NUREG-1105

Review and Evaluation of the Nuclear Regulatory Commission Safety Research Program for Fiscal Years 1986 and 1987

A Report to the Congress
of the United States of America

Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

February 15, 1985

The Honorable George H. W. Bush
The President of the Senate
Washington, DC 20510

Dear Mr. President:

I am pleased to transmit to the Congress the report of the Advisory Committee on Reactor Safeguards on the Nuclear Regulatory Commission Safety Research Program for Fiscal Years 1986 and 1987. This report is required by Section 29 of the Atomic Energy Act of 1954 as amended by Section 5 of Public Law 95-209.

Part I of this report is intended to serve as the Executive Summary. Part II includes specific comments and recommendations on the research involved in various Decision Units of the NRC research program.

Respectfully submitted,

David A. Ward
Chairman

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

February 15, 1985

The Honorable Thomas P. O'Neill, Jr.
Speaker of the United States
House of Representatives
Washington, DC 20510

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PREFACE

This is the eighth report by the Advisory Committee on Reactor Safeguards (ACRS) that has been prepared in response to the Congressional requirement for an annual report on the Nuclear Regulatory Commission (NRC) Reactor Safety Research Program. As previously requested by the Congress, the timing of this report has been adjusted to enable the ACRS to address the proposed budget for FY 1986 and 1987 that has been submitted to the Congress by the President.

Detailed comments and recommendations are provided for the research programs and budget proposed for FY 1986. Because both the budget for FY 1987 and the research programs for that period are highly uncertain at this time, comments on these are not provided.

As in previous reports, we have interpreted the words "reactor safety research" to include safety-related research in all phases of the nuclear fuel cycle and power plant operations, excluding only those having to do with nonsafety-related environmental concerns.

Part I is a compilation of our general comments and recommendations regarding the NRC Safety Research Program budget for FY 1986. It is intended to serve as the Executive Summary.

Part II is divided into five chapters, each of which represents a Decision Unit of the NRC research program. In each chapter, we have included specific comments on the research involved in the Decision Unit, an assessment of priorities, and recommendations regarding new directions and levels of funding.

All references to funding in this report relate to funds budgeted for program support and equipment. Funds allocated for NRC personnel and administrative support have not been included.

PART I

GENERAL COMMENTS

AND

RECOMMENDATIONS

GENERAL COMMENTS AND RECOMMENDATIONS

1. Introduction

This report provides a review and evaluation of the Nuclear Regulatory Commission (NRC) Safety Research Program with comments in depth on the activities and budget proposed for FY 1986. Because both the budget for FY 1987 and the research programs for that period are highly uncertain at this time, comments on these are not provided.

Our report to the Congress in February 1984 (Ref. 1)* contained comments on the continuing decrease in funding for the NRC Safety Research Program over the period 1982-1984. This trend is continuing, and at an increasing rate. The proposed level of funding for FY 1986 is $121 million. This is about 10 percent less than the level of $134 million for FY 1985, but is about 20 percent less than the level of $151 million for FY 1985 that we discussed in our report to the Congress in February 1984.

We have expressed concern in the past about this continuing decrease in funding for the NRC Safety Research Program, but have been able to justify or accept it in view of decreasing research needs and decreasing research activity in certain areas requiring expensive physical test facilities. We have also noted greater efforts and success in obtaining both financial and in-kind support from industry and from other countries. These offsetting factors, however, are no longer sufficient to justify the reductions that have brought the proposed funding level for FY 1986 to about one-half that for FY 1982, in constant dollars.

The NRC Staff believes that there is some level of research funding below which it will be very difficult to maintain a level of knowledge and expertise adequate to address and solve current problems, and more important, to address new problems in a timely manner when they arise, as they certainly will. We agree, but do not now know what this base level should be. The NRC Staff is preparing a Safety Research Program Plan which addresses this issue. During the next few months, we expect to review and comment

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*References appear in Appendix A.

on this plan and on the need for, and appropriate level of, a base research program. A copy of our comments will be provided to the Congress.

2. General Comments

We find the proposed funding of $121 million for FY 1986 to be barely acceptable to meet the NRC's regulatory needs. Reduction of the research program to this level has required significant reductions in some programs and the complete elimination of others. In some cases we agree with these changes, in others we do not. In particular, we deplore the elimination of all research on human factors and recommend strongly that funding be provided for continuation of this program. Other recommendations are offered below and, in more detail, in Part II of this report.

3. Budget Recommendations

We urge the Congress to make no further reduction in the proposed budget. We believe that the NRC has contributed more than its share to the reduction of Federal expenditures and that any further reduction will be borne heavily by the Safety Research Program, which is a large proportion of the total NRC budget.

Our recommendations for allocation of the proposed funds among the five Decision Units are given in Table 1.

3.1 Reactor Engineering

Funding for this Decision Unit is adequate, at a level approximately the same as for FY 1984 and FY 1985. The research programs all relate to assuring or verifying the safety of operating reactors, and appropriate priorities have been assigned.

3.2 Thermal-Hydraulic Transients

Funding for this Decision Unit is adequate, although it is about 9 percent below the level for FY 1985. The reduction has been achieved chiefly by eliminating funds for design of a Modular Test Facility (MTF) to replace the several existing thermal-hydraulic facilities that were to be phased out over the next two years. Because the merits of a single MTF versus several special facilities have not yet been established conclusively, we are unable to judge the impact of this decision on future research needs and activities. Nevertheless, we believe that, if such a facility is found necessary or desirable, it should be funded and operated by the Department of Energy (DOE) for use by the nuclear

industry as well as by the NRC. In this case, support by the Congress for such a facility in the DOE might be required.

3.3 Accident Evaluation

Funding for this Decision Unit has been decreasing each year as testing in the Power Burst Facility (PBF) has been phased out and as other programs or portions of programs have been completed. The proposed budget for FY 1986 is 30 percent below that for FY 1985 and is based in part on the assumption that the costs of decommissioning the PBF will be assigned by the Congress to the DOE. In addition, no funds are allocated in FY 1986 for research related to Liquid-Metal-Fast-Breeder Reactors (LMFBRs) or to High-Temperature-Gas-Cooled Reactors (HTGRs). We concur in these bases for a reduced budget.

All of the work in this Decision Unit in FY 1986 is part of the Severe Accident Research Program, which continues at a level only about 17 percent below that for FY 1985, in spite of the fact that the NRC Staff has reached a consensus on a draft Policy Statement on Severe Accidents. We are still concerned with the objectives and conduct of the programs related to the Damaged Fuel and to the Fission Product Source Term. We continue to question the need for extensive and expensive in-pile tests. We believe that these portions of the programs can be reduced in scope and cost, and that $2.5 million of the funds proposed for this work should be reallocated to support research on human factors, as discussed in Section 3.4, below.

3.4 Reactor Operations and Risk

The major portion of the research in this Decision Unit is related to reliability and risk, with a considerable emphasis on risk from severe accidents. The level of funding for this Decision Unit is about the same as for FY 1985. The funds allocated to research on reliability and risk are appropriate, but we continue to believe that the scope and emphasis of this research should be redirected and funds should be reallocated as needed within this Decision Unit. This is discussed further in Chapter 4 of Part II of this report.

The NRC has proposed no research on human factors in FY 1986. We disagree strongly with this decision and recommend that funding in the amount of $2.5 million be provided for such research, as discussed further in Section 4.7 of Part II of this report. If the Congress agrees with this recommendation, we hope that it will be given appropriate recognition.

3.5 Waste Management, Earth Sciences, and Health

This Decision Unit includes three disparate areas of research. The overall funding is $1.5 million below that for FY 1985; we consider it adequate, subject to the recommendation below regarding research on High-Level Waste (HLW) Management.

We consider both the programs and the funding levels adequate but marginal in the areas of Earth Sciences, Health Effects, and Low-Level Waste (LLW) Management.

Funding for the program on HLW Management has been reduced by $2 million from the FY 1985 level. We are concerned that this reduction will make it difficult for the NRC Staff to meet the schedule for licensing a HLW repository. An appropriate remedy for this concern would be for the Congress to devise a mechanism that would allow the NRC to draw on the Nuclear Waste Fund to increase the funding for this program from the proposed $3 million to $5 million for FY 1986.

4. Specific Comments and Recommendations

Specific comments and recommendations regarding the scope, nature, and funding levels of the various elements of the NRC Safety Research Program are presented in Part II of this report.

TABLE 1

PROPOSED BUDGET
FOR THE NRC SAFETY RESEARCH PROGRAM
FOR FY 1986
(DOLLARS IN MILLIONS)

DECISION UNITS	PROPOSED BUDGET	ACRS RECOMMENDATIONS
1. REACTOR ENGINEERING	40.3	40.3
2. THERMAL-HYDRAULIC TRANSIENTS	21.7	21.7
3. ACCIDENT EVALUATION	30.7	28.2
4. REACTOR OPERATIONS AND RISK	16.5	19.0
5. WASTE MANAGEMENT, EARTH SCIENCES, AND HEALTH	11.8	11.8
TOTAL	121.0	121.0

PART II

SPECIFIC COMMENTS

AND

RECOMMENDATIONS

1. REACTOR ENGINEERING

1.1 Introduction

The programs in this Decision Unit are directed toward developing a basis for evaluating reliability and safety margins in components, equipment, and structures of nuclear power plants.

1.2 Mechanical and Structural Engineering

The research in these areas are divided into three categories: Containment Integrity, Seismic Design Margins, and Mechanical Equipment Qualification.

1.2.1 Containment Integrity

This research is concerned with the ability of containments and their penetrations to resist the large internal pressures that could result from a severe accident without releasing an undue amount of radioactive material to the environment. Tests are being made on scale-model containments to provide a basis for validating analyses predicting capacity or leakage. Tests are being made also on large containment penetrations, such as equipment or personnel access hatches, and on the behavior of seals and gaskets. (Leakage through electrical penetrations and the operational integrity of valves are being considered in other programs.) Because the integrity of the containment is a major factor in determining the risk from severe accidents, we assign a high priority to this program.

1.2.2 Seismic Design Margins

Because earthquakes as large as those for which nuclear power plants are designed seldom occur, the complex methods used for seismic analysis and design, and for probabilistic risk assessments (PRAs) considering earthquakes, have never been validated. Research to provide greater confidence, or improvements, in this methodology is being carried out in cooperation with the Federal Republic of Germany (FRG) and the Electric Power Research Institute (EPRI). This research involves tests on a decommissioned nuclear power plant in the FRG, subjected to man-made shaking, and on actual or simulated installations in Taiwan, subjected to real earthquakes.

The estimation of risk from earthquakes requires knowledge of how structures and components respond to earthquakes and how and at what level of shaking they fail. Research in this area includes:

- Shake-table tests of model concrete shear-wall structures, at various scales, to determine failure modes and levels, and especially to determine those changes in stiffness and natural frequency of vibration that would affect components supported by them.

- Studies of failure modes of piping as related to the design criteria now being used.

- Tests of mechanical and electrical equipment to determine the level of shaking at which it will fail (seismic fragility tests).

The research results relating to methodology and to response and fragility taken together provide a basis for evaluating the reserve capacity or margins that the structures and components have to resist earthquakes larger than those for which the plant was designed. A panel of experts has been established to define research needs, to interpret and integrate the results, and to develop preliminary screening criteria in an attempt to develop the bases and criteria for determining seismic margin in general or for specific components, structures, or plants. The results will be useful in determining the continued acceptability of existing plants if new information regarding earthquake frequency or magnitude or plant design bases or methodology should lead to questions regarding their safety.

1.2.3 Mechanical Equipment Qualification

This research is intended to develop an improved technical basis for specifying dynamic (seismic) qualification requirements for both mechanical and electrical equipment and design-basis accident (DBA)-environment qualification for mechanical equipment. The research involves chiefly analyses and reviews and studies of existing information, including some from other countries. It does not include a significant amount of actual qualification testing. It is important to the regulatory process because of uncertainties regarding the qualification of equipment in existing plants and how acceptable qualification should be specified and demonstrated. Its significance to safety will not be clear until the research and the consequent qualification criteria have been applied.

1.3 Primary System Integrity

1.3.1 Reactor Vessels

This research continues to provide a sound basis to judge and assure the toughness of the reactor pressure vessel. It provides a series of largely confirmatory tests to check the conservatisms in the Commission's regulations concerning the integrity of the pressure vessels under normal and faulted plant conditions. Results of this research have been extremely useful in the past and we support its continuation.

1.3.2 Piping and Steam Generators

Much of the primary system pressure boundary is found in piping and steam generators. The NRC has a major effort confirming the integrity of ferritic and austenitic stainless steel piping systems, and a very small project on the cast stainless steel found in most pressurized water reactor (PWR) and in some boiling water reactor (BWR) piping systems. The cast stainless steel material is quite tough when it goes into service, but it can lose a significant part of its toughness with increasing operating time. Additionally, and in view of the difficulty in performing reliable nondestructive inspection of this material, we believe that there should be some redistribution of funding from the Degraded Piping project to the Cast Stainless Steel project to better address the potential risk to the public that stems from potential pressure boundary failures.

1.3.3 Nondestructive Examination

To confirm the integrity of the primary piping system, nondestructive examinations (NDEs) are performed. The research efforts are aimed at determining whether the NDE techniques being used in the field can and will detect the flaws of interest. This work should continue because it is essential to the NRC's ability to carry out its role.

1.4 Electrical Equipment Integrity

This program includes research on Fire Protection, Plant Aging, Equipment Qualification for DBAs, and Equipment Survivability in a hydrogen-burn environment.

1.4.1 Plant Aging

The Plant Aging project includes evaluation of operating experiences, risk and systems oriented identification of components for which aging is most likely to have a safety impact, assessments of aged components from operating and decommissioned plants, and evaluation of effectiveness and cost of inspection, surveillance and monitoring techniques.

In our letter to the Commission (Ref. 2)*, we questioned the cost effectiveness of examining a limited number of aged components from a very small number of facilities as a basis for developing constructive guidance or techniques concerning aging. After several discussions with the NRC Staff, we are now satisfied with the proposed research and funding in this area.

1.4.2 Equipment Survivability

Also included in the Electrical Equipment Integrity program are analyses and tests to predict the survivability of equipment in a hydrogen-burn environment. Funds in this area were eliminated in FY 1985 but have been reallocated in FY 1986 to evaluate research conducted by the industry at the Nevada Test Site, to provide support for the implementation of the hydrogen rule for Mark III BWRs and ice condenser plants, and to review the need for future regulation regarding large dry PWR containments. We believe that this reallocation is appropriate.

1.5 Control Room Habitability

In response to our previous recommendations to the NRC concerning control room habitability (Ref. 3), the NRC Staff established in 1983 a Working Group to develop a plan for dealing with issues relative to the habitability of control rooms at nuclear power plants under accident conditions. In a paper presented at the 18th Department of Energy (DOE) Conference (Ref. 4), the Working Group presented a series of recommendations that addressed our concerns as well as those raised by the NRC Staff during the course of their review. Several of these recommendations involve research. Those considered to be important include:

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*References appear in Appendix A.

- The development of limiting steady-state environmental conditions for operations within a control room. These should be based on:

  - Consideration of effective human performance.

  - Consideration of effective operation of the associated equipment.

- The conduct of generic studies related to the following aspects of control room habitability:

  - Evaluation of the potential for loss of both trains of the emergency ventilation system, the associated potential impact on safe operation of a plant, and the development of appropriate procedures for recovery.

  - Development of an in situ method for conducting leakage tests on ventilation system isolation and fire dampers.

  - Assessment of the potential release of toxic gases in the event of fires in the furnishings, construction materials, and equipment located within the control room envelope.

We concur and support these recommendations for research.

1.6 Chemical Engineering

This program includes research designed to verify the effectiveness of hydrogen and fission product control within containment following major accidents, to evaluate the effects on fuel cladding and other interfacing components and systems of hydrogen additions to the coolants in BWRs, and to assess the effectiveness of various approaches for decontaminating nuclear power plant systems for occupational exposure control.

Although we endorse the scope of the proposed work, we recommend that further evaluations be made of the potential increases in dose rates that may accompany the use of hydrogen for the control of stress corrosion cracking.

Included in this Chemical Engineering program are studies on special problems that may be encountered in the disposal of liquid wastes generated as a result of the decontamination of nuclear power plant systems. Because such wastes may have constituents that promote the migration of radionuclides within the soil and groundwater, we support the proposed studies. At the same time,

however, we urge that these efforts be closely correlated with related work being sponsored by EPRI.

1.7 Recommendations

1.7.1 Overall Budget Recommendations

We endorse the proposed funding level of $40.3 million for this Decision Unit in FY 1986. However, we recommend some internal reallocation of funding within the project on Piping and Steam Generators.

1.7.2 Summary of Specific Recommendations

a. Some funding from the Degraded Piping project should be redistributed to the Cast Stainless Steel project to better address the potential risk to the public that stems from potential pressure boundary failures (Section 1.3.2).

b. We endorse the recommendations of the Control Room Habitability Working Group that limiting steady-state environmental conditions for operations within a control room be developed, generic studies relative to loss of both trains of the emergency ventilation system be conducted, an *in situ* method for leakage tests be developed, and the potential release and impact of toxic gases be assessed (Section 1.5).

c. In the Chemical Engineering program, further evaluations should be performed of the potential increases in dose rates that may accompany the use of hydrogen for the control of stress corrosion cracking (Section 1.6).

d. The proposed studies in the Chemical Engineering program should be correlated closely with related work being sponsored by EPRI (Section 1.6).

2. THERMAL-HYDRAULIC TRANSIENTS

2.1 Introduction

Research on Thermal-Hydraulic Transients is intended to provide experimental data and analytical methods needed for understanding and predicting the behavior of primary and secondary cooling systems in all types of plant transients and abnormal events, including the full range of possible loss-of-coolant accidents (LOCAs).

2.2 General Comments

Funding for programs in this Decision Unit shows a slight decrease in FY 1986 following the trend of the past few years. We believe that this decreasing support fairly reflects the success of the program in the past and is appropriate. Many of the important questions and uncertainties related to thermal-hydraulic transients have been answered. Improvements have been incorporated into operating plants and regulations. However, this technical area is central to nuclear power plant safety and it is important that a viable technical program be maintained to ensure continuation of the availability of tools and skills to deal with ongoing and possible future problems.

2.3 Integral Facilities

2.3.1 Semiscale

In our last report to the Congress (Ref. 1), we noted our continuing support for an experimental program at the Semiscale facility. The Office of Nuclear Regulatory Research (RES) now plans to phase out testing at Semiscale in FY 1987. We concur with this phase-out provided the additional tests requested by the Office of Nuclear Reactor Regulation (NRR) are completed in FY 1986.

2.3.2 Multi-Loop Integral System Test Facility and Related Programs

The Multi-Loop Integral System Test Facility (MIST) is a cooperative effort between NRC and industry with a goal of providing integral experimental data related to Babcock and Wilcox (B&W) nuclear steam supply systems (NSSSs) and for assessment of calculations of B&W plant response to small-break LOCA and other transients.

In our last report to the Congress (Ref. 1), we identified two concerns:

- There is a lack of an authoritative oversight group to ensure effective coordination of the MIST program with supporting programs at the University of Maryland, the Stanford Research Institute, and several small separate-effects experimental programs. While the MIST program has an effective Program Management Group, our concern has been that MIST, in itself, is not an adequate experimental program for answering all of the questions related to B&W plants. We believe that MIST with the essential supporting programs is adequate, but that stronger coordination of the overall effort is necessary.

- There is an apparent lack of sufficient coordination among integral tests, separate-effects tests, and analyses. Because the ultimate tool for understanding NSSS thermal-hydraulic behavior will be the integral codes (such as TRAC or RELAP), we believe that code developers should have a role in planning experiments. Similarly, we believe that the results of inexpensive separate-effects tests should be factored into the design and planning of the very expensive integral tests.

While some progress has been made in regard to these concerns, we still favor the establishment of a separate management oversight group to assure effective coordination of the several elements of this overall program.

NRR has proposed an additional series of tests following the planned MIST program. These would involve upgrading the MIST facility to operate at higher power and permit simulation of an extended range of realistic plant transients. These would be similar to tests applicable to Westinghouse and Combustion Engineering plants that have been conducted at Semiscale in the past few years. We support this extension of the MIST program.

2.3.3 Fully Integrated Test Facility (for BWRs)

RES proposes to terminate funding for the Fully Integrated Test Facility (FIST) after FY 1986. While we agree with this proposal, in that there seems to be no present need for a BWR experimental program, given data already available and relevant foreign programs, we are concerned about the loss of this important experimental capability. This concern is addressed in the following paragraph.

2.3.4 Future Options

Last year, RES initiated studies on the feasibility and design of a new "Modular Test Facility" (MTF) which would replace the existing integral test facilities - Semiscale, FIST, and MIST. In our June 20, 1984 report to the Commission (Ref. 2), we expressed concern about the usefulness of an MTF. We note that NRR has stated that it does not see, at this time, a need for such a facility. We understand that RES has now terminated work on the MTF concept.

We believe that it is important for the NRC to consider, in its long-range planning, various options that might be evaluated for ongoing experimental work in NSSS thermal-hydraulics. While many of the important questions and concerns have been reasonably well-resolved, thermal-hydraulic issues remain central to the safety of nuclear power plants. For this reason, a viable technology in this area should be maintained to provide skills and tools for the future. It might be most cost-effective to build smaller, low-pressure integral test facilities (such as that being operated at the University of Maryland for B&W plants) for each plant type rather than to maintain the present high-pressure systems. Or, NRC might become one user of a general-purpose facility sponsored by DOE and the nuclear power industry. We recommend that the development of a future test program be studied and that consideration be given to a companion code-development capability.

2.4 Separate-Effects Testing and Model Development

Research in this area provides detailed understanding of specific thermal-hydraulic phenomena important in the overall behavior of plant cooling systems during transients and LOCAs. It provides models for the integral codes, code verification data, and input to planning experimental programs in the integral facilities. Because of the low cost of these programs, the value of the data, and the benefits of extending thermal-hydraulic research broadly into the technical community, we believe that this program should be maintained approximately at the present level.

2.5 Transient Models and Codes

This work includes the application of computer codes to the analysis of transients in light-water reactors (LWRs) to help resolve licensing and safety issues, and the assessment of these analytic capabilities against experimental data to ensure accuracy and reliability of calculated results.

We agree with the stated NRR position that the advanced codes are sufficiently developed for current licensing needs and that the

code assessment work can be cut back substantially. We recommend that a critique be made by RES of the base assumptions and other relevant aspects of the existing methodology to evaluate possibly significant deficiencies in the codes. A review should be made also of additional thermal-hydraulic phenomena, such as water hammer, that may warrant inclusion in the code models.

As we have stated in our previous report (Ref. 1), we believe that RES should continue its program of international agreements to obtain foreign experimental data in exchange for overseas use of the TRAC and RELAP codes. We note that it will be necessary to commit resources in maintaining these codes to ensure their continuing utility.

In the past, we have supported the development of the Plant Analyzer and the Plant Data Bank. These programs are intended to make the large integral codes more "user friendly;" that is, making the accuracy and repeatability of code calculations less dependent on the skill and experience of the user and permitting faster setup and turn-around times for calculations. While we still support the goals of these programs, we believe that they could be curtailed if necessary to provide funds for other essential safety research. The major impact of such curtailment would be no improvement in the time required (several months) for first-time TRAC or RELAP calculations for a given plant or on a new safety issue.

Over the last ten years, research in the thermal-hydraulics area has led to much improved understanding of reactor system behavior during a large-break LOCA. This improved understanding can, in turn, permit elimination of some of the conservatisms mandated by Appendix K to 10 CFR 50.46 regarding large-break LOCA analysis. For some plants, this may permit substantial economic benefits, increased power, or improved fuel utilization. RES now has an effort under way to revise Appendix K. We believe that RES should continue work in this area, as needed, to develop an appropriate rule change and to provide staff capability for evaluating licensee-proposed revisions. We believe also that the rule should be cast in such a way that leaves the initiative and as much of the analytical work as possible to the industry.

2.6 Recommendations

2.6.1 Overall Budget Recommendations

The proposed budget for FY 1986 is $21.7 million. Although this represents a slight decrease from the FY 1985 budget level, we believe, subject to the comments above, that RES can provide effective research support at this level.

2.6.2 Summary of Specific Recommendations

a. We support the phase-out of the Semiscale program provided that the additional tests requested by NRR are completed in FY 1986 (Section 2.3.1).

b. We continue to recommend that a separate management oversight group be established to ensure successful coordination of the disparate elements of the joint program associated with the MIST facility. We support the NRR request for a follow-on test program in MIST (Section 2.3.2).

c. The need for a future integral test program and companion code development capability should be evaluated as part of the NRC long-range planning. Such an evaluation should consider the merits of low-pressure integral facilities (such as that being operated at the University of Maryland for B&W plants); or, NRC might become one user of a general-purpose facility sponsored by DOE and the nuclear power industry (Section 2.3.4).

d. Funding for the Separate-Effects Testing and Model Development program should be maintained approximately at the present level (Section 2.4).

e. Funding for the code assessment work should be substantially reduced. A critique should be performed of the base assumptions and other relevant aspects of the existing methodology to evaluate possibly significant deficiencies in the codes. A review should be made also of additional thermal-hydraulic phenomena, such as water hammer, that may warrant inclusion in the code models (Section 2.5).

f. The program related to international agreements should be continued to obtain foreign experimental data in exchange for overseas use of the TRAC and RELAP codes. Sufficient funding should be committed in maintaining these codes to ensure their continuing utility (Section 2.5).

g. Funding for the Plant Analyzer and Plant Data Bank can be curtailed, if necessary, to provide funds for other essential safety research (Section 2.5).

h. Work should be continued, as needed, to support the ongoing effort in revising Appendix K to 10 CFR 50.46 and also to ensure staff capability for evaluating licensee-proposed revisions. We believe that the revised rule should be cast in such a way that leaves the initiative and as much of the analytical work as possible to the industry (Section 2.5).

3. ACCIDENT EVALUATION

3.1 Introduction

The research in this Decision Unit is intended to provide the technical bases for decisions to be made by the Commission with respect to severe accidents. The program is said to fall into the categories of preliminary research that is needed to arrive at a policy on severe accidents; and of confirmatory research designed to confirm the initial policy decision, and to decrease uncertainties that may be associated with the initial approach. Principal products of the preliminary research are said to be:

- Further development of methods for power plant risk calculations and efforts to use these to arrive at an up-to-date assessment of the risk of those nuclear power plants now in operation.

- Reassessment of source terms, which includes a number of associated studies such as severe fuel damage, core melt progression, and containment system behavior.

Much of the preliminary part of the program, designated as Phase I, is scheduled to be completed in FY 1985. Phase II, said to be the confirmatory part of the research program, on which we are commenting, is scheduled to be performed during FY 1986 and 1987.

Research being proposed for FY 1986 includes severe accident sequence analyses, studies of damage progression in severely degraded cores, efforts to improve the modeling of partial and total core melts and their consequences, prediction of containment loading as a result of severe accidents, improved definition of the radioactive materials available in containment for release during severe accidents, and studies of systems for mitigating the consequences of severe accidents. If the topics sound familiar, it is because they have also been the items for major consideration during Phase I.

The NRC Staff is also reviewing work being done in this area by EPRI, by an industry group organized as the Industry Degraded Core Rulemaking (IDCOR) program, and by the DOE.

3.2 General Comments

We have recommended repeatedly over the past several years that the NRC Staff give priority to the formulation of a policy for dealing with the severe accident issue in the licensing of new plants and the regulation of operating plants (Refs. 1, 5). We have also previously stated that since this policy is closely related to the Commission policies on safety goals, backfitting, and siting, the development of these policies and of the associated research must be carefully coordinated, and must have a well-defined and common objective.

The NRC Staff has reached a consensus on a Severe Accident Policy. This policy, described in a draft policy statement, is based on the assumption that the risk from accidents beyond the analyzed DBAs, for plants now in operation or nearing completion, is acceptable. This conclusion is said to be subject to some minor changes that may be required for a few plants, but no major changes are expected to be needed.

Severe accident risk from new plants will be dealt with in the future through rulemaking for standard plants. One of the requirements of the rulemaking process will be a full-scope PRA for the proposed standard plant. A major consideration in dealing with the severe accident issue for new plants will be the results and insights gained from the PRA.

Previously, research in severe accident phenomena has been justified primarily as being required to provide the information needed to formulate and to implement a Severe Accident Policy. It might be plausible to conclude, therefore, that since such a policy has been established, no further research would be needed unless, in the course of additional operation, some unexpected problems arose.

The position taken by the NRC Staff appears to be that although enough information now exists to establish a Severe Accident Policy, there is still sufficient uncertainty about some severe accident phenomena and some of the associated consequences that a significant research program, focused on these uncertainties, should be continued over the next several years. For FY 1986, this uncertainty is valued at $30.7 million. The proposed program is said to be based on the assumption that the proposed Severe Accident Policy will be adopted by the Commission.

Given this approach, it would appear necessary, in the planning of an appropriate research program in the severe accident area, to identify:

- Those phenomena, accident sequences, or areas in which the existing uncertainties are unacceptable.
- The amount or kind of uncertainty believed to exist.
- The amount or type of uncertainty that would be acceptable.
- The research needed to reduce the unacceptable uncertainties to an acceptable level.

The NRC Staff has not provided us with an identification of those key areas or phenomena needing further special investigation. We have recently received and have begun the review of a supplement to NUREG-0900 (Ref. 6). This document does not contain the needed analysis of the results of research that has been completed, nor does it identify the unacceptable uncertainties in understanding or analyses of existing plants that require further elaboration.

We believe that planning that will identify information of the kind indicated above is required to ensure that the needed information will be obtained, and that the research funds are expended effectively. In the meantime, we are faced with a program of proposed research that we might describe by saying, "The research program will have produced a lot of useful information concerning severe accident phenomena by the end of FY 1985; beginning in FY 1986, there will be a start toward repeating the program, but this time it will be done better."

Our comments on the specific program elements proposed in this Decision Unit follow.

3.3 Severe Accident Analysis

This program is designed to provide information concerning the response of a number of selected power plants to severe accident conditions, taking into account not only the behavior of the hardware, but also the performance of the operating staff. Efforts will be made to use improved methods and best-estimate analyses to arrive at an approach which can be extended to all operating plants. It is hoped that a better estimate of the risk produced by all operating plants can be gained thereby.

On the basis of information that has been developed in connection with this program, and from experience with other PRAs, we doubt that results of studies of a few plants can be used generically to give a reliable risk estimate for all of the variety of plants now operating. Furthermore, even for the plants being analyzed, the choice of models seems inconsistent. For example, instead of

modeling a plant as it was before the Three Mile Island, Unit 2 accident (TMI-2) or will be after the TMI-2 mandated fixes have been installed, the approach is to use that list of fixes (not necessarily complete) that are in place at the plant when the group doing the work makes its inquiry.

The method and models being developed are being proposed as part of the calculational techniques to be used in the risk-benefit analyses that may help decide whether backfitting of existing plants should be required. We recommend that, if serious consideration is to be given to using this approach, a test of the method be made by calculating the risk reduction produced by the TMI-2 required changes.

3.4 Damaged Fuel

This program is designed to provide data and analytical models for use in assessing the consequences of LWR accidents that involve severe fuel damage. The work includes the analyses of the completed tests at the Power Burst Facility (PBF) and the proposed alternative tests at the National Research Universal Test Reactor (NRU) and the Annular Core Research Reactor (ACRR) to replace the cancelled Phase II PBF tests.

The sharpest departure from the FY 1985 proposed research is in this program element where a discontinuance of the experimental work making use of PBF has occurred. An amount of $3.3 million is being allocated for an investigation that will serve as a follow on to the investigations previously carried out with PBF. The alternative experiments proposed in lieu of PBF will make major use of the ACRR and NRU. We remain unconvinced of the merit of the work to be done in NRU and ACRR. It is far from obvious that the results will provide information that is directly applicable to an understanding of power reactor core damage accidents. Because of the expense involved in in-pile experiments, we urge that alternative ways of obtaining the needed information be thoroughly explored. We recommend a careful analysis of what has already been learned in NRC-supported research and in other relevant programs both in the United States and abroad.

We recommend that $2.5 million be reallocated from those portions of the research dealing with in-pile tests to support research on human factors.

In addition to experimental work, major effort and importance are assigned to the development of the MELPROG suite of codes. We have earlier expressed skepticism that these codes will be able to model the complicated processes involved in a melting core in a way which

will have very much physical significance. The NRC Staff continues to give MELPROG code development a high priority.

It may be useful to develop a code which provides some correlation among experimental results. This can be done if the code is made sufficiently flexible. It is a mistake, however, to assume that once this objective has been accomplished, the resulting code can be relied upon to describe the complex phenomena present in the meltdown of a power reactor core, even though it might be comforting to have such a tool. We recommend that more emphasis be given to alternate and perhaps more transparent methods of analysis that can be used if inadequacies of the MELPROG code make it unusable in some important situations.

3.5 Containment Loading

This program is designed to provide information on containment loading due to deflagration or detonation of hydrogen and other combustible gases, due to effects of rapid quenching of hot core materials (nonexplosive steam overpressure and steam explosions) and due to basemat melt processes.

We believe that the hydrogen investigations being proposed are appropriate and well-designed to produce information likely to be needed.

The proposed budget shows no financial support for any further investigation of steam explosion phenomena. Although we do not believe that the large experiment originally proposed should be carried out at this time, we do believe that some funding should be provided for analysis of the experiments that have already been done by a number of investigators. The reported results do not seem consistent. A moderate investment in analysis might provide valuable insights as to whether additional large-scale experimental work should be done. We also believe that additional small-scale experimental work could be valuable in providing information concerning ex-vessel hydrogen generation. We recommend a reallocation of $0.5 million within this Decision Unit for additional analysis of previous experimental work and for some additional small-scale experimental work.

We have some concern that the work on core-concrete interaction is duplicative of the rather extensive program being carried out in the FRG. Investigation of core-concrete interaction is difficult and expensive, and except for the generally expressed opinion that information is needed to calculate containment performance, no definite program exists for using the information that may be developed. We recommend that attention be given to the possibility

of using the results of the FRG work, at least until a more specific need for the results of the proposed work is developed.

Finally, we note that there is still little or no research commitment to the development of containment performance criteria. Almost all of the proposed research is aimed at efforts to predict the performance of existing containment systems. Such information is of limited use until some decision is made about performance criteria. We believe that effort to develop containment performance criteria should be given a priority at least equal to the work on containment loading. We recommend that at least $0.5 million be reallocated within this Decision Unit to such a program in FY 1986.

3.6 Fission Product Source Term

It is proposed to continue experiments and the development of analytical models that will be used to calculate a revised set of accident source terms for severe accident analysis. It is proposed also to estimate the uncertainties associated with current information and models, and to reduce the uncertainties in the existing information and in the existing calculational models.

We give high importance to developing information needed to predict fission product release during severe accidents. Whether the funding requested is appropriate is impossible to judge with the information available to us. We need more information than we have on the uncertainties that will exist at the end of the current (Phase I) program, and on the uncertainties that will be acceptable. The NRC Staff appears to be waiting for the results of the American Physical Society Review Group before deciding on some of the questions. Certainly the report of that group must be taken into account, but the NRC Staff should be formulating its own independent judgment on the basis of its evaluation of existing information and defined needs.

A void in the characterization of the accident source term is the absence of a campaign to determine the effects of radiation fields on the growth and deposition of aerosols in reactor cores and containments. The results of laboratory studies of such effects, dating back to the early 1970s, are equivocal: In some experiments growth and deposition rates were enhanced; in others, the rates were diminished. All of the currently used aerosol codes ignore radiation effects as do, for example, the recently published American Nuclear Society and IDCOR source term studies. We urge that the discrepancies be resolved.

We endorse the objectives of the Quantitative Uncertainty Estimate for the Source Term (QUEST) program and similar efforts to calculate or estimate uncertainties, and to identify the reason for them. Reports so far, however, indicate that any quantitative results are largely the product of engineering judgment. Nevertheless, it is worthwhile identifying the source of uncertainty and estimating the amount. Care must be taken, in reporting and in using the uncertainties calculated to date, to recognize and to make clear that what is reported and used has been arrived at by some combination of judgment and quantitative analysis.

3.7 Observations

We make the general observation that the work in the Severe Accident Research program suffers from a lack of thoughtful analysis of the results of the research. Much of the investigation involves large and expensive experiments. Since the facilities required are expensive even if they are not being used, there is pressure to go ahead with the next experiment before analysis of the last experiment has given the direction needed for a next step. We have no sure cure for this malady, but are convinced that it is unproductive.

3.8 Advanced Reactors

The NRC has proposed to eliminate all research related to Liquid-Metal-Fast-Breeder Reactors (LMFBRs) and High-Temperature-Gas-Cooled Reactors (HTGRs). We agree with this plan if adequate funding is provided for NRR to continue to interact appropriately with the DOE and industry in the area of new designs, and if NRR is able to follow foreign advanced reactor efforts effectively. Further, the agency must be prepared to initiate new programs in this area when the need for NRC research is more urgent than it is now.

3.9 Recommendations

3.9.1 Overall Budget Recommendations

We recommend that the funding for this Decision Unit be reduced by $2.5 million, from $30.7 million to $28.2 million, to support research in the human factors area. We recommend that this be achieved by reducing the funding for those portions of the research in this Decision Unit dealing with in-pile tests.

3.9.2 Summary of Specific Recommendations

a. In the planning of an appropriate research in the severe accident area, the following should be identified (Section 3.2):

- Those phenomena, accident sequences, or areas in which the existing uncertainties are unacceptable.
- The amount or kind of uncertainty believed to exist.
- The amount or type of uncertainty that would be acceptable.
- The research needed to reduce the unacceptable uncertainties to an acceptable level.

b. Methods and models being developed are being proposed as part of the calculational techniques to be used in the risk-benefit analysis that may help decide whether backfitting of existing plants should be required. We recommend that, as a test case, these methods and models be used to calculate the risk reduction produced by the TMI-2 required changes (Section 3.3).

c. We remain unconvinced of the merit of the work to be done in the NRU and ACRR. Because of the expense involved in in-pile experiments, we urge that alternative ways of obtaining the needed information be thoroughly explored. We recommend a careful analysis of what has already been learned in NRC-supported research and in other relevant programs both in the United States and abroad (Section 3.4).

d. We recommend that $2.5 million be reallocated from those portions of the research dealing with in-pile tests to support research on human factors (Section 3.4).

e. More emphasis should be given to alternate and perhaps more transparent methods of analysis that can be used if inadequacies of the MELPROG code make it unusable in some important situations (Section 3.4).

f. At least $0.5 million should be reallocated within this Decision Unit for additional analysis of previous experimental work in the steam explosion area and for some additional small-scale experimental work (Section 3.5).

g. Attention should be given to the possibility of using the results of the FRG core-concrete work, at least until a more specific need for the results of the proposed core-concrete work is developed (Section 3.5).

h. Effort to develop containment performance criteria should be given a priority at least equal to the work on containment loading. At least $0.5 million should be reallocated within this Decision Unit to the development of containment performance criteria (Section 3.5).

i. The RES Staff should formulate its own independent judgment of the adequacy of their source term reassessment on the basis of its evaluation of existing information and defined needs (Section 3.6.).

j. We urge that the discrepancies between the NRC Staff's assumptions in the aerosol codes regarding effects of radiation fields on the growth and disposition of aerosols and results of laboratory studies be resolved (Section 3.6).

k. We agree with the RES plan to eliminate all funding related to LMFBRs and HTGRs provided adequate funding support is given for NRR to continue its interaction with DOE and industry on new designs, and also to follow foreign advanced reactor efforts effectively (Section 3.8).

4. REACTOR OPERATIONS AND RISK

4.1 Introduction

This Decision Unit contains research programs directed toward risk analysis and safeguards. The programs in risk analysis are directed toward the development of methods for risk assessment and reduction, the assessment of risk presented by existing and planned nuclear power plants, and the evaluation of transportation risk. The programs in the area of safeguards are designed to improve the physical protection features employed at nuclear facilities, to improve systems for control, accounting, and protection of special nuclear materials, and to reduce the likelihood of sabotage with possible radiological consequences.

4.2 General Comments

We have in a number of past reports (Refs. 1, 5) stated that we believe that an agressive research program on risk analysis is necessary for the accomplishment of the NRC's mission. We support the general levels of funding proposed by the NRC in this area. However, we continue to believe that important problems are not being addressed adequately. We find that the most significant deficiencies are in the areas of risk reduction analysis, decision making in the face of large uncertainties, the characterization of uncertainties, and certain difficult PRA methodologies such as those for evaluating the impacts of design errors and external floods.

Research in the human factors area has been eliminated from the FY 1986 NRC Safety Research Program. We believe that an effective research program in this important area is necessary and recommend that a funding of about $2.5 million be specified for this purpose in FY 1986.

4.3 Reliability and Risk Metholodology

4.3.1 Value/Impact Evaluation

As discussed in our last report to the Congress (Ref. 1), value/impact evaluations (regulatory analysis) are being used more and more frequently in the regulatory decision-making process. However, the value/impact analyses used today are incomplete, suffer from poor cost and risk reduction data, and are deficient for the purposes to which they are being applied. Sometimes, they are used only to support preconceived points of view. We continue

to believe that better value/impact evaluation methods should be developed and that criteria for their prudent application should be identified. It is also important to assess critically a number of basic philosophical differences among experts as to how evaluations of this type should be performed. An example of an issue which should be addressed is that of whether or not future health effects should be discounted and, if so, at what rate.

4.3.2 PRA Methodology Development

A major portion of the funding for PRA methodology development is carried out in the Risk Methods Integration and Evaluation Program (RMIEP) and in related programs in methods improvement, software development, and external events analysis.

We support the general level of funding for RMIEP, PRA methods development, and external events analysis. The proposed work on PRA software development will be for the purpose of an integrated analysis package based on the best features of a number of existing computer codes. Development has begun in FY 1985 and will continue through FY 1986. The completed package is supposed to result in a mechanized method for performing PRA calculations. We recommend that this part of the methods development work be given the lowest priority.

The RMIEP is stated to be designed to produce the next major advance in the state of the art for PRA methodology. Major objectives for this work are improvements in dependent failure analysis, a more consistent treatment of internal and external events, the modeling of human error starting from the misdiagnosis of accidents and human action taken to recover from an accident, improved thermal-hydraulic modeling, and the improved analysis and display of uncertainty.

New research should be initiated or existing research should be augmented on methodology to include design errors, aging, and environmental effects in PRAs. Funds for these efforts should be obtained by reallocation within the Reliability and Risk Methodology work, from the MELCOR code development and validation effort, from the Accident Sequence Evaluation Program, and/or from the Reliability Maintenance work.

External floods remain a largely uncertain contribution to risk. In spite of this, the NRC has placed a very low priority on such research for the past half decade. There is a promise of such research in FY 1986. This should be made a firm commitment.

4.3.3 A Search for Oversights

Current PRAs appear to be yielding lower core melt frequencies and smaller releases per core melt. This is encouraging information. However, lest this leads to complacency, it is important to be sure that a significant gap in the total logic does not exist. We recommend that a thoughtful research effort be devoted to a search for possible weaknesses (e.g., accident paths either not currently evaluated or dismissed as insignificant) which may, on closer examination, prove to be important to risk.

4.4 Data and Uncertainties

4.4.1 Decision Making in the Face of Large Uncertainties

It is to be expected that uncertainties in PRA (and, for that matter, in deterministic analysis) will remain large for the foreseeable future. We believe that it is important to learn how best to make decisions in the face of these uncertainties. This is a difficult area which has not been addressed in the research program. We have recommended in the past (Ref. 1) that work be carried out in this area and made some specific recommendations as to how it might be initiated. We believe that important NRC policy decisions, such as the recent one on severe accidents, might be improved by a better understanding of this process.

We recommend that, if necessary, funding be reallocated from the reliability and risk analysis portion of this Decision Unit in order to enable a better attack on this issue in FY 1986.

4.4.2 Characterization of Uncertainty

A reading of NUREG-1050 (Ref. 7) and other recent Commission documents reveals considerable differences in the definition of uncertainty and its relevance to median or mean estimates of risk. The large uncertainties to which we have referred above can have a substantial impact on the meaning of the statement of risk. As a result of this, an improved understanding and definition of these concepts must precede this use in any form of probabilistic analysis that involves large uncertainties. We recommend that work be performed in this area utilizing the insights of sophisticated statisticians.

4.5 Regulatory and Inspection Applications

4.5.1 Reliability Maintenance

The NRC Staff is engaged in the development of reliability assurance and maintenance programs. As we said in our last report

(Ref. 1), we believe that, as with quality assurance and quality control, the success of such programs will depend on the skill and enthusiasm with which the individual utilities implement them. We recommend that the NRC actively seek to develop industry cooperation in this effort.

4.5.2 Emergency Response

In terms of research planned for FY 1986, we support the efforts of the NRC Staff to develop better methods for the utilization of in-plant conditions as guides for off-site emergency responses. We also encourage the NRC Staff to continue the development of a report that provides information on the accident potential of nuclear fuel cycle and other radioactive material facilities. Such a report should be especially useful to public officials who may be called upon to respond to accidents in these types of facilities. The completion of such a report is also necessary to provide technical support to the rulemaking currently under way to require nuclear fuel cycle and other radioactive material licensees to establish appropriate levels of emergency preparedness.

Relevant research on emergency preparedness and response is also under way within the Environmental Protection Agency and the Federal Emergency Management Agency. We encourage the NRC Staff to maintain close ties with these groups. Such ties should include the sharing of data and information, and the joint planning and conduct of related research.

4.6 Severe Accidents Risk

The research in this area is being performed in support of the NRC activities on Severe Accident Policy and supplements the work described in Chapter 3 of this report. The programs are grouped into the four general areas: Accident Likelihood Analysis, Risk Code Development and Applications, Risk and Risk Reduction Analysis, and Severe Accident Decision Making.

The Accident Likelihood Analysis project is one that appears not to have paid dividends commensurate with the effort. Robust justification for its continued support at a high level should be provided, particularly for the accident sequence evaluation effort.

The Risk Code Development and Applications work includes the MELCOR code development and validation. The MELCOR code is to be debugged and ready for use in FY 1985. Code modeling improvements, which as planned will require some experiments, are being planned for FY 1986. The proposed funding for FY 1986 is $2.1 million. We

recommend that this work be given the lowest priority of the projects in the Severe Accidents Risk area.

We believe that the NRC Staff has not been providing adequate support to the Risk and Risk Reduction Analysis work. In FY 1985, about $0.5 million has been allocated for this effort and about $0.7 million has been proposed for FY 1986. This represents an increase over earlier proposals but not to the levels we believe appropriate. At a time when the NRC Staff remains unable to specify containment performance criteria and a time when Severe Accident Policy is in a new and untested state, it is a mistake on the part of the NRC not to deepen and broaden the scope of research on risk reduction. We recommend that the level of funding for the Risk and Risk Reduction Analysis effort be increased from $0.7 million to $1 million by internal reallocation from the MELCOR code developoment and validation effort, and that an effort be made to seek input from more than one contractor source. We believe that the use of more than one contractor source is important if the benefits of the use of more than a single approach to the problem is to be realized.

4.7 Human Factors

Operating experience is unambiguous in emphasizing the lesson that human performance has a strong influence on the safety of a nuclear power plant. There is a clear need for improved understanding, both from the point of view of reducing the error rate in operation and maintenance and also in understanding the benefits that might accrue from positive human intervention during the course of an upset. To the extent that research offers the prospect of leading toward an improved regulatory posture on these matters, it should be supported. At the present time, there is no research proposed in the human factors area in FY 1986.

We find an irony in a continued major investment of research funding in risk analysis accompanied by reluctance to commit even a small fraction of that funding to research on human factors. Risk analysis, no matter how sophisticated and comprehensive, does nothing to improve the safety of nuclear power plants unless lessons learned from the analyses are implemented in hardware or operational changes in actual plants. One of the most pervasive indications from risk analyses completed so far is that the performance of humans in the operation and maintenance of a nuclear power plant has a powerful influence on safety. Further polishing and refining of the risk analysis methodologies will do little to change that important message. What is needed now is a more complete and effective response; that is, development of a better

understanding of how human performance can be improved to reduce the risk from operation of nuclear power plants.

The Human Factors Program Plan (Ref. 8) and a number of industry initiatives are steps in the right direction, but they are not research. To the contrary, it has become apparent in the course of these programs that there is an insufficient knowledge base for many of the proposals. This is not surprising. Recognition that human factors are of primary importance to the safety of nuclear power plants has existed for only a few years. While it is clear that certain things can be and are being done, there is uncertainty, disagreement, and lack of consensus about others. The major reason for this lack of consensus is the insufficient base for developing and justifying improvements. This base can be expanded only by human factors research that is tuned to the needs of nuclear power safety.

We believe that while the industry and other public institutions can do much of the research, the NRC must take a leadership responsibility, just as it has in the past in other technical areas. Therefore, we believe that a substantial program of human factors research, of the order of $2 million to 3 million per year, should be funded in RES in FY 1986 and in ensuing years. This program should address longer range needs and should not be constrained by immediate user needs and the Human Factors Program Plan. The necessary support could be obtained by reducing the funding for the in-pile experimental work in the Accident Evaluation Decision Unit. To initiate this program in FY 1986, a vigorous planning effort, in which ACRS would like to participate, will be required during FY 1985.

4.8 Recommendations

4.8.1 Overall Budget Recommendations

We endorse the proposed funding level of $16.5 million for the reliability and risk analysis portion of this Decision Unit. However, our recommendations in the preceding sections will require some reallocation of funding within this Decision Unit. We believe that this can be accommodated by an increase of $0.25 million for Reliability and Risk Methodology, an increase of $0.15 million for Data and Uncertainties, a decrease of $0.3 million for Regulatory and Inspection Applications, and a decrease of $0.1 million for Severe Accidents Risk. In addition, some specific recommendations for the reallocation of funds within the Severe Accidents Risk area are given in Section 4.6.

The NRC has proposed no research in the human factors area in FY 1986. This is a serious weakness in the proposed research program. We recommend that $2.5 million be reallocated from the in-pile experimental work in the Accident Evaluation Decision Unit to fund human factors research within this Decision Unit.

4.8.2 Summary of Specific Recommendations

a. We continue to believe that important problems are not being addressed adequately in the reliability and risk analysis research. The most significant deficiencies are in the areas of risk reduction analysis, decision making in the face of large uncertainties, and certain difficult PRA methodologies such as those for evaluating the impacts of design errors and external floods (Section 4.2).

b. An effective research program in the human factors area, with a funding level of about $2.5 million, should be estabilished in FY 1986 (Section 4.2).

c. Better value/impact evaluation methods should be developed and criteria for their prudent applications should be identified. In accomplishing this, it is important to assess critically the basic philosophical differences among experts as to how evaluations of this type should be performed (Section 4.3.1).

d. We support the general level of funding which is proposed for RMIEP, PRA methodology development, and external events analysis. A portion of this work is software development directed toward the production of an integrated analysis package. We recommend that this part of the work be given the lowest priority (Section 4.3.2).

e. New research should be initiated or existing research should be augmented on methodology to include design errors, aging, and environmental effects in PRAs. Funds for this effort should be obtained by reallocation within the Reliability and Risk Methodology work, from the MELCOR code development and validation effort, and/or from the Reliability Maintenance work (Section 4.3.2).

f. RES should make a firm commitment to providing the proposed funding levels for the external flood risk work (Section 4.3.2).

g. A thoughtful research effort should be devoted to a search for possible weaknesses (e.g., accident paths either not currently evaluated or dismissed as insignificant) which may, on closer

examination, prove to be very important to risk (Section 4.3.3).

h. RES should initiate research directed at finding better ways to make decisions in the face of large uncertainties. If necessary, funding for such research should be reallocated from the reliability and risk analysis portion of this Decision Unit (Section 4.4.1).

i. RES should initiate research directed at arriving at a improved understanding and definition of uncertainty and its relevance to median or mean estimates of risk. This work should utilize the insights of sophisticated statisticians (Section 4.4.2).

j. RES should actively seek to develop industry cooperation in the development of reliability assurance and maintenance programs (Section 4.5.1).

k. Development of a report that provides information on the accident potential of nuclear fuel cycle and other radioactive material facilities should be continued (Section 4.5.2).

l. We encourage the NRC Staff to maintain close ties with the U.S. Environmental Protection Agency and the Federal Emergency Management Agency for the purposes of sharing data and information, and the joint planning and conduct of related research in the area of emergency preparedness (Section 4.5.2).

m. The MELCOR code development and validation effort should be given the lowest priority of the projects in the Severe Accidents Risk area (Section 4.6).

n. The level of funding for the Risk and Risk Reduction Analysis effort should be increased from $0.7 million to $1 million by internal reallocation from the MELCOR code development and validation effort, and an effort should be made to seek input from more than one contractor source (Section 4.6).

o. We recommend that a substantial program of human factors research should be funded in RES in FY 1986 and in ensuing years. Such a program should address longer range needs and should not be constrained by immediate user needs and the Human Factors Program Plan (Section 4.7).

p. To initiate human factors research in FY 1986, a vigorous planning effort, in which the ACRS would like to participate, should be carried out during FY 1985 (Section 4.7).

5. WASTE MANAGEMENT, EARTH SCIENCES, AND HEALTH

5.1 Introduction

This Decision Unit includes research on Earth Sciences, Health Effects, and on High-Level Waste (HLW) and Low-Level Waste (LLW) Management. The overall objective of the Earth Sciences and Health Effects programs is to develop a better understanding of problems related to the siting, operation, and eventual decommissioning of nuclear power plants. The objective of the Waste Management program is to provide the NRC Staff with the technical capability to assess the compliance of proposed waste management systems with regulatory requirements. Such requirements include those pertaining to operational safety, occupational radiation protection, long-term waste isolation, and the assessment of associated risks.

5.2 Earth Sciences - Geology and Seismology

Research in the Geology and Seismology area is designed to develop a better understanding of the seismic hazard with the major emphasis being placed on the Eastern United States. We support the level of funding proposed for FY 1986 and are in general agreement with the programs which are proposed. However, we have the following comments:

- Much of the NRC funding in this area supports portions of the seismic network in the Eastern United States. This network has in the past gathered a substantial amount of data on small earthquakes, which has recently added to the understanding of the general pattern of seismicity in this region. More recently, strong motion instruments have been deployed to gather data on large earthquakes. We recommend that more emphasis be given to further deployment of strong motion instruments and the development of systems for the rapid placement of such instruments following a strong earthquake.

- In our previous reports (Refs. 1, 5), we have recommended that "conscious efforts be made within the scope of this research program to include, as practical, studies that will make more meaningful and less uncertain the prediction of the severity of earthquake-induced ground motion having a likelihood of occurrence of 10^{-4} to 10^{-5} per year, or less, in the United States east of the Rockies." We repeat our previous recommendation.

5.3 Health Effects and Occupational Radiation Protection

5.3.1 Health Effects

The efforts in this area include the continuation of ongoing research to determine the metabolism of selected radioactive materials in workers and to study the health effects of ionizing radiation.

We are pleased to note the care that is being exercised to ensure that NRC research and associated needs relative to the health effects of ionizing radiation are closely coordinated with other Federal agencies. The NRC Staff should continue its research on improving radiological assessments associated with the human intake of various chemical forms of uranium and thorium. The data supporting permissible intakes of these two materials are inadeqate and the responsibility for research on their biological effects falls almost exclusively within the jurisdiction of the NRC.

We continue to support the NRC plans to provide funds to the National Council on Radiation Protection and Measurements (NCRP), and the International Commission on Radiological Protection (ICRP). We also support the cooperative program with the U.S. Environmental Protection Agency to fund the work of the National Academy of Sciences on the biological effects of ionizing radiation.

5.3.2 Occupational Radiation Protection

Among the research projects to be conducted within this program during FY 1986 are the development and refinement of the Radiation Exposure Information Reporting System, the surveillance of the industry/DOE dose reduction research, and the review and evaluation of commercial nuclear power plant As Low As Reasonably Achievable (ALARA) engineering programs. All of these activities will assist in controlling occupational exposures within the nuclear industry. We support these activities.

5.4 HLW Management

Both the Nuclear Waste Policy Act of 1982 and the schedules of the DOE point to the submission of a license application for a HLW repository by the end of this decade. The NRC Staff must, by that time, be prepared to accept and analyze the license application and to evaluate the pertinent data on both generic and site specific issues. It is appropriate, therefore, that the HLW research focus on the anticipated licensing actions but, at the same time, be carefully structured to ensure pursuit of the more important

issues. A similar approach is dictated by the restrictions on research funding.

As indicated in the letter of October 15, 1984, from the President of the NCRP (Ref. 9), there is an urgent need for the development of a generally accepted definition of HLW. We are encouraged to note that the NRC is proceeding to respond to the NCRP, and we endorse the conduct of any research needed in support of the development of such a definition.

Since HLWs must be carefully isolated to ensure protection of the public, it is important that they be classified properly so that those wastes requiring permanent isolation can be correctly identified and that wastes for which a lesser degree of protection will be sufficient are not required to be placed in deep geological repositories that are expensive to build and will be of limited capacity. As a basic underlying philosophy, the NCRP recommended that the classification of radioactive wastes be based on those factors that determine radiation risk. We concur in this recommendation.

The establishment of a HLW Oversight Committee by the NRC is commendable. In June 1984, the Oversight Committee issued an executive summary of the Committee's conclusions and recommendations (Ref. 10) that properly noted that better methods for the assessment of the environmental and public health impacts of a HLW repository must be developed. The Committee report also called for greater attention to the validation of models for assessing near-field effects, and evaluations of corrosion rates and leaching rates for spent fuel (as contrasted to glass waste forms). If these recommendations are followed, it will help ensure a well coordinated in-house program that addresses some of the most important research needs.

We are concerned that the reduction for the HLW Management research budget will hinder the ability of the NRC Staff to meet the schedule for licensing a HLW repository. The reduction in the number of candidate sites to five has not lessened the need for generic data applicable to the geologic strata selected for exploration. Owing to the slow and often difficult nature of repository-related research, programs need to be initiated in the near term in order to provide the information anticipated to be needed in the early 1990s. We encourage the Congress to devise mechanisms through which the NRC might draw upon the Nuclear Waste Fund (established under Section 302 of the Nuclear Waste Policy Act) to increase the total funding for this program from the proposed $3 million to $5 million for FY 1986.

5.5 LLW Management

Research in the LLW Management program provides support for the development of rules and regulations that provide technical guidance for the shallow-land burial of LLWs. The development of the accompanying technical data base is essential to the States in the implementation of their LLW disposal programs.

We are encouraged to note that the NRC Staff, in its evaluations of the risks of LLWs, is currently taking into account both their chemical and radiological properties. We believe that this is a sound step forward. We join with the NCRP in supporting the decision of the NRC to classify those wastes destined for shallow-land burial into three categories of required confinement. The categories will be defined on the basis of risk, including factors such as activity level and half-life. We believe that closer coordination of research in this area with other organizations, most particularly the United States Geological Survey and EPRI, would be beneficial.

Essentially all of the States are currently in the process of selecting LLW disposal sites on an individual basis, or as part of a regional compact. As a result of these efforts, questions are being developed that must be answered as a part of the licensing process. Although the States may be able to address some of these questions, they will not be able to handle them all. For this reason, it is essential that the NRC maintain the capability to render assistance, as necessary. We believe that the research budget allocated for this program is the minimum necessary to ensure that the NRC can provide the needed support to the States.

5.6 Recommendations

5.6.1 Overall Budget Recommendations

We consider the proposed budgets for research on Earth Sciences, Health Effects, and LLW Management to be marginal. We believe that the proposed budget for research on HLW Management is inadequate. As mentioned above, we recommend that the Congress explore mechanisms through which the NRC might draw upon the Nuclear Waste Fund to increase the budget for research on HLW Management from $3 million to $5 million for FY 1986.

5.6.2 Summary of Specific Recommendations

a. We recommend that more emphasis be given to further deployment of strong motion instruments and the development of systems for the rapid placement of such instruments following a strong earthquake (Section 5.2)

b. We continue to recommend that efforts be made within the scope of the Geology and Seismology research to include, as practical, studies that will make more meaningful and less uncertain the prediction of the severity of earthquake-induced ground motion having a likelihood of occurrence of 10^{-4} to 10^{-5} per year, or less, in the United States east of the Rockies (Section 5.2).

c. Research on improving radiological assessments associated with the human intake of various chemical forms of uranium and thorium should be continued (Section 5.3.1).

d. We continue to support the NRC plans to provide funds to the NCRP and the ICRP. We also support the cooperative program with the U.S. Environmental Protection Agency to fund the work of the National Academy of Sciences on the biological effects of ionizing radiation (Section 5.3.1).

e. With respect to the control of occupational exposures in the nuclear industry, we support the development and refinement of the Radiation Exposure Information Reporting System, the surveillance of the industry/DOE dose reduction research, and the review and evaluation of commercial nuclear power plant ALARA engineering programs (Section 5.3.2).

f. We endorse the conduct of any research needed in support of the development of a generally accepted definition of HLW and recommend that the classification of radioactive wastes be based on those factors that determine radiation risk (Section 5.4).

g. We concur with the HLW Oversight Committee's recommendation that greater attention be placed on the validation of models for assessing near-field effects, and evaluations of corrosion rates and leaching rates for spent fuel (as contrasted to glass waste forms) (Section 5.4).

h. Owing to the slow and often difficult nature of repository-related research, programs need to be initiated in the near term in order to provide the information anticipated to be needed in the early 1990s. Resources adequate for these

tasks should be made available. We encourage the Congress to examine mechanisms through which the NRC might draw upon the Nuclear Waste Fund to increase the total funding for the HLW Management program from $3 million to $5 million for FY 1986 (Section 5.4).

i. Although the States may be able to address some of the questions on the siting and operation of LLW disposal facilities, they will not be able to handle them all. For this reason, it is essential that the NRC maintain the capability of rendering assistance, as necessary. We believe that the budget allocated for the LLW Management research is the minimum necessary to ensure that the NRC can provide the needed support to the States (Section 5.5).

APPENDIXES

APPENDIX A

REFERENCES

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APPENDIX B

GLOSSARY

ACRS	Advisory Committee on Reactor Safeguards
ACRR	Annular Core Research Reactor
ALARA	As Low As Reasonably Achievable
B&W	Babcock and Wilcox
BWR	Boiling Water Reactor
CFR	Code of Federal Regulations
DBA	Design-Basis Accident
DOE	Department of Energy
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FIST	Fully Integrated System Test
FRG	Federal Republic of Germany
FY	Fiscal Year
HLW	High-Level Waste
HTGR	High-Temperature-Gas-Cooled Reactor
ICRP	International Commission on Radiological Protection
IDCOR	Industry Degraded Core Rulemaking
INPO	Institute of Nuclear Power Operations
LLW	Low-Level Waste
LMFBR	Liquid-Metal-Fast-Breeder Reactor
LOCA	Loss-of-Coolant Accident

LWR	Light-Water Reactor
MELCOR	Methods of Estimating Leakage from Containment of Radionuclides
MELPROG	Mechanistic In-vessel Melt Progression Analysis Code
MIST	Multi-loop Integral System Test
MTF	Modular Test Facility
NCRP	National Council on Radiation Protection and Measurements
NDE	Nondestructive Examination
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
NRU	National Research Universal Test Reactor in Canada
PBF	Power Burst Facility
PRA	Probabilistic Risk Assessment
PTS	Pressurized Thermal Shock
PWR	Pressurized Water Reactor
QUEST	Quantitative Uncertainty Estimate for the Source Term
RELAP	Advanced System Code Used To Model Loss-of-Coolant Accidents
RES	Office of Nuclear Regulatory Research
RMIEP	Risk Methods Integration and Evaluation Program
SSE	Safe Shutdown Earthquake
TMI-2	Three Mile Island, Unit 2
TRAC	Transient Reactor Analysis Code

APPENDIX C

THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The Advisory Committee on Reactor Safeguards was established as a statutory Committee in 1957 by revision of the Atomic Energy Act. The ACRS was charged with the responsibility for review of safety studies and facility license applications submitted to it, and to make reports thereon, advising the Commission with regard to the hazards of proposed or existing reactor facilities and the adequacy of proposed reactor safety standards, and to perform such other duties as the Commission might request. Section 182b of the Atomic Energy Act requires ACRS review of the construction permit and operating license applications for power and testing reactors and spent fuel reprocessing facilities licensed under Section 103, 104b, or 104c of the Atomic Energy Act; any application for a research, developmental, or medical facility licensed under Section 104a or c of the Act and which is specifically referred to it by the Commission; and any request for an amendment to a construction permit or operating license under Section 103 or 104a, b, or c which is specifically referred to it by the Commission. The Energy Reorganization Act of 1974 transferred operation of the ACRS from the Atomic Energy Commission to the Nuclear Regulatory Commission.

In 1977, Public Law 95-209 added to its other duties a requirement for the ACRS to undertake a study of reactor safety research and to prepare and submit annually to the United States Congress a report containing the results of this study. The first of these reports was submitted to the Congress in December of 1977.

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Public Law 95-209 includes a requirement that the Advisory Committee on Reactor Safeguards submit an annual report to Congress on the safety research program of the Nuclear Regulatory Commission. This report presents the results of the ACRS review and evaluation of the NRC safety research program for Fiscal Years 1986 and 1987. The report contains a number of comments and recommendations.

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