DETAILED RESPONSES RECEIVED FROM MPA

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

NOV 2 1 1978

MEMORANDUM FOR: Harold Denton, Director
Office of Nuclear Reactor Regulation

FROM: Norman M. Haller, Director
Office of Management and Program Analysis

SUBJECT: REVIEW OF REGULATORY ACTIONS AND STAFF POSITIONS WHICH RELY ON WASH-1400

Mr. Gossick's October 27 memorandum on the above subject requested that offices listed as cc's contribute to the review to the extent possible.

We have conducted an internal MPA survey. The results of our survey do not appear to lend themselves to the categorization of licensing actions in Attachment 1 of Mr. Gossick's memo. However, we want to pass the results along to you to help ensure that you do have available a more complete response.

Four attachments are relevant:

-- A discussion of the use of WASH-1400 in connection with abnormal occurrence reporting;

-- A discussion of uses in value/impact guidelines and preparation of information for Commissioners;

-- References from the 1975, 1976, 1977 and Draft 1978 NRC Annual Reports listing various applications of WASH-1400; and

-- An extract from the National Journal in which a number of uses are identified.

I hope this information will be useful in preparing your report.

Norman M. Haller
Norman M. Haller, Director
Office of Management and Program Analysis

Attachments:
As stated

CONTACT:
Roger Moore, MPA
492-7851

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

November 8, 1978

MEMORANDUM FOR: Roger H. Moore, Chief
Applied Statistics Branch
Division of Technical Support, MPA

FROM: R. A. Hartfield, Chief
Licensee Operations Evaluation Branch
Division of Technical Support, MPA

SUBJECT: REVIEW OF REGULATORY ACTIONS AND STAFF POSITIONS WHICH RELY ON WASH-1400

Generally, the only use made of WASH-1400 by LOEB is to support reviews of off-normal events for abnormal occurrence reporting. For example, a recent use of WASH-1400 techniques was made as indicated in Enclosure 1. However, for this event, the data in the report was not of major importance as to whether or not the event was an abnormal occurrence. The report was used only as another source of information; the particular data used could have varied by a considerable margin and it would not have affected the determinations.

In summary, our use of WASH-1400 techniques is to add to our analysis, but not as a major decision tool.

R. A. Hartfield, Chief
Licensee Operations Evaluation Branch
Division of Technical Support, MPA

Enclosure:
1. Events Reviewed for Abnormal Occurrence

cc: N. M. Haller
J. L. Crooks

EVENTS REVIEWED FOR ABNORMAL OCCURRENCE DETERMINATION IN WHICH WASH-1400 WAS USED AS ONE SOURCE OF DATA

1. Davis-Besse Unit 1: Diesel Generator Automatic Load Sequence Failure:

   This event was reviewed by the staff for possible abnormal occurrence reporting but rejected. A description of the event, together with the reasons for rejection (Attachment 1-1) will be included in Enclosure 3 to the Commission paper which forwards the 3rd Quarter CY 78 AO Report to Congress to the Commission for approval.

   The licensee performed a detailed probabilistic assessment of the event based on WASH-1400, including the cases of loss of offsite power before, during, and after a LOCA (both a large LOCA and a small LOCA). The calculated probabilities ranged from $1.4 \times 10^{-7 \pm 1.2}$ to $3.2 \times 10^{-10 \pm 1}$. However, for abnormal occurrence reporting purposes, the important fact is that on-site and off-site power was not lost simultaneously during the period of sequence failure. The sequence failure alone did not result in a major reduction in public health or safety. Even if the probabilistic analysis was off by a significant margin, the overall risk would be little affected.

OTHER EVENTS CONSIDERED FOR ABNORMAL OCCURRENCE REPORTING

The following incidents are a sample of incidents seriously considered for abnormal occurrence reporting. The incidents are briefly discussed and the reasons why they are not being reported are stated. All were judged not to have involved a major reduction in the level of protection provided for public health or safety.

This enclosure is provided to the Commission per Commission comments on SECY-76-471; the enclosure will not be a part of the published report.

1. Diesel Generator Automatic Loading Sequence Failure

On June 5, 1978, Toledo Edison Company reported a design error at Davis-Besse Unit No. 1, a pressurized water nuclear plant located in Ottawa County, Ohio.

The licensee notified the NRC that, during a refueling outage surveillance test of the Integrated Safety Features Actuation Systems (SFAS), a design error was discovered which would have prevented certain safety systems from functioning during a loss of offsite power in combination with actuation of the SFAS. The design error involved a plant modification made in February 1977, which erroneously sealed in certain relays in the SFAS system. This prevented the operation of the automatic load sequencer which serves to bring critical loads onto the emergency power bus at predetermined intervals. Sequencing is necessary to prevent overloading the diesel generator if a loss of offsite power occurred in combination with an SFAS signal. If an SFAS actuation occurred with normal offsite power available, the circuit would have performed normally.

The event also raised concerns relative to the management control of modification activities. Manual actuation of these circuits, though available, is not an acceptable alternative in certain postulated worst case accidents since the operator cannot always respond within the time frames required.

The apparent cause was a design error and inadequate testing or operational control problems. Periodic surveillance testing is also conducted to verify satisfactory system performance. (The design error was not discovered at the time the change was made

because the scope of the testing conducted was not inclusive enough to detect the error.)

The licensee established and implemented a system to verify that slide link connectors (a terminal block with movable metal strips used to make or break the electrical connection) in safety-related panels are in the correct position and that the holding screws are tight.

The licensee established and implemented a program, including acceptance criteria, that verifies adequacy of procedures used to determine equipment operability. The licensee reviewed all safety-related plant procedures related to the onsite and offsite power systems and verified that design features are not inadvertently defeated or compromised by operator action. The licensee will establish additional administrative controls to ensure that changes or modifications to systems are made utilizing drawings that have been verified as correct.

The NRC issued an Immediate Action Letter to the licensee on June 12, 1978. This letter outlined actions to be taken by the licensee to correct the present problem and to prevent recurrence. An inspector was dispatched to the site to verify corrective measures taken by the licensee as outlined in the Immediate Action Letter.

On September 1, 1978, the NRC issued a Notice of Violation to the licensee in regard to the incident and the subsequent investigation. The forwarding letter also expressed concern in regard to the effectiveness of management control over testing activities; the licensee was requested to describe the actions taken or planned to correct these inadequacies.

The NRC reviewed the incident and concluded that it did not involve a major reduction in the degree of protection for public health or safety. No unscheduled event involving complete loss of power to the systems occurred, i.e., both onsite and offsite power were not lost simultaneously. Surveillance testing identified the deficiency as intended. In addition, postulating an accident, assuming no additional failures, does not lead to consequences exceeding 10 CFR Part 100, since offsite power was available to power the emergency systems. Finally, the licensee's analysis, and NRC's review, showed that the overall risk of an accident was not significantly increased.

M. Haller

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

NOV 2 1 1978

MEMORANDUM FOR: Roger Moore, Applied Statistics Branch, MPA

FROM: Steve Conver, Analysis and Planning Branch, MPA

SUBJECT: CLARIFICATION OF APB'S USE OF WASH-1400

In my November 14 memo to you, I indicated that WASH-1400 had been used to prepare Commissioner Kennedy's "Information Card." A more correct statement is that WASH-1400 was "considered" in preparing the card; WASH-1400 results or methods were not actually "used" in the sense of being incorporated into the facts presented on the card.

The card contains one section titled, "Average Risk of Fatality by Various Accidents (1975)." This section lists estimates of the numbers of deaths and the individual chance of death per year for each of 12 types of accidents, not including nuclear accidents. We obtained this information from the Statistical Abstract of the U.S. (1977). Our staff did compare the "statistical abstract" data with that presented in WASH-1400, and attempted to determine whether the NRC staff had developed more accurate or more current information for our use in preparing the card. Because neither the NRC staff nor WASH-1400 itself offered additional insights or improvements, our staff used the "statistical abstract" data exclusively in preparing the card.

I hope this clarifies our use of WASH-1400.

Steve

Steve Conver
Analysis and Planning Branch

cc: N. Haller
H. Bassett

Note: Current version of Commissioners' Card, prepared by MPA, does not use WASH-1400. Attached is an earlier version of a similar card that used two tables from the WASH-1400 Executive Summary.
SHC

Original Commissioners' Information Card (page 1)
Author: Unknown
Date: Circa 1976

YEARLY SPENT FUEL DISCHARGES FROM A 1,000 MWE REACTOR[a]

Material Description	Volume (m^3)	Weight (Kg)	Heat Output (KW)	Curies	Water to Dilute to RCG[f] (m^3)
Spent Fuel[c]					
Actinides	–	26,500	25	3.5×10^6	6.8×10^{10}
Fission Products	–	950	540	1.2×10^8	1.25×10^{13}
Total	8.5	27,500	565	1.2×10^8	1.25×10^{13}
Liquid Wastes from Reprocessing[d]					
Actinides	–	150(190)[b]	22(280)	$5.7 \times 10^5 (7.1 \times 10^6)$	$3.6 \times 10^{10} (4.7 \times 10^{11})$
Fission Products	–	950(960)	540(580)	$1.2 \times 10^8 (1.25 \times 10^8)$	$1.5 \times 10^{13} (1.0 \times 10^{13})$
Total	40	1100(1150)	562(860)	$1.2 \times 10^8 (1.3 \times 10^8)$	$1.5 \times 10^{13} (1.0 \times 10^{13})$
Solidified Wastes from Reprocessing[e]					
Actinides	–	150(190)	2(34)	$5.5 \times 10^4 (9.0 \times 10^5)$	$8.2 \times 10^9 (1.3 \times 10^{11})$
Fission Products	–	950(960)	28(24)	$8.5 \times 10^6 (7.4 \times 10^6)$	$5.8 \times 10^{12} (3.5 \times 10^{12})$
Total	2.5	1100(1150)	30(58)	$8.6 \times 10^6 (8.3 \times 10^6)$	$5.8 \times 10^{12} (3.6 \times 10^{12})$

[a] Based on a 1000 MWe PWR 80% Load Factor. Does not include transuranic wastes.

[b] Value in parentheses are for PWR with plutonium recycle.

[c] Spent fuel after 150 days cooling. Immediately after reactor shutdown the radioactive decay heat and total curies of activity will be nearly a factor of 100 greater.

[d] High level waste from reprocessing assuming reprocessing immediately after 150 days of cooling of spent fuel. Assumes 0.5% fuel loss (uranium plus plutonium) to waste stream.

[e] Based on characteristics of solidified waste 10 years after the initial reprocessing.

[f] RCG refers to the radiation control guideline limit concentration for concentrated release, as given in Federal Regulations, Title 10, Part 20, Appendix B, Table II. These units are meant to correspond to a maximum whole body dose of 0.5 rem/year. These units are appropriate in water used for drinking, but do not include possible concentrations of specific isotopes by biota in the water.

AVERAGE PROBABILITY OF MAJOR MAN-CAUSED AND NATURAL EVENTS

Type of Event	Probability of 100 or More Fatalities	Probability of 1000 or More Fatalities
Man-Caused		
Airplane Crash	1 in 2 years	1 in 2000 years
Fire	1 in 7 years	1 in 200 years
Explosion	1 in 16 years	1 in 120 years
Toxic Gas	1 in 100 years	1 in 1000 years
Natural		
Tornado	1 in 5 years	very small
Hurricane	1 in 5 years	1 in 25 years
Earthquake	1 in 20 years	1 in 50 years
Meteorite Impact	1 in 100,000 years	1 in 1,000,000 years
Reactors		
100 plants	1 in 100,000 years	1 in 1,000,000 years

From WASH-1400 Exec. Summary (page 10)

ESTIMATED ANNUAL DOSE FROM NATURAL RADIATION

Cosmic Radiation (44 mrem At Sea Level) Increases 1 mrem for Each 100 Feet of Elevation		44
House Construction		45
Brick	45	
Stone	50	
Wood	35	
Concrete	45	
Terrestrial		15
Water, Food, Air		25
Weapons Test Fallout		4
Total Annual		133 mrem

Genetically Significant Medical and Dental Radiology
Fair Estimate – in 1970 Mean Abnormal Dose was 72 mrem.

DOMESTIC ENERGY PRODUCTION BY ENERGY SOURCE for 1978, and ENERGY FORECAST for 1978, 1985, 1990

Qs,

Energy Source	1977	1978	1985	1990
Nuclear	2.69	2.90	6.2	10.3
Coal	16.94	17.70	23.1	27.5
Hydro/Geothermal	2.36	2.88	4.2	5.0
Oil				
Crude	17.4	18.83	19.0	18.0
Inventory	-0.84	+0.8	+2.0	–
Gas				
Natural	18.84	17.98	17.2	16.7
NGL	2.37	2.27	–	1.8
Solar	–	–	–	–
Shale	–	–	0.1	0.3
TOTAL	59.75	62.64	71.8	79.6

AVERAGE RISK OF FATALITY BY VARIOUS CAUSES

Accident Type	Total Number (197X)	Individual Chance per Year
Motor Vehicle	55,791	1 in 4,000 ✓
Falls	17,827	1 in 10,000 ✓
Fires and Hot Substances	7,451	1 in 25,000 ✓
Drowning	6,181	1 in 30,000 ✓
Firearms	2,309	1 in 100,000 ✓
Air Travel	1,778	1 in 100,000 ✓
Falling Objects	1,271	1 in 160,000 ✓
Electrocution	1,148	1 in 160,000 ✓
Lightning	160	1 in 2,000,000 ?
Tornadoes	91	1 in 2,500,000
Hurricanes	93	1 in 2,500,000 ✓
All Accidents	111,992	1 in 1,600 ✓
Nuclear Reactor Accidents (100 plants)	–	1 in 5,000,000,000

From WASH-1400 Exec. Summary (page 3)

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

NOV 1 4 1978

NOTE TO: Roger Moore, ASB

FROM: Steve Conver, APB

SUBJECT: REGULATORY ACTIONS RELYING ON WASH-1400

We have surveyed the APB staff to identify those instances where WASH-1400 results or methods have been used in regulatory actions.

Because of the nature of work in our Branch, we do not have any "regulatory actions" that have used WASH-1400. We do have two applications in our Branch:

1. Value Impact Guidelines - suggests using WASH-1400 results under certain circumstances (high expected impacts on safety, data available).

2. Preparing Information for Commission. WASH-1400 used to prepare information for Comm. Kennedy "information card."

I hope this information satisfies your request.

Steve

Steve Conver, APB

cc: H. Bassett

SECY-77-388A, Dec 19, 77

GUIDELINES FOR CONDUCTING VALUE-IMPACT ANALYSIS

The objectives of these guidelines are to provide NRC staff with criteria for application and techniques for preparing value-impact analysis.* These guidelines are intended to provide general instructions. Each NRC office should develop its own specific guidelines (e.g., emphasizing format) which are adapted to the particular issues analyzed by that office.

What is Value-Impact Analysis?**

Value-impact analysis is a method enabling comparison of consequences associated with alternatives identified to satisfy some objective or to meet some goal. Examples of objectives associated with NRC policy actions are:

1. Increase the level of safety (or decrease adverse health effects and property damage) associated with the operations of a nuclear reactor by:
   a. Reducing routine emissions of radioactive materials, or
   b. Reducing the probability of accidental release of such materials, or
   c. Reducing the magnitude of undesirable effects associated with accidental release of such materials (e.g., through regulations related to siting decisions).

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* Criteria are discussed and applied to a sample of Commission papers in Appendix I.

** In order to promote uniformity and to avoid misunderstanding, an analysis should be referred to as "value-impact" rather than "impact-value" or "value/impact."

Enclosure F

If expected value or cost is high and data are available, more detailed analysis should be attempted.* For example, a more detailed analysis of the value (impact or costs are discussed in a subsequent section) of inerting would apply "Rasmussen's techniques"** and go through the following steps:

a. Utilize a dispersion model and actual data on population density around a model or reference plant site to estimate the man-rem dosage associated with the accident.

b. Estimate the probability of an explosion in terms of reactor years and multiply this probability times the man-rem numbers developed in step "a" to provide a "best estimate" or "expected value."

c. Multiply the amount in step "b" by $1,000 per man-rem (or other agreed upon value).

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* Where value or cost appear to be substantial, more effort should be devoted to collecting appropriate data when the analysis is initiated.

** See the Reactor Safety Study, WASH-1400.

d. Estimate the dollar loss of plant and equipment, the value of replacement electricity which would have to be purchased after the explosion, the decrease in property values associated with an accident, and the costs of decontaminating property (and any revenue losses during the contamination period), and multiply these estimates by the probability of an explosion. These are expected costs which could be avoided through inerting and thus can be included as part of the value of inerting when compared with the status quo.

e. Add the dollar amounts in step "c" to those in step "d" to obtain the expected value or benefit of requiring that reactors be inerted.

f. Repeat steps "a" to "e" for any other alternatives which would either reduce the probability of an explosion or would reduce the magnitude of the release if there were an explosion.

5. Cost or Impact Estimate

This element should include all undesirable consequences associated with various alternatives. This consideration is particularly important when evaluating changes to engineering systems; if one subsystem or component of a system is changed other components may become less effective or less reliable.

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

OFFICE OF
MANAGEMENT AND
PROGRAM ANALYSIS

September 8, 1978

Note to Norm Haller

Re your note on WASH-1400, attached are pages from the NRC 1975, 1976 and 1977 Annual Reports indicating usage of the methodology employed in the Rasmussen report for regulatory purposes. Another use, I seem to recall, was to assess the risk of another Browns Ferry-type fire.

Bill Dooly

Attachments:
Pages fm 1975, 1976 and 1977
annual reports

Conclusion: Risks Very Low

Among specific conclusions in the study were the following:

- Nuclear power plants are about 10,000 times less likely to produce fatal accidents than many nonnuclear activities or events, such as fires, explosions, toxic chemical releases, dam failures, airplane crashes, earthquakes, tornadoes, and hurricanes.
- Nonnuclear accidents involving comparable large dollar-value damage are about 1,000 times more likely than nuclear power plant accidents.
- The chance that a person living in the general vicinity of a nuclear power plant will be fatally injured in a reactor accident is one in five billion per year, as compared with one in 4,000 for a motor vehicle accident and one in 10,000 for a fall. The chance that a person will be injured in a reactor accident is one in 75 million per year.
- In the event of an unlikely reactor accident, with a probability of one in a million per reactor per year, latent health effects, such as cancer fatalities and genetic defects, would be such a small percentage of the normal incidence rates that they would be essentially undetectable. Another latent health effect, thyroid nodules, would occur at about 15 percent of the normal incidence rate, so that the increase would be detectable. These nodules can be diagnosed readily and treated successfully.

Calculations Improved

The final report differs from the August 1974 draft report with regard to the consequences of accidents. Based on advice from eminent scientists in all relevant disciplines calculations were substantially revised. In most cases, the improved calculations resulted in increasing the consequences of accidents over the levels indicated in the draft, although risk levels remain very low compared to nonnuclear risks. With regard to accident probabilities, the final report differs only in minor respects from the draft report.

NRC Chairman Anders said of the final report:

"The Commission believes that the Reactor Safety Study report provides an objective and meaningful estimate of the public risks associated with the operation of present-day light water power reactors in the United States. The final report is a soundly based and impressive work. Its overall conclusion is that the risk attached to the operation of nuclear power plants is very low compared with other natural and man-made risks. The report reinforces the Commission's belief that a nuclear power plant designed, constructed and operated in accordance with NRC's comprehensive regulatory requirements provides adequate protection to public health and safety and the environment. Of course, such regulatory requirements must be continually reviewed in the light of new knowledge, including that derived from a vigorous regulatory research program."

Significant Step Forward

Since there have been no nuclear power accidents to date which have resulted in significant releases of radioactivity to the environment, nuclear risks could only be estimated in the study. Many of the methods used in the study, including "event trees" and "fault trees," were developed by the Department of Defense and the National Aeronautics and Space Administration in the last 10 years. The specific application of these methods in the reactor safety study represents a significant step forward in risk assessment capability.

Following publication of the final NRC report, copies were made available for pub-

1975 Annual Report

lic inspection in the Commission's public document room at 1717 H Street, N.W. in Washington, D.C., and the NRC's five regional offices in Philadelphia, Pa.; Atlanta, Ga.; Chicago, Ill.; Dallas, Texas, and San Francisco, Calif. (Copies may be purchased from the National Technical Information Service, Springfield, Va. 22161.)

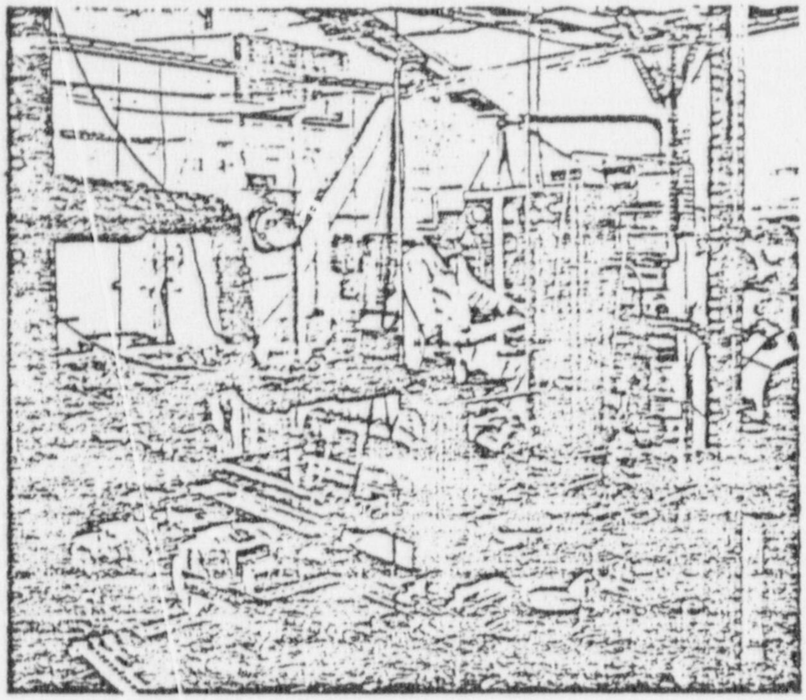
Use of Techniques to Be Studied

The publication of this report raises the question of how the advanced techniques employed can be used in the future in connection with NRC's licensing responsibilities.

As part of NRC's ongoing effort, it is planned that the insights gained in the study will be used to identify the relative importance of various contributions to potential reactor accident risks. This knowledge can be used to achieve a better balance of effort in the safety reviews of reactor plants, and can eliminate from these reviews itmes that are not contributors to the risk. This will reduce the effort spent by the industry and the government in the licensing of reactors and should result in a decrease in licensing time and in a stabilizing of the process.

Plans over the next year call for the Offices of Nuclear Regulatory Research and Nuclear Reactor Regulation to cooperate on the:

(1) Identification of areas that are potentially fruitful in this regard,
(2) Analysis of each identified area to determine a suitable course of action to be taken, and
(3) Implementation of appropriate modifications to reactor technical review procedures.



High temperature test loop at Brookhaven National Laboratory used for exposure of graphite and steel to helium at temperatures up to 850°C (1562° F).

Analysis: The ability to predict the behavior of an HTGR system under transient conditions is a necessary prerequisite for predicting system response to various accident initiating events. The initial version of the CHAP program, which models large HTGR systems, has been completed. The code is structured as a modular system to facilitate adaptation to other reactor types.

Risk Assessment

Ways are being explored in which the probabilities and risk assessment techniques developed in the *Reactor Safety Study* (WASH-1400) can be implemented in the regulatory process and applied to help resolve both specific and generic technical issues. Several such issues, including those suggested by the ACRS and the Office of Nuclear Reactor Regulation have been identified.

The Office of Nuclear Regulatory Research has provided assistance to other offices of NRC in several areas; for example, in:

- Preparation of the environmental impact statement and assessment of the proposed reliability programs for the CRBR;
- Review of portions of the generic study of the potential liquid pathways for radioactive material to reach man from a land based plant comparable to a floating nuclear power plant;
- Review of the draft environmental impact statement on the transportation of radioactive materials; and
- Development, using statistical modeling, of improved testing schemes for diesel generators.

Additionally, a computer code has been developed for detailed analysis of nuclear power plant reliability data. The code may be used to calculate the sensitivity of system unavailability to variations in test-related characteristics and to design changes.

Several studies were concluded to provide information needed in risk assessment and licensing. These included: (1) one phase of a study to formulate a methodology, based on WASH-1400 techniques, to examine the risk to the public of reprocessing of nuclear fuels; (2) analysis of the effect of engineered safety features on the risk of hypothetical LMFBR accidents; and (3) an analysis of data on fires at nuclear power plants to be used in the development of a risk assessment.

To facilitate transfer of the techniques used in the *Reactor Safety Study* to NRC staff and

1976 Annual Report

to contractor personnel, courses on "System Safety and Reliability Analysis" and "Human Factors Engineering" were conducted.

Safeguards Research

Nuclear materials safeguards are those activities which protect the public against death, injury, or property damage resulting from malevolent use of nuclear materials or sabotage of nuclear facilities. The main safeguards question arising in recent years has been directed to whether the risk of these societal consequences is "acceptable," that is, whether or not safeguards are effective enough. This question has two aspects—scope and level of protection. "Scope of protection" refers to the spectrum of possible adversaries, and malevolent acts to be protected against and target materials to be protected. "Level of protection" refers to the residual level of societal risk in the presence of current safeguards protection.

The main thrust of the safeguards research program has been to provide methods of assessing as quantitatively as possible the level of protection achieved by licensee safeguards systems. Although the safeguards issue, like the safety issue, can be expressed in terms of public risk, the socioeconomic elements of the safeguards problem make it unlikely that an adequate quantitative assessment of the absolute levels of societal risk can be made; however, a quantitative expression of safeguards effectiveness can be derived in terms of other relevant parameters. The goals of the research program related to the NRC regulatory function have therefore been expressed in terms of providing technical bases for improving the following capabilities:

(1) The capability for assessing the effectiveness and socioeconomic impact of safeguards policy options and alternative national strategies or procedures;

(2) The capability for predictive evaluation of the effectiveness of licensee safeguards proposals; and

(3) The capability for assessing the effectiveness of licensee safeguards as implemented.

During 1976, implementation of the safeguards research program formulated in 1975 was initiated. Individual projects are divided into three categories.

Projects in the first category are directed toward identifying measures of effectiveness for each of the safeguards subsystems and developing methods and models for evaluating them. Some work has already been done on these, but the first major results will be obtained in fiscal year 1977. Analytical methods will be developed to predict and evaluate the performance of safeguards subsystems for LWR plutonium recycle facilities. In fiscal year 1978 these models will be improved and translated into operational use, while work will begin on application to highly enriched uranium facilities, including enrichment plants, and high-level waste storage facilities.

Projects in the second category are in direct response to requirements of other NRC offices. Work in fiscal year 1977 will emphasize devices and techniques in support of inspection and the design of the integrated safeguards information system.

Projects in the third category are not yet firm in detail, as they will depend on research results as well as operational and policy developments in the coming months. However, work is planned on communications effectiveness in dealing with the industry, the public and the potential adversaries; on the parameters involved in national priorities; and on ways of increasing flexibility and responsiveness of the regulatory process.

Major projects were contracted through ERDA with Sandia Laboratories on physical protection and transportation evaluation and with Lawrence Livermore Laboratory on material control and accounting evaluation. In addition, studies to develop new concepts for safeguards systems and subsystems were initiated with private firms through competitive proposals.

During these first years of independent NRC existence, the safeguards research program is being pursued across a broad front and into new areas. The results of these early efforts will provide a basis for selection of promising techniques for intensive further development. The keynote of this relatively new program is

tion of radioactive materials are adequate; however, studies are continuing on certain aspects to determine whether changes should be made. In this regard, the NRC staff is preparing an environmental statement on transportation of radioactive materials through urban areas, and conducting a joint study with DOT of the adequacy of existing requirements for shipment of low-level radioactive materials. The results of these studies will be useful to the Commission in considering a petition from two Congressmen and several consumer-interest and environmental organizations asking that regulations on shipments of radioactive materials be amended.

Public concern over increasing shipments of highly enriched uranium through Chicago's O'Hare Airport led to a decision in December 1977 that such shipments would be moved through other airports until completion of a joint study by the NRC and the Office of the Mayor of Chicago. An NRC task force was participating in the study at the end of the year. A New York City ordinance, passed in 1975, which virtually bans the transport of significant amounts of radioactive material within the city, continued in litigation. A hearing was held on the matter in November 1977 by DOT, which is considering the compatibility of the ordinance with Federal regulations.

The NRC expects to be able to certify to the Congress early in 1978, in response to P.L. 94-79, that it has developed and tested a container for air transport of plutonium that can withstand virtually any type of aircraft accident.

RESEARCH

The third year of NRC's research program produced substantial results, particularly in the area of light water reactor safety research where the principal effort is concentrated.

Results of the NRC's confirmatory research add to the understanding of the margins of safety which NRC licensing requirements are intended to provide in nuclear power plants. Important advances were made in the loss-of-fluid test (LOFT) program, in measuring the oxidation of nuclear fuel cladding, in computer code development, in fracture mechanics, and in the area of fire protection research. Experimental data from LOFT tests are showing good agreement with predictions. The non-nuclear tests in LOFT—NRC's largest experimental facility—were completed, and preparations are underway for tests with a nuclear core, anticipated to begin in the spring of 1979.

Significant progress also was made in research programs supporting advanced reactor safety, safeguards, and the fuel cycle and the environment.

NRC efforts in risk assessment were concentrated on the use of techniques developed in the *Reactor Safety Study* (also known as the Rasmussen Report) and further development of probabilistic analysis and risk assessment and their application in the licensing and other regulatory functions. A seven-member group of scientists from outside the NRC was appointed by the Commission in mid-1977 to review the *Reactor Safety Study* and comments received on it. The panel conducted several public meetings during the year. The report of this independent group, expected in mid-1978, will clarify the achievements and limitations of the *Reactor Safety Study* and present recommendations to the Commission on the further development and use of risk assessment methodology.

During 1977 the NRC investigated the pros and cons of constructing a facility in the range of one-third to one-half the actual size of pressurized water reactor vessels to conduct tests concerning emergency core coolant bypass and steam-water mixing phenomena. In December, after considering the staff's proposal and comments of the Advisory Committee on Reactor Safeguards, the Commission decided to defer a request for funding in the fiscal year 1979 budget pending further study and the consideration of possible alternatives.

At year-end the Commission established a research review group to implement an amendment (P.L. 95-209) of the Energy Reorganization Act of 1974 which directs NRC to "develop a long-term plan for projects for the development of new or improved systems for nuclear power plants." The Congressional intent behind this effort is "the improvement of reactor safety and not the enhancement of the economic attractiveness of nuclear power versus alternative energy sources."

THE NUCLEAR FUEL CYCLE

The relationship between United States foreign policy interests and domestic decisions concerning the future course of civilian nuclear power was redefined during 1977. Salient developments regarding the fuel cycle included (*1*) President Carter's nuclear policy statement in April in which he said that commercial reprocessing and recycling of plutonium produced in U.S. reactors would be deferred indefinitely, (*2*) establishment in October of an

1977 Annual Report

signed to retain its contents under conditions equivalent to the crash and explosion of a high flying aircraft. Performance test standards for this package were developed by NRC and reviewed by the ACRS and a select committee of the National Academy of Science.

Other plutonium package research is underway to determine the containment required to prevent the escape of powdered plutonium oxide and other powders through fractures in vessels and vessel seals. Major test fixtures were designed and delivered during 1977 and some initial results have been obtained.

Other major research tasks are directed at providing the licensing staff with analytical methods to evaluate the performance of shipping packages. One task saw an initial version of a computer program called SCALE completed. The program is capable of performing the criticality safety, thermal and radiation shielding calculations which are required in the analysis of safety during transport. A second task involved measurements of shock and vibration experienced by shielded casks during actual truck transport.

Risk Assessment Research

Methodology Development

In order to improve the quality of future risk assessments, a significant amount of work is now being done in the area of methodology development. This work includes:

- Applying and modifying Reactor Safety Study (RSS) methodology and insights to the nuclear fuel cycle. Programs dealing with the long-term storage of high level waste in geologic media, fuel processing and the management of radioactive gases, are designed to provide information important to safety. One result of this work will be the identification of areas where resources should be directed to gain more information. Programs covering the front end of the nuclear fuel cycle and the management of low level wastes are in the planning stage.
- Checking and improving the RSS consequence model in regard to meteorology, the effect of rain, and better predictions on health effects, as well as making sensitivity studies to determine important parameters.
- Improving modeling capabilities in regard to seismic effects, fire effects, human errors, and common cause failures.

Methodology Applications

The methodology employed in the Reactor Safety Study has proven useful in a number of areas. These are discussed in the following paragraphs.

A sizeable effort is underway to examine reactors whose safety feature designs are significantly different from those of the two reactors examined in the RSS, in order to extend the applicability of engineering insights gained in the RSS and to explore their effects on predicted risks. This effort will aid in the future application of probabilistic techniques to licensing processes and risk assessments.

In-house analyses and research to assist other NRC offices continues as a major effort. Requests from the ACRS and the various NRC program offices attest to the growing recognition of the usefulness of probabilistic techniques in regulatory processes. Examples of such applications are the assessed impacts of seismically induced fires, turbine missiles, DC battery failures, reactor vessel overpressurization incidents and computerized reactor protection systems.

The FRANTIC computer code (NUREG-0193), which estimates reactor system reliability as a function of tests, maintenance and hardware characteristics, was transmitted to the Office of Nuclear Reactor Regulation (NRR) by Research Information Letter #18, November 1977. The code is used by NRR to establish improved technical specifications for testing and allowed downtimes.

The computer code OCTAVIA has been developed to calculate the failure probabilities of pressure vessels, and in particular, to assess the potential impact of overpressure transients on vessel integrity.

Studies have been performed on safety improvements achievable by alternate containment designs. Work is underway to provide a quantitative assessment of the risks from accidents equivalent to or less than the design basis accident in severity. Work also is underway to examine ways in which probabilistic techniques can be used to aid inspection and enforcement processes. And work is underway to provide a technical basis for guidance to states on emergency plans.

A program has continued for the training of NRC personnel in the techniques and applications of the Reactor Safety Study methodology. Five

two-week courses have been conducted, and more are planned. Plans are also being developed to train NRC personnel to help develop probabilistic analysis capabilities in the work of other offices.

There is some opinion that it is necessary to define criteria for an acceptable level of risk for nuclear power plants. The quantitative determination of acceptable levels of risk on a broad socially acceptable basis for any endeavor is a formidable task. Although the Reactor Safety Study made a first step in quantitative risk assessment, the quantification of benefits and the comparison of risks and benefits in commensurate terms appear to be extraordinarily difficult tasks which may require many years of research. It has been determined that such analyses would be a useful, long-term program, and such a program is now in the process of formation.

Risk Assessment Review Group

During the report period, the Commission appointed a Risk Assessment Review Group to review the peer comments in the final Reactor Safety Study (RSS) report, to clarify the achievements and limitations of the study, and to make recommendations on the further development and use of risk assessment methodology in the regulatory process. The group consists of seven distinguished scientists under the chairmanship of Professor Harold Lewis of the University of California, Santa Barbara. The group has met monthly since August 1977 and expects to report to the Commission by June 1978. It has heard presentations from the staff of NRC and other Federal agencies, critics of the RSS, experts in risk assessment from overseas and distinguished scientists in the many disciplines involved in the RSS.

ments will provide assurance that te NRC has considered those activities under its control to reduce risks from radiation exposure from nuclear power plants.

Value Impact Analysis for ATWS

The staff prepared a value-impact analysis for its proposed requirements for Anticipated Transients without SCRAM (ARWS). The staff determined that ATWS had the potential for core-melt accidents with significant offsite releases, and proposed requirements to reduce the probability of such accidents to 10^{-6} per reactor-year. Employing methods developed during the Reactor Safety Study, the staff estimated the dollar value of the risk that would be averted by the proposed ATWS requirements and weighed that valve against the costs entailed in meeting the new requirements. This risk analysis tended to support the reasonableness of the requirements.

ADVANCED NUCLEAR POWER PLANTS

In October of 1976, then President Ford stated that the United States and other nations "...should increase their use of nulear power...," but that "...reprocessing and recycling of plutonium should not proceed unless...the world community can effectively overcome the associated risks of proliferation of nuclear weapons capabilities."

Shortly after taking office, President Carter expressed similar views and, on April 7, 1977, issued a statement on Nuclear Power Policy which reconfirmed the share that nuclear energy was to have in the total energy prospects of the country. The President's program would also defer indefinitely the commercial reprocessing and recycling of plutonium produced in nuclear power

1978 Draft

Nuclear Safety Report Is Not So 'Fail-Safe' After All

Since 1975, the so-called Rasmussen Report has been used to prove nuclear reactors are safe. But now many of the report's conclusions have been questioned.

BY WILLIAM J. LANOUETTE

The Nuclear Regulatory Commission is in a quandary.

As the federal agency charged with regulating the safety of nuclear power plants, the NRC must soon make a difficult public admission. It must somehow explain that the principal document used to show that reactors are safer than many other hazards is misleading and technically flawed.

A recent review of that document for the NRC, sharply questioning its co clusions, could become the vehicle or renewed national attention to reactor safety in the next Congress.

The document in question, known as the Reactor Safety Study, was begun in 1972 by the NRC's predecessor, the Atomic Energy Commission, and directed by Norman C. Rasmussen, a professor at the Massachusetts Institute of Technology. It attempted to quantify the risks and hazards of nuclear power so that Congress could have a frame of reference when considering whether or not to extend the Price-Anderson Act, a federal insurance and indemnity program for nuclear plants first passed in 1957.

A staff of more than 60 completed the $3 million in-house study in two years, releasing a draft in August 1974 and a final report in October 1975.

The most memorable calculation to emerge from the 2,300-page "Rasmussen Report" showed that the odds of dying from a nuclear power plant accident are about as great as being struck by a meteorite—about one in a billion. This calculation, and others, were heralded by some commission officials, nuclear industry spokesmen, electric utility executives and publicists, pro-nuclear Members of Congress and nuclear proponents in several state referenda. "It was useful when we needed it," a nuclear industry official commented recently.

"All other accidents . . . that have been examined in this study," declared the report's widely distributed, 12-page executive summary, "are much more likely to occur and can have consequences comparable to or greater than nuclear accidents."

The Rasmussen Report's main conclusions received wide attention from the press, which created an impression that scientists had somehow proved that nuclear plants were safe. "There was a great hue and cry from the [nuclear] industry side, that, by George, there has now been verification that things were okay. . . ," NRC chairman Joseph Hendrie said at a commission meeting last month. "I think you can certainly say that was an excessive use of the report." Added NRC commissioner Victor Gilinsky: "It became a propaganda tool . . . . It got misused."

Hendrie, Gilinsky and the three other commissioners, in discussing the Rasmussen Report and the year-long review of that report just completed at their request, were wondering aloud how it had been used and misused. They have already held three public meetings on the new Risk Assessment Review Group Report and plan more in December. The review was conducted by a seven-man panel headed by Harold W. Lewis, a physicist at the University of California (Santa Barbara).

"The problem is that a methodology of this kind, which tries to look through accident sequences for complex systems like a nuclear power plant, must deal with zillions of accident sequences," Lewis told the NRC commissioners in presenting his group's report. "I don't know what zillions are, but they are certainly larger than billions. And, it is just physically impossible to do that."

Lewis's group concluded that while the Rasmussen Report's basic methodology was sound, the document and many of its components were not. Its prose, the Lewis Report complained, is "inscrutable," and "the executive summary is a poor description of the contents of the report, should not be portrayed as such, and has lent itself to misuse in the discussion of reactor risks."

The Lewis Report also said that the Rasmussen Report suffered from:

- a data base that was at times "very skimpy";
- an "arbitrariness" that in some instances "boggles the mind";
- a peer-review process that was hampered by shortcuts and "often defensive" responses from the NRC staff;
- a few techniques for determining probabilities that were deemed "unnecessary and plain wrong."

Most disturbing to Lewis's group, however, was the fact that after more than a year's review of the Rasmussen Report, they still could not say whether the report's estimate of the probability of a serious nuclear plant accident was correct. "I doubt that we could do so even if we were given three years and the megabucks that were involved," Lewis told the commission. "What we are certain of is the error bounds shown in [the Rasmussen Report] for this risk estimate are too small."

Lewis added, "Anyone who tries to work with the thing and learned how any given calculation was really done comes away drinking heavily."

The Lewis group also warned that the Rasmussen Report should not be used in setting government nuclear policy, a finding that sent the NRC staff scrambling to find out how often it had been used. Not very often, a preliminary survey revealed, because the NRC staff itself found many of the Rasmussen Report's data and calculations outdated

or unreliable, according to Lee Gossick, the commission's executive director for operations.

USING THE REPORT

The Rasmussen Report has been used to set policy on a few occasions, however. For example, it supported an environmental impact statement minimizing the potential hazards at the Diablo Canyon nuclear plant in California. NRC staff members used probable health effects from the Rasmussen Report, and specific figures from the report were quoted in speeches by former commission chairmen Dixy Lee Ray, William A. Anders and Marcus A. Rowden. NRC researchers also used some of the report's calculations in at least 37 studies of potential reactor safety problems.

"Some of the numbers are being used, explicitly and implicitly," Stephen Hanauer, an NRC technical adviser, told the commission this month.

"There are several levels to this," said Gilinsky in an interview. "On a technical level, we'd like to know where [the Rasmussen Report] was used in the regulatory process. It may have been used, and we certainly want to make corrections where they are necessary.

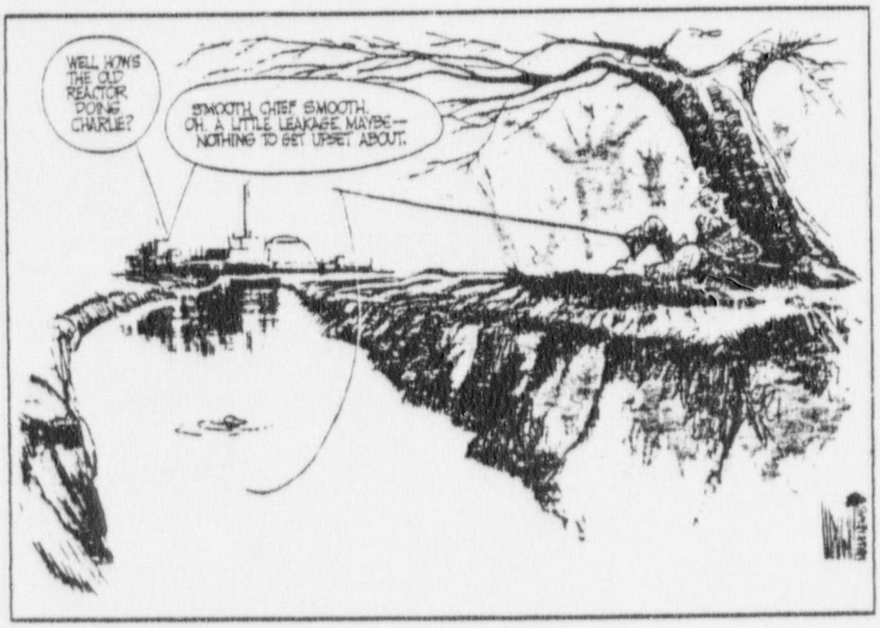
"A more important task, however, is to right the balance on that report's use in the larger debate about nuclear energy. The report was used as part of the effort to sell nuclear energy and was certainly used uncritically. So the commission has got to try to correct its own former statements and issue a new statement about what it thinks can and cannot reasonably be concluded about nuclear safety on the basis of the original report."

Not much has been made of the Lewis Report—by either boosters or critics of nuclear power—in the weeks since its release, but over time it could focus renewed attention on questions of reactor safety. "I have not observed a reaction one way or the other," said an official of the Atomic Industrial Forum Inc., the trade association for the nuclear industry. "We have a brochure on reactor safety, but we haven't reviewed it to see what it says. The next time it comes up for revision, though, we'll make sure the Lewis group's comments are taken into account."

Said A. Dave Rossin of the Commonwealth Edison Co., a Chicago-based utility with seven reactors: "I don't see changes coming from industry. I think some critics [of nuclear power] may try to capitalize on it. . . . We have handed out lots of copies of the Rasmussen Report's executive summary to people who asked us about nuclear plant safety. If they come back, I'd be pleased to give them the Lewis Report—but not copies of the newspaper coverage of the Lewis Report, because they were mostly based on Lewis's summary, which is more negative than the body of the report."

David Comey, a critic of nuclear power at Citizens for a Better Environment in Chicago, said the Lewis Report is "a healthy start on the outside review process that should be pursued in many other nuclear areas. I'm also concerned about how the Rasmussen Report has been used. It has been used in every [nuclear plant] construction permit hearing where the NRC staff took the position that unresolved safety problems need not be resolved prior to plant operation because the probability of those problems initiating an accident is too small to be significant.

"They're doing it right now on the pipe-cracking problem with General Electric reactors, saying the probability of pipe rupture is so low that they can continue to let the plants operate without replacing the stainless steel piping that one of their own reports said should be replaced."



PREPARING A RESPONSE

The NRC staff plans to determine how it used the Rasmussen Report by Dec. 1, and the commissioners hope to complete their statement on nuclear safety by the end of the year. The Union of Concerned Scientists, a public policy study group critical of nuclear power, has sent the NRC a draft statement it wants the commission to issue. Predictably, the proposal is tough on the nuclear industry. It calls for possible suspension of reactor construction permits and operating licenses, among other measures.

Two other draft statements were prepared by the NRC staff, but both were denounced by commissioner Richard Kennedy as being "so much mumbo-jumbo" and "guff." "We have to describe [reactor safety] in terms 220 million people can understand," Kennedy said at a commission meeting, "and we don't do that very often."

The commission faces yet another task resulting from the Lewis Report: preparing a response to Rep. Morris K. Udall, D-Ariz., the chairman of the House Interior and Insular Affairs Committee. It was Udall who asked for the sort of study that Lewis's group conducted. After holding hearings in June 1976, Udall concluded that "the Reactor Safety Study was presented in a manner which created a misleading impression of the certainty and comprehensiveness of its conclusions."

Lewis was even more critical when he told the NRC commissioners: "On the specific issue of whether I can learn anything from [the Rasmussen Report] that will enable me to say whether reactors are [illegible]ptably safe or not, I can't. I did[illegible] it from [the report]."

Thus, [illegible]ely unnoticed in the nuclear [illegible]ar, the Lewis Report could [illegible]ole in future debates.

Ye[illegible]e report's conclusions may ha[illegible]found effects abroad. *The Wa[illegible]r* recently reported that the [illegible]ector of the Kurchatov Institute o[illegible]mic Energy, asked about the Soviet [illegible]nion's optimistic view of nuclear power, "said Russian scientists were buoyed by the findings of an MIT study, headed by Dr. Norman Rasmussen, that said the chance of a person's being killed in a major nuclear power plant accident are about the same as the chance of being hit by a meteor." □