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E. T. Boulette, PhD
Senior Vice President — Nuclear

April 25, 1997

Dr. David Morrison
USNRC, Office of Nuclear Regulatory Research
Mail Stop TD5, Washington, DC 20555

Dear Dr. Morrison:

Enclosed is the report of the NSRRC Committee meeting on April 3 & 4, 1997. Please note that the subcommittee reports are attached.

If you have any questions on the contents, please call me.

Sincerely,

E.T. Boulette

E. Thomas Boulette, PhD

CC: NSRRC Committee Members
J. Cortez

Encs.
:vep

**NSRRC REPORT**
**APRIL 3-4, 1997**

The Nuclear Safety Research Review Committee met on April 3-4, 1997 at Two White Flint North Bldg., Rockville, MD. Members in attendance included E.T. Boulette, Chair, S. George Bankoff, Michael Golay, Christine Mitchell, John Taylor and Sumio Yukawa. Also attending the meeting were David Morrison, RES Director, Jose Cortez, DFO, and several members of the RES staff. A copy of the meeting agenda is attached.

Boulette opened the meeting by reviewing the agenda and emphasizing the need for preparing for the meeting with the commission on May 2. The committee briefly discussed the format for that meeting, with the position taken that each member would make a brief report in their areas of review.

Morrison then made a few remarks regarding the recent management changes in the NRC, with emphasis on the RES organization. Morrison also discussed the evolutions in the NRC's strategic plan emphasizing anticipated changes expected in the next year or so.

Golay, with the assistance of Mitchell, next made a presentation of the joint meeting of the PRA/I&C and Human Factors Subcommittees held on January 24, 1997. The report was reviewed and commented upon, with some discussion of the subcommittees' response to the commission's questions in this area posed last September, 1996. The major observations and recommendations are summarized as follows, with the complete report attached.

The current RES human factors (HF) and human reliability analysis (HRA) programs are largely unrelated. The current HRA programs also are not coupled by work of AEOD in assessing actual event experiences. That situation should change; reorganization would be helpful. The HF/HRA programs of RES are too much dominated by User Needs, uncoordinated, short term-oriented and therefore too often lacking in genuine research content, and typically not organized to formulate and resolve hypotheses.

The HRA program is underfunded and optimistic. It consists of only two projects: ATHENA - for errors of commission, and a project concerning Organizational Factors.

Currently HRA in PRAs relies upon empirical data for quantifying the reliability of simple human actions. With current capabilities HRA is not ready to quantify the reliability of commission errors, cognitive errors, crew performance, human-machine interface effects upon human performance, information technology effects and social and organizational effects upon human performance.

Reorganization of current efforts can be valuable. Important foci should include coupling of HF and HRA efforts, linking HRA/PRA advancement to work of AEOD and NRR, and cooperation with the complementary research programs of other organizations.

The next area discussed by the committee was a report by Mitchell of the NAS final report "Digital Instrumentation and Control Systems in Nuclear Power Plants, Safety and Reliability Issues". Major points of discussion and observations are summarized as follows:

The Committee on Application of Digital Instrumentation and Control Systems to Nuclear Power Plant Operations and Safety of the National Research Council submitted its final report to the U.S. Nuclear Regulatory Commission (US NRC) in December 1996. In the report, the Committee made several points. First, the Committee noted that while digital instrumentation and control equipment is state-of-the-art technology, it is widely used both inside and outside the nuclear industry; thus, a large body of experience continues to accumulate. Second, digital technology, including hardware and software, has the potential to enhance safety and increase overall system effectiveness in both nuclear and non-nuclear applications. Finally, due to significant differences between analog and digital technologies, the nuclear industry must implement digital technology with care and caution, particularly in safety-critical systems.

The Committee conducted its analysis in the context of eight key issues: six technical and two strategic. A total of 39 recommendations were made. Technical issues included consideration of characteristics that highlight differences between traditional analog technology and emerging digital systems. Technical issues include systems aspects of distributed systems, software quality assurance, and software reliability. Strategic issues address the regulation process including 10 CFR 50.59 reviews and the adequacy of the US NRC technical infrastructure to respond to quickly emerging technologies.

The Committee reviewed a range of past experience that the US NRC and the nuclear industry have had with digital applications in both current and advanced plants. The Committee endorses the current position of the US NRC and its application of 10 CFR 50.59 with respect to the use of digital technology. The Committee strongly encourages the maintenance of the distinction between digital upgrades that are significant (i.e., pose unreviewed safety questions) and those that are not. Based on this distinction, the Committee recommends that the US NRC tailor the scope and depth of regulatory review in a manner commensurate with significance.

The Committee stressed the importance of maintaining a technical infrastructure which allows the US NRC to address emerging opportunities and issues. The continued change in digital technology and an increase in the rate of change appears inevitable. It is difficult but critical for the US NRC staff to ensure that the vision and technical skills of the staff keep abreast of rapid technology change and potential applications in nuclear applications.

A knowledgeable infrastructure will allow the US NRC to address technical issues in both the regulatory and research areas. The Committee noted that while there are no 'silver bullets' to finally resolve the myriad of technical issues associated with digital

technology, adequate resources and experience exist to permit the incremental incorporation of such technology in nuclear power plants in a manner that ensures the necessary levels of safety and reliability.

Committee deliberations and the revision of the Standard Review Plan proceeded concurrently. At this point, the US NRC staff is reviewing the National Research Council report to ensure that either the Standard Review Plan revision or subsequent deliberations address each of the issues identified in the report.

Professor Bankoff next reported on the Accident Analysis Subcommittee meeting held on April 2, 1997. Several of the subcommittee members were not in attendance for this meeting because of the northeastern blizzard. The principal observations and recommendations of this subcommittee are as follows, with the full report attached.

## Coordination with ACRS

George Bankoff attended as an observer and invited participant of the meetings of the ACRS Thermal Hydraulics Subcommittee on December 18-19, 1996 on AP600 PIRT/scaling analysis with Westinghouse and NRR representatives and on February 12-14, 1997 to discuss application of the RELAP code to integral test data obtained in the three integral test facilities (OSU, Italy, Japan).

As a result of these meetings, some apparent difficulties in the current scaling methodology were identified, as described in the letter from Dr. Bankoff to Dr. Catton, dated March 13, 1997, who was the ACRS Subcommittee Chair at the time. It was suggested that this would be an appropriate subject for the study.

The available member of the AA Subcommittee met with RES staff on April 2, 1997 to discuss the severe accident program in the light of recent work by Theofanous, et al., suggesting the strong likelihood of in-vessel core retention for a reactor whose lower head is immersed in a flooded cavity (AP600 and others). There is an active RES program on lower head integrity. The subcommittee wishes to emphasize the following point: the CHF for boiling heat transfer from a submerged lower head has been correlated as a single function of the polar angle, for data from several scales and locations. The minimum CHF is sufficient to keep the lower head cool (a few tens of degrees above the saturation temperature), so that thermal failure, due to creep or local melting, cannot occur. This possibility needs to be thoroughly researched.

## Code Updating

The four major codes are slated to be combined into a single modern, modular code. This is a worthwhile project, but needs to be carefully monitored and tested to see whether the technical capabilities of the present codes are being retained.

It is also proposed to convert the fundamental equations (heat, mass and momentum) to more suitable dependent variables, such as interfacial area per unit volume. This should be done very cautiously.

It is also proposed to conduct a continuing experimental program in an NRC-supported facility, such as at Purdue. The subcommittee recommends that prior to running any experiment the gaps in existing knowledge, based on available data, be identified and an analysis be made showing how the experiment will remedy the situation.

Next on the committee's agenda was a briefing by S. Yukawa on the Materials and Engineering Subcommittee meeting also held on April 2, 1997. Attendance for this meeting was also limited by the April 1 storm. Major findings of this subcommittee are as follows with the full text of the report attached.

In a one-half day meeting on April 2, 1997 RES staff presented the status of and plans for research programs in two program areas:

**Environmental Qualification (EQ) of Electric Cable Systems**
**ECCS Strainer Blockage**

The presentations indicated that both programs are proceeding on schedule with useful results. Through year 2000, the focus of research on EQ of Cables is on the effect of thermal and radiation aging on the performance of cables used in I&C systems. After that, studies on power cables and connections are planned. The subcommittee's one recommendation for this program is to be sure that the anticipated testing results will be sufficient to fulfill the data needs of PRA methodology for I&C systems.

The testing and experimental phase of the research on Strainer Blockage will be completed in FY 97 and some regulatory actions have already been issued. Additional actions may be issued as needed. This research program has the elements of a useful and beneficial coordination between NRC RES, nuclear industry groups and component suppliers.

Several weeks prior to this committee meeting, an NRC-industry meeting on safety research was held at NRC Headquarters. The meeting took place on March 25th and was attended by utility representation, NRC staff, EPRI, regulatory owners groups, major nuclear vendors, NEI and DOE. The meeting was sponsored by David Morrison of the RES staff, Andrew Kadak of YAEC and John Taylor, member of the NSRRC. Taylor reported the observations coming from the March meeting to the NSRRC and, after some discussion with the committees, compiled the following observations:

RES is to be commended for their efforts, as they developed the methodology to obtain the viewpoints of the NRC user offices, NRC Program Managers in the national labs, deans of nuclear engineering of six universities, and industry personnel involved in nuclear research.

The following suggestions are made which the committee judges will enhance the results of application of the methodology:

Thirty-nine areas of research have been identified, primarily in terms of technical skills, where the potential need for core capabilities will be assessed. To provide a clearer basis for the prioritization of these needs, it would be appropriate to define the RES R&D objectives as well as the technical skills. The methodology provides a detailed form of prioritization by assessing for each skill area the regulatory needs which would be fulfilled in that area. Yet, review of the two examples of application of the methodology shows a relatively small difference in capability requirement between an area of high activity (work-load driven) and one which is relatively inactive (expertise driven).

In the planned application of the methodology, existing research core capabilities are derived only from the RES staff. NRR staff should also be considered as contributing to core capabilities where they have appropriate skills.

From the two examples of application of the methodology, it appears that less important areas will be assigned a minimum of one RES staff member. This may impose a higher staff requirement than funding permits. Consideration should be given to providing all of the needed capability in such areas through contractors, particularly the national labs.

The planned scope of the evaluation is limited to the current understanding of the regulatory environment and does not consider potential future needs. This restriction inhibits planning for new initiatives, particularly in anticipatory research. The lead times in developing new skills can be lengthy.

Although the implementation of the core capability program logically follows the completion of the assessment and Commission approval of core capability needs, preliminary planning should be defined as to how these needs will be maintained or remedied. The implementation will be difficult because of the present and continuing budget restraints and further guidance can come on priorities by assessing the specific difficulties and costs of maintaining capabilities in each area.

This capability assessment is key to retaining the necessary research competence to permit RES to meet its responsibilities. Accordingly, it is being given in-depth and high priority attention by RES management. The above comments are intended on the one hand, to help meet the capability requirements in a limited resource context; but on the other hand, to enlarge the assessment to include anticipatory research needs.

The remainder of the meeting was devoted to a review of the committee's effectiveness in supporting RES and preparation for the meeting with the commission on May 2. With regard to the subcommittee's effectiveness, several observations were made. First, the committee believes it should continue to emphasize a longer term view of research. To that end, the committee needs to spend more attention on the long-term

plans of RES, to ensure appropriate priority is placed in anticipating future needs. An associated concern is related to how much of RES' efforts are devoted to user needs response. Adequate resources need to be reserved for the longer term view, which will require managing the user need responses appropriately.

The committee believes that it can assess its effectiveness by requiring a periodic review of the staff's response to its recommendations. This activity will become a standard agenda item for future committee meeting, with a request that RES formally address all committee recommendations and observations, with a discussion about their resolution.

The committee wants to bring to the commission's attention recent recommendations from the ACRS, the NAS and the NSRRC all supporting continuing safety research. It is considered a vital activity for the NRC, and, in spite of necessary budget reductions, must be managed to ensure maintenance of primary functions.

The final segments of the meeting were devoted to preparations for the meeting with the commission.

Attachment #1

# Report of the NSRRC Subcommittees of Probabilistic Risk Assessment and Human Factors Concerning the NRC Human Factors and Human Reliability Analysis Research Programs

## INTRODUCTION

The NSRRC Subcommittees of Probabilistic Risk Assessment (PRA) and Human Factors & Instrumentation and Control (HFIC) held a joint meeting on January 24, 1997 to review the progress of Human Factors research and to discuss the Commission's questions in a September 10, 1996 SRM. The purpose of this meeting was to respond to the Commission's request for the NSRRC to:

1) Continue to review the progress of human factors research

2) Identify those human factor areas that can be treated adequately in PRA

3) Identify human factors areas where progress for inclusion in PRA is likely.

Reference material provided by RES included:

1) The December 30, 1996 ACRS Questions on Human Performance Plan addressed to the EDO

2) Presentation materials provided by RES for the last meetings of the two subcommittees

3) The NSRRC report on the last PRA and HFIC subcommittee meetings

4) The August 1995 and July 1996 versions of the Human Performance Program Plan

5) The January 13, 1997 Quarterly Status Update for the PRA Implementation.>

## HUMAN PERFORMANCE PLAN

The Human Factors Coordination Committee meets approximately every six months to coordinate the NRC's human factors activities and to update the NRC's Human Factors Program Plan as necessary. Revision 1 to this plan (July, 1996) summarizes the goals, objectives, lead office, and other information supporting this plan.

RES is the lead office in this plan for accomplishing the following goals:

GOAL 1: Assure the Adequate Safety Performance of Nuclear Facility Personnel

Objective 1.1 Assure that nuclear facility personnel are adequately qualified and that staffing is appropriate

- 1.1.3 Modify Regulatory Guide 1.8
- 1.1.6 Develop Performance-based Approach to Determining Fitness-for-Duty
- 1.1.4 Develop Guidance for Staffing at Operating Reactors
- 1.1.8 Develop Guidance for Staffing for Advanced Reactors

Objective 1.2 Assure that nuclear facilities have effective human-system interfaces

- 1.2.4 Develop NUREG-0700, Rev.1
- 1.2.5 Develop Guidance for Advanced Alarm Systems
- 1.2.6 Develop Guidance for Hybrid Control Rooms
- 1.2.7 Develop Guidance for Display Navigation
- 1.2.8 Prioritized Human-System Interface Issues
- 1.2.9 Develop Future Revisions to NUREG-0700
- 1.2.11 Develop Guidance for Computerized Job Performance Aids

Objective 1.3 Assure that nuclear facilities have effective organizational practices

- 1.3.2 Develop Method to Quantify Organizational Performance Factors

GOAL 2: Provide Empirically Based Information to the Regulatory Process

Objective 2.1 Assure that human performance is effectively assessed

- 2.1.3 Revise Human Performance Related Management Directives
- 2.1.4 Revise Human Performance Investigation Process
- 2.1.5 Analyze and Disseminate Human Reliability Assessments / Probabilistic Risk Assessments (HRA/PRA Information

Objective 2.2 Assure the availability and use of adequate human performance information

- 2.2.10 Determine the Feasibility of Using Task Network Modeling for Regulatory Applications

□ 2.2.11 Develop Methods to Obtain Empirical Operational Data

□

□ Objective 2.3 Assure the use of empirically-based HRA in PRA as appropriate

□

□ 2.3.1 Develop Methods for Quantifying Errors of Commission

□ 2.3.2 Develop Methods for Quantifying Organizational Factors for PRAs

□

□ Objective 2.4 Assure that research is focused is based on providing technical bases for Commission policies and regulatory decisions

□

□ 2.4.4 Develop Standardized Format for User Needs

□ 2.4.7 Conduct Feasibility Studies of Emergent Issues

□

□GOAL 3: Ensure Adequate Availability and Effective Coordination of NRC Resources to carry out the Human Performance Programs.

□

□ Objective 3.2 Assure effective communication within and across offices

□

□ 3.2.2 Develop and Implement Human Performance Orientation Training

□

□ Under Objective 2.2 Assure the availability and use of adequate human performance information in the Human Performance Program Plan, AEOD has the following six activities:

□

□ 2.2.1 Integrate Human Performance Information Into a Consolidated Event Data Base

□ (Schedule TBD)

□

□ 2.2.2 Modify the SCSS to Include More Human Performance Information and make

□ SCSS More Widely Available

□ (continuing)

□

□ 2.2.4 Make AEOD Human Performance Event Database Available Throughout the

□ Agency

□ (Schedule TBD)

□

□ 2.2.5 Revise NUREG-1022 to Better Define the Human Performance Information

□ Required in Licensee Event Reports

□ (Schedule TBD)

□

□ 2.2.6 Determine Information Needs for HRAs

□ (Schedule TBD)

□

□ 2.2.7 Assess HRA Models to Assure Human Performance Databases Contain

□ Information Useful for HRA Models

□ (Schedule 3Q/FY97).

□

Of these items, only Objective 2.3 is related to the use of HRA in PRA. Human reliability data and such as being collected by the AEOD would appear to be essential to the development of HRA models and their incorporation in PRA.

□

**□PRA**

□

□In the January 13, 1997 Quarterly Status Update for the Probabilistic Risk Assessment (PRA) Implementation Plan (SECY-97-009), the Subcommittee found RES referenced as a lead office in the following categories:

□

□1.7 Regulatory Effectiveness Evaluation (With NRR)

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Assess the effectiveness of two major safety issue resolution efforts (i.e. SBO and ATWS rules) for reducing risk to public health and safety.

□

□1.8 Advanced Reactor Reviews - (with NRR)

□

□ Develop independent technical analysis and criteria for evaluating industry initiatives and petitions regarding simplification of emergency preparedness regulations.

□

□1.9 Accident Management (with NRR)

□

□ Develop generic and plant specific risk insights to support staff audits of utility accidents management programs at selected plants.

□

□1.10 Evaluating IPE Insights to Determine Necessary Follow-up Activities (with NRR)

□

□ Use insights from the staff review of IPEs to identify potential safety, policy, and
□ technical issues, to determine an appropriate course of action to resolve these potential issues, and to identify possible safety enhancements.

□

□2.1 Develop Regulatory Guidelines

□

□ Regulatory Guides for industry to use in risk-informed regulation (General, IST, ISI, GQA, TS).

□

□2.2 Technical Support

□

□ Provide technical support to agency users of risk assessment in the form of support for risk-based regulation activities, technical reviews, issue risk

assessments, statistical analyses, and develop guidance for agency uses of risk assessment.

□

□2.3 Support for NRR Standard Reactor PRA Reviews

□

□ Modify 10CFR52 and develop guidance on the use of updated PRAs beyond design certification.

□

2.4 Methods Development and Demonstration

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□ Develop and demonstrate methods for including aging effects in PRAs.

□

□ Develop and demonstrate methods for including human errors of commission in PRAs.

□

□ Develop and demonstrate methods to incorporate organizational performance into PRAs.

□

□ Develop and demonstrate risk assessment methods appropriate for application to medical and industrial licensee activities.

□

□2.5 IPE and IPEEE Reviews

□

□ To evaluate IPE/IPEEE submittals to obtain reasonable assurance that the licensee has adequately analyzed the plant design and operations to discover vulnerabilities; and to document the significant safety insights resulting from IPE/IPEEEs.

□

□2.6 Generic Issues Program

□ To conduct generic safety issue management activities, including prioritization, resolution, and documentation, for issues relating to currently operating reactors, for advanced reactors as appropriate, and for development or revision of associated regulatory and standards instruments.

□

□3.2 Accident Sequence Precursor Program

□

Complete quality assurance of Rev. 2 simplified plant specific models.

□

□ Complete feasibility study for low power and shutdown models.

□

□ Complete initial containment performance and consequence models

□

□3.6 Staff Training (with AEOD)

□

□ Develop and present Appendix C training courses

□

□4.1 Validate risk analysis methodology developed to assess most likely failure modes and human performance in the use of industrial and medical radiation devices.

□ Continue the development of the relative risk methodology, with the addition of
□ event tree modeling of the brachytherapy remote afterloader.

□

□ Extend the application of the methodology and its further development into
□ additional devices, including teletherapy and the pulsed high dose rate afterloader.

□

□4.2 Continue use of risk assessment of allowable radiation releases and doses associated with low-level radioactive waste and residual activity (with NMSS).

□

□ Develop decision criteria to support regulatory decision making that incorporates
□ both deterministic and risk-based engineering judgment.

□

□4.3 Develop guidance for the review of risk associated with waste repositories (with NMSS).

□

□The only two activities related to the incorporation of HRA in PRA are the 2.4 Methods
□Development and Demonstration activities of

□

□ - Develop and demonstrate methods for including human errors of commission in
□ PRAs

□

□ - Develop and demonstrate methods to incorporate organizational performance into
□ PRAs.

## OBSERVATIONS OF THE SUBCOMMITTEES

The subcommittees have several areas of consensus concerning the information presented to us. We summarize them in the following discussion.

The RES Projects in the Areas of Human Factors (HF) and Human Reliability Analysis (HRA) are largely unrelated

In the presentations from the RES and NRR staff members concerned with the HF and HRA programs, respectively, it became evident that the great majority of the HF programs have been formulated without regard to the need to improve the understanding of HRA. Rather, most of the work being done is in response to NRR user needs. As such each element is typically short term-focused and not coordinated with the others. The fact that user needs are not formulated in a coherent fashion is sufficient to explain the latter aspect.

This incoherence is also reflected in the apparent lack of interaction by the HF and HRA efforts with the real-world analysis efforts of AEOD. In an effective, comprehensive research program it would be logical to expect a portion of to be comparing knowledge gained in individual projects with what is being learned about actual operating plants, and also contributing to the formulation of the AEOD research plan. Further, a connection between the operating plant analyses and the research program would be expected to provide theoretical models in terms of which to make sense of the observed operating results. The absence of such interactions is symptomatic of the absence of a meaningful HF/HRA research plan within RES.

As most of the current user needs and independent research efforts were formulated prior to the current NRC emphasis upon Risk Informed Performance Based Regulation (RIPBR) it is perhaps not surprising that they are unconcerned with how the work to address these user needs could be useful in the HRA portion of a probabilistic risk assessment (PRA).

However, regardless of the cause of the lack of connection between the HF and HRA programs, it would be valuable to coordinate them Logically each HF project should have an implication for the understanding of HRA, and should be able to contribute to an increasing body of knowledge in this area. Hopefully this will be done.

The HRA Program is Far Too Small for Likely Success

In addition to the problems mentioned above the HRA program appears to have two main elements: the ATHENA project - intended to provide models and data concerning errors of commission and of cognition and the Organizational Factors (OF) project - intended to provide contributions concerning the effects of organizational structure and management approach upon power plant risks. In fact the information provided to our Subcommittees to-date has been so little that it is impossible to make any meaningful statement concerning the goals or methods of either project. However, we can note that the ATHENA budget

of $700k annually is small in terms of the challenges of developing a deep understanding the problems being addressed; the area of HF is one where the NSRRC has repeatedly recommended either termination of the work of RES or a fresh start, based upon new and better ideas. We have seen no evidence of the latter; so we remain skeptical that the OF project will be useful.

The HF approach within RES is apparently based upon simple empirical handbook models of human error rates, developed about 17 years ago. These are not very useful concerning such topics as digital human-machine interfaces, cognitive errors, crew interactions, psychological motivations of human performance and social and organizational interactions. Progress in these areas is difficult and requires a sustained and substantial research commitment. Such a commitment is not evident in the RES program, which can be characterized as under-funded and optimistic. The two current efforts may have the right goals, but we would expect them to be accompanied by several more projects, at a much more substantial budgetary level in order to have any reasonable chance of making important contributions. Rather, the current approach appears to be one of doing what is feasible under stringent circumstances, and hoping for good luck.

However, it is conceivable that things are much better than this summary indicates. We need much more information from RES before we can say more. Through this letter we request that information.

## DISCUSSION OF THE RES PROGRAMS

An essential tool in the current NRC thrust to implement RIPBR is PRA. An area of important PRA uncertainty and weakness is that of HRA (as is recognized among the NRC staff). As is discussed above the current program of RES does not promise to improve this situation. This is because currently RES lacks an effective research program in this area. Rather they have two small projects, and poor linkage of HRA improvement to most of the relevant efforts within the overall HF program. Much of this can be explained by the internal NRC policy of focusing RES's resources upon user needs, upon severe budgetary restrictions and perhaps from too much experience within the research organization of focusing upon short term requirements.

If the NRC is to be realistic about improving the current state of knowledge in HRA it is necessary to establish a long duration (i.e., > 10 years), substantially funded (i.e., > $3 Million annually) program for this purpose. Much of this could be done by reprogramming the combined HF and HRA efforts, but doing so would likely require serving NRR's user needs elsewhere.

The test of whether a revised research program is likely to be effective could be provided by examining the degree to which it would be able to help answer the following questions adequately:

1. What questions must be answered in order to understand HRA sufficiently,

2. How is the overall NRC effort trying to get these answers,
3. How does the work of RES fit into the overall NRC effort,
4. What are the important elements of the RES HRA and HF programs, and how do they conform to the rationale of the overall NRC effort,
5. How are the expected products of these elements planned to be employed?

One should expect the answers to these questions to provide the bases of the HF/HRA research program.

However, we asked these questions in examining the HF and HRA programs and still need much more information before we will know the staff's understanding of them. This situation is symptomatic of the weakness of current efforts in attempting to constitute an effective HF/HRA research program.

Attachment #2

# ACCIDENT ANALYSIS SUBCOMMITTEE REPORT

1. Coordination with ACRS

In accordance with the letter from John Larkins to David Morrison, dated December 13, 1996, on ACRS and NSRRC coordination, the Accident Analysis (AA) Subcommittee Chair, George Bankoff, attended the meetings of the ACRS Thermal Hydraulics Subcommittee on December 18-19, 1996 to review AP600 PIRT/scaling analysis with Westinghouse and NRR representatives, and on February 12-14, 1997 to discuss application of the RELAP code to integral test data obtained in the three integral test facilities (OSU, Italy, Japan). A substantial fraction of both meetings was occupied by the application of the current scaling methodology to the small-break accident. This is not the most dangerous one, but exercises the passive features of the AP600 design more fully. For the December meeting Westinghouse provided two major reports:

WCAP-14727, "AP600 SCALING AND PIRT CLOSURE REPORT" Propriety Class 2, and
WCAP-14772, "AP600 TEST PROGRAM OVERVIEW" Non-Proprietary Class 3.

The first was a comprehensive summary of previous work, detailed in a large number of previous reports of the past six years. In itself, it was quite massive, containing more than 190 figures and running about 300 pages. The second was intended as a guide to the first, although there were a number of complaints by the consultants that the necessary information to back up statements made during the presentation could not easily be found. It was requested that a "guide to the guide" be supplied, in the form of an additional summary report pointing to the evidence supporting all assumptions and conclusions.

The plant structure is quite complex, and when added to the changes in behavior in various time periods in a small break accident, the level of detail becomes too much to describe even briefly.

The Phenomena Identification Ranking Table was developed for each type of transient, including LOCA, SBLOCA, operational transients and long-term cooling. The scaling analysis is performed by writing the global conservation equations for mass, momentum and energy at the system level for specific time periods during the transient, and normalizing by dividing through by the coefficient of the driver term in each equation. The coefficient of the driver term, such as the hydrostatic head term in the momentum equation, is then unity, while the coefficients of the other terms can be used to evaluate which terms are of minor importance. In a loop the sum of the pressure drops, including frictional and inertial terms, is equal to the hydrostatic pressure difference. This means that the sum of the dimensionless coefficients should be close to unity if the dimensionless dependent and independent variables are properly scaled. This turns out frequently to be not the case. Other difficulties exist, which are described in the letter from Bankoff to Dr. Catton, dated March 13, 1997, who was the ACRS Subcommittee chair at the time, .

2. The available member of the AA Subcommittee met with RES staff on April 2, 1997 to discuss the severe accident program, in the light of recent work by Theofanous, et al. suggesting the strong likelihood of in-vessel core retention for a reactor whose lower head is immersed in a flooded cavity (AP600 and others). There is an active RES program on lower head integrity, as summarized in the accompanying viewgraphs. The subcommittee wishes to emphasize the following points:

   1. The CHF for boiling heat transfer from a submerged lower head as summarized on

pp. 30, 31 of the viewgraphs, is correlated as a single function of the polar angle, $\theta$, where at the bottom of the reactor $\theta=0^{\circ}$. The minimum CHF is sufficient to keep the lower head cool (a few tens of degrees above the saturation temperature), so that thermal failure, due to creep or local melting, cannot occur.

2. This possibility needs to be thoroughly researched, and the subcommittee recommends switching of some funds from internal heat transfer dynamics in the lowe: head, as well as ex-vessel acci'ent analysis, to provide an adequate budget. If verified, this scenario means that for floodable cavities the ex-vessel portion of the severe accident scenario is of negligible probability.

3. It is early to make a judgment, but the RASPLA V experiment, being a full-scale melting experiment with electrical heat, is difficult to instrument, expensive, prone to failure, and slow to reconstruct and to run. This may be a place to economize.

3. Code Updating

The four major codes are slated to be combined into a single modern, modular code. This is a worthwhile project, but needs to be carefully monitored and tested. Some simplifications, like going to a two-fluid code, may lead to reduction of capability of handling some types of boiling and dispersed flows, especially with multiple materials. Nevertheless, this is the proper direction to go, but with constant checking, evaluation and reevaluation to see whether the technical capabilities of the present codes are being retained.

It is also proposed to convert the fundamental equations (heat, mass and momentum) to more suitable dependent variables, such as interfacial area per unit volume. This should be done very cautiously, in view of the large body of experiments in which these measurements were not made, together with the correlations based on these experiments.

It is also proposed to conduct a continuing experimental program in an NRC-supported facility, such as at Purdue. The subcommittee recommends that prior to running any experiment, the gaps in existing knowledge, based on available data, be identified, and an analysis be made showing how the experiment will remedy the situation.

Attachment #3

# NSRRC SUBCOMMITTEE ON MATERIALS AND ENGINEERING
## MINUTES OF APRIL 2, 1997 MEETING

The Subcommittee met in a morning session on this date at the NRC offices in Rockville. Sumio Yukawa, Subcommittee Chair, was the only member able to attend the meeting. E. T. Boulette and John Taylor were unable to attend due to a New England snowstorm and a prior commitment.

The meeting concentrated on presentations and discussions on two research program areas which were:

Environmental Qualification (EQ) of Electric Cable Systems
presented by Michael E. Mayfield, Chief Electrical, Materials, and
Mechanical Engineering Branch
Division of Engineering Technology
ECCS Strainer Blockage Research
presented by Michael L. Marshall, Jr.
Generic Safety Issues Branch
Division of Engineering Technology

The funding for these two program areas together total approximately $1.5 million in FY97. The funding in FY94 was about $2.0 million. The following is a brief summary of the issues, scope, contents, and status of research in these two program areas.

EQ of Electrical Cables

The current research in this area concentrates on cables and associated connectors used in instrumentation and control applications inside the containment. The concern relates to the reliability, capability, and performance after thermal aging and radiation damage effects on the insulations and connections. Testing requirements and qualification criteria for the cables have changed over the last twenty years so that cables in operating plants have been "qualified" to differing requirements. The staff initially identified 43 EQ technical issues deriving from these differing requirements. A literature review effort has reduced these to 19 issues and further resolutions are likely.

The ongoing research program includes studies to understand the differences, if any, between artificial and natural aging on the chemical, electrical, and mechanical characteristics of the cables. These characteristics will be measured on new and artificially aged items. Additionally, cables have been acquired from Yankee Rowe and Trojan plants which had twenty and ten years of service respectively. The testing includes exposure to steam conditions representative of LOCA events. Among the expected results is

verification of aging models that can be used for time extrapolations for license renewal purposes.

The program plans schedule completion of major part of the research on I&C cables by the year 2000. After that, research on power cables and penetrations are planned.

The Subcommittee believes that results of this research are vitally needed. The program is well structured and proceeding on schedule. There is some concern about whether the scope and extent of the program will fulfill the needs for a PRA analysis of the I&C system. This concern should be discussed with those responsible for PRA methodology of the I&C system to determine if the anticipated results are sufficient for their needs. The discussion should include the fact there may be a paucity of and uncertainty in the data between the observed aging deterioration and the functionality of the I&C system which may reduce the value of PRA applications to this problem.

STRAINER BLOCKAGE

The strainer prevents passage of deleterious debris in the water drawn from the wet well and their entrance into pumps, valves, and nozzles of the ECCS system. Recent plant incidents and studies of potential circumstances of a LOCA event indicate that blockage in and damage to the strainers may occur more easily and quickly than anticipated which could reduce the flow required for ECCS conditions. One possible consequence of a LOCA event involves a water jet that can disintegrate and spread fibrous thermal insulation and other materials into the wet well. Test and analysis results point to a very high conditional probability of loss of ECCS capabilities. A computer code to analyze strainer blockage has been developed and is publicly available. To date, the studies have been primarily on BWRS in cooperation with the BWR Owners Group (BWROG) but studies for PWRs are ongoing.

Recent regulatory action has requested BWR licensees to implement appropriate actions during outages starting after January, 1997, to ensure that ECCS functions are not impaired. The NRC has determined that this is a compliance issue, not a safety enhancement issue.

The research schedule is that all of the experiments and tests will be completed in FY97. The currently remaining FY97 work is principally concerned with debris transport. The NRC RES results and plans plus those of BWROG and new design strainers by vendors should bring a closure to this problem.

The Subcommittee believes that this research program contains a beneficial and coordinated mix of inputs from NRC, nuclear industry groups, and component suppliers.

Attachment #4

# AGENDA

## NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE (NSRRC)

April 3-4, 1997

Room T-10A1. Two White Flint North (TWFN) Building

11545 Rockville Pike. Rockville. MD

Thursday, April 3

| | | |
|---|---|---|
| 9:00 - 9:30 | Opening remarks | E. Thomas Boulette. Chairman. NSRRC |
| | Current status | D. Morrison. Director RES |
| 9:30 - 10:15 | Report of the Joint Meeting of the PRA/I&C and Human Factors Subcommittees on their meeting of January 24, 1997 | M. Golay. NSRRC |
| 10:15 - 10:45 | Report of the NAS final report "Digital Instrumentation and Control Systems in Nuclear Power Plants. Safety and Reliability Issues" | C. Mitchell. NSRRC |
| 10:45 - 11:00 | BREAK | |
| 11:00 - 11:30 | Report of the Accident Analysis Subcommittee on its meeting of April 2, 1997 | S. George Bankoff. NSRRC |
| 11:30 - 12:00 | Report of the Materials and Engineering Subcommittee on its meeting of Aril 2, 1997 | S. Yukawa. NSRRC |
| 12:00 - 1:00 | LUNCH BREAK | |
| 1:00 - 2:00 | Industry meeting report on core research competencies | J. Taylor. NSRRC |
| 2:00 - 2:15 | BREAK | |
| 2:15 - 5:00 | Discussions on Research Core Competencies | NSRRC Committee RES Staff |

Friday, April 4

| | | |
|---|---|---|
| 8:30 - 10:45 | Continuation of Discussions on Research Core Competencies | NSRRC Committee<br>RES Staff |
| 10:45 - 11:00 | BREAK | |
| 11:00 - 12:00 | Review of NSRRC Committee Effectiveness | NSRRC Committee<br>RES Staff |
| 12:00 - 2:30 | LUNCH BREAK | |
| 2:30 - 5:00 | Preparation for May 2. 1997 NSRRC meeting with the Commission | NSRRC Committee |
| | 3:00 - 3:15 BREAK | |
| 5:00 PM | ADJOURN | |