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

August 5, 1992

52-003

MEMORANDUM FOR: The Chairman
Commissioner Curtiss✓
Commissioner Rogers
Commissioner Remick
Commissioner dePlanque

FROM: James M. Taylor
Executive Director for Operations

SUBJECT: STAFF COMMENTS AND OBSERVATIONS ON DR. N. ZUBER'S REPORTS

On July 10, 1992, R. Fraley of the ACRS forwarded to the Commissioner's technical assistants two reports prepared by an ACRS consultant, Dr. N. Zuber, on the subject of AP600 thermal hydraulic testing. Dr. Zuber's reports give his assessment of the proposed AP600 passive safety system testing in the Japanese ROSA facility.

The Office of Nuclear Regulatory Research staff has reviewed these reports and has views that differ from Dr. Zuber's on a number of points. Accordingly, RES has prepared comments and observations on Dr. Zuber's assessment. I am enclosing these staff comments and observations for your information and use. I believe they will be helpful to the Commission as it deliberates on this important issue.

In addition, I enclose three additional reports of ACRS consultants, which the Commission may not have seen yet: V. K. Dhir's letter on the June 3 and 4 meeting in Idaho Falls, his letter on the June 23 and 24 meeting of the ACRS Thermal-Hydraulic Subcommittee, and V. E. Schrock's June 15 letter on the NRC (RES & NRR)/INEL/JAERI Joint Meeting on AP600 integral system testing, June 3 and 4, 1992.

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Enclosures:
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(ENCLOSURE)
COMMENTS/OBSERVATIONS ON DR. N. ZUBER'S MEMOS

Dr. Novak Zuber has prepared two memos, dated 6/23/92 and 7/7/92, with comments on the planned NRC use of the ROSA test facility for AP600 confirmatory testing. The RES program for this planned use was developed in response to user-need requests from NRR (References 1 and 2). Dr. Zuber's technical conclusions fall into three major categories:

Conclusion 1. Geometrical and configurational distortions in ROSA will generate questionable experimental data; the INEL RELAP5 analyses confirm the deficiencies in ROSA.

Conclusion 2. The NRC research program indicates a lack of planning and integration of experiments with code development and validation.

Conclusion 3. Formulation of a Task Force is needed to assure NRR will have a validated code for the certification process.

The NRC staff response to these major conclusions forms the main part of this report. Staff responses to each specific comment by Dr. Zuber follows in Appendix I. Also included in Appendix Ic is an independent response by M. Modro of INEL. Independent evaluations of the planned ROSA test program are given in Appendix II (P. Griffith, MIT, M. diMarzo, UMCP and B. Boyack, LANL; also official comments of W made at an ACRS meeting). Of particular note in the beginning of Appendix II is the evaluation of the NSRRC performed on July 1 and 2, 1992. This is presented in the letter from N. Todreas (MIT) to E. Beckjord (NRC). A response to separate comments by two other ACRS consultants follows in Appendix III (V. Schrock, UCB and V. Dhir, UCLA). Appendix IV is a historical summary of the RES program on AP600.

Conclusion 1. Geometrical and configurational distortions in ROSA will generate questionable experimental data; the INEL RELAP5 analyses confirm the deficiencies in ROSA.

When the NRC staff started to investigate hardware modifications for the ROSA test facility, we shared the above concern. The ROSA-V facility, as it exists today, must be modified before it can simulate AP600 behavior. It has no passive safety injection systems and no automatic depressurization system. However, the ROSA facility is a large-scale (~ 1/40 by volume), well-instrumented, full height, and full pressure two loop simulation of a four loop W PWR.

The NRC staff knew that it had to investigate potential hardware modifications to make ROSA-V simulate the AP600 design. We did this in a systematic way, working our way up through successively more detailed levels of modifications. Our objective was to see which are the minimal set of most cost-effective modifications that would give the most valid data for code assessment purposes.

It should be emphasized that the criterion the staff used to make their judgement on which level of configurational modifications is most cost-effective for ROSA was the value of the data for code assessment. It must also be emphasized that ROSA (modified for AP600) was never meant to be a demonstration facility. Neither had any previous test facility (e.g., LOFT, Semiscale) ever been a demonstration facility. That is, test data are used to assess computer codes and the codes are then used to predict the behavior of the full-scale plant. The data are never used by itself to infer full-scale plant behavior since every test facility has distortions, even those with "correct" geometric and configurational similitude.

Further, as was the case on our previous testing programs having facilities of different scales, codes are used to calculate initial and boundary conditions, not the test data itself. As the OSU study pointed out, one cannot scale all processes equally; scaling compromises must always be made among choices of many variables, some of which are scenario dependent. In particular, every scaled facility suffers from excessive heat transfer between the solid walls and the fluid coolant, because of their reduced size.

What this means for ROSA, or any other test facility, is that the calculated results are never expected to exactly match calculations of the same transient for the full-scale plant. We have seen this before in other testing programs, such as LOFT and Semiscale. What is important is that the test facility exhibit the same general processes and phenomena as are expected to occur in the plant, so that the data can be used for code assessment.

First, as a result of previous scaling studies (References 3, 4, 5, and 6), using "local" scaling criteria similar to that used in the OSU draft scaling study, we knew that the ROSA piping sizes, vessel, and steam generator all met the most stringent geometric scaling criteria for a full-height, full-pressure test facility. For example, the pipe sizes met the 1/6 diameter scale criteria for preserving the Bond number (related to preserving counter-current flow effects). It is of interest to note that the OSU facility piping is also being designed to meet this same scale. We do not have a complete scaling study for SPES, so it is not possible to state definitively whether it meets the stated criterion or not. We will review the scaling study when it is available to determine if this is a crucial issue.

After convincing ourselves that ROSA was large enough to meet geometric scaling criteria, we next had to determine what additional hardware, representing the AP600 safety systems, had to be added to the existing ROSA test facility to achieve an appropriate "configurational" simulation of AP600 so that the thermal-hydraulic processes and phenomena would be similar to those expected in AP600 and, therefore, the data would be valid for code assessment purposes. We also had to determine whether there are any distortions introduced by using the existing ROSA hardware, such as the steam generator. We approached this problem using RELAP5 as our scaling tool and considered four different levels of hardware modifications; each increasing level presumably getting closer to the actual AP600 configuration. Use of a computer code as a scaling tool was particularly appropriate since we were interested in scaling the effect of system interactions among geometrical components and investigating the effect of early high pressure behavior on

longer term low pressure cooling. System interactions had been identified by NRR as the key concern related to the behavior of the AP600 design at high pressure.

Every additional modification was calculated to improve the simulation between ROSA-V and AP600 except one. Adding a second cold leg per loop, but having only one cold leg connection to the vessel actually made the calculated difference larger (worse) for a cold leg pressure balance line break because it introduced a nontypical low resistance flow path to the break. The cold leg connection to the vessel was a restriction JAERI imposed because they were concerned that the ROSA pressure vessel might not pass the yearly high pressure inspection if two large new holes (for two additional cold legs) were machined into it.

The June 3-4, 1992, meeting at INEL concentrated on results from the first level of modifications, with a few results from the 2nd and 3rd level of modifications. These results were quite encouraging to the staff, to personnel from INEL and JAERI, and to two outside consultants (P. Griffith of MIT, and B. Boyack of LANL). That is, the calculations showed that with most of the investigated hardware modifications, ROSA would provide good data for code assessment for small break LOCA, SGTR, and MSLB transients.

Our judgement of even the first (simplest) level of modifications is that ROSA provided good data for code assessment. The final level of modifications (level 4) provided what was felt to be the best configurational similarity to AP600 and the best data for code assessment. Once these final configurational modifications were defined, INEL started new calculations to compare the improvements with previous levels of modifications, so that they could be presented at the June 23-24 ACRS subcommittee meeting and the July full ACRS meeting.

The final configuration chosen for ROSA modifications, the level 4 modifications, gave the most representative calculated agreement of phenomena and rate processes with AP600 behavior from high pressure down through low pressure for the transients investigated, Thus, the results of our scaling study clearly showed that ROSA-V (modified) is expected to provide particularly useful data for code assessment.

Conclusion 2. The NRC research program indicates a lack of planning and integration of experiments with code development and validation.

The NRC research program on AP600 has been in progress since 1989. The historical details of this program are given in Appendix IV; the following summarizes the results and progress.

The first tasks in this program were to become familiar with the AP600 design and how it is supposed to work in response to accidents. This was complicated by the fact that the design was still evolving during the initial time period. Initially our understanding was based largely on information provided by W, supplemented by the experience of NRC staff and contractors. Insights were soon obtained from independent analyses by NRC contractors.

These insights led to the evaluation that any "new" phenomena or processes expected in AP600 would not require major alteration to current modeling in RELAP5. Some modeling, however, was identified for improvement, based on engineering judgement and before any formal assessment began. These improved models are expected to be ready for formal assessment by the end of the year, to meet NRR schedules to perform independent analyses using an assessed code before the FDA (November 1994). These model improvements are listed in Appendix IV. What was needed was assessment of RELAP5 against data to confirm the adequacy of this modeling. An assessment matrix was developed, largely based on W separate effects test data and supplemented with existing data in the literature. Programs were planned to perform this assessment once the data was obtained from W.

In parallel with this effort, NRC staff was reviewing the W testing program in support of the AP600, and providing suggestions for improvements, which W has incorporated. Early on, 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.

Further, the OSU facility, again with NRC-suggested modifications, would provide the needed data for code assessment on system interactions at low pressure. The initial W testing program did not include testing of system interactions at high pressure; W now plans testing at SPES to obtain such data. NRR also requested that RES obtain integral system test data from a full-pressure, full-height facility in a user-need letter dated November 15, 1991. To meet NRR's user-need request for such data, RES evaluated the cost and schedule of a new facility versus modification of an existing facility and found that the only prudent alternative was to explore if modifications to ROSA-V could be made so that the resulting data would be useful for code assessment. The decision to go this route was based on several factors, both technical and administrative.

First, NRC, DOE, and industry have all agreed to make every effort to meet the schedules for the FDA (11/94) and the DC (5/96). The research information that comes in beyond these dates will be of less value to the staff although it will still be useful to confirm the staff's conclusions on AP600. Second, the currently planned research on assessing codes against separate effects data and other integral test data from W experiments, should be sufficient to provide an adequate assessment of code accuracy and uncertainty for Part 52 design evaluation, as well as Part 50 operational issues for the AP600. However, a confirmatory research program would allow the staff to independently evaluate AP600 performance and increase the staff's confidence in its licensing decision. Finally, ROSA-V was an existing full-pressure, full-height test facility which met 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.

RES undertook a study of possible modifications to the ROSA-V facility to provide data for code assessment in time for the FDA and DC of AP600. The RELAP5 analysis study comparing AP600 with ROSA (modified) was the most

systematic and comprehensive conducted by RES (or anyone else) for any test facility or testing program. The results clearly showed the transient conditions for which ROSA-V (modified) would provide very useful data for code assessment and the transient conditions for which ROSA-V would provide less useful data for code assessment.

Conclusion 3. Formulation of a Task Force is needed to assure NRR will have a validated code for the certification process.

RES staff has maintained close interaction with NRR staff while performing its function of supplying research in response to NRR user needs on the AP600 design. NRR staff has publicly commented on the usefulness of this research in providing them with the insights they need to perform their evaluation of the AP600 design. Furthermore, the NRC already uses technical consultants and peer review groups to help it evaluate its research programs on the AP600.

Thus, NRC staff does not see any merit in Dr. Zuber's suggestion to transfer the management of AP600 research to NRR. The current mode of cooperative interaction between RES and NRR staffs, which has existed since NRC was formed over 15 years ago, is working quite well in the evaluation of the AP600 design. This process and interactions is described in the comments on Conclusion 2 above.

REFERENCES

1. Research User Needs for Advanced Passive Reactors, Memo, T. Murley, NRR, to E. Beckjord, RES, December 11, 1990.

2. Research User Needs for Confirmatory Thermal-Hydraulic Testing of Westinghouse AP600 Design, Memo, T. Murley, NRR, to E. Beckjord, RES, November 15, 1991.

3. Evaluation of Scaled Integral Facility Concepts for the AP600, M. Modro, et al, M. Modro, INEL, June 13, 1991,

4. Scaling Issues for a Thermal-Hydraulic Integral Test Facility, T. Boucher, INEL, M. diMarzo, UMCP, and L. Shotkin, RES, WRSIM, October 1991.

5. Evaluation of Internal Continuing Experimental Capability Concepts for LWR Research - PWR Scaling Concepts, K. Condie, et al, NUREG/CR-4824, February 1987.

6. An Investigation of Integral Facility Scaling and Data Relation Methods (Integral System Test Program), T. Larson, NUREG/CR-4531, February 1986.

APPENDIX Ia

APPENDIX Ia

Subject: Comments on the June 23, 1992 Memorandum of Dr. N. Zuber

The following responds point-by-point to comments provided in Dr. Zuber's memo. The organization follows that of the memo.

Section A: In July 1991, RES selected several transients to evaluate the ability of a modified ROSA facility to reproduce the most important phenomena expected to occur in an AP600. These transients were chosen to cover a range of conditions important to analysis of passive safety system performance.

Before the calculations were started, RES had directed INEL to perform two prerequisite tasks: (1) perform a phenomena identification and ranking table (PIRT) to identify the important AP600 phenomena (Refs. 1 and 2); and (2) perform a code applicability review of the RELAP5 models and correlations to assure that the code possessed an adequate ability to model these phenomena. The review indicated that RELAP was applicable (Ref. 2) for AP600 transient analyses. Thus, we do not agree that RELAP was employed in a range beyond its currently known applicability. However, we do agree that this perceived applicability must be quantified by assessment against test data. As a result of this planned assessment, additional model improvements may be identified.

Nevertheless, we note that the range of conditions under which AP600 phenomena are expected to influence operations of the new safety systems have not been extensively studied in previous testing programs (Refs. 2 and 3). This has led to plans by RES for additional code validation.

Dr. Zuber also states that INEL had to use an imperfect tool (RELAP5). As we have explained in detail to the ACRS subcommittee, the codes are sufficient for the ROSA studies. Moreover, we have also explained that the purpose of the integral tests is to validate the codes and the models in the codes. Thus, we will never have "perfect" tools for analyzing AP600 until we validate the codes against the integral data.

We also take exception to the implication that INEL was constrained in providing a candid and forthcoming presentation of conclusions from its evaluation of ROSA. A check with the INEL Principal Investigator on July 15, 1992 confirmed that such was not the case.

Section B: There is here the implication that NRR developed its position of integral testing in isolation. RES has worked closely with NRR in reviewing the AP600 vendor testing programs and the need for full pressure integral system testing. Reference 4 provided a documented summary of our views which were subsequently utilized by NRR in

Reference 5. It is NRR, not RES, that has the responsibility to interact with and inform the vendor of staff requirements.

Section C: INEL analyses of ROSA are documented in "Investigation of the Applicability and Limitations of the ROSA-IV Large Scale Test Facility for AP600 Safety Assessment" (Draft), NUREG/CR 5853, M. G. Ortiz et al, May 1992. Note that this is a Draft report and did not incorporate reviews by RES. The analyses were also directed primarily at a set of modifications that differ significantly from that decided upon by RES. Much of the analyses in fact were used in reaching these decisions. The report continues to undergo revision and development and is scheduled to be released in August, 1992. We do have a comment on a point made by Dr. Zuber.

- The divergence in vessel mass beginning at 1400 seconds shown in Figure 28 is due to a difference in calculated ADS stage 3 discharge mass flow rate as well as a RELAP modeling artifact in calculating CMT draining behavior in ROSA. It has nothing to do with differing initial conditions between ROSA and AP600 and little to do with the early high pressure period of the transient. In section A, Dr. Zuber himself noted that ROSA-IV and AP600 used "similar initial and boundary conditions."

He also implied that ROSA conditions at low pressure would be used to get the initial conditions for the low pressure OSU tests. We do not agree with this.

Westinghouse has indicated in presentations to the staff and the ACRS that they plan to begin the tests in the OSU facility with a "water-solid" loop. In our view, it makes sense to run tests from high to low pressure at SPES and ROSA. These will be used to assess codes which in turn could be used to determine AP600 initial conditions for an OSU test, if it were desired to perform such a test. However, the OSU tests will be done before all of the data from SPES and ROSA are available for code assessment. If it turns out that initial conditions from AP600 calculations are significantly different from OSU initial conditions, and if significant differences in test results are predicted to occur, it may be advisable to redo some low pressure tests at OSU.

The staff is still examining the appropriateness of starting OSU tests from a water solid condition. Based on our experience running SBLOCA tests in the UMCP facility, we have concerns with the plan to scale pressure in OSU. We will closely follow this program to see how this is accomplished.

In addition. Dr. Zuber wrote that ROSA is nonconservative with respect to AP600. Such a concept defies meaning. The purpose of an experiment is to study physical processes and phenomena by producing data over a representative range of conditions. See also the response by M. Modro of INEL in Appendix Ic.

Section D: We point out that the existing ROSA pressurizer has correct volume scaling, but incorrect elevation and length scaling. The calculations show that this is not a significant distortion. In any event, RES has provisions for replacing the pressurizer with one that is "correctly scaled."

We also note that Dr. Zuber highlighted the word "delayed" in his statement that "a direct result of this difference was a delayed ADS initiation in ROSA IV calculations." As we have stated previously, neither ROSA, nor any other test facility we have run, is or was intended to be a demonstration facility. The key factor is whether the actuation time leads to unique behavior or different phenomena.

We also note that we agree with Dr. Zuber's three implications, and note that they are equally applicable to SPES, OSU, and any other test facility for that matter. These implications are:

1. No general or blanket statement can be made concerning the effects that a distortion will have on various transients.

2. The effects of distortions will have to be evaluated on a case-by-case basis, and

3. Scaling analyses will have to be performed with great care and detail, so as not to be misled by the data.

Section E: The principal difference in configuration between ROSA and AP600 is that ROSA has two cold legs whereas AP600 has four. The question is whether this is a significant difference. The RELAP analyses indicate for the transients of interest that it is not. We obtain similar results between ROSA and AP600.

Dr. Zuber states that RELAP cannot address reliably issues related to flow asymmetries. No basis was provided for this statement. RELAP is a one-dimensional code, but can approximate two-dimensional flow in the downcomer by using parallel channel nodalization with cross flow junctions. Such nodalization is being used in the downcomer region for AP600 analysis. The limitation in this approach is that momentum transfer in the horizontal direction is neglected. While this may be important during a large break LOCA, it is not important during small breaks where gravity is important and flow rates are low. Thus, we believe the current treatment of two-dimensional flow in AP600 by RELAP5 is perfectly adequate and acceptable. It should be added that we are developing an AP600 input model for TRAC and will be performing analysis at LANL. Thus, we can confirm the acceptability of the RELAP5 approximation. Finally, we have available a three dimensional RELAP vessel formulation that was developed by DOE. Should we define a need for such capability in the future, we will add it to RELAP5/MOD3.

Most of the analyses reported in NUREG/CR-5853 (Draft) were conducted with a single CMT in ROSA representing the two CMTs of the AP600. These comparisons showed that for transients that result in symmetric draining of the two CMTs in the AP600, the ROSA representation provided good agreement with respect to important phenomena/processes. The agreement was not as good for transients that result in asymmetric CMT draining. Such transients involve breaks in the cold leg pressure balance lines or the direct vessel injection lines. To enable ROSA to cover these transients, RES devised a ROSA configuration that calls for two CMTs, two direct vessel injections lines, and cold leg pressure balance lines for the two separate cold legs in ROSA. Calculations show that this configuration provides a good representation of the important phenomena/processes (Ref. 6).

Dr. Zuber attributed an interval of core uncovery (Figure B-4) in the ROSA calculation to differences in cold leg configuration between ROSA and AP600. This is incorrect. The result was due to a difference in upper plenum to upper head configuration that is currently in the facility. ROSA is configured to resemble a current Westinghouse 4-loop plant. The design of the upper head has now been changed in the AP600 to allow more communication between the upper plenum and the upper head. JAERI will make this modification in ROSA for AP600 testing. The RELAP calculation was repeated with this modification, and the results showed similar behavior between ROSA and AP600.

Section F: We do not agree that a blanket statement that "the performance of the new passive safety systems in AP600 is very sensitive to small perturbations in pressure" is accurate. Our calculations have indicated that there _is_ sensitivity to systems interactions, at both high and low pressures. Influences can include depressurization rate, and changes in flow regimes, flow paths, and inventory distributions. Thus, there are many system interactions, which led NRC to recommend integral testing.

We do not agree that ROSA has significant distortions at high pressure that distort inventory at low pressure. The whole body of analyses must be considered and not one figure from one transient at one point in time. The figure selected by Dr Zuber (Figure 28 from NUREG/CR 5853-Draft) refers to vessel inventory. Dr. Zuber stated incorrectly that _system_ inventory differed by a factor of 2.5. Rather, _vessel_ inventory differed by about a factor of 2, and only late in time prior to start of IRWST injection at very low pressure (~ 100 psia). This difference in terms of _system_ inventory is about 8%. It should be remembered that RES provided the ACRS with the report, even though it is a draft undergoing review and revision. As stated previously, Figure 28 is partly in error due to an artifact of the RELAP calculation of ROSA that was subsequently corrected. The numerical artifact, which was only experienced for that one calculation, was that the CMT level stayed at a node boundary for several seconds.

The difference in calculated inventory at this time is primarily related to a difference in the timing of the actuation of ADS stages 2 and 3 and discharge mass flow rate. To begin, one must have some appreciation of how the AP600 behaves as a system. ADS actuation is tied to CMT level, which is a function of the draining rate. The CMT draining rate can be affected by accumulator injection, which can hold the CMT check valve closed and, thus, slow or interrupt CMT draining. This can lead to differences in timing of events in the AP600 and ROSA calculations. This caused stage 2 actuation some 200 seconds earlier in ROSA than AP600, which in turn increased the flow velocity through the surge line, which in turn changed the flow regime from slug to annular mist. This increased the ADS discharge quality and thus, brought about a more rapid depressurization in ROSA. Later during stage 3 actuation when the deviation in vessel mass occurred, ROSA was at a lower system energy level (and hence lower pressure) than AP600, and thus the discharge rate was lower. Thus, there resulted a "time shift" in ROSA compared to AP600. Such time shifts can be visually misleading in terms of their significance. They do not mean that the two facilities are behaving differently. Rather, in this case it points to the significance of CMT draining and ADS actuation in depressurizing the AP600.

It must be noted that all experimental facilities have scaling distortions and limitations in initial and boundary conditions. This was true of the entire large break LOCA experimental program. LOFT was a shortened facility with distortions in inventory distribution and a half-length core. The 2D/3D facilities were operated "on the fly" with initial conditions defined by code analyses. SEMISCALE had severe limitations due to atypical structural heat input to the fluid. These are but a few examples that extend to every experiment in every facility. In fact, most of these facilities had distortions and differences between the test facility and the prototypical plant that were much larger than what we predict for ROSA. Note that the learning of these lessons led to improved approaches with the more recent facilities to be designed such as the French BETHSY program, ROSA-IV, the Integral System Test Program (MIST, UMCP), and the Oregon State University AP600 program.

It should also be noted that the application of the CSAU process to the TRAC code utilized the data from LOFT and SEMISCALE extensively, and concluded that the data could be used for not only validating the codes, but also for quantifying the uncertainties.

We do not agree that RES has acted with haste and imprudence in its proposal for AP600 testing in ROSA. To the contrary, we have carried out a well-thought out, systematic approach to evaluating the ROSA facility that has in fact extended about 3 years, when one includes the initial studies on AP600 behavior. We have also carried out one of the most thorough, systematic assessment of an integral facility that has ever been performed.

We began with studies to explore AP600 phenomenology and safety system operations (e.g., Refs. 1-3). These studies identified issues requiring high pressure integral system testing. We also developed the basic scaling requirements for an integral facility (Ref.7) and this was independently reviewed. We considered the world-wide availability of existing integral facilities that could be modified to perform AP600 testing and decided that ROSA offered the best option in terms of availability, scale, and cost-benefit. JAERI was formally notified of our interest in such testing on August 23, 1991 (Ref. 8).

Analyses specific to modifying ROSA have been underway for one year. An interim meeting on January 31, 1992, showed that ROSA would provide a reasonable representation of important phenomena and processes. The reports of two independent consultants, Professors Peter Griffith of MIT and Marino diMarzo of University of Maryland, are given in Appendix II. A final meeting was held on June 2-3, 1992. Again, the reports of two independent consultants, Professor Griffith and Dr. Brent Boyack of LANL, are also given in Appendix II. NRR was represented in both meetings. SECY-92-037 dated January 31, 1992 presented our ROSA testing plans to the Commission. The ACRS reviewed these plans and commented on them (Ref. 10).

In its letter of March 10, 1992 (Ref. 10) the ACRS stated:

> "Inasmuch as FHFP integral system testing will require at least three to four years to complete, there is a risk that the present certification schedule will be affected unless the test program is begun now. We believe the likelihood of such an impact is great. If the present certification schedule is to be adhered to, we recommend that a FHFP integral system testing program be initiated now."

Though it is clear that the confirmatory testing in ROSA is not a requirement for AP600 certification, NRR has indicated that it will be highly desirable to have ROSA test data in advance of AP600 design certification. Therefore, RES agrees with the ACRS's assessment.

Finally, in Item 1 of "T-H Response of ROSA-IV," Dr. Zuber states that "... a comparison with AP600 calculations indicates that at low pressure ROSA-IV will have a liquid inventory 2.5 times larger than AP600. This is a non-conservative result." Again, we emphasize that ROSA-IV is not a demonstration facility and it is inappropriate to draw conclusions regarding conservative or non-conservative behavior of ROSA compared to AP600, based on how closely temporal parameters from both facilities will overlie each other. ROSA is designed to exhibit the same general processes and phenomena as we expect to see in AP600. These processes and phenomena do not necessarily occur either on the same time scale or with all parameters at the same magnitude. Thus, there is no such thing as

conservative or non-conservative behavior of ROSA when compared to AP600. See also the comments of INEL on this same matter in Appendix Ic.

Section G: We agree with Dr. Zuber that every effort should be made so that experimental data is not generated in atypical test facilities and/or under atypical test conditions. That is precisely why we performed such extensive scaling studies on ROSA-V hardware modifications. The staff realizes, however, that every test facility has scaling distortions that must be accounted for and quantified as part of the process of using the data for code assessment. That is the reason why the staff is careful not to extrapolate test data directly to the full-scale plant, but always first assesses codes against the scaled data and then uses the assessed codes to analyze behavior in the full-scale plant.

Thus, following the process of data-to-code-to-plant, we do not agree with Dr. Zuber that data from scaled test facilities with known (and quantifiable) distortions "can create artificial safety issues which do great harm to society...and burden the economy." To the contrary, the staff is convinced that the numerical evidence reported in NUREG/CR-5853, and in subsequent calculations with additional hardware modifications, confirm that the distortions in ROSA-V are known, quantifiable, understandable and have little influence on the type of phenomena and processes which are being simulated for purposes of code assessment. Moreover, these analyses neither predict nor in any way indicate that ROSA will exhibit "artificial" safety problems. We are convinced that the ROSA-V tests will satisfy their intended purpose.

Section H: All meeting attendees received copies of the vugraphs presented at the meeting. The number of attendees was more than anticipated, and not enough copies were brought the first morning. The meeting was being held at a hotel 2 miles from the INEL offices, and the situation could evidently not be remedied as quickly as Dr. Zuber would have liked. However, by the afternoon of the first day, sufficient copies of the INEL presentation (which formed the bulk of the presentations) had been made and distributed.

This INEL handout contained curves and major conclusions of NUREG/CR-5853. Copies of NUREG/CR-5853 had been mailed by INEL to the ACRS about three weeks before the meeting, at the same time they were mailed to everyone else, including NRC and JAERI. We were thus surprised that ACRS had not given copies to their consultants.

Dr. Zuber did have a copy of the INEL viewgraphs which included the computational results from the key parts of this report. When he complained that he did not have a copy of the complete report, we said we would mail another copy.

APPENDIX Ib

APPENDIX Ib

Subject: Comments on the July 7, 1992 Memorandum of Dr. N. Zuber

The following responds point-by-point to comments provided in Dr. Zuber's memo. The organization follows that of the memo.

I. Presentations by Westinghouse

A. SPES Facility

SPES is a volume scaled full height, full pressure integral facility. This compares to the world's other integral PWR facilities as follows:

SEMISCALE	1:1700
MIST	1:800
LOBI	1:712
SPES/AP600	1:395
BETHSY	1:100
ROSA/AP600	1:30

Analyses of test facility data using codes such as RELAP have shown that it is very important to have an accurate description of facility characteristics. The smaller the facility, the more important this becomes. Unintended system leaks, structural heat losses, structural heat addition to the fluid, inaccurate characterization of pressure drops, inaccurate characterization of component volumes, inaccurate characterization of bypass flow paths, and other attributes can strongly affect the results. As a result, we do not believe that Dr. Zuber's statement that SEMISCALE was the most useful facility for addressing and resolving thermal hydraulic issues related to present PWRs is correct. In fact, SEMISCALE data are in general no longer used for assessing codes.

The quality of SPES data will be evaluated on its own merits. It should be noted that CSNI conducted a "blind" international standard problem (ISP22) based on a previous SPES experiment. The CSNI subsequently concluded the pre-test calculations were rendered invalid because of system heat and mass losses and inaccurate characterization of the steam generator secondary side masses. It should be noted that W has indicated that, as part of its modifications to the SPES facility for the AP600 test program, the previous problems with mass and losses will be corrected to minimize their effects.

We do not know what information Dr. Zuber has used to evaluate the SPES facility. 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 on record as believing that data from an appropriately modified SPES facility will be adequate for its design certification evaluation.

B. OSU Facility

We wish to point out that a critical scaling criterion is to ensure that piping diameters are sufficiently large to maintain similitude in flow regimes, flow regime transitions, and flooding. The dimensionless scaling parameters are the Froude number and the Bond number. Both the OSU report (Ref. 9) and Ref. 7 reach the same conclusion regarding scaled pipe diameters and both ROSA and OSU meet the criteria.

C. Separate Effects Tests

In its letter of March 10, 1992 (Ref. 10), the ACRS stated "Westinghouse has planned a robust separate effects test program..." RES agrees with the assessment, noting that Westinghouse has incorporated the suggestions we provided to NRR into its testing plans. Thus, NRC plans to use data from the Westinghouse separate effects test program to assess its codes.

D. Computer Codes

We have not been hindered in our RELAP calculations by run time considerations. Our calculations are performed on work stations. Computer charges are not significant.

Dr. Zuber states that RELAP is based on a technology 18 years old. It is true that the RELAP code originated in the 1960s. RELAP5 has been under development since 1976. The first two-fluid version of RELAP5 (MOD2) was frozen in 1985. The current version (MOD3) was extensively modified and improved with the incorporation of new models and code methods prior to its release in 1989. At each stage of development, current useable technology has been employed. The code is, therefore, based on technology of the past few years. In fact, based on its world-wide use it is safe to say that RELAP5 is state-of-the-art for thermal-hydraulic plant system analyses.

II. Presentations by RES

A. ROSA-IV Facility

Most of Dr. Zuber's comments are included in the June 23, 1992, memo and are already addressed above.

Dr. Zuber implies that RES acted in haste to perform calculations which justify use of ROSA-IV, and that we "... accept the implication of a single new calculation which contradicts previous results." This was not the case. We recognized early on that

because of the single cold leg per loop in ROSA, we might not be able to adequately simulate asymmetric breaks in the pressure balance lines. An obvious potential design modification was to split the cold legs immediately downstream of the pump and upstream of the vessel.

We simulated this potential configuration in the RELAP5 model of ROSA and ran several analyses. These analyses confirmed that the proposed splitting of the cold leg would produce atypical behavior due to more pronounced differences in flow resistances. We, therefore, did not pursue this modification. Nothing was done in haste, nor did we conclude that a single cold leg per loop imposed no configurational distortions. What we concluded was that we could not adequately represent the split cold legs in ROSA, and therefore, the facility could not provide completely prototypical data for code assessment in its current configuration of one cold leg per loop for a break in the cold leg pressure balance line. These breaks would lead to asymmetric draining of the two CMT's, one in the affected loop and the other in the unaffected loop, which can only be partially simulated in ROSA. Therefore, in discussions with JAERI, we devised an alternate configuration for such breaks of connecting the cold leg pressure balance line to the other cold leg. Calculations with this arrangement show adequate agreement between ROSA and AP600 with respect to asymmetric draining of the CMTs.

We also became aware of the difference in configuration between ROSA and AP600 in the communication between the upper plenum and upper head. Westinghouse had changed this in the AP600 as compared to their 4-loop plant, upon which ROSA was based. At the June 3-4 meeting we discussed this design difference and its effects. JAERI committed to make a change to ROSA to provide similar communication between the upper plenum and upper head. With this in hand, we repeated the calculation and the results came out as we expected. We wanted this work done in time to present to the ACRS so that the ACRS could be provided a clear view of our ROSA plans. We performed this analysis expeditiously, but not in haste.

B. RELAP5

We do not have a lengthy inventory of models which must be incorporated into RELAP5. We have identified certain areas where the code must be assessed or where model enhancements may be of benefit. These enhancements are now being incorporated into RELAP5. However, we do not agree that it is required to incorporate all of the model improvements we plan before the code can be used with confidence. Based on our review of phenomena and RELAP applicability, we have sufficient confidence in using the code for the analytic studies required today. Future improvements and assessment exercises will improve our confidence accordingly. Our plans already integrate separate effects testing, code assessment, model development, and integral testing. However, only <u>after</u>

assessment against data can we be certain that all needed code improvements are complete.

C. Separate Effects Tests

RES was not asked by the ACRS to address separate effects tests. Had we been, we would have described our review of the Westinghouse vendor testing program, which supports the conclusion reached in the ACRS letter of March 10, 1992 (Ref. 10). We would also have described our overall RELAP validation plans (e.g., Ref. 11), which includes analyses of all relevant Westinghouse separate effects testing. Since it is the responsibility of the vendor to provide experimental data necessary for design certification, if RES forms an opinion that the testing is in some way deficient, we would inform NRR so that they could take whatever action they deemed appropriate.

Dr. Zuber states that the main efforts of RES were directed towards ROSA-IV tests. This is incorrect. Planning for ROSA is only a part of a comprehensive research program began in 1989 (see Appendix VI).

III. Conclusions

1. W must demonstrate to the staff in its forthcoming scaling analysis that SPES will adequately simulate the processes and phenomena expected in AP600.

2. OSU is a low pressure reduced height facility intended to address low pressure processes. For that application, we agree that it should provide valuable data.

3. NRC staff will have to determine if the data from these two facilities will provide an adequate basis upon which the design of AP600 can be certified.

4. We do not agree. Additional tests by W on the PRHR and passive containment heat removal are also necessary to assess codes in order to address NRR concerns.

5. We have not seen a calculation of the OSU facility, since none exist. Only two SPES calculations exist, and these were performed with an earlier facility configuration and include such assumptions as simultaneous actuation of ADS stages 1 and 2. In contrast, an extensive number of calculations have been performed on ROSA, in addition to the basic scaling analysis (Ref. 7). There has been no evaluation of the effects of structural heat losses and inputs in SPES, and this will be an important consideration. In fact, Westinghouse is considering oversizing the stage 4 valves in SPES to compensate for structural heat. The effects of SPES scale will have to be carefully considered during the conduct of the program. Finally, our extensive analyses of ROSA show that the facility is

expected to behave in a predictable manner that adequately simulates the thermal hydraulic processes and phenomena expected in AP600, and that no artificial safety issues will arise due to the experimental data.

The memo provides no indication of any separate effects tests that should be done, but which are not now planned. The principal issues identified for the AP600 involve systems interactions, which can only be studied with integral systems testing.

6. Calculations performed for both ROSA and AP600 with and without loop seals show no material difference in results. This has been confirmed by Westinghouse. Initial conditions are no more or less important in AP600 experiments than for current plants. ROSA <u>does</u> provide correct initial conditions in terms of system energy and distribution. These are the important criteria, not absolute core power. Reduced power capability (15% of full power) is not a significant facility limitation since the scram setpoint is quickly reached and, thereafter, the experimental facility operates on the decay heat curve. Thus, in a facility with full power capability such as SPES, full power actually comes into play for a few seconds. The only transients for which such capability is valuable are ATWS and large break LOCA.

7. We disagree with the conclusion that artificially created safety issues will lead to a delay in the certification process. Our reasons have been delineated in our other comments on this letter as well as our comments on his June 23, 1992 letter in Appendix Ia.

8. It is our position that ROSA will be a more than adequate facility when modified.

9. We believe that the ROSA-V tests are appropriate and needed for the reasons previously discussed.

10. We have reviewed in-depth the Westinghouse separate effects testing program and provided our comments to NRR. We believe that the current Westinghouse separate effects testing program is sufficient and adequate for our needs.

IV. Recommendations

1. The staff does not have enough information on SPES to make a judgement on whether the suggested modifications can or will be made. In any event, the worthiness of SPES does not negate the need for confirmatory research on ROSA.

2. <u>W</u> will perform tests in SPES 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.

3. While we believe this would be a worthwhile exercise, we will defer the imposition of such a requirement to NRR.

4. We do not disagree with this conclusion but defer the decision to NRR.

5. RES already had plans in place to do this.

6-9. We have given our comment on the Task Force recommendation already and believe that the important activities have been planned and are being carried out including coordination with NRR, expert review, etc.

References for Appendices Ia and Ib

1. Safety Assessment Needs of the AP600 Nuclear Power Plant, S. Michael Modro, June 8, 1990.

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

3. RELAP Enhancement Needs, Letter from S. Michael Modro, to G. Rhee, September 23, 1991.

4. Vendor Testing Programs for AP600 and SBWR, Letter from Louis M. Shotkin, to R. Jones, NRR, July 31, 1991.

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

6. Analysis of Modified ROSA/LSTF - presentation to ACRS, Marcos G. Ortiz, July 9, 1992.

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

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

9. Scaling Analysis for the OSU AP600 Integral System and Long-Term Cooling Test Facility, Jose N. Reyes, Jr., June 1992.

10. Letter, D. Ward, ACRS to Chairman Selin, NRC, Requirements for Full-Height, Full-Pressure Integral System Testing of the Westinghouse AP600 Passive Plant Design, March 10, 1992.

11. RELAP5/MOD3 Code Assessment Studies Performed in Support of AP600 Thermal-Hydraulic Analysis, S. M. Sloan, September, 1991.