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October 13, 1982

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Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

SUBJECT: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
NUREG-0737 Item II.K.3.30 -
Small Break LOCA Methods

Gentlemen:

On July 29, 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 plan to resolve the two separate areas identified by the Staff in the April 16, 1982, meeting between the Staff and the B&W Owners Group Analysis Subcommittee. 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 second area deals with the analytical basis for recovery of natural circulation and long term cooling. B&W Owners propose to benchmark our best estimate codes with Integral System Test (IST) data from the GERDA SB LOCA test facility. This facility was designed to provide better understanding of the longer term response of the B&W system. The inclusion of GERDA and SRI-II test data should also alleviate the general uneasiness regarding the need for improved understanding of the B&W design which has been expressed by the staff. GERDA will provide test data for natural circulation, interruption of natural circulation, the

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transition to boiler-condenser mode of cooling and the long term cooling of the system. This additional data should provide the Staff with sufficient confidence in the validity of B&W best estimate codes to accept the Owner's program as resolution of staff concerns. The B&W Owners Group has prepared a number of reports as a result of the recent joint test evaluation with the Staff which are identified in Attachment 2.

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:

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

2. The SB LOCA methods should be revised to address their specific concerns.

These recommendations were implemented as requirements in NUREG-0737, Item II.K.3.30 except that the need for code revisions was not taken as given as in NUREG-0565. NUREG-0737 permitted justification of the existing code using Semiscale and LOFT data.

Discussion

We initially proposed to justify the existing code using existing test data as suggested in NUREG-0737. Our April 30, 1981, letter documented this proposal in formal response to NUREG-0737 and addressed every concern listed in NUREG-0565. 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.

Since configurations tested in Semiscale and LOFT do not reflect all plant designs and arrangements, the acceptance by the Staff of benchmarks by other vendors would seem to be also applicable to B&W benchmarks of the same tests as adequate testing of computer codes used in SB LOCA calculations.

In mid-1981, the Staff began informally expressing dissatisfaction with our response. Continuing informal dialogues with the Staff in the months following our submittal identified the fact that the Staff was unfamiliar

with effects of the unique aspects of the B&W design and that their unfamiliarity caused them to be less than comfortable with our ability to model the B&W system. It wasn't until October 23, 1981, in a meeting with B&W Utility Executives that the Staff concerns were defined as regarding uncertainties related to hot leg "bubble dynamics" during the transition from natural circulation to the boiler-condenser mode. At that meeting it became apparent that the Staff would not seriously consider our previous submittal. Therefore, without any formal response from the Staff to our previous submittal, we committed to an extensive code modification program (Small Break LOCA Methods Program) and the installation of high point vents and hot leg level measurement to address the Staff's hot leg "bubble dynamics" concerns.

In the October 23, 1981, meeting the Staff agreed to participate in an in-depth review of the Small Break LOCA Methods Program, including the verification base. At the same time we 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, and available experimental data substantiating their validity will be reviewed. This would be done 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. We 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 outside of II.K.3.30 (reference 5). Since we 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 perceived by us as being well received by the Staff and to date no negative comments have been received from the Staff on that meeting.

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.

We are continuing our 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. In further compromise, we offer to 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. Before proceeding, however, we must receive adequate assurance that the Staff will accept our previous work on II.K.3.30 as closing out that licensing issue. We believe that GERDA is a technically acceptable test facility to address the phenomenon 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 test focused on 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 has sent you, under separate cover, a description of the GERDA and SRI-II test programs. We propose that a cooperative evaluation program be established that would support our continuing work to address Staff concerns in this area. This cooperative evaluation program is designed to satisfy the following objectives.

- Expand the test data base for SB LOCA phenomena by providing two-phase IST data to enhance calculational tools used to predict long term plant performance with an SB LOCA.

- Improve the Staff's knowledge of the B&W plant design and increase their confidence in our prediction of plant performance under various transients.

The cooperative evaluation program outlined in figure 1 is responsive to the Staff request of July 20, 1982, because it leads to the development of research priorities and the determination of the most cost-effective method of satisfying those priorities. The near term test data from GERDA will be evaluated to verify scaling assumptions and predicted loop performance for that facility. The program outlined herein will provide a comprehensive data base for code benchmarking by the Staff and the Owners and should result in codes of equal validity. Such codes should then provide the Staff with more confidence in the analytically predicted behavior of B&W plants and any future deviations between Staff and Owner calculations would be easier to explain. The GERDA test data would be made available on a proprietary basis to the Staff free of charge for their code benchmarking efforts. Such benchmarking would improve our confidence level in the staff's LOCA models.

If upon completion of the evaluation, the residual needs justify further action, then this program will provide valuable input into the design, modification, or confirmation of a test facility by minimizing the potential for inadequate facility design and by maximizing the chance to emphasize the design to better replicate key phenomena.

The success of this cooperative program is dependent on all parties striving, despite varying initial technical views, to reach a common point. To achieve this end several associated requirements should be satisfied. All parties must agree to commit the necessary resources to obtain the objectives of the program and a joint level management review forum should be established to review and monitor progress of the program. As a B&W Owner, we will obtain the integral system test data from the German GERDA facility. We will also continue to support the on-going SB LOCA Methods Program to assure timely delivery of our report to the Staff. For us to do this, it is essential that the NRC Staff develop and issue an SER that closes out II.K.3.30 so that II.K.3.31 work on operating and NTOL plants may proceed without further diversion of Owner and Staff resources as noted in the above paragraph. We would offer to provide GERDA data to the NRC Staff at no cost for your use in benchmarking TRAC and RELAP5 provided that the NRC Staff submit their models of a B&W plant to B&W for review and QA. The cost of this effort is expected to be borne by the NRC.

We have selected this approach because it provides near term test results that are of value to both the NRC Staff and the B&W Owners. It is very cost effective because it takes advantage of readily available IST data from an existing facility representative of the B&W design. The program provides an expanded base of knowledge about the B&W design which will aid the Staff in future regulatory actions and will prove invaluable in the decision making process regarding future testing and test facilities.

We are not averse to testing once the technical justification is clear and a cost-benefit analysis supports the need. Therefore, in considering changes to the program provided in this letter, we reserve the right to reconsider our commitments if the above two criteria are not satisfied. In addition, due to the failure to reach an agreement as to the acceptability of our proposal, and due to continuing activity within the Staff relative to RCS level instrumentation we have been unable to provide design and schedule information for RCS hot leg level instrumentation.

We have initiated contact with H. Sullivan of the NRC Staff and the first meeting of the Test Advisory Group was held on September 17, 1982. At the meeting, the NRC Staff provided the preliminary cost benefit analysis of the various IST options performed by their consultants. The charter and approach to be used by the TAG is summarized in Attachments 3 and 4.

We are moving forward on the GERDA IST evaluation and are willing to participate in a joint panel with the NRC as outlined in this letter. Our program is one we can defend both technically and financially and we invite the NRC to join us in this effort. If you have any questions, please call.

Very truly yours,

John R. Marshall

John R. Marshall
Manager, Licensing

JRM/DRH/jm

Attachments

REFERENCES

1. "B&W's Post Test Evaluation of LOFT Test L3-1", Document No. 51-112598-00, 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. 86-112588-00, May 1981.

4. Summary of Meeting with the B&W Owners Group Concerning 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.

INTEGRATED SCHEDULE FOR TAG AND OWNERS GROUP ACTIVITIES

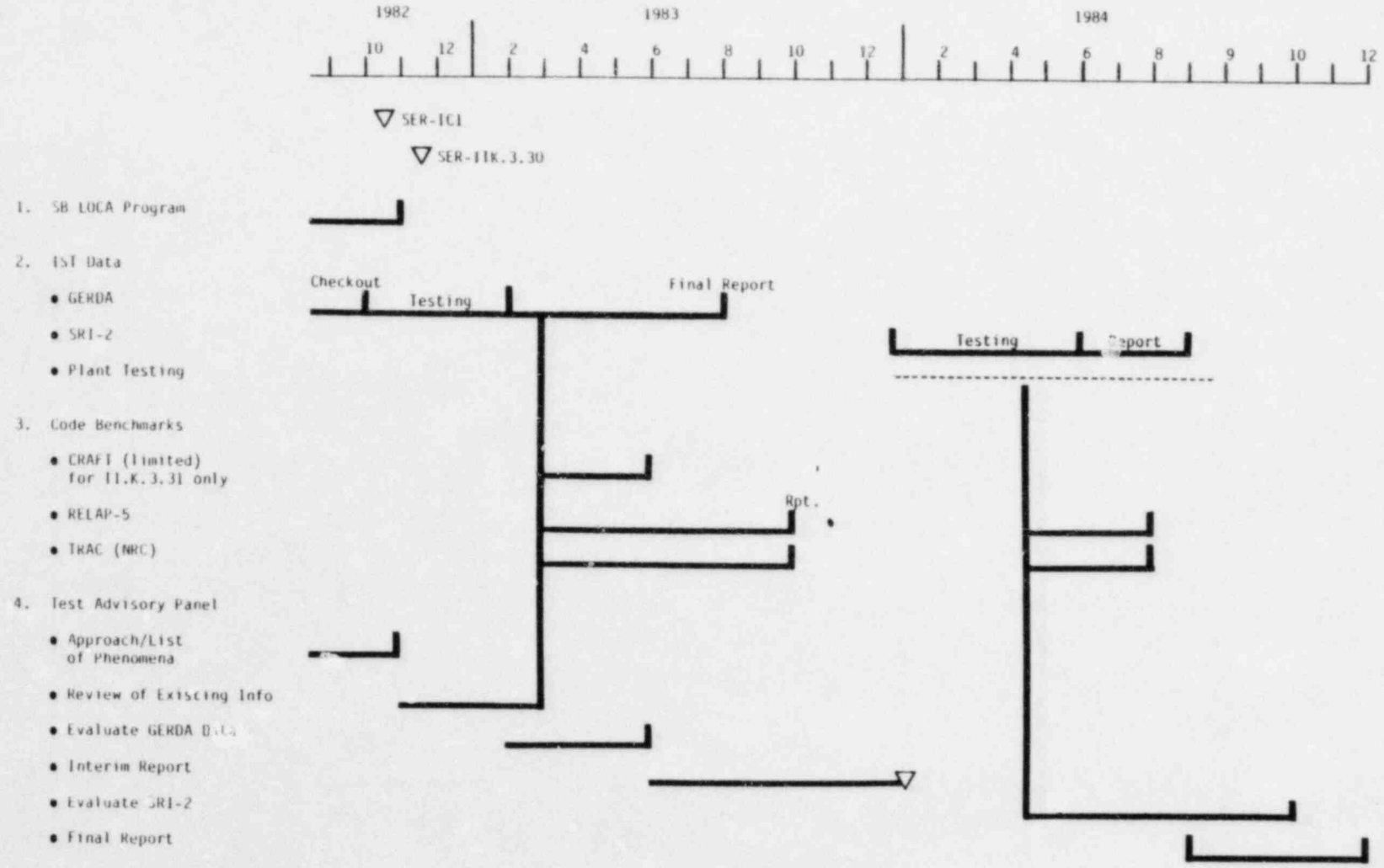

FIGURE 1

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. 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 SB LOCA. This report will be submitted to the NRC in October 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 October 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 October which justifies the current B&W ECCS evaluation model which utilitizes 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 October 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 October 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 SB LOCA 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 October 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. Test L3-5 was determined to be not applicable.)

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 October 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 THE 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 October 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, 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", 12-113255-00, April 1982

This report contains the benchmark results of the AFW models against actual plant data from four plants 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 Recover 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 SB LOCA 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

CHARTER FOR TEST ADVISORY GROUP (TAG)

Objective:
- Evaluate Testing Needs
- Develop Cost Benefit of Future Testing

1. Members:

- NRRES - Sullivan (Chair)
- B&W Owners Group Analysis Subcommittee
- B&W
- Reactor System Branch
- EPRI

2. Scope:

- Develop List of Phenomena that Codes Simulate
- Identify Benchmark Needs
- Evaluate the Acceptability of Current Data
- Evaluate the Acceptability of GERDA/SRI-II/Plant Testing to Satisfy POI
- Identify Possible Ways to Fill Residual Testing Needs and Cost Benefit

Evaluation panel will not manipulate/control GERDA/SRI-II Testing or Code Benchmarking by the Owners.

3. Products:

- Listing of Phenomena in Codes that Data Must Support
- Phenomena Supported by Current Information
- Phenomena Supported by GERDA/SRI-II/Plant Testing
- Cost Benefit of Facilities to Address Residual Issues

4. Conditions:

- List is Composed of Phenomena, Not Licensing Concerns
- Commitment of Resources by all Participating Parties
- We Will Provide Data to benchmark TRAC. NRC to Agree to Certify a Deck for B&W Plants to be Approved by B&W.
- Reports Must Include All Participants' Positions (i.e. Dissenting Views)

ATTACHMENT 4

DETAILED APPROACH AND PRODUCTS OF GROUP

The panel would be expected to first identify the phenomena (not the licensing issues) which both the TRAC and RELAP-5 models simulate. Once this list is established, we will identfy the phenomena for which test data already exists. (It is recognized that the data in some cases may not completely satisfy benchmarking needs, but it is very important that this approach be comprehensive so that needs can be put into perspective.) Using the GERDA test plan, the panel can speculate on the phenomena which it can replicate; thus, focusing in on an initial list of residual needs.

Once GERDA testing is complete in March of 1983, the panel will be in the position to identify a list of final residual needs, alternatives for resolving these needs, and the cost-benefit of each. At that time one loop hot leg bubble dynamic data will be available, the performance of GERDA will be known, the basis for loop modifications to study any residual needs will be better understood, and any outstanding issues from GERDA can be incorporated into future actions.