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

August 5, 1992

Dr. David A. Ward, Chairman  
Advisory Committee on Reactor Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

Dear Dr. Ward:

SUBJECT: STAFF RESPONSE TO JULY 17, 1992, ACRS LETTER ON "INTEGRAL SYSTEM AND SEPARATE EFFECTS TESTING IN SUPPORT OF THE WESTINGHOUSE AP600 PLANT DESIGN CERTIFICATION"

The staff appreciates your concerns on this important issue and we have reviewed your statements carefully. Attachment 1 contains detailed responses to each of the statements in the subject letter.

In summary, our responses are as follows:

WESTINGHOUSE PROGRAM

The ACRS provided comments in 6 areas of the Westinghouse program. The subjects and the staff response are as follows:

NOTRUMP

- The recent decision by Westinghouse to switch from COBRA-TRAC to NOTRUMP for small-break analysis must be considered carefully. The staff recognizes that NOTRUMP will need to be validated over the range of conditions that exist in AP600 and that NOTRUMP does not appear to have an adequate capability to model the behavior of noncondensable gases.

Test Matrices

- Until we receive and review the updated test matrices for the Westinghouse separate effects tests, we cannot be sure that ACRS and staff concerns have been addressed.

Separate Effects Tests

- We will pursue with the ACRS the concern about downcomer and steam generator related asymmetric behavior.

SPES Scaling

- The staff has requested that W provide a comprehensive scaling analysis for the modified SPES facility. When it is available, the staff will evaluate the capability of the facility to provide adequate data to assess W's accident analysis codes. The staff is convinced that the data from an appropriately modified SPES facility will be adequate for its design certification evaluation.

### Steam Generator Tube Rupture

- Regarding the SPES SGTR capability, we will, as noted above, review the detailed test specifications to be provided by Westinghouse.

### OSU Tests

- The staff concurs that the OSU low-pressure test facility is well conceived. The draft scaling report provided by Westinghouse provides a sound basis. We note with caution, however, that pressure scaling in practice is difficult and SPES will be relied upon to provide required high pressure data.

### NRC PROGRAM

The ACRS had five observations on staff plans for confirmatory testing in ROSA. The subjects and the staff response are as follows:

#### Arguments for Confirmatory Testing

- The staff needs a confirmatory research program to allow it to independently evaluate AP600 performance and increase the staff's confidence in its decision on AP600 Final Design Approval (FDA) and Design Certification (DC). The ACRS has been kept informed of the staff needs for data to assess its computer codes for the unique conditions of the AP600 system. The data will be used to assess the performance of the new passive safety injection systems, and system interactions among them, under conditions of low flow and low driving heads. This data is especially useful at high pressure and in the transition from high pressure to low pressure.

Data for integral effects at high pressure will come from the independent facilities, SPES and ROSA. We will perform tests in SPES to satisfy staff requirements for AP600 design certification, and NRC will perform tests in ROSA. Our opinion is that confirmatory testing in ROSA is needed to enhance the staff's ability to evaluate the vendor testing program and to assess its own computer codes. The data from both SPES and ROSA will provide a more robust basis for code assessment and analysis of AP600 behavior since data will be obtained at two different scales. ROSA will effectively double the available data base and will expand the confidence that the staff has in using its computer codes to evaluate AP600 safety performance.

The staff has recommended that confirmatory testing be performed in the ROSA facility for several reasons. First, ROSA is an existing full-pressure, full-height test facility which meets all important local scaling criteria. It could thus minimize distortions due to heat and mass loss which might make the data less valid for code assessment, especially at lower pressures overlapping the OSU test pressures. Second, ROSA was a factor of 10 larger in volume than SPES and would provide a scaled complement to the SPES data. Third, RES had previous beneficial

experience with ROSA and JAERI. Fourth, RES determined that ROSA would be available for use and could provide the confirmatory data needed, before the FDA, for code assessment. Finally, W had no objection to providing proprietary information on AP600 to JAERI.

#### Use of SPES for Confirmatory Testing

- If the staff were to rely on SPES for its confirmatory testing, it would not be able to use the facility until W was finished. The end date of W testing is at present uncertain, especially if NRR has additional requirements for W testing based on the results of the presently planned program.

#### RELAP5/MOD3 Code Evaluation

- The staff does plan to use the data from both SPES and OSU, as well as ROSA, to assess its computer codes. The data from these facilities will expand the transient conditions to those that may go beyond the design basis. It will also provide prototypical data for the phenomena and processes important in the transition from high pressure to low pressure.

#### ROSA-V Atypicalities

- Every scaled test facility has atypicalities, including both SPES and ROSA. With the use of two facilities at different scales, these atypicalities can be better understood and quantified during the process of code assessment. This has been true in past research programs on LBLOCA and B&W SBLOCA, which assessed codes against test facilities at more than one scale.

#### Test Location

- Both SPES and ROSA are outside the continental United States. The number of tests in ROSA is not limited by the expense since JAERI is assuming the cost of operating the facility. The instrumentation for ROSA has been increased by the NRC. This is in our estimated costs and is firmly in our plan. We will not compromise on having adequate instrumentation suitable for code assessment.

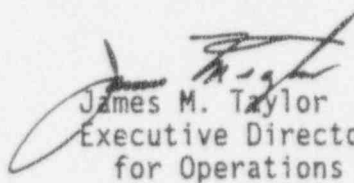
The ACRS had two additional comments, one on the need for NRC-sponsored separate effects tests and the other on the establishment of a Task Force to assist in development of the research programs for AP600.

- NRC staff has reviewed the W testing program in support of the AP600 and provided suggestions for improvements, which W has incorporated. It was concluded that the W separate effects testing program, with the NRC-suggested modifications, would provide sufficient data for assessing code modeling of the major phenomena and processes in individual components of the AP600 system. NRC has developed an assessment matrix and programs are

being initiated to perform code assessment as soon as the SET data is available from W.

- The NRC is now using one peer group for review of the ROSA/AP600 testing program and a second peer group for review of the codes for AP600. We believe that this approach is consistent with, or can be readily modified to be consistent with the ACRS recommendation.

The staff feels that with the comprehensive testing and analysis program it has planned, it will have the information it needs to provide a technically sound evaluation of the AP600 design, and do it in time to meet the schedules for the FDA and DC.

  
James M. Taylor  
Executive Director  
for Operations

Attachment:  
Staff's Response to Specific  
Comments

cc: The Chairman  
Commissioner Rogers  
Commissioner Curtiss  
Commissioner Remick  
Commissioner de Planque  
SECY  
OGC

## ATTACHMENT 1

The following is the staff's response to specific comments provided in the subject letter, dated July 17, 1992.

### BACKGROUND

#### ACRS Statement:

"The other two codes, WCOBRA/TRAC and RELAP5/MOD3, are more mechanistic codes that have been qualified as best-estimate tools only for large-break LOCAs. All of these analysis tools will be required to simulate the AP600 behavior in regimes where the codes are known to be weak. These regimes include phenomena such as horizontal (perhaps countercurrent stratified) flows, interface movements, thermal stratification, rapid "shock" condensation, boron mixing, and low-pressure gravity-driven flows."

#### Response:

We disagree with the ACRS statement that RELAP5/MOD3 has been qualified only for large break LOCAs (LBLOCA) and are not sure how the ACRS could have formed this impression. Large-break capability was never one of the primary goals for RELAP5/MOD3. The NRC LBLOCA code is TRAC-PWR and the ACRS reviewed the application of the CSAU methodology to this code. Also, the ACRS has been kept informed that the NRC has just completed the application of CSAU to RELAP5/MOD3 for small-break LOCA. Nevertheless, several specific LBLOCA tasks were performed during the development of RELAP5/MOD3. A large portion of these were funded by Siemens of Germany. These included improvements in reflood heat transfer, downcomer penetration, upper plenum de-entrainment, CHF, and blowdown rewet. Some minimal 2D/3D assessment was performed but not nearly as extensive as for TRAC-PWR. No comprehensive CSAU approach was used to evaluate RELAP5/MOD3 for its large-break capability. However, as mentioned, a CSAU program for RELAP5 was recently completed for SBLOCA. In fact, over the years, much more RELAP5 SBLOCA assessment has been done than LBLOCA assessment. It is, therefore, not at all clear why the assertion is made regarding RELAP5 qualification only for large-break LOCAs.

Several "weaknesses" in RELAP5 and other codes are enumerated. One issue, horizontal, countercurrent stratified flow has been raised by an ACRS member several times. As has been stated before, RELAP5 has the inherent conceptual capability to analyze this situation and has been assessed against several sets of data where horizontal stratified and countercurrent flow is important. If the ACRS has some specific concern about the RELAP5 capability in this area, the staff would appreciate added dialogue so that we can grasp these concerns in detail, including references.

A second issue mentioned is low-pressure gravity-driven flows. This is an extremely broad characterization. Obviously, it is a key issue in ALWR analysis. The specific ACRS concern related to this very broad issue has not been detailed to the staff, and we would appreciate added dialogue on this matter, also. It is the staff's view that this type of general concern can only be addressed as the code is assessed against the appropriate spectrum of experimental data and the uncertainties evaluated.



Several of the other issues (interface movements, thermal stratification, and boron mixing) are also identified as weaknesses. The staff has already performed an evaluation of RELAP5/MOD3 to determine where enhancements to existing thermal-hydraulic models are needed. As a result these upgraded models are being implemented and will be assessed against appropriate W and other AP600 related SET and IST data. Further code enhancements will be considered based on the assessment results. If the ACRS believes improvements are needed in areas such as "rapid shock condensation," we would appreciate added dialogue on details of their reasoning and rationale for believing the code to be inadequate and the importance of the phenomena of concern to the proposed analysis requirements.

#### WESTINGHOUSE PROGRAM

##### ACRS Statement

"We are concerned that Westinghouse plans to rely primarily on its NOTRUMP evaluation model (EM) code. It is a step backwards to use computer codes of only EM sophistication and capabilities to evaluate the thermal-hydraulic behavior of new nuclear power plants."

##### Response:

While the staff encourages applicants for design certification to utilize best-estimate codes, the regulations do not prohibit the use of evaluation models. We note that NOTRUMP is an approved code for performing SBLOCA calculations. Our concerns stem primarily from the degree to which NOTRUMP has been or will be validated over the range of conditions that will exist in the AP600. We are aware, for instance, that NOTRUMP does not appear to have an adequate capability to model the behavior of noncondensable gases. The staff will make sure that Westinghouse incorporates the proper additional models into the code, to handle AP600-related phenomenology, and that the code is then sufficiently validated against pertinent experimental data.

##### ACRS Statement:

"The Westinghouse separate effects tests of most importance to the certification of AP600 are the Core Makeup Tank (CMT) tests and the Automatic Depressurization System (ADS) tests. The test matrices for these do not cover ranges of conditions that are broad enough to yield an adequate data base for the required model development. We recommend that pressure disturbances of the types that would be caused by either ADS valve actuation or by rapid steam condensation when cold CMT fluid is injected into the downcomer region be part of the test program."

##### Response:

We are waiting for updated test matrices for Westinghouse's separate effects tests, especially the ADS and CMT tests, to see if the planned tests cover a sufficiently broad range of operating conditions. The layout of the CMT tests is a particular concern, since the test facility is not a faithful representation of the real system geometry and, as a result, may miss certain

important phenomena. We will review closely the updated information we receive from Westinghouse, and we will continue our dialogue with the vendor, to make sure that the tests in these facilities provide an adequate database for qualification of the codes and evaluation of AP600 behavior, as required by 10 CFR 52.47.

ACRS Statement:

"An additional separate effects test facility is needed to investigate the asymmetric effects associated with the downcomer and with the cold-side plenum of the steam generator."

Response:

It is not clear to us why the ACRS believes that this test facility is needed, nor to what specific asymmetric effects the Committee is referring. We will pursue this matter further with the Committee, and if we agree such data are needed for certification, we will forward the concern to Westinghouse.

ACRS Statement:

"SPES is generally a good choice for conducting full-height, full pressure integral system tests. However, in addition to the scaling problems associated with a high ratio of surface area to fluid volume that plague small-scale simulations of this kind and must be dealt with), the proposed modified version, SPES-II, has two important scaling defects that should be eliminated: (a) the aspect ratio (height to diameter) of the simulated pressurizer is different from that of the AP600 and (b) the cold leg configuration is not geometrically similar to that of AP600.

We recommend that Westinghouse be required to preserve the scaling of the pressurizer and the geometrical configuration of the cold legs, to better simulate AP600 behavior (this would include simulation of a reactor coolant pump in each leg)."

Response:

The staff has already discussed the issue of pressurizer scaling in SPES with Westinghouse, and in fact shares the Committee's concern about the height and aspect ratio of the SPES PZR. We concur with the ACRS's recommendation in this area, especially as it also bears upon other aspects of the system simulation, such as how proper elevations of the ADS valves and the PZR-CMT pressure balancing lines are obtained, and the resultant impact on flow behavior in small lines as compared to a large pressurizer. We have also discussed the issue of the cold leg configuration in SPES with the vendor. Since the pumps will not be running throughout most of the duration of transients/accidents to be simulated in SPES (the pumps trip on receipt of an "S" signal), the physical existence of a pump in each cold leg pipe may not be essential. However, it is important that the flow resistance between the two cold leg pipes in each loop be properly represented, especially through the steam generator channel head. We will evaluate Westinghouse's proposed SPES

modifications, and the associated scaling report for the facility, to ensure that it provides adequate data for code assessment.

ACRS Statement:

"The method proposed for simulating steam generator tube ruptures in SPES-II is flawed in that it does not appear to allow break flow from the primary system to be from both the hot and cold side of the tube. We recommend that Westinghouse develop a better simulation method."

Response:

We are still awaiting a detailed test specification, including methods for simulating and instrumenting pipe breaks (including SGTRs), from Westinghouse for SPES testing. We will evaluate the specification when it is available, to ensure that physical conditions in the plant during accidents and transients are simulated as closely as possible. However, we note that the general simulation of the SGTR event proposed for SPES appears very similar to that used successfully in previous test facilities.

ACRS Statement:

"The OSU low-pressure integral system testing facility is well conceived. We commend Westinghouse for its efforts with respect to this facility. Our evaluation of the scaling rationale for the facility design (discussed during the subcommittee meeting of June 23-24, 1992 ) is that it is soundly based. Further, the 400 psia design capability should allow considerable simulation of high-pressure effects, while providing the more important low-pressure behavior."

Response:

We concur in the ACRS's evaluation of the OSU facility's design. The staff has recently received the draft scaling report for the facility; while the draft is incomplete, our review to this point indicates that it does indeed appear to present a sound and consistent basis for the scaling approach taken for the facility. We would like, however, to sound a cautionary note, in that RES's experience using the UMCP loop has shown that pressure scaling, while possible in theory, is extremely difficult in practice, especially in two-phase flow regimes. The staff still will rely on SPES data to represent high-pressure phenomena; the new upper pressure limit in the OSU facility will, however, allow a larger overlap range through which to compare and correlate (to the extent possible) OSU and SPES data.

NRC PROGRAM

ACRS Statement:

"The NRC Staff has not presented convincing arguments supporting its needs for confirmatory testing, particularly at high pressures."



Response:

Evidently the ACRS is convinced that high pressure testing is needed, since it endorses the SPES program. What ACRS is not convinced of is the need for NRC to have a confirmatory test program. The ACRS has not explained why it is well-assured that additional testing of high pressure systems interactions is not a worthy subject area for confirmatory testing. The ROSA tests are planned to cover the full pressure range from full system pressure to IRWST injection. They will, thus, overlap both the SPES high pressure and the OSU low pressure testing.

ROSA testing will double the data base for code assessment and increase the robustness of this data. It will provide data at a scale which is 10 times larger than SPES which will help to understand and quantify any scaling distortions in SPES. The expanded data base will increase the staff's confidence in the assessment of its codes. Finally, conducting tests in a facility that is uniquely NRC's will provide an immeasurable increase in our experience base that could not be obtained by observing testing in someone else's facility.

ACRS Statement:

"The SPES-II facility appears to be sufficient to meet all the high-pressure integral system testing needs. The NRC will be able to use the SPES-II facility for its confirmatory testing needs just as it plans to use the OSU facility."

Response:

If the staff were to rely on SPES for its confirmatory testing, it would not be able to use the facility until W was finished. The end date of W testing is at present uncertain, especially if NRR has additional requirements for W testing based on the results of the presently planned program.

The staff stated its interest in both high pressure and low pressure confirmatory testing. We explained to the ACRS that at the time when the staff was proposing to do separate low pressure confirmatory testing, the facility we envisaged was identical to OSU. At the time we were precluded from interacting with OSU due to conflict of interest considerations. Once these were resolved, we could no longer justify pursuing a duplicate facility.

In contrast, based on our interest in high pressure systems interactions phenomena and processes, by June 1991 we had identified ROSA as the best candidate for performing high pressure confirmatory testing. We have been working since that time towards formulating a technically sound program to modify the facility and conduct testing.

In terms of experimental programs in scaled facilities intended to model full scale power reactors, it is a well-established principal that facilities of different scales and scaling approaches should be used to ensure that the effects of scale are well-understood. By definition, scaling introduces distortions in all scaled facilities. Testing programs must be formulated

accordingly. The integral system test program carried out to study small break LOCAs in Babcock and Wilcox reactors was an example of such a program. Research Information Letter 164 describes the results of this program. We would like to refer the ACRS to Commissioner Rogers' memorandum to J. Taylor (January 18, 1990) on this program, a copy of which is attached. In addition, to quote from MIT Professor Peter Griffith's review of the ROSA program:

"This is a well structured program which clearly benefitted from our experience with the LOCA work done on LWRs during the 70's and 80's. Because the experimental program consists of three integral tests being run on three quite different rigs each scaled according to three different rationales, I can't imagine that there will be many questions outstanding about the system performance when these experiments are completed.

We have, in addition, got an operating, documented computer code, RELAP5, which can be used for the prediction and analysis of the ROSA-IV experiments. The pieces of the program will come together in a timely way so that the results of this program can be used to design out any problems which might arise in the course of this research."

ACRS Statement:

"The desired staff experience will come from pre-test and post-test evaluations of the various tests using the RELAP5/MOD3 code. This experience can just as easily be obtained by evaluating the SPES-II and OSU tests and results."

Response:

To a degree this is true, and the staff already planned such activities. However, this is not a substitute for nor an equivalent to conceiving, planning, and conducting an independent program from scratch. This forces much deeper and more comprehensive independent thought and analysis. For example, we believe these analyses were useful to the ACRS in arriving at its recommendation to replace the pressurizer in SPES.

ACRS Statement:

"The ROSA-V facility contains several atypicalities that will manifest themselves in difficult-to-explain behavior relative to that expected for AP600 (the sensitivity of the ROSA-V thermal-hydraulic behavior is well documented in the INEL report, NUREG/CR-5853)."

Response:

The staff believes that the INEL study on AP600 testing in ROSA provided the information needed to understand and quantify the scaling atypicalities in the ROSA facility. In fact, the facility hardware modifications finally chosen were based on this study and were chosen to minimize these atypicalities.

ACRS Statement:

"The tests would be in a distant location. There would be a very limited number of tests, because of the expense involved. In addition, we are concerned that the adequacy of instrumentation (for example) might have to be compromised in order to reduce overall program costs."

Response:

Both SPES and ROSA are at distant locations and neither are of day to day convenience to access. We intend to station a resident engineer at JAERI. Such an arrangement worked very well during the conduct of the UPTF program in Germany.

The number of tests is not limited by expense. The number of tests we plan is comparable to the number that Westinghouse plans for SPES. JAERI will fully cover the costs of operations. The main cost to the NRC is for facility modifications, and this is independent of the number of tests.

We have made no compromises in instrumentation based on program costs and foresee no compromise that would affect the adequacy of ROSA test information.

ACRS Statement:

"For the above reasons, we believe that NRC resources would be better used by focusing on three areas: (a) possible additional separate effects testing to support the modeling needs for RELAP5/MOD3, (b) participation in the pre-test and post-test analyses efforts associated with the SPES-II and the OSU test programs, and (c) consideration of utilizing the SPES-II facility for high-pressure confirmatory testing needs in the same way the staff plans to use the OSU facility for its confirmatory low-pressure testing needs."

Response:

These have all been answered above. (a) We do not agree that additional separate effects tests, beyond that being supplied by W are necessary; (b) we have plans to perform pre-test and post-test analyses for the SPES-II and OSU test programs; and (c) we support the use of ROSA for confirmatory testing at high pressure and for the transition from high pressure to low pressure.

ACRS Statement:

"To accomplish the above objectives, we believe that the staff should consider the establishment of a task force of experts in related fields to assist it in the development of the analytical and experimental programs necessary for timely certification of the AP600 passive plant."

Response:

NRR and RES have already planned a coordinated review of the AP600 vendor testing programs. RES has fully planned a confirmatory test program in ROSA. RES has also planned a complete AP600 validation and development program for RELAP5. This includes the utilization of independent consultants and the application of CSAU methodology. Thus, we have a well-coordinated and well-founded program relating to AP600 design certification.

We are currently using three consultants on the ROSA/AP600 test program and an additional four consultants on a peer review of RELAP5 documentation and modeling. It is our intention to utilize these and other consultants as necessary to review and advise us on the AP600 testing and analysis programs. We think this approach is consistent with, or can be readily modified to be consistent with the ACRS recommendation.



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON D C 20555

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*  
Kenneth C. Rogers  
Commissioner

cc: ~~Chairman Carr~~  
~~Commissioner Roberts~~  
~~Commissioner Curtiss~~  
~~Commissioner Renick~~

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Date: 1-18-90



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