discussed with the Staff on December 16, 1981 and the report will be provided to the Staff in August 1982.

ATTACHMENT #2

Documents prepared and submitted to the Staff from the B&W Owners' participation in the joint test evaluation task with the NRC.

"The GERDA Test Facility"

This report was prepared in fulfillment of the October 23 commitment by B&W.

"CRAFT 2 Prediction of ARC Loss-of-Feedwater Test", 12-1132544-00, April 1982

This report shows that the revised steam generator model adequately predicts the temporal response of key once-through steam generator parameters after a complete loss of feedwater.

"Auxiliary Feedwater Penetration", 12-1132513-00, April 1982
"Auxiliary Feedwater Axial Flow Distribution", 12-1132543-00, April 1982

The first report describes the calculation model and testing basis for the penetration of the auxiliary feedwater in the OTSG, and the second report uses this model and shows how the axial flow distribution was derived from FOAK testing at Oconee 1.

"Benchmarks for AFW Models", 12-1132555-00, April 1982

This report contains the benchmark results of the AFW models against actual plant data from four plant transients. The ability to predict plant response following loss of offsite power for the extreme conditions under which the AFW system will function is demonstrated in this report.

"Bubble Dynamics", 12-1132565-00, April 1982

This report is focused on the main phenomenological aspects of steam in the hot leg "U" bend and addresses test data and engineering evaluation used to understand "bubble dynamics". Based upon the focused Staff concern on the dynamics of a trapped steam bubble in the inverted U-bend of the hot legs, two issues were identified:

1. During the blowdown portion of the transient, does the code properly predict the formation of the steam bubble and its resultant interruption in natural circulation?

2. During the system refill phase of the transient, how does the trapped steam bubble behave?

In addressing these issues, a review of the calculated plant response was performed in order to assess the controlling phenomena. As a result of that review, it was determined that the governing phenomena were:

1. Interruption in Natural Circulation

   - Spatial heat transfer in the steam generator
   - Distribution of steam flow from the core
   - Phase slip within the hot leg
   - Steam condensation in the steam generator

2. System Recovery Phase

   - Steam condensation on steam-liquid interface

Test data supporting the modeling of these phenomena has been evaluated and reported in the documents listed above. Further understanding of the plant response is provided in a qualitative assessment of plant behavior to various input and modeling assumptions contained in this report. It is clear that the concern on the interruption of natural circulation is a byproduct of the Appendix K assumption on HPI flow. Using the single failure assumption of Appendix K, it is shown in this report that phase slip modeling is important to the development of the plant response. Phase slip modeling is a part of the current SBLOCA Methods Program. The adequacy of current phase slip modeling was shown in the evaluation of test data discussed in the April 16 meeting with the Staff and summarized in this report.

ATTACHMENT #3

Responses to the Eisenhut to Mattimoe letter of March 25, 1982.

1. Interruption of Natural Circulation

   - Branch Flow

     The effect of preferential steam flow to the hot leg or the RV head has been addressed in the "Bubble Dynamic" report (see Attachment #2). Branch flow was discussed with the Staff in the April 16, 1982 meeting.

   - Hot Leg Flow Regime

     This was addressed in the Slip model presentation to the Staff on April 16, 1982 and is discussed in the report "Bubble Dynamics" (see Attachment #2).

2. Cold Leg Thermal Shock

   The concern over cold leg thermal shock was derived, as we understand, from TRAC computer calculations performed by LASL for the Staff wherein significant cyclic temperature variations were shown in the vicinity of the cold leg ECC injection. We encourage the Staff to have an independent QA performed on these calculations by an organization familiar with the hardware and components of the B&W designed system If the cyclic behavior is confirmed, programs are already in place to address thermal shock and this item would be included in that effort.

3. Hydraulic Stability Following Accident Recovery

   This concern is addressed in the report "Bubble Dynamics" and was discussed with the Staff on April 16, 1982. In addition, the presentation given in that meeting, "Steam Condensation on Steam-Liquid Interface", also addresses the governing phenomenon in the recovery phase.

Other concerns in the March 25 letter were: break isolation, steam generator tube rupture, and cooldown and depressurization following a SBLOCA. These concerns are covered by the ATOG Guidelines and some are specific per plant type. Further discussion on these items is expected but not as a part of 11.K.3.30.