OFFICE OF THE
COMMISSIONER

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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January 18, 1990

MEMORANDUM FOR: James M. Taylor
Executive Director for Operations

FROM: Kenneth C. Rogers

SUBJECT: RESEARCH INFORMATION LETTER 164 ON THERMAL-HYDRAULIC DATA FOR B&W LOWERED LOOP DESIGN

I have recently had an opportunity to review Research Information Letter 164, Thermal-Hydraulic Data Base Relevant to Plants of the Babcock and Wilcox Lowered-Loop Design. I wish to congratulate the staff on their clear and convincing explanation of the need for the UMCP 2x4 Loop in addition to the MIST facility.

I have long been concerned that individuals unfamiliar with the basic principles of experimental design do not have a good understanding of why research must often be performed in several different ways to develop assurance that what an experiment measures is not merely some artifact of the experimental design. The paragraph in RIL 164 did an excellent job of providing such an explanation for this particular case. I would like to see more explanations of this kind in descriptions of NRC activities, particularly in documents prepared in support of our budget, in responses provided to Congressional inquiries, and in descriptions of our research accomplishments.

Kenneth C. Rogers
Commissioner

cc: Chairman Carr
Commissioner Roberts
Commissioner Curtiss
Commissioner Remick

Subject: Reply to Memorandum of June 3-4 Meeting by Virgil E. Schrock

Dr. Schrock made three comments which can be responded to.

1. "The obvious problem here is that the process being pursued assumes that RELAP5 is capable of capturing the phenomena in both systems. An example of where this may be untrue is the mixing that could be caused by jetting of the steam into CMT with consequent rapid condensation. This potentially important phenomenon is not well modelled in RELAP5. Suppose it is not seen in ROSA-IV. This will provide no assurance that it will not be important in AP600."

   Reply: We note that we expect to have the results of the Westinghouse CMT component tests prior to the start of ROSA testing. This should provide the information needed to determine if this phenomena is "potentially important" and if modelling improvements are required in RELAP5.

2. "Use of a single CMT causes atypical condensation in PBL. This looks like a major problem."

   Reply: This is one reason we decided on two CMTs for ROSA. With this configuration, we can obtain more similar condensation behavior between ROSA and AP600.

3. "I was not persuaded by this meeting that it is a good idea to use ROSA to meet the AP600 IST needs."

   Reply: We believe we have established a sound basis for the ROSA program. We reiterate this is a confirmatory test program. and it should be remembered that RES will also be utilizing the results of the Westinghouse test programs to validate RELAP. ROSA must be considered within that context. Our calculations demonstrate good similitude between ROSA and AP600 such that we have confidence that conduct of the program will meet its objectives of providing data for code assessment.

Subject: Reply to Memorandum by V. K. Dhir on the June 23-24 ACRS Thermal Hydraulic Subcommittee Meeting

The following responds point-by-point to comments provided by Dr. Dhir on the subject meeting. It is organized according to Dr. Dhir's memo.

Westinghouse Presentations

1. No comment.

2. No comment.

3. We agree with Dr. Dhir's statement.

4. We agree with Dr. Dhir's statement that SPES has several desirable features. We will evaluate the effect of the non-prototypicalities when we obtain the SPES scaling study.

5. Qualitatively, one would expect these changes to be of benefit. The staff will evaluate whether the SPES cold leg configuration and pressurizer significantly impacts the adequacy of SPES as part of our scaling review.

6. No comment.

7. No comment.

NRR Presentations

1. NRR expects, at this time, that SPES should provide data Westinghouse needs for design certification. The ROSA program will provide confirmatory research needed by the staff to make more intelligent and informed judgements concerning the certification of the AP600 design and the supporting material provided by Westinghouse.

Research Presentation

1. There was no attempt on the part of Research to confuse the issues with respect to modification and atypicalities of the ROSA facility and the results obtained with the RELAP code. There is, however, a considerable body of information that can be difficult to convey and grasp in a short period of time.

2. We do not view the absence of two cold legs per loop as a crucial non-prototypicality. The ROSA testing is not intended as a <u>demonstration</u> of the AP600, rather, it is intended to reproduce similar phenomena and processes for the purpose of code assessment. Our scoping calculations show that this is indeed the case.

3. We have performed a RELAP applicability review that concluded that RELAP is capable of calculating the important phenomena and processes in the AP600. Thus, we have reasonable confidence that our ROSA and AP600 calculations are not misleading. Our confidence in RELAP will be further established through our overall validation program that includes the Westinghouse separate effects and component tests, SPES, and OSU.

4. This is unfounded and reflects a lack of knowledge of the overall research program. In fact, we will have completed our currently envisaged program of code modifications well prior to the start of ROSA testing. We will also have completed a substantial part of the RELAP validation. The belief that Research is rushing into tests with ROSA is completely erroneous, considering that the preplanning for the ROSA program has been at least two years in the making. Perhaps Dr. Dhir does not have an appreciation of this background. The schedule is such that if a decision is not made immediately on ROSA, then a confirmatory test program in keeping with FDA is impossible.

5. i. It is not clear which modifications Dr Dhir is referring to. We presume they are the reconfigured cold legs and full length pressurizer. However, it is not clear what reference material Dr. Dhir has reviewed that would have allowed him to draw a conclusion that "SPES will be very close to prototypical."

   ii. We already plan to perform this task.

   iii. We already have a clear view of what is involved in adding another cold leg to each loop of ROSA. The costs and schedule would be effectively prohibitive. We have already given serious consideration to a domestic facility. We have stated that, ideally, this is our preference, however, such a facility could not be built within the FDA schedule, and would be considerably more expensive than the ROSA program.

   iv. We already have an aggressive program to enhance the capability of RELAP to model the phenomena and interactions expected to occur in AP600. This already includes the Westinghouse separate effects tests, OSU, and SPES. The value of performing integral tests on a smaller scale than OSU is dubious, at best. This suggestion is without merit, given the OSU facility already exists.

APPENDIX IV

APPENDIX IV

Subject: Historical Development of the RES AP600 Research Program on Thermal Hydraulic Transients

Some comments have been made that the RES ROSA-AP600 testing program has been hastily conceived and is not well-founded. The following is intended to provide some perspective on the research program that has led to the current plans. It will be shown that the research was well-planned from the start and has progressed methodically.

RES began planning its research program on the AP600 and SBWR in August 1988. Following internal planning and discussion, RES provided INEL with a broad description of the research objectives and asked INEL to submit a research proposal. This was provided by INEL in November, 23, 1988 (Ref. 1). Tasks described included:

- o Review AP600 and SBWR System Designs;
- o Establish Objectives and Criteria for Analysis of ALWRs;
- o Assess the Applicability of Current Analysis Tools for Design Basis Accidents;
- o Provide Experimental Support; and
- o Provide Additional Model Development and Code Assessment Work.

RES started a research program at INEL on June 15, 1989 (Ref. 2). This was approximately one year before the first user need on the subject was received from NRR (Ref. 3). The research called for INEL to perform the following tasks:

1. Review the design and operational characteristics of the proposed passive LWRs.
2. Perform a comparative study to identify important safety related design differences between the reactor and plant systems of the proposed designs and the present generation of LWRs.
3. Identify the systems and phenomena that pose new analysis requirements for predictions of system response under accident conditions.
4. In conjunction with the above, review the current applicable regulatory rules, SRP requirements and policies for the passive LWRs to support identification or research and analyses needs.

Conduct of this work resulted in the preparation of Refs. 4, 5, and 6. These documents review the designs from the perspective of identifying transients, phenomena, and processes of interest to safety assessment, as a precursor to reviewing and identifying data and code modeling needs.

In FY 1990, the work continued and evolved with the following tasks (Ref. 7):

1. Based on the review of the data base for unique thermal hydraulic behavior for APWR transients, identify what additional experimental data are needed.

2. Based on the determination of the adequacy of NRC best-estimate thermal hydraulic code(s) in predicting unique behavior, recommend actions to correct code deficiencies.

3. Develop a code input deck and perform sensitivity calculations to assess the effect the lack of experimental data identified in task 1 above.

INEL responded to task 1 with the following conclusions (Refs. 8, 9, 10, 11):

1. There are basically no new phenomena involved in the AP600, however the physical parameter ranges and applications of the phenomena may be different than those in present generation reactors.

2. The most important and least known aspects of AP600 safety functions and responses are the system and phenomena interactions in the presence of low driving heads.

3. The Westinghouse experimental program seems to comprehensively address most of the problems associated with the new AP600 design characteristics. Also, there is a large data base unrelated to the AP600 design which may provide information for code model assessment of the particular phenomena of interest.

4. In experimentally evaluating the behavior of thermal hydraulic systems, one needs separate effect experiments and integral type of experiments. The AP600 system interaction concerns lead to a need for a flexible integrated facility.

Task 2 provided the following modeling requirements that must be assured or added to RELAP5. A RELAP5 code applicability review was also performed (Ref. 12). RELAP models and correlations were reviewed from the perspective of new AP600 phenomena and features that could be important to reactor safety. The purpose was to identify those areas in which new mathematical models of physical phenomena would be required to be added to RELAP5. In most cases, the AP600 design and its systems and the planned and off-normal operations were found to be similar enough to current PWRs that RELAP safety analysis applicability was unchanged. Nevertheless, a list of recommended enhancements or validation requirements was identified by INEL as follows (Ref. 10):

- Noncondensible effects
- Thermal stratification
- Containment

- o 1-D kinetics
- o Boron transport
- o Mixture level tracking
- o Draining from sump to vessel
- o 3-D hydrodynamics
- o Sparger model

Work on these enhancements to existing code modeling did not begin immediately, being deferred approximately 6 months due to the press of higher priority problem resolution in RELAP5/MOD3 (Ref. 13, 14).

Task 3, the development of an AP600 RELAP5 input model, was reported as Ref. 15. Following completion of the model scoping calculations were begun (e.g., Refs. 16, 17).

On July 13, 1990, the first NRR user need was received on thermal hydraulic research needs for passive plants (Ref. 3). This was followed by a broad user need received on December 11, 1990 (Ref. 18). These needs were basically reiterated in April 24, 1991 (Ref. 19). These user needs did not point towards integral system testing requirements for RES or the vendor, rather, RES was requested to evaluate the need for such testing. The common view of RES and NRR staff at that time was that the W separate affects testing program, once modified per NRC suggestions, would provide adequate data for modeling separate effects phenomena and processes. In the spring of '91, NRR decided that a full-height full-pressure facility would be required for design certification and informed the Commission in SECY-92-030. On May 15, 1991, NRR provided RES with a white paper on the need and scaling considerations for FHFP testing of AP600 (Ref. 20). This was as yet not a formal user need, however, in June 1991 RES began considering the possibility of using ROSA for such testing.

In FY91, in keeping with the original work plan developed by RES and the NRR user needs, work was continued with the following tasks (Ref. 21):

1. Review AP600 design information for evolving design changes with potential safety implications. Review operation of non-safety systems for possible impact on the performance of safety functions. Include operating experience of passive systems, if available.

2. Based on current information, complete development of the AP600 RELAP5 input deck and prepare an interactive NPA mask. Keep informed on evolving design changes and modify the deck as necessary.

3. Perform AP600 scoping calculations to explore unique system behavior during postulated accidents. Identify the minimum safety system configuration capable of coping with postulated accident initiators.

4. Develop and support an experimental program which will enhance understanding of AP600 safety systems functions and provide needed data base for model assessment.

5. Develop an assessment plan and initiate code assessment using the available thermal hydraulic experimental data base. Applicable experiments shall be simulated and code adequacy assessed.

In addition, based on the identified need for integral system testing on AP600, work was carried out to define scaling requirements for an integral facility. This resulted in preparation of Refs. 22-24, the latter issued on June 13, 1991. This work built on previous scaling studies including reviews of LOFT, SEMISCALE, MIST, University of Maryland (UMCP), Continuing Experimental Capability, BETHSY, ROSA-IV, and others (see Ref. 24). It included results of a peer review conducted by RES during 1990 of the UMCP facility and experimental results. This peer review concluded that scaling up pressure from a low pressure facility is difficult at best. The scaling evaluation concluded that full height full pressure (FHFP) volume scaling should ideally be at least 1:40 and that reduced height reduced pressure (RHRP) scale should be at least 1:4 scale in height. By June, 1991, RES began evaluating the possibility of performing FHFP AP600 testing in ROSA (Ref. 25-28). At the same time, RES began to develop an RFP to construct a RHRP pressure test facility in order to cover the range of AP600 operation.

RES also formally notified NRR of our support for vendor integral testing of the AP600 at this time (Ref. 29). Shortly after, in August, 1991, the staff informed the Commission of its preliminary review of vendor test programs to support design certification of passive light water reactors (Ref. 30). In this paper, the staff noted its concern about a lack of integral system testing for the AP600 on the part of the vendor and indicated a further Commission paper on the subject would be forthcoming. This Commission paper was issued on January 27, 1992, and called for Commission endorsement on requiring FHFP vendor AP600 integral testing (Ref. 31). On November 15, 1991, NRR first issued a user need for RES to conduct independent integral system testing of the AP600 (Ref. 32). NRR requested large scale, full pressure, full height integral testing as well as reduced height low pressure testing. RES responded (Ref. 33) by describing its plans to conduct high pressure testing in ROSA and to issue an RFP for low pressure testing.

RES had formally notified JAERI on August 23, 1991 (Ref. 34) of its interest in performing AP600 testing in ROSA. This facility was judged to be the best existing facility in the world based on its scale and configuration. JAERI immediately indicated its interest (Ref. 35) and an initial meeting between RES and JAERI was held in September 1991. Analyses were in progress by INEL during this period. In November 1991, JAERI attached a ROSA engineer to assist INEL in their calculations.

On January 31, 1992, RES held a meeting to review the INEL calculations. The attendance included INEL, JAERI, NRR, and two RES consultants. It was concluded that ROSA would provide acceptable similitude of AP600 phenomena and processes and that an experimental program would be cost-beneficial (see for example Appendix III). INEL was instructed to perform additional calculations to help decide on the best set of AP600 modifications to the ROSA facility. These

calculations were completed in early May 1992 (Ref. 36), at which time a copy was transmitted to the ACRS.

On January 31, 1992, the Commission was requested to approve RES plans for RHRP testing (Ref. 37). The staff also presented options and sought Commission guidance with respect to FHFP testing. The benefits and drawbacks of the different options were described. This included the possibility of conducting FHFP testing in ROSA, which the staff stated was under continuing review. RES provided the ACRS an earlier draft Commission paper that covered Refs. 31 and 37 on November 29, 1991 (Ref. 38).

On March 10, 1992, a proposal was received from Westinghouse for a cooperative integral system testing program that would allow: NRC participation in Westinghouse's RHRP Oregon State University (OSU) facility; participation in Westinghouse FHFP SPES testing; and NRC FHFP confirmatory testing in ROSA (Ref. 39). This proposal was presented by Westinghouse and the staff to the Commission on March 11, 1992. This proposal obviated the need for the staff to construct its own RHRP facility, therefore RES withdrew its RFP and terminated this effort, focusing instead on confirmatory FHFP testing. Details of this cooperative integral system program with W are still being developed.

With a view to the above developments, the Commission responded to SECY-92-037 with Staff Requirements Memoranda (SRM) on March 19, 1992 and on April 23, 1992. The staff responded to the SRMs on March 27, 1992 and on June 4, 1992, respectively (Refs. 40, 41). The Commission authorized the staff to proceed with discussions with JAERI and planning for ROSA testing, and to inform the Commission of progress. RES visited JAERI to discuss the conduct of AP600 testing in ROSA during April 27 to May 1, 1992. On June 2-3, RES met with INEL to decide on the set of modifications to be made to ROSA for AP600 testing. NRR, JAERI and Westinghouse attended the meeting, as well as two RES consultants. General agreement was obtained on the scope of modifications and an experimental program (see Appendix II for consultants and other reports evaluating the proposed use of ROSA for AP600 testing). The staff presented its findings to the Commission in SECY-92-219, and recommended the Commission approve its proposed testing program in ROSA (Ref. 43).

During this period, RES staff met several times with the ACRS to present the above program. We also discussed this in two recent Commission papers (SECY-92-037 and SECY-92-219). A list of these meetings, and their main topics, were on:

i. June 8, 1989, plans to initiate ALWR research;

ii. November 7, 1991, Review of Vendor's Test Programs for Advanced Passive Reactors (SECY-91-273);

iii. December 17, 1991, Issues Related to Integral Systems Testing for the AP600 Design, Staff Plans for Confirmatory Research on AP600 Thermal-Hydraulic System Performance, Scaling Issues for a Thermal-Hydraulic Integral Test Facility for the AP600 Reactor Design, ROSA-IV/LSTF Facility Applicability to AP600 Safety Research, Preliminary Results;

iv. January 9, 1992, Need for Large Scale Integral Systems Testing to Support AP600 Design Certification, Staff Plans for Confirmatory Research on AP600 Thermal-Hydraulic System Performance;

v. February 6, 1992, Staff Views on Integral Systems Testing Requirements for the AP600, Status of AP600 Confirmatory Integral System Testing;

vi. March 3, 1992, Need for AP600 Integral System Testing, Scaling Issues for AP600 Integral Testing, Use of Code for Code Validation, Staff Plans for Confirmatory Research on AP600 Thermal-Hydraulic System Performance, Lessons Learned from Past Integral System Test Programs and Results of Recent RELAP5 Analyses, Key Phenomena, Capability and Limitations of ROSA-IV to Simulate AP600, Analyses of AP600 and ROSA-IV/LSTF Calculational Results of AP600 vs. ROSA-IV Behavior for Selected Transients;

vii. March 5, 1992, Need for AP600 Integral System Testing, NRC Staff Technical Concerns Related to the AP600 Design;

viii. June 23, 1992, Status of Test Program Plans, NRR Views on NRC Confirmatory Testing, Current Status of ROSA/AP600 Testing Program, RELAP5 Status and Development Plans, CSAU Approach to RELAP5 ALWR Code Development, AP600/ROSA Comparisons, Final Modifications to ROSA, Preliminary Instrumentation Plans for the Modified ROSA, Proposed ROSA/AP600 Test Matrix;

ix. July 9, 1992, Status of Test Program Plans (Views on ROSA Confirmatory Tests), The Basis for Independent Confirmatory Research on AP600 Passive Safety System Performance, Analysis of Modified ROSA/LSTF.

References

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2. Statement of Work: Advanced Light Water Reactor Safety Research, June 15, 1989.

3. Thermal Hydraulic Research Needs for Passive Plants, Note from Robert Jones to Louis M. Shotkin, July 13, 1990.

4. AP600 System Description and Comparison to a Current Generation Reactor, J. D. Miller and S. M. Modro, February 7, 1990.

5. Safety Assessment Needs of the AP600 Nuclear Power Plant, J. D. Miller, S. M. Modro, June 8, 1990.

6. Review of AP600 Unique Behavior, Letter from S. M. Modro to Gene Rhee, October 10, 1990.

7. Statement of Work: Advanced Pressurized Water Reactor Safety Research, FY89.

8. Recommended AP600 and SBWR Experiments, Letter from S. M. Modro to L. Shotkin, September 19, 1990.

9. Survey of the AP600 Experimental Data Base, S. M. Modro, September 28, 1990.

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11. Comments on AP600 Experimental Program, S. M. Modro, March, 1991.

12. Applicability of RELAP5 for AP600 Safety Analysis, Chester G. Motloch, February 7, 1991.

13. Plan for RELAP5/MOD3, Letter from Gary Johnsen to L. Shotkin, December 4, 1991.

14. Letter to P. McDonald from Brian W. Sheron, December 13, 1991.

15. RELAP5 Input Deck, Letter from S. M. Modro to L. Shotkin, July 9, 1990.

16. An SBLOCA Scoping Calculation for the AP600 Design, S. M. Sloan, R. J. Beelman, February, 1991.

17. Modeling AP600 with RELAP5, R. J. Beelman, S. M. Sloan, ANS Topical on the Safety of Thermal Reactors, July 21-25, 1991.

18. Research User Needs for Advanced Passive Reactors, Memorandum from Thomas E. Murley to Eric Beckjord, December 11, 1990.

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22. Scaling Considerations for Design and Operation of an Experimental Facility to Support AP600 Safety Research, INEL, December 1990.

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24. Evaluation of Scaled Integral Test Facility Concepts for the AP600, S. M. Modro et al, June 13, 1991.

25. Statement of Work: Advanced Pressurizer Water Reactor Safety Research, June 21, 1991.

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27. Accelerated AP600 Exploratory Analyses, S. M. Modro, July 11, 1991.

28. Review of Large Scale Test Facility (LSTF) at JAERI, Letter from S. M. Modro to G. Rhee, August 20, 1991.

29. Vendor Testing Programs for AP600 and SBWR, Memorandum from Louis M. Shotkin to Robert Jones, July 31, 1991.

30. Review of Vendors' Test Programs to Support the Design Certification of Passive Light Water Reactors, SECY-91-273, August 27, 1991.

31. Integral System Testing Requirements for Westinghouse's AP600 Plant, SECY-92-030, January 27, 1992.

32. Research User Need for Confirmatory Thermal Hydraulic Testing of Westinghouse AP600 Design, Memorandum from Thomas E. Murley to Eric Beckjord, November 15, 1991.

33. Response to User Need for Confirmatory Thermal Hydraulic Testing of Westinghouse AP600 Design, Memorandum from Eric S. Beckjord to Thomas Murley, December 20, 1991.

34. Letter to Dr. Kazuo Sato from Eric S. Beckjord, August 23, 1991.

35. Letter to Dr. Rhee, NRC from Dr. Y. Kukita, JAERI, August 23, 1991.

36. Investigation of the Applicability and Limitations of the ROSA-IV Large Scale Test Facility for AP600 Safety Assessment (Draft), M. G. Ortiz et al, May, 1992.

37. Need for NRC-Sponsored Confirmatory Integral System Testing of the Westinghouse AP600 Design, SECY-92-037, January 31, 1992.

38. Proposed Commission Paper on AP600 Integral Systems Testing, Memorandum from Brian W. Sheron to Raymond Fraley, November 29, 1991.

39. Letter to Dr. Murley, NRC from C.L. Caso, Westinghouse Electric Corporation dated March 9, 1992.

40. Staff Requirements - SECY-92-037 - Need for NRC-Sponsored Confirmatory Integral System Testing of the Westinghouse AP600 Design, James M. Taylor, March 27, 1992

41. NRC-Sponsored Confirmatory Testing of the Westinghouse AP600 Design, SECY-92-219, June 16, 1992.

DHIR AND SCHROCK REPORTS