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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Three Mile Island: The Most Studied Nuclear Accident In History

On March 28, 1979, the Federal Government and the nuclear power industry were awakened by the most serious accident in the history of U.S. commercial nuclear power. Although no one died as a result of this accident, the realization that a major accident is possible renewed the national and international debate on the safety and reliability of nuclear power.

Reactor safety and Federal regulatory policies and practices have been thoroughly examined and criticized since the accident. Long overdue changes in reactor operations and designs have been made and others are being considered.

Both the nuclear industry and Federal Government appear to have changed their attitudes toward improving safety and reducing the probability of future accidents. Only time will tell, however, whether this change is permanent or short-term. GAO believes that oversight of Federal plans to correct known safety and regulatory deficiencies should continue.

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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To the President of the Senate and the
Speaker of the House of Representatives

This report discusses the nuclear accident at Three Mile Island, Pennsylvania, the safety problems identified by investigations of the accident, and the actions taken or proposed by the Nuclear Regulatory Commission and others to correct the problems.

This review was performed at the request of the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce.

We are also sending this report today to the Chairman, Nuclear Regulatory Commission.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

THREE MILE ISLAND: THE MOST STUDIED NUCLEAR ACCIDENT IN HISTORY

D I G E S T

A simple equipment malfunction that could have been controlled without difficulty touched off what has been called the worst commercial nuclear accident in U.S. history at Metropolitan Edison's Three Mile Island nuclear facility in March 1979.

A bizarre sequence of events followed the malfunction--operator misjudgments, errors, and other equipment malfunctions--which led to a major nuclear accident and sparked a wave of studies and investigations by numerous groups, including a commission appointed by the President, congressional committees, Nuclear Regulatory Commission groups, State agency and legislative groups, and various industry organizations. (See pp. 1 to 3.)

The Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce, asked GAO to determine whether the major investigations fully and accurately disclosed the reasons for the accident. GAO reviewed eight investigative reports and other supporting material and concluded that the investigations varied in depth and comprehensiveness but were generally consistent in their account of the accident, why it happened, and the health effects of the radioactive releases. Some of these reports were very comprehensive and took almost a year to complete. (See p. 3.)

Most investigators agreed that the accident was caused by a combination of factors, including equipment malfunctions, inadequate operator training, poor designs, and inadequate operating and emergency procedures. Further, the Nuclear Regulatory Commission's practices, procedures, and attitudes were challenged to such an

extent that a major reorganization and restructuring of the agency was recommended. (See pp. 37 to 41.)

Over the past 5 years, GAO has issued over 50 reports on various aspects of the Commission's activities. Those reports identified many of the same problems as found by the Three Mile Island investigations, including (1) inadequate preparations for nuclear emergencies by State and local governments, (2) no systematic method to analyze powerplant accidents and disseminate important information on lessons learned, and (3) lack of aggressive leadership at the Nuclear Regulatory Commission.

This report summarizes some of these findings and highlights areas where major improvements are needed in reactor safety.

ACCIDENT-RELATED RADIATION EXPOSURE CONSIDERED SMALL

Several groups which made studies of the radiation doses received by the population around Three Mile Island and by plant workers concluded that the accident had a negligible effect on the physical health of these people. (See pp. 5 to 9.)

Some groups found, however, that the accident had a demoralizing effect on the public living around Three Mile Island and on the workers directly involved in the accident. While this effect was short-lived in most people, some living near the plant are still upset about the accident, concerned about their safety, and distrustful of Federal, State, and utility officials. (See pp. 9 to 11.)

IMPROVEMENTS IN POWERPLANT DESIGN, OPERATION, AND EMERGENCY PLANNING OVERDUE

The investigations identified or highlighted many deficiencies in reactor designs, powerplant operations, and planning for peace-time

nuclear emergencies. Many of these deficiencies had been known by the Commission and others for some time, but most were not considered important in view of the Commission's strategy for reactor licensing and design.

The Commission has, in the past, relied on a licensing and design strategy called "defense in depth" to bring three levels of safety to the design of nuclear powerplants:

--Accident prevention by using quality standards and engineering practices.

--Special safety features, such as emergency core cooling systems to further prevent or control potential accidents.

--Other plant features, such as massive containment buildings, to control or limit radioactive releases to the atmosphere if other features should fail.

The Commission reasoned that it was not necessary to know everything about a reactor's design or how it would respond in various situations. Instead, it thought that reactors could be built with enough safety features to account for any unknowns in design or to prevent or control almost any conceivable accident. (See pp. 12 and 13.)

The defense in-depth strategy tended to cause the Commission to ignore signs of design or operating weaknesses in nuclear powerplants. For instance, if important components or systems failed, the Commission expected a back-up to take their place so the plant could be safely shut down. If plant operators were not as qualified or trained as they should have been, the defense in-depth strategy had, the Commission thought, created a plant that could safely shut itself down in an emergency with little or no operator

intervention. Likewise, State and local governments' emergency plans and evacuation procedures were not mandatory for licensing because the possibility of off-site releases was considered remote.

These are only some of the Commission's myths before Three Mile Island. The accident investigations reported many others which if corrected, might have prevented the accident or, at least, reduced its severity. (See pp. 12 to 36.)

IMPROVEMENTS NEEDED IN COMMISSION ORGANIZATION, MANAGEMENT, AND MEHTODS OF REGULATION

The Three Mile Island investigations were generally consistent in their evaluation of the Commission's organization, management, and methods of regulation. They found that it had become satisfied with the level of safety it was providing and slow or reluctant to seek or accept change to the licensing process.

Management direction provided by the Commissioners was particularly deficient. The Commission staff generally managed itself and the Commissioners tended to respond only to crisis situations or when asked to respond by the staff. (See pp. 37 to 39.)

The investigations cited a lack of clear definition of responsibilities for either the Chairman, the other Commissioners, or the Executive Director of Operations (the Chief executive officer under the Commission). The real authority of the agency resided in collegial action and not in the Chairman. This was found to be a very ineffective management structure. (See pp. 38 and 39.)

In a concurrent review of the Commission's performance over its first 5 years of existance, GAO generally reached the same conclusions. Without considering the poor performance of the Commission during the

Three Mile Island accident, GAO found that the Commission lacked effective leadership and management direction. (See p. 39.)

Although two major investigations recommended that the Commission be replaced with a single administrator, the President has decided to retain the commission type of management structure. The President's reorganization plan, ammended on May 5, 1980, greatly expanded the management role and authority of the Chairman but left the Commissioners responsible for setting policy and providing the overall framework within which the Chairman would operate. (See pp. 39 to 41.)

GAO endorses this reorganization plan, believing that if properly carried out, it offers an opportunity for an effective management structure. (See p. 41.)

The investigations recommended many ways to improve the regulatory process of the Commission, including such things as establishing safety goals, making powerplant standardization mandatory, improving the role of the Advisory Committee on Reactor Safeguards, and providing funding and legal counsel to public groups or individuals intervening in licensing proceedings. (See pp. 41 to 52.)

While the Commission has taken or planned action on most of the recommendations, little progress has been made on establishing goals and criteria which describe what level of safety and nuclear regulation is enough. (See pp. 42 to 44.)

In this context, the Senate Committee on Environment and Public Works included a provision in the Commission's fiscal year 1981 authorizing legislation, directing the Commission to develop a proposed safety goal for nuclear reactor regulation. This proposed goal would be reported to the Congress by June 30, 1981. GAO endorses the draft legislation and believes congressional action is necessary to ensure that the

Commission gives proper attention to the development of a safety goal for nuclear regulation. (See pp. 43 and 44.)

In addition, the Commission needs to develop some systematic way to increase its participation in important licensing and regulatory decisions. The Commissioners currently have several options under study for increasing their decisionmaking role. These range from eliminating the Atomic Safety and Licensing Appeal Board to having one or more Commissioners participate on each Appeal Board panel.

GAO does not believe the Board should be eliminated. The insulation the Board provides is necessary to keep the Commission focused on important safety issues and policy considerations. To make all the Commissioners responsible for reviewing the appeal of every licensing application would take up most of their time and detract from their other regulatory and public responsibilities.

GAO favors options that increase the Commissioner's role in the licensing and adjudication process while retaining the Appeal Board and its basic agency responsibilities. (See pp. 51 and 52.)

NEED FOR CONTINUED OVERSIGHT

The Commission appears to have recognized past inadequacies and to be taking corrective action.

For example, it has started to rethink its positions on safety and to improve its understanding and analysis of potential problems. Among other things, it has (1) started special studies and proposed several rulemaking proceedings that could lead to drastic revisions in the design and siting requirements for nuclear powerplants, (2) increased emphasis on the role of plant operators and the educational and design tools they need to properly operate

a powerplant in both normal and emergency situations, (3) recognized the need for adequate emergency planning and preparations around powerplants, and (4) taken steps to improve local capabilities to handle civilian nuclear accidents. (See pp. 12 to 36.)

While the Commission has taken many short-term actions to improve specific design and operating problems, many longer term and possibly more important actions are yet to be completed. Until they are, the accident's full impact on reactor safety will not be known.

GAO endorses a recent proposal by the President to create a special "Nuclear Safety Oversight Committee" to oversee the improvement in reactor safety and the Commission's implementation of certain Three Mile Island-related recommendations. In addition, GAO (as recommended in a separate report to the Senate Subcommittee on Nuclear Regulation, Committee on Environment and Public Works) believes that the Commission should, at a minimum, submit annual reports to the Congress on its progress in implementing the Three Mile Island Action Plan. The Action Plan is a document developed by the Commission that transforms the hundreds of Three Mile Island recommendations into specific Commission plans.

This annual report should contain enough information to keep the Congress fully informed on the Commission's progress in improving reactor safety. It should also (if considered necessary by congressional oversight committees) serve as a basis for potential congressional oversight hearings on reactor safety. (See pp. 54 and 55.)

In commenting on this report, the Commission suggested that its annual report to the Congress should be used to convey the information GAO suggests. GAO agrees with this suggestion as long as enough information is included to clearly describe the

progress made in improving reactor safety and meeting the objectives of the Three Mile Island Action Plan. (See p. 55.)

The Commission also made several clarifying and editorial comments on this report. The only major disagreement related to GAO's characterization of the Commission's new Office for Analysis and Evaluation of Operating Data. These comments, along with GAO's responses, are included in appendix II. (See pp. 63 to 74.)

Contents

ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
AEOD	Office for Analysis and Evaluation of Operating Data
EDO	Executive Director for Operations
FEMA	Federal Emergency Management Agency
GAO	General Accounting Office
IE	Office of Inspection and Enforcement
IREP	Interim Reliability Evaluation program
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
OL	operating license
RES	Office of Regulatory Research
TMI	Three Mile Island

CHAPTER 1

THREE MILE ISLAND--A RENEWED DEBATE ON NUCLEAR REACTOR SAFETY AND RELIABILITY

On March 28, 1979, at Three Mile Island (TMI), Pennsylvania, a satisfied, if not complacent, Government and nuclear industry were abruptly awakened by the worst commercial nuclear accident in the Nation's history. No one died as a result of this accident, but the realization that an accident can happen renewed the national and international debate on the safety and reliability of nuclear reactors.

The accident at TMI--what happened, why it happened, the radiological effects, the lessons learned, and the impact of the accident on the Nuclear Regulatory Commission (NRC) and the nuclear industry--has been under scrutiny by congressional committees; the President's Commission on the Accident at TMI; several NRC groups, including a Special Inquiry headed by an independent law firm; State agency and legislative groups, and various industry organizations.

NRC's practices, procedures, and attitudes have been challenged to such an extent that a major reorganization and restructuring of the agency has been recommended. The President's Commission concluded that NRC does not have the organization and management capabilities necessary to effectively pursue safety goals. The NRC Special Inquiry stated that NRC "is not so much badly managed as it is not managed at all." Deficiencies in design; operator training; plant operating procedures; and State, local, and utility emergency preparations were identified. Most of these issues are not new, however. Many had been known by NRC long before TMI but no corrective action had been taken.

THE ACCIDENT--WHAT HAPPENED?

The Nation's worst nuclear accident began at about 4 a.m. on Wednesday, March 28, 1979, when several water pumps shut off in the TMI Unit 2 powerplant. That touched off a series of poorly understood events over the next few days that aroused fears of a catastrophe.

The stopped pumps had supplied water that normally drew heat from the pressurized water reactor's cooling water. After the pumps shut off, pressure from expanding hot water built up in the reactor, a relief valve opened to release the pressure, and the fission process in the core of the reactor was automatically stopped.

But, instead of closing after the reactor pressure had fallen, the relief valve became stuck and stayed open for 2 hours and 22 minutes, which the operators did not realize. Radioactive cooling water flowed out of the reactor through the open valve and was inadvertently pumped out of the reactor containment building into an auxiliary building.

About 2 minutes into the accident, the emergency core cooling system started pumping water into the reactor core. Operator training and instructions were so deficient, however, that the operators, unaware that cooling water was escaping through the stuck relief valve, turned off most of the water flowing from the emergency core cooling system. They did that intending to prevent the reactor system from becoming filled with water, a condition they were required to prevent. All concerned were unaware of the far greater threat--that the loss of reactor cooling water could uncover the core. Although the effects are really unknown, an uncovered core could overheat until the uranium fuel melts through the reactor vessel--commonly called a meltdown--perhaps releasing a large amount of radioactive materials.

Hydrogen gas was produced in the core after it became partly uncovered, severely overheated, and damaged to some unknown extent. 1/ Radiation rose rapidly in the containment and auxiliary buildings and about 3 hours into the accident radiation levels were increasing throughout the plant.

Nearly 4 hours into the accident, the containment building automatically became "isolated," meaning that all paths by which radioactive gases and liquids could escape from the building were blocked--except one. Experts generally agree that most of the air-borne radioactivity released from the plant likely came from the water that moved into and out of the reactor coolant system during the accident. This highly contaminated water continued to flow for several days from the containment building to the auxiliary building.

Nearly 10 hours into the accident, a hydrogen gas explosion occurred in the containment building, but the operators did not realize it until late the next day, Thursday. Fears of another explosion spread over the weekend when a hydrogen gas bubble was found in the reactor system. These fears, however, were based on an NRC miscalculation and were later shown to be unfounded.

1/The hydrogen gas was created by the chemical reaction of superheated steam in the reactor with the zirconium casing around the uranium fuel.

From the start of the accident, the operators did not understand what was happening in the powerplant, and therefore, were not able to control the recovery. There were delays in informing local and State authorities about the situation, and the public received conflicting reports about the hydrogen bubble. An accident that started with water pumps stopping should have caused only a minor incident--instead it threatened catastrophe.

SCOPE AND METHODOLOGY OF REVIEW

At the request of the Chairman, Subcommittee on Energy and Power, House Committee on Interstate and Foreign Commerce, we attempted to determine what caused the accident and to answer other questions raised by the accident. To do this, we relied largely on the numerous investigations and reports prepared after the accident. These reports included:

(1) "Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station," Preliminary Estimates Prepared by the Ad Hoc Interagency Dose Assessment Group, NUREG-0558, May 1979.

(2) "Investigation Into the March 28, 1979, Three Mile Island Accident by Office of Inspection and Enforcement," NUREG-0600, Aug. 1979.

(3) "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations," NUREG-0578, July 1979.

(4) "TMI-2 Lessons Learned Task Force Final Report," NUREG-0585, Oct. 1979.

(5) "Report of Special Review Group, Office of Inspection and Enforcement on Lessons Learned From Three Mile Island," NUREG-0616, Dec. 1979.

(6) "Report of the President's Commission on the Accident at Three Mile Island," Oct. 1979.

(7) "Three Mile Island, A Report to the Commissioners and to the Public," Mitchel Rogovin, Director, NRC Special Inquiry Group, Jan. 24, 1980.

(8) "Report of the Governor's Commission on Three Mile Island," State of Pennsylvania, Feb. 26, 1980.

We evaluated these reports in terms of their scope, approach, and consistency of findings. With the aid of several consultants, we reviewed the reasonableness of the conclusions and recommendations based on the factual data

presented in each report and on the data contained in the other reports. We held discussions with members of these investigations and studies to gain additional insight or information.

Because of the volume of data involved, we did not attempt to verify the factual data contained in the reports except for the investigation report by NRC's Office of Inspection and Enforcement. Because that report was one of the first to contain a detailed sequence of events and was heavily relied upon by the rest of the studies, we verified a random selection of factual data in the report by tracing it to NRC's supporting documentation. We generally concluded that the body of the report presented a factual account of the accident.

PURPOSE OF REVIEW

Our intent was to determine whether the various TMI investigations fully and accurately disclosed what happened and why it happened. In this context we have concluded that the findings of the various investigations are generally consistent and cover almost every conceivable cause and effect of the accident. Some reports have limitations and some do not always provide the proper emphasis. But overall, we believe that the major issues have been addressed, and there is general agreement on the causes of the accident, the radiation released and its possible health effects, and the major issues facing NRC and the nuclear industry. (See app. I for a synopsis of the major TMI accident investigations.)

This report, therefore, contains our assessment of some of the major TMI-related findings and recommendations and the corrective actions being proposed by NRC. To provide a focus for these issues, this report will discuss the

- --radiological releases during the TMI accident and the expected affect on the population surrounding the plant;
- --deficiencies in reactor design, powerplant operations, and emergency preparedness;
- --poor management at NRC and deficiencies in the regulatory process; and
- --actions taken by NRC since the accident and the need for continued oversight of NRC.

CHAPTER 2

TMI-RELATED RADIATION EXPOSURE IS CONSIDERED SMALL, WITH MINIMAL OR NO HEALTH EFFECTS

The radioactive material released during the accident has had a negligible effect, if any, on the physical health of people living within 50 miles of the Three Mile Island plant. This conclusion was independently reached by the Ad Hoc Interagency Dose Assessment Group, the President's Commission on Three Mile Island, and a consulting firm for the utility. The NRC Special Inquiry, after reviewing and analyzing the work of these three groups, accepted their conclusions and decided not to do an independent analysis of the data.

The President's Commission and a Pennsylvania Governor's Commission also investigated the effects of the accident on the mental health of the public and the TMI workers. They found that the accident had a demoralizing effect on the public living in the vicinity of TMI and on the workers directly involved in the accident but concluded that this effect was short-lived in all groups except the TMI workers. A Pennsylvania Department of Health study recently found that some of the people living around TMI still reported symptoms frequently associated with lesser forms of mental stress which began at the time of the accident and continued through the period of its study.

RADIOACTIVE RELEASES TO THE ENVIRONMENT--HOW ARE PEOPLE EXPOSED?

Two kinds of radioactive materials were released to the atmosphere by the accident--between 2.4 million and 13 million curies 1/ of noble gases, mainly Xenon-133, and about 15 curies of radioactive Iodine-131. People, however, are only exposed to those materials with which they come in contact. Thus, meteorological conditions such as wind speed and direction, as well as whether one is indoors or outdoors when the wind carrying the radioactive material passes by, are significant factors in determining an individual's exposure to airborne radioactive material.

The noble gases only expose people when they are immersed in a cloud of the gases or are within the range of the radiation emanating from the cloud. These gases are not retained by the

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1/A curie is a unit of intensity of radioactivity in material.

body. The radioactive iodine, however, will (if inhaled or ingested) concentrate in the thyroid gland of the body and remain there until it has been eliminated or has undergone radioactive decay. This significantly increases the time of exposure.

STUDIES FOUND SMALL POTENTIAL HEALTH EFFECTS FROM RADIOACTIVE RELEASES

Population dose estimates and the potential health effects from the TMI accident were made by various TMI investigative groups. These are summarized in Table 1.

The Ad Hoc Interagency Dose Assessment Group was the first to estimate radiological effects

The Ad Hoc Interagency Dose Assessment Group, composed of representatives from NRC, the Environmental Protection Agency, and the Department of Health, Education, and Welfare, was the first group to assess the effect of the radioactive releases on the population around TMI. Its estimates of offsite doses were based primarily on data provided by thermoluminescent dosimeters, placed at locations within 15 miles of the plant before, during, and after the accident. Dosimeters are devices which record the total radiation dose an individual would receive for the given time period of the dosimeter. Although the number of dosimeters was relatively small, the Ad Hoc Group concluded that this data allowed reasonable population dose estimates to be made.

Several methods were used to estimate population dose

The group made four separate estimates of the total radiation dose to the total population living within a 50-mile radius of the plant. These estimates ranged from 1,600 to 5,300 person rem 1/ depending on the methods used to extrapolate data from the limited number of dosimeter measurements. Because of the uncertainties involved in determining which method of data extrapolation was the best, the group averaged the four estimates to arrive at a total population dose of 3,300 person rem.

Based upon this dose calculation, the projected health effects during this population's lifetime were estimated to be about two cases of cancer and genetic ill health. One of

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1/See footnote 3 in Table 1.

TABLE 1

Estimated Offsite Doses and Potential Health Effects as a Result of the TMI Accident

Study group	Maximum dose to individual a/ (millirem)b/	Maximum thyroid dose a/ (millirem)b/	Total population dose c/ (person-rem)	Non-fatal cancers	Fatal cancers	Genetic ill health	Total health effects	Normally expected cancer cases in TMI population
Ad Hoc Inter-agency Dose Assessment	d/100	5	3,300	d/1	d/1	d/1	2	541,000
Presidential Commission	70	6.9	e/2,000	d/e/1	d/e/1	d/1	f/1.5	541,000
NRC Special Inquiry	100	-	2,000	d/e/1	d/e/1	d/1	f/1.5	541,000
Utility contractor	76	9.8	3,500	-	-	-	-	-

a/The maximum radiation dose which could have been received by a hypothetical individual from the accident.

b/A rem is a unit of radiation dose. A millirem is 1/1,000 of a rem.

c/The total population dose is the sum of the individual doses received by the population in a given area. It is calculated by multiplying the average dose per person by the number of persons in the population. ("Collective dose" is a synonym for "Population dose.") The unit of population dose is the person rem.

d/Less than.

e/Includes a correction for the protection afforded by shelter.

f/Zero not excluded.

the two cases was expected to be a fatal cancer. Using the highest estimate of population dose (5,300 person rem) would increase the number of health effects to about three cases instead of two. In contrast, the expected cancers in the same population but from other causes is expected to be 541,000.

This group also used two additional methods to independently check population dose estimates. One method used meteorological disperson factors and an estimate of the radioactive material released to the environment. The second method used radiation measurements made from Department of Energy helicopters during the accident. The population dose estimates for these two methods were about 2,600 and 2,000 person rem, respectively.

Maximum individual dose was small in comparison to dose from background radiation

The maximum dose that any one individual located near TMI could have received was estimated by this group to be less than 100 millirem. This estimate was based on the cumulative dose recorded by an offsite dosimeter located near the plant and in the path of the radioactive materials released during the accident.

By contrast, an individual living in Harrisburg, Pennsylvania, receives about 116 millirem each year from natural background radiation. This background radiation arises from naturally occurring radioactive materials present in the environment and in the body as well as from cosmic rays from outer space.

Environmental measurements confirmed internal dose calculations

Milk and food samples were collected and analyzed for the presence of radioactivity by the Food and Drug Administration. Iodine-131 was the only reactor-produced radioactivity detected in milk samples during the period March 31, through April 4, 1979. No reactor-produced radioactivity was found in any of the 377 food samples collected between March 29 and April 30.

This data was evaluated and used by the Ad Hoc Interagency Dose Assessment Group to estimate the amount ingested by the population. They concluded that the maximum internal dose for an individual would have been received by an infant if he or she drank one liter of milk per day having the highest concentration of iodine found in any of the samples. This

infant would have received a total dose of 5 millirem to the thyroid, well within the Food and Drug Administration limit for milk of 1,500 millirem.

This low internal dose was verified by testing several hundred local residents to determine the amount of radioactive material(s) present in their bodies. These tests did not find any radioactive materials which could have been released during the accident.

Other groups confirm findings of the Ad Hoc Interagency Dose Assessment Group

Several other groups reviewed the available radiological release data and generally confirmed the findings of the Ad Hoc Interagency Dose Assessment Group. These were the President's Commission, a contractor hired by the utility company, and the NRC Special Inquiry.

The President's Commission and the utility contractor, using different methods to estimate and check the population dose calculated by the Ad Hoc Group, concluded that the radioactive materials released at TMI were negligible and would have a minimal effect on the health of people around TMI. The NRC Special Inquiry did not perform independent calculations but reviewed and confirmed the conclusions of the other groups.

The President's Commission also evaluated the available radiation exposure data for TMI workers and found that three had received radiation doses of 3-4 rem during the period of March 28, to June 30, 1979. This exceeds the NRC permissible limit of 3 rem for a calendar quarter but not the yearly limit of 5 rem. The President's Commission staff concluded, therefore, that the plant personnel are unlikely to suffer adverse health effects from the accident.

IMPACT ON THE MENTAL HEALTH OF THE INDIVIDUALS LIVING AROUND TMI

Three groups investigated the impact on the mental health of the individuals living in the vicinity of TMI. These were the President's Commission, the Pennsylvania Governor's commission, and the Pennsylvania Department of Health. The first two groups studied the mental stress on both the public and the TMI workers, while the third focused only on the public. All three groups generally agreed that higher forms of mental stress were short-lived for most people living close to TMI, but that distrust of utility and public officials was continuing.

The President's Commission finds demoralization short-lived except for TMI workers

In its study the President's Commission surveyed about 2,500 people from four different groups including (1) heads of households within 20 miles of TMI; (2) mothers of preschool children from the same area as well as from Wilkes-Barre, which is about 90 miles away; (3) teenagers in the 7th, 9th, and 11th grades from a school district within 20 miles of TMI; and (4) workers employed at TMI at the time of the accident and a control group of workers from the Peach Bottom nuclear plant about 40 miles away.

The President's Commission found that severe mental stress, in the form of demoralization, was high immediately after the accident but disappeared rapidly among most groups. The exception was TMI workers who continued, throughout the study, to exhibit higher levels of demoralization than workers at the Peach Bottom nuclear plant. The Commission estimated that about 10 percent of the household heads showed severe demoralization during and soon after the accident but that the most demoralized people were household heads and teenagers living within 5 miles of TMI, and mothers and teenage siblings of preschool children.

Besides this higher form of mental stress, the Commission found that the people living within 20 miles of TMI continued to be upset and had a larger than normal distrust of Federal, State, and utility officials. Workers at both TMI and Peach Bottom also expressed distrust of Federal and State authorities but not of the utilities.

The Pennsylvania Governor's Commission study which was done at about the same time, essentially substantiated the findings of the President's Commission.

The most recent study found that lower forms of mental stress are continuing

The most recent study of the mental attitude of the people around TMI, completed in April 1980 by the Pennsylvania Department of Health, found that the more severe and chronic symptom of mental stress--demoralization--was not long-lived. Lesser forms of stress, however, such as being upset about TMI or concerned about safety for themselves and their families, was higher than normal in about 10 to 20 percent of the population within 15 miles of TMI (as compared to people living beyond 40 miles of TMI).

THE HEALTH EFFECTS OF THE TMI ACCIDENT IN PERSPECTIVE

The various studies concluded that the radioactive releases from the accident will have no or negligible effect on the physical health of individuals. The most serious health effect was found to be severe mental distress which was short-lived in all groups except the TMI workers. Milder symptoms of distress were found to be still continuing in the general population living close to TMI.

The scientific community, however, is unsure about the health effects of exposure to low-level radiation such as that received by the people living near TMI. Because of the lack of unequivocal evidence, the health effects of low-level radiation are estimated by using data from high-level radiation studies. To do this, scientists have assumed that health effects of radiation are proportional to the size of the dose received (i.e., the lower the dose, the lower the health effect). These assumptions, however, are generally believed to be conservative--that is, they tend to overestimate the health effects of low-level radiation. There are a few recent studies that contradict this position, but these have generally been rejected by the scientific community.

In any event, the health effects from TMI were considered negligible by the various TMI studies because of the low estimated radiation dose received by the general population around TMI. These estimated doses were believed to be lower than the doses received from natural background radiation each year.

CHAPTER 3

IMPROVEMENTS IN NUCLEAR POWERPLANT DESIGN, OPERATIONS, AND EMERGENCY PLANNING ARE LONG OVERDUE

For almost the entire history of commercial nuclear power, NRC and the nuclear industry emphasized building reliable plants--plants that would not experience an accident like that at TMI. To do this, NRC devised a "defense in depth" strategy that brought three levels of safety to the design of a nuclear powerplant. The first level of safety stressed the prevention of accidents by using quality standards and engineering practices. This, it was hoped, would lead to a sound design and limit the likelihood of an accident during operation.

Recognizing, however, that equipment failures and accidents will always occur, NRC required a second level of safety to prevent or safely control serious accidents. As part of this approach, NRC identified a series of potentially serious accidents that were likely to happen--called "design basis accidents"--and required special design features in each plant that would prevent these accidents or control their effects.

As a final measure of protection, NRC assumed that these special design features would fail and that radioactive fission products would be released from the reactor. This formed the basis for requiring plant features--such as the massive containment building--that could mitigate the potential consequences of such accidents. This safety measure, over the years, received much less attention than the first two levels of safety.

The TMI investigations, however, identified flaws in this safety strategy. They found that (1) the TMI accident went beyond the "design basis accidents" and created problems that NRC never considered; (2) the methods NRC used to identify potential accidents and design problems were inadequate, and more serious design deficiencies could exist at other plants; (3) the importance of powerplant operations, including the role of plant operators during the accident, had been largely neglected by NRC; and (4) the value of good emergency planning was never considered important, due to the misconceived idea that a major accident would not happen.

More importantly, many of the major deficiencies reported by the TMI investigations had been known by NRC for some time. NRC had either already studied the problems or had been aware of them but had never taken corrective action. Instead,

because of complacency, manpower limitations, or failure to recognize their significance, NRC concentrated its efforts on other items it considered more important and relied on the "defense in depth" philosophy to take care of any unknowns in reactor design and to protect the public from unexpected radioactive releases.

The remainder of this chapter summarizes these deficiencies and describes NRC's and the industry's action in dealing with them.

IMPROVEMENTS IN PLANT DESIGN ARE LONG OVERDUE

The TMI investigations found that the accident resulted from a sequence of events more severe than the system was designed to handle. They identified specific design deficiencies in all types of plants and concluded that NRC does not have a logical system in place to identify and address design weaknesses. Consequently, NRC has failed to include significant safety features in current reactor designs and does not fully understand how reactors will respond in accident conditions.

While no investigation recommended that existing plants be closed or that new plants not eventually be licensed, many recommendations were made to improve NRC's methods of analyzing reactor safety and for determining what design features are or are not important. These include requirements to

--analyze existing plants to determine if new design features should be added to mitigate the effects of core-melt accidents,

--evaluate interactions between safety and nonsafety systems and components,

--evaluate designs using human factors engineering,

--resolve generic safety issues in a timely manner, and

--site future nuclear plants in more remote areas.

Additional design features should be required for core-melt accidents

Present-day powerplants are designed to contain or control very large loss-of-coolant accidents. 1/ This was demonstrated at TMI when the containment building withstood a medium-sized hydrogen explosion and kept large amounts of radioactivity from reaching the public. However, NRC is not sure that any containment building is capable of containing the effects of a complete core-melt accident.

It is generally thought that a molten core, under the right circumstances, would eventually melt through a containment building floor and into the ground, dispersing radioactive particles to the surrounding ground water. But this might be the least-it-could do. Studies have also postulated that a molten core could breach the containment building, resulting in the immediate release of radioactivity to the atmosphere--a situation that could cause many exposures, illnesses, and deaths before evacuation could take place.

This is important because the accident at TMI demonstrated to NRC and others that core-melt accidents (either partial or full core-melts) are possible, no matter how many preventive measures are added to the design. It was recommended, therefore, that NRC require additional powerplant features to mitigate the effects of core-melt accidents. Mitigation does not necessarily mean to "contain or prevent" the release of radioactivity; it may not ever be possible to completely contain a complete core-melt accident. Instead, it could mean delaying the release of radioactivity to the atmosphere so that control or evacuation measures can be completed.

In response to this recommendation, NRC has proposed a rulemaking proceeding that would consider the need for such core-melt mitigating features as

--"controlled filtered venting" systems which would prevent the containment building from overpressurizing during an accident by filtering and then releasing the containment gases to the atmosphere,

--core ladels or "catchers" that would slow down the melt-through of the molten core through the containment floor,

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1/Accidents where a valve sticks open or pipes break, letting reactor cooling water escape.

--hydrogen control measures that would monitor the build-up of hydrogen and remove it through containment venting or some sort of controlled burning or explosion, and

--other specific design features to monitor and limit the release of radioactivity during a core-melt accident.

These features are not new. Although they have been considered and studied by NRC and others for several years, TMI provided the impetus for their serious consideration.

This rulemaking proceeding may, if history is a guide, take several years to complete. The nuclear industry has already gone on record opposing additional plant mitigation features, and much debate will take place before such features are approved or rejected. The industry believes that these features are too costly, considering the low probability of large core-melt accidents. It prefers to continue to emphasize and improve safety features that will prevent nuclear accidents.

In the meantime, existing plants will continue to operate, and new ones will be constructed on the premise that core-melt accidents can be prevented. NRC has, therefore, identified four operating plants, all located in highly populated areas, which it believes should be reviewed immediately to determine if mitigating features should be added to their designs. NRC believes that these plants are in such populous areas that enough time (following a core-melt accident) might not be available to complete an evacuation. Thus, it might require additional mitigating design features to make these plants at least as acceptable as plants in more remote locations.

Interactions between safety and non-safety systems should be evaluated

NRC's licensing review places primary emphasis on those items labeled "safety related." Systems or components not labeled safety related are not considered important to safety, are not required to meet NRC design criteria, are not reviewed in the licensing process, are not required to have backups in case they fail, and do not receive continuing NRC surveillance. In addition, the utility, not NRC, initially designates which systems are safety related and which are not.

A clear distinction between safety and non-safety systems does not exist, and the interactions between the two are numerous, varied, and complex. Not only have these interactions

not been systematically evaluated by NRC or the nuclear industry, but also there are no precise criteria to define which components are safety related. As a result, NRC's past emphasis on ill-defined, safety-related systems and components has caused it to miss important safety issues. For example, the TMI accident was triggered by a failure in a non-safety system and aggravated by a stuck-open relief valve and misleading instrumentation, both of which are also regarded as non-safety related.

The TMI investigations agreed that this was a problem at all plants and recommended that interactions between safety and non-safety systems be studied. NRC, however, had known of this potential problem for some time. In fact, it had started a study in May 1978 that was supposed to look at all systems interactions, including those between safety and non-safety systems. NRC anticipated, however, that this study would not find anything new and would confirm that existing designs and review approaches were adequate--a clear example, in our view, of NRC's closed mind (before TMI) to the significance of potentially severe safety-related problems.

Since TMI, NRC has placed renewed interest in the interaction among various plant systems. In its Interim Reliability Evaluation Program, which will be discussed later in this chapter, NRC has studied one plant to determine what systems are high contributors to risk. It has found that the so-called non-safety systems play a much more important role than ever believed. NRC, therefore, is continuing with its systems interaction study, hoping to identify those items which should receive greater emphasis during the licensing review.

Human factors engineering can improve reactor design

One of the more important lessons learned from the TMI accident is the need to include human factors engineering in the design and operation of nuclear powerplants. Human factors engineering is a discipline concerned with designing equipment and facilities around the needs of human beings. The TMI study groups found that both the industry and NRC had failed to integrate the needs of reactor operators and other plant personnel into the design of present day reactors. Deficiencies were noted in the overall reactor design, control room design, and instrumentation. NRC has known of some of these deficiencies since 1969 but has taken no action. Instead, it chose to believe that designed safety features would safeguard a reactor without reliance on human performance.

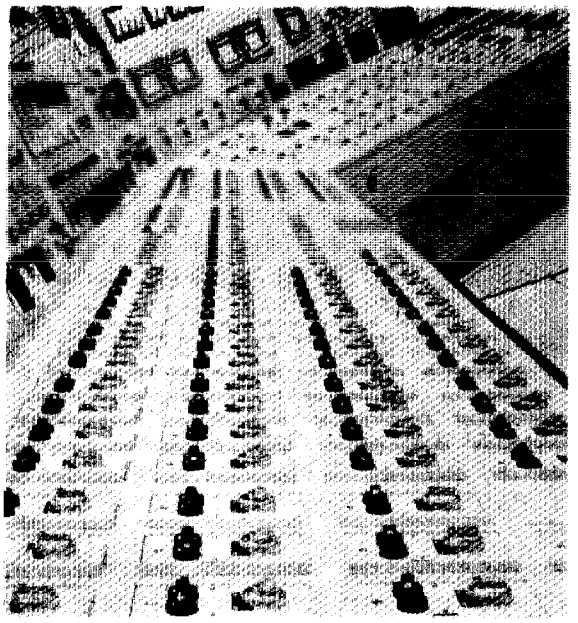
Control room design is a prime example of human factors engineering being virtually ignored by both NRC and the industry. During the TMI accident, the control room instrumentation misled the reactor operators and failed to supply enough clear, concise, and timely information to describe what was happening. As with most control rooms, TMI's was designed to provide information on normal operating conditions but not on abnormal or accident conditions.

NRC was well aware of the problems of control room design. Many studies were done by both the industry and the Federal Government (some dating back to 1974) which told of control room designs that were archaic and which placed unnecessary burdens on the operator, especially in high stress emergency situations. In fact, in many instances operators were found to have "jury rigged" aids such as labeling and color coding to compensate for control room inadequacies. Some of the inadequacies can best be demonstrated by the pictures on pages 18 and 19.

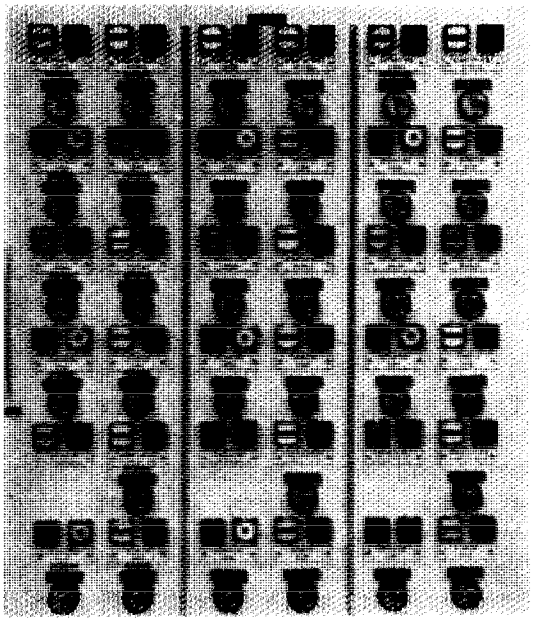
Why did NRC not respond to these studies? Stated quite simply, NRC did not have enough people to review every part of a powerplant's design. It had a limited staff, no systematic method of determining which parts of the reactor design should receive priority attention, and was being pressured by many groups to reduce the time it took to license a powerplant. Thus, NRC placed emphasis on ensuring that accidents would not happen and, if one did, guaranteeing that the design could handle it with little or no operator intervention. These are the areas in which NRC thought it could make best use of its limited resources. Because the operator was not as important under this philosophy, however, NRC did not place a high priority on reviewing individual control room designs.

The TMI studies, quite logically, identified control room design and instrumentation as a major factor in the accident. While not recommending that control rooms be completely torn out and replaced--an operation that might take years--the studies suggested a number of actions to improve both existing and future control room designs.

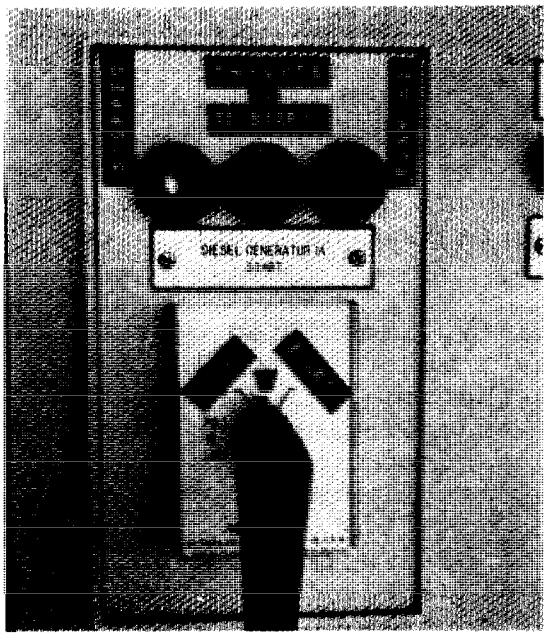
Besides requiring the addition of specific TMI-related instrumentation, NRC is directing all utilities to comprehensively review and upgrade their control room designs and instrumentation. This is expected to take place at some time after August 1980 when NRC completes review guidelines for utilities to follow. In the meantime, several utilities are expected to receive new operating licenses. Instead of waiting until after August, NRC has required each of these, as a condition of licensing, to perform a quick and partial



Massive arrays of identical control/display units with no clearly identified subpanel grouping.

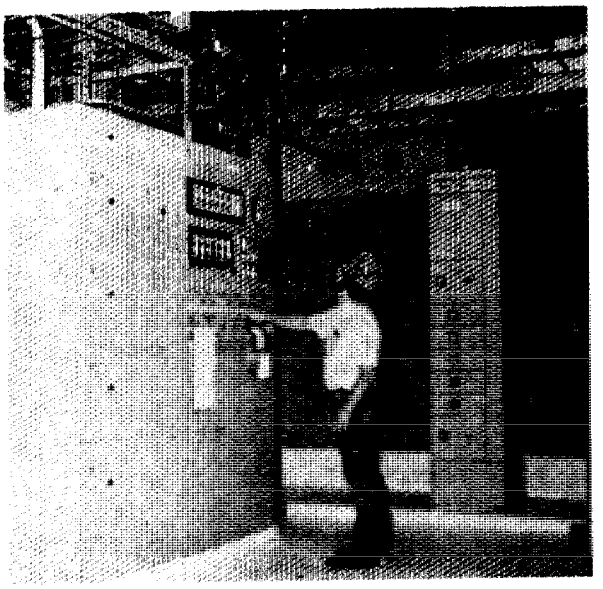


Operators use tape to segregate related panel elements.



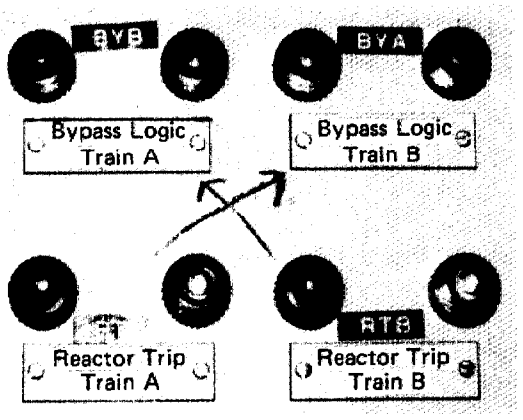
Operators make extensive changes to board labeling.

Novel shape coding of rod motion controls.

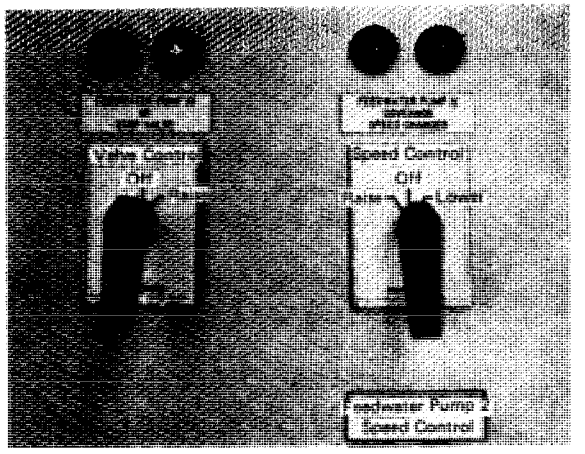


Operator must monitor gauges placed about 12 feet above floor level.

The benchboard provides a natural foothold to replace expended lamps.



Operator improvised cue to alert himself and others to an illogical grouping.



Note the inconsistent positions to the RAISE options on the two adjacent controls.

control room design review. Each will, however, still be obligated to perform the full design review after August. The partial review was only an interim step taken to give NRC some assurance that new plants would not be licensed with major control room design flaws.

Probabilistic risk assessment could be used to augment the design review

In October 1975, NRC issued a document that had been in development for over 3 years. Known as "WASH-1400," the "Reactor Safety Study," or merely the "Rasmussen Report" (after Dr. Norman Rasmussen, the director of the study), this report was often cited by NRC as the most definitive work produced on reactor safety. Using what are known as "probabilistic risk assessment" techniques, the study attempted to make realistic estimates of the risks of using nuclear power to generate electricity. It generally concluded that such risks were much smaller than originally thought and within acceptable societal limits. NRC and the nuclear industry quickly accepted this overall assessment of risk and used it as an endorsement for the safety of nuclear power.

But this was not the greatest value of the "Reactor Safety Study." In fact, the overall numerical assessment of reactor safety soon came under attack and was generally thought to be overstated. Instead, the value of the Study was that it applied new analytical tools to the assessment of reactor safety. These tools could have been further developed and used in the licensing process to

--determine the relative importance of various powerplant safety features so that NRC could better establish review priorities,

--evaluate alternative approaches to resolve outstanding safety issues, and

--determine the need to implement new design requirements on operating powerplants.

NRC, although endorsing these new analytical techniques, never adopted them for systematic use in the regulatory process. Instead, it continued to use the licensing methods that had been developed over the years and with which it was most familiar. These methods had helped create a high-technology industry with an almost spotless safety record, and NRC was convinced that it had achieved the best method of nuclear regulation, considering its financial resources and manpower.

Not until TMI did NRC realize the importance of using probabilistic risk assessment techniques in the licensing process. The TMI investigations found that the accident involved many problems that had previously been ignored by NRC but which were identified as high-risk contributors in the "Reactor Safety Study" (i.e., small loss-of-coolant accidents, relatively routine transients, multiple failures of equipment, and human error). This lead to recommendations that NRC begin using risk assessment to augment its current licensing process and identifying which accidents are important and which approaches are best to reduce their probability and consequences.

In response, NRC has already started to use risk assessment in some parts of its licensing process. Possibly the most important, at this time, is in the newly created Interim Reliability Evaluation Program. In this program, NRC is attempting to use risk assessment techniques to evaluate accident sequences at individual operating reactors. This, NRC hopes, will identify weak spots in the plant designs and lead to corrective actions. At present, NRC is doing a pilot study on one plant and hopes to do studies on four or more plants by early next year. Beyond that, plans are uncertain. NRC could decide to do similar reviews on all operating powerplants; require each utility to do the review on its own plant, subject to NRC review and verification; or require the utility to do a concurrent review in addition to the one done by NRC. The option selected will depend on resources available and agency priorities.

Clearly NRC seems to have recognized the value of probabilistic risk assessment. It is attempting to use these techniques to improve reactor safety and to provide a more rational decisionmaking process. Much is yet to be done before these techniques become an everyday part of the licensing process, but NRC appears to be moving in the right direction.

Generic safety issues receive a lower priority

The resolution of generic safety issues has been a matter of congressional and public concern for quite some time. NRC determines safety issues to be "generic" when they are related to a particular class or type of nuclear facility rather than a specific plant. The TMI investigations that examined generic safety issues found that once a safety issue is labeled "generic," NRC removes it from the licensing process. By so doing, one investigation found, NRC effectively removes incentive for licensees to

resolve these items. Responsibility then falls on NRC, which has a history of leaving generic safety problems unresolved for a period of years.

The TMI investigations that examined generic safety issues believed that many of these unresolved issues contributed to the accident at TMI. One investigation even went so far as to say that resolution of certain generic issues could have prevented or altered the course of the accident. These investigations reported that NRC's inability to resolve significant safety issues could be remedied by requiring deadlines for resolution or by Congress' holding NRC accountable with respect to such issues.

NRC, before TMI, had already gone through the process of identifying generic safety issues, prioritizing them according to their safety importance, and developing plans to resolve those considered most important to safety. The observations made by the TMI study groups, however, are still valid. NRC does not have a good track record for disposing of outstanding generic safety issues. In addition, this situation may be aggravated by the staff resources needed to study and resolve TMI-related findings and recommendations.

For instance, NRC has identified 133 generic safety issues, 22 of which have been classified as needing immediate attention. Of the 142 staff-years previously programmed for resolving these issues over the next 2 years, NRC is planning to use 73 of them to study and resolve TMI-related issues. This means that only the highest priority generic issues will continue to receive NRC's attention. The rest will be deferred until specific TMI-related safety concerns are resolved.

Powerplant siting should be the final level of public protection

From the early days of commercial nuclear development until the mid-1970s, NRC permitted nuclear powerplants to be located closer and closer to high-population centers. Additional engineered safety features gradually took the place of remote siting as the final level of public protection against radioactive exposures. Consequently, nuclear powerplants are now located very close to New York City, Chicago, and other major metropolitan areas.

In the mid-1970s, NRC recognized the importance of this trend and established population guidelines for various zones surrounding nuclear powerplants. Since then, NRC has

been moving informally toward requiring reactors to be sited farther from large population centers.

The TMI studies recognized NRC efforts during the past few years but recommended that siting provisions be formalized as part of NRC's regulations. NRC agrees with this recommendation and is proposing that a rulemaking procedure be used to establish minimum population exclusion distances around future plants. Before entering such a rulemaking proceeding, however, NRC plans to evaluate the safety features generally common to present-day reactors--using probabilistic risk assessment techniques--and to determine what reasonable exclusion distances should be established. These distances will be subject to scrutiny by the public and other interested parties and could be revised during the rulemaking proceeding. Once established, however, every new powerplant will have to meet the exclusion distances regardless of the engineered safety features added to the plant's design.

POWERPLANT OPERATIONS HAVE BEEN NEGLECTED

The TMI accident raised genuine concerns about the ability of utilities to ensure the safe operation of nuclear plants and to react to emergency conditions. These concerns stemmed from the utility's inability to cope with the unexpected events that occurred and were reinforced by other findings which disclosed that neither the utility's operating practices and procedures at TMI nor NRC's review of those procedures was adequate.

Specific operational problems found by the TMI investigations were the need to

--improve the training of operators and other plant personnel and to upgrade experience and education requirements for operators;

--collect and analyze operating experience to identify safety implications and ensure that the results are communicated to all licensees;

--review and analyze operating and emergency procedures to ensure that they clearly set forth the actions to be taken by operators, particularly when abnormal events occur; and

--expand utility quality assurance programs to all system components that may affect plant safety and assure utility compliance with program requirements.

NRC has taken action and has made proposals to correct these deficiencies. For the most part, we agree with the intent of the proposed solutions, but found that many have not yet been definitized to the point where we can determine how effective they will be.

Training and qualifications of plant operators and other personnel must be improved

Many of the TMI investigations reported that the qualifications and training of TMI personnel were inadequate and that this contributed significantly to the seriousness of the accident. More importantly, the investigations discovered that the situation at TMI was no worse, and maybe a little better, than at other plants across the country. In response, NRC has required some short-term actions to improve the quality of supervision at all reactor sites and has proposed, along with the industry, other long-term actions to upgrade the general level of technical expertise of plant operators, supervisors, and other plant personnel.

Generally, the TMI investigations found that NRC and the nuclear industry had neglected and largely underestimated the value of plant operators and other personnel during an accident. At TMI, the operators lacked the technical knowledge to understand what was happening to the reactor and took certain actions that caused the accident to be more serious than it should have been. Although the design of the plant and the inadequate control room instrumentation contributed significantly to the accident, the investigators concluded that more knowledgeable and better trained personnel might have averted the uncovering of the reactor's core.

The finding of the TMI investigations included criticisms of an NRC regulatory program that set no minimum educational requirements for plant operators and did not review the substance or adequacy of utility training programs. Instead, NRC emphasized the testing of plant personnel as part of a formal operator licensing program. If the personnel passed the test, they were considered qualified and were licensed to operate a nuclear powerplant. These tests, however, were not adequate to judge the operators' ability to run a powerplant, particularly in accident situations. Not only did the tests fail to measure the ability and knowledge of the operators, but they also allowed the operators to fail certain parts and still pass the overall exam.

Likewise, the nuclear industry was criticized for not doing a better job of preparing its personnel to understand and control a powerplant during abnormal operating

conditions. Most training, including simulator training, was geared toward preparing the operator to run the plant during routine situations, instead of understanding or coping with the unexpected. Also, the training programs at TMI, which are thought to be typical, were either understaffed or run by people who had no better educational qualifications than the people they were training; the supervisory and management personnel at TMI were unable to contribute very much during the accident because they lacked familiarity with the plant; and the real operation of the plant was left to underqualified and undertrained plant operators, who were not able to understand the accident.

To solve these problems, a number of recommendations were made to upgrade the qualifications of plant personnel and to improve the overall quality of utility training programs. In some cases, NRC has already taken action. For instance, it has proposed that each shift supervisor have a Bachelor of Science degree in engineering and each reactor operator have some engineering training. Until these people can be hired (or until the existing people can upgrade their qualifications) NRC has required utilities to appoint shift technical advisors who must have engineering expertise. The primary role of these advisors is to be on-site at all times and assist shift supervisors if an accident occurs.

In addition, NRC has

--required additional plant personnel to relieve the shift supervisors of administrative duties and permit them to concentrate on plant operations;

--required utilities to hire, by July 1982, additional qualified reactor operators for each shift;

--started efforts to revise the scope and criteria for licensing exams given to prospective plant operators;

--proposed that licensees develop and conduct in-plant drills for both normal and abnormal operating conditions and to test the adequacy of reactor and plant operating procedures;

--started efforts to study and improve reactor simulators; and

--started long-term efforts to develop new regulations for training and qualifications of reactor operators and other plant personnel.

The nuclear industry has also taken steps to improve the quality of plant operators and utility training programs. Recognizing that it has the most to lose if another TMI occurs, the industry is attempting to assume a greater role in determining safety criteria. In this respect, it created a new organization called the Institute of Nuclear Power Operations. This group is attempting to set industry-wide benchmarks for excellence in the management and operation of nuclear powerplants and to upgrade each utility organization to those benchmarks. It hopes to review and analyze all existing utility training programs and to establish educational and training requirements for all plant personnel.

Clearly, these actions show that NRC and the industry have discovered the importance of people to the safe operation of nuclear powerplants. But much is yet to be done. It is not going to be easy for the industry to upgrade the qualifications of plant operators, improve their training programs and simulators, or find new engineers to meet NRC's revised staffing requirements. Likewise, NRC already has its ranks thinned by new TMI requirements and will have difficulty in monitoring or controlling the industry actions that have been proposed or required to improve operator training and qualifications.

This latter point is important because two of the major TMI investigations recommended that NRC take a direct role in training operators. The NRC Special Inquiry, for instance, suggested that the industry would not sufficiently upgrade its training programs unless pushed by NRC. It recommended, therefore, that NRC certify training facilities, establish a minimum training curriculum, and certify instructors. The President's Commission on TMI recommended similar roles for NRC. In response, NRC has initiated studies to reassess the requirements for selecting, training, and licensing reactor operators and other plant personnel. One of these studies will address the NRC certification of a training curriculum, facilities, and instructors.

Operating experience has not been used to improve safety

One finding that we had reported on in the past 1/ and that was highlighted by several TMI investigations, was the failure of NRC to improve reactor safety by systematically

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1/"Reporting Unscheduled Events at Commercial Nuclear Facilities: Opportunities to Improve Nuclear Regulatory Commission Oversight," EMD-79-16, Jan. 26, 1979.

evaluating nuclear powerplant operating experience. The NRC Special Inquiry did a particularly good job of explaining this issue and describing what action NRC should take.

In short, the Special Inquiry noted that previous accidents had occurred that were very similar to the accident at TMI. The difference was that the operators recognized the nature of the problem and took corrective action before the situation became serious. Neither NRC nor the industry, however, had any structured system in place to evaluate the significance of these accidents or to disseminate important lessons learned to other plant operators. Thus, the TMI operators did not learn of the other accidents until it was too late.

But this was not viewed as an isolated example. The Special Inquiry concluded that NRC and the industry have done almost nothing to systematically evaluate the operation of existing reactors, pinpoint potential safety problems, and eliminate them by requiring changes in design, operating procedures, or control logic. It found this an "unacceptable situation that compromises safety and that cannot be allowed to continue."

In response to this criticism, NRC has been attempting to establish an integrated program to systematically collect, review, and analyze information on operating experience. Among its actions, NRC has

--created a special "Office for Analysis and Evaluation of Operating Data" that will serve as the central point of coordination for data collection and analysis both within and outside of NRC;

--required each major office in NRC to establish a group to perform special analyses in support of the new office mentioned above;

--contracted with a Department of Energy national laboratory to evaluate the significance of foreign reactor experience to U.S. operating reactors;

--started several research efforts to determine failure rates for nuclear powerplant components and to look for problems relating to particular types and sizes of plants or to specific manufacturers;

--proposed that each utility develop onsite capability to evaluate operating experience and to feed this information to NRC and back into its own training programs; and

--proposed that utility reporting requirements be improved to ensure that all safety-related events are consistently and accurately reported.

In addition, NRC is trying to coordinate activities with two new industrial organizations that will also be reviewing powerplant operating experience and looking for events with safety significance. These groups are the Institute of Nuclear Power Operations, which was mentioned earlier, and the Nuclear Safety Analysis Center, both of which are outgrowths of TMI. The first group will look at operating experience from a human factors standpoint--how can or did the experience relate to operator performance and training. The second group will look at operating experience and events from a hardware standpoint--was the event caused by the failure of a particular design or piece of equipment and what are the implications of this on other plants.

These efforts appear impressive, but it is much too soon to tell how effective they will be. NRC's program is just beginning, and it will be some time before results of increased surveillance of operating experience will be evident.

One potential problem, however, is that the program is still fragmented. Each major NRC office is still responsible for analyzing specific operating events and accidents either on its own or at the request of the new Office of Analysis and Evaluation of Operating Data. This creates some duplication of effort and fails to focus the review and analysis of operating data into one central office. This could, depending on the degree of management support given to the new office, dilute its power and reduce its effectiveness in correcting safety deficiencies.

For instance, the new office must depend on (1) other NRC offices to help review and analyze powerplant operating experience and (2) top-level NRC management to support its recommendations and ensure they are effectively implemented. In other words, the new office does not appear to have either the manpower or the authority to guarantee an effective review and analysis of operating experience without the cooperation and support of other NRC entities. Therefore, although clearly an improvement, the success of the newly created office is dependent upon factors that could vary with the changing priorities and management structure of the agency.

Operating procedures need to be more clearly written

Every nuclear powerplant is required to have written procedures that govern operating or emergency situations.

Plant operators not only have to be thoroughly familiar with these procedures but also have to know which one to use in a particular situation.

Perhaps the most important procedure from the standpoint of the TMI accident was the one governing a loss-of-reactor coolant and pressure. The TMI investigations concluded, however, that this procedure was poorly written, difficult to follow, and included confusing terminology. More importantly, the procedure, if followed, would not ensure that the integrity of the core would be maintained in the event of a loss-of-coolant accident.

The investigation groups not only recommended that more attention be paid to writing, reviewing, and monitoring plant procedures, but also that greater care be taken to ensure that the procedures reflect both engineering and operating practicalities. They suggested that NRC increase the number of procedures it reviews and place greater emphasis on auditing the technical content of the procedures.

In response, NRC has directed all operating licensees (and soon-to-be-licensees) to analyze their procedures governing reactors accidents and submit the results for NRC review. Some of these plant reviews have already been completed. In addition, NRC plans to institute a long-range program to study how plant procedures should best be written; the interrelationships among administrative, operating, maintenance, and test procedures; and the depth and content of NRC's regulatory review. Also, NRC's inspection procedures will place increased emphasis on reviewing utility operating and emergency procedures.

Quality assurance programs have been neglected

The investigation groups that reviewed Metropolitan Edison's quality assurance program were critical of the utility's and NRC's roles in applying and reviewing the program. One group concluded that the deficiencies in the quality assurance program at TMI were a factor in the accident.

In constructing and operating nuclear powerplants, many regulatory and industrial standards must be followed to ensure that the plants are built and operated safely. To measure compliance with these standards, every utility is required to have a quality assurance organization that is separate from, and independent of, the utility's other operating departments. In short, this group audits the performance of

the rest of the utility organization to ensure compliance with established requirements.

NRC's role in this area is to review the quality assurance organization of each utility and guarantee that it is properly staffed and is effectively doing its job. NRC does not perform quality assurance operations itself; it merely audits the utility to ensure that such operations are being properly carried out.

The TMI investigations reported several deficiencies in the quality assurance program at TMI. One of the more serious deficiencies is that the program did not extend to non-safety related hardware or to radiation survey instruments. This is important because several non-safety related pieces of equipment played a major role in the accident: the power-operated relief valve that stuck open, the thermocouples that were so important in determining the temperatures inside the reactor system, and the condensate polisher--the piece of equipment that started the accident. In addition,

--two of four radiation monitors were not working at the time of the accident, and more than half of the radiation survey instruments were not operational;

--there was no licensee plan to review quality assurance operating procedures, although such reviews are required every 2 years;

--problems identified by the utility in the quality assurance program were not resolved in a timely manner; and

--not enough people were available to do the required quality assurance inspections.

Although the review of a utility's quality assurance organization is part of NRC's function, the TMI investigations reported that most of NRC's review takes place before the operating license is issued. Very little is done after the plant begins to operate to determine the adequacy of the quality assurance procedures or to follow up on identified problems. For instance, NRC knew of the problems associated with the radiation survey instruments but took no action to ensure that the problems were resolved.

To correct these problems, the investigators recommended that the industry and NRC set higher quality assurance standards and extend quality assurance coverage to non-safety items. They also suggested that NRC extend its coverage and review of utility quality assurance programs.

In response, NRC has acknowledged the importance of quality assurance programs in all phases of nuclear powerplant design, construction, and operation. It has reaffirmed that adequate quality assurance programs are a proper condition for all construction permits and operating licenses and has begun to take a more active role in reviewing those programs. In addition, NRC is planning to develop new guidelines for determining what equipment is important to safety and should be covered by the utilities' quality assurance programs.

As with most newly proposed actions by NRC, however, much is yet to be done. How many resources and what priority NRC assigns to these tasks will determine how well the problems will be corrected. At this stage, it is too early to tell.

EMERGENCY PLANNING AND EVACUATION PROCEDURES MUST BE IMPROVED

The TMI accident demonstrated that no one was adequately prepared for a nuclear emergency. NRC, thinking that large accidents were very remote, paid little attention to either its own emergency planning procedures or those of the utility and State and local governments. Consequently, the role of NRC during the accident was ill-defined, the local governments around TMI had no emergency plans which included adequate procedures for evacuation, and the TMI utility was not adequately prepared to deal with the radiological aspects of the accident.

In this respect, we issued a report on March 30, 1979, 1/ (two days after the TMI accident) which told of many of these deficiencies and recommended that nuclear powerplants begin operation only when State and local emergency response plans meet all the NRC requirements. NRC disagreed with this recommendation (NRC had commented on the report prior to the accident), stating that we had exaggerated the problem and that such plans are not essential in determining whether nuclear powerplants could be operated without undue risks to public health and safety.

Since the accident, NRC has apparently changed its attitude and taken a number of specific actions designed to improve its own emergency response capability as well as those of the utilities and the State and local governments.

1/"Areas Around Nuclear Facilities Should Be Better Prepared for Radiological Emergencies," EMD-78-110, Mar. 30, 1979.

For instance, it has established six teams to travel to all nuclear powerplants and assess the emergency planning and preparations of each. It has also signed a Memorandum of Understanding with the Federal Emergency Management Agency that tranfers to that Agency the lead responsibility for reviewing State and local emergency plans. In addition, the Congress has directed, and NRC has begun to act on, recommendations to make the licensing of new plants conditional on the development of acceptable emergency plans.

NRC disorganization led to poor management of the emergency response

One of the more disappointing aspects of the TMI accident was the emergency response of NRC. The accident clearly demonstrated that NRC had grown complacent over the years and had never planned for the situation into which it was thrust.

Possibly the most important observation of many of the TMI investigations was that NRC did not know its role during the accident. It had always been thought that any accident would be short-lived and that the utility would, by necessity, be responsible for making all safety-related decisions. Thus, NRC's emergency response capability was geared to monitor the utility's response, not to provide any real-time or immediate decisions that would affect the utility's actions.

TMI was not short-lived, however. The accident itself lasted most of the first day, and the threat of additional problems lingered on for several more days. It was during this situation that NRC's emergency response weaknesses became evident. For instance, the NRC group sent to the TMI site on the first day of the accident lacked detailed knowledge of the plant and could not effectively report on what they first observed. In addition, this group was not given any specific instructions, did not know who was in charge, lacked enough people to respond to requests for information, and was inadequately equipped.

On the second day of the accident, NRC sent another team to the site but again without any specific instructions. This group set up a different organizational structure and acted independently of the first NRC group. NRC did not have a coordinated onsite effort until the third day of the accident when, at the request of the President, an official NRC representative was sent to TMI.

Meanwhile, at NRC headquarters in Bethesda, Maryland, a special organization of senior NRC officials and support staff convened to monitor the TMI events and to give specific

direction if needed. Their contribution was limited, however, because of poor communications with the site and a general lack of information on what was happening. In addition, this organization, called the Incident Response Center, was poorly planned and managed. No one seemed to know who was in charge or clearly understood their roles. As a result, major decisions were sometimes made haphazardly and without the benefit of all the facts. In one particular instance, the Response Center recommended--without notifying the Commissioners--that the State evacuate up to 10 miles from the plant. The State refused, however, because it had better information and knew that evacuation was not necessary. NRC officials at the TMI site also knew that evacuation was unnecessary, but were not consulted before the evacuation recommendation was made.

A host of recommendations were made to improve this situation. Among the more important were suggestions that NRC (1) designate a single executive to manage and coordinate NRC's emergency response functions; (2) transfer the management of NRC's overall accident response to the powerplant site as soon as possible, with the headquarters serving as back-up or support; (3) provide direct communication links between plant sites and NRC headquarters; and (4) develop a policy statement on NRC's role in response to nuclear accidents.

In response, NRC has taken several actions to improve its emergency response capabilities:

--The Chairman of NRC has been designated to take over and manage NRC's emergency response activities.

--New emergency response procedures are being developed.

--Direct telephone lines have been installed between each operating powerplant and NRC headquarters.

--Studies are being done to determine the feasibility of installing equipment at each plant that would transmit vital plant information directly to NRC headquarters.

--NRC personnel are being trained and drilled in emergency response procedures.

These actions, if fully implemented, will help to improve NRC's emergency response capability.

Planning for nuclear emergencies by State and local authorities was inadequate

During the accident, State, county, and local governments were largely unprepared to respond to the emergency. Particularly deficient were the local communities around TMI. Lacking any adequate emergency evacuation plans, these communities did the majority of their emergency planning during the accident.

Until TMI, no one was particularly concerned about the lack of nuclear emergency evacuation plans. In fact, NRC fostered an attitude that major radioactive releases would not happen and never took steps to ensure that States and local governments had adequate plans and resources to deal with nuclear emergencies. Indeed, NRC considered the probability of a large accident so remote that emergency planning never received proper attention or funding at any governmental level.

While NRC requires each utility to plan for offsite releases of radioactivity, the utilities' major responsibilities generally stop at the powerplant site boundaries. Beyond that point, the States have the primary responsibility to plan for any protective action needed to deal with the releases. One of the TMI investigations reported, however, that the degree of emergency planning differs substantially from State to State, depending on local concern and interest. The investigations attributed this to NRC's failure to effectively plan for emergencies and require each State to meet those plans as a condition of licensing nuclear powerplants.

As far as TMI is concerned, Pennsylvania had emergency plans, but they had not been approved by NRC. More importantly, Pennsylvania's plans relied on the county and local governments to execute any needed evacuations. While counties within a 5-mile radius of the plant had developed plans for this purpose, the major TMI investigations found that no counties beyond the 5-mile radius or any communities in the area had prepared for potential evacuations. These local governments had to react very quickly when NRC and the State began to discuss potential evacuations up to 20 miles from the plant. This lack of planning, according to one investigation, could have caused important delays if an immediate evacuation had been necessary.

To solve these problems, the investigators recommended that renewed emphasis be placed on developing State and local emergency and evacuation plans. To do this, the investigators generally thought that all operating licenses should be

conditioned upon the State and locality having federally approved emergency plans and suggested that Federal funds be used to help develop these plans. One study cautioned, however that strict compliance with this requirement could give local municipal governments the power to close a plant by refusing to develop emergency evacuation plans.

The investigators did not believe, however, that NRC should be the agency to review, approve, and coordinate State and local emergency plans. Instead, they recommended that the new Federal Emergency Management Agency perform this function. This agency was created by the President in 1978 to serve, among other things, as a single point of contact for State and local governments in all types of Federal emergency planning and preparation.

It was also recommended that NRC determine how far a local government must plan for potential evacuations. In other words, NRC was recommended to develop a "minimum evacuation planning zone," where local jurisdictions must be able to safely evacuate their people within prescribed time periods. For those plants that could not meet this new criterion, one study suggested that they remain open only if the President determines that continued operation is vital to national interests.

NRC has taken several actions in response to these recommendations. For instance on January 14, 1980, it signed a memorandum of understanding with the Federal Emergency Management Agency that tranfers NRC's responsibility for evaluating State and local emergency plans. The administration, in turn, has requested a supplemental appropriation for this agency which includes $2.7 million to help State planners develop emergency response plans.

In this latter case, NRC's fiscal year 1980 authorization act (signed by President Carter on June 30, 1980) provides, in essence, that NRC shall issue an operating license for a nuclear plant only if (1) the State and local governments have federally approved emergency plans or (2) NRC determines that existing emergency plans provide reasonable assurance that public health and safety is not endangered by operation of the plant.

The bill does not deal with existing plants and their need to have adequate emergency plans as a condition for continuing to operate. NRC, however, is taking measures to upgrade emergency plans at all existing nuclear powerplants and to ensure that each has the capability to handle a nuclear emergency.

Radiological equipment and training at TMI was deficient

During the TMI accident, the utility could not perform certain radiological monitoring duties because of inoperable equipment and untrained personnel. For example, less than one-half of the utility's portable radiation dose rate instruments were operable at the time of the accident. This directly contributed to unnecessary radiation exposures of some TMI personnel. In one instance, a TMI employee was required to enter the auxiliary building without a radiation detection instrument--none was available at the time--and unknowingly received a dose of 1.25 rem.

In addition to this type of equipment problem, one TMI investigation found that 48 TMI employees had not been trained to perform certain required emergency response duties. Nevertheless, these employees were assigned to radiological monitoring and repair teams during the accident and generally demonstrated a lack of understanding of their emergency duties. In particular, they were unable to operate radiation air samplers.

In response, NRC has increased its surveillance of utilities to ensure that they comply with radiological emergency requirements.

CHAPTER 4

MAJOR IMPROVEMENTS ARE NEEDED IN NRC'S ORGANIZATION, MANAGEMENT, AND METHODS OF REGULATION

The accident at TMI highlighted many of the organizational, managemental, and regulatory deficiencies that have been known to exist at NRC for some time. Because of the severity of the accident, however, NRC can no longer disregard its critics by citing the safety record of the industry it regulates. It must now demonstrate the willingness and capability to comprehend its weaknesses and to take corrective action.

The TMI investigations--particularly the "President's Commission on the Accident at TMI" and NRC's "Special Inquiry" --stressed many of the management weaknesses of the presently constituted Commission and recommended many changes, even to the point of eliminating the Commission in favor of an agency headed by a single administrator. Other findings and recommendations centered around deficiencies in the management and organization of the NRC staff and their inspection roles and methods of regulation.

In response to the recommendation to restructure NRC, the President announced an amended reorganization plan on May 5, 1980. While the plan will not abolish the Commission, it makes the Chairman the principal executive officer and spokesman for NRC. We endorse this plan and believe that it offers an opportunity for an effective management structure at NRC.

THE COMMISSION FORM OF MANAGEMENT AS PRESENTLY CONSTITUTED IS NOT WORKING

The most significant finding of both the President's Commission and the NRC Special Inquiry is that the Commission form of management, as presently constituted, has not worked. They both recommended, with some variations, the abolition of the five-member Commission in favor of a single administrator, responsible to the executive branch and subject to congressional oversight.

The NRC Special Inquiry gave some very convincing arguments why it was not enough to merely increase the powers of the Chairman. Possibly the most important is that NRC has been paralyzed in the past few years because, as an independent Commission, it has been pressured into considering and resolving

competing public attitudes about nuclear power in every individual safety decision. The Special Inquiry felt that decisions about the ultimate safety goal of the regulatory programs, plus the decision to expand or reduce this country's reliance on nuclear power, should be made or concurred in by the executive and the Congress as part of the Nation's overall strategic energy policy. A nuclear regulatory administration, working through the executive branch but subject to congressional oversight, was thought to be better suited for this type of regulation.

Many other reasons are given in these reports for the poor performance of the Commission. Some of the more important are that:

--The Commissioners have not clearly defined either their own roles in nuclear regulation or their relationship to the Executive Director for Operations and the major NRC staff offices.

--The Commissioners have adopted certain ex parte rules that are intended to preserve their impartiality in licensing proceedings but, in effect, are unnecessarily severe and have effectively prohibited the Commissioners from talking with the staff--their best source of information about reactor safety. As a consequence, artificial barriers have been set up between the Commissioners and the staff, and communications are handled in a stiff and formalized manner.

--The Commission has traditionally spent the bulk of its meeting time on specific, isolated, safety-related matters, administrative chores, and such issues as export licensing rather than deliberating or deciding the broad, important issues relating to reactor safety. For instance, the Commission has not established measurable safety goals and objectives or ways to effectively evaluate the performances of its regulatory operations. Thus, the staff is left to define for itself what level of safety is enough and whether its performance adequately protects the public health and safety.

--The present statutes give each commissioner equal responsibility and authority in all decisions and actions of the Commission. While the Chairman has some undefined administrative and executive functions as the principal executive officer, the real authority and power of the agency resides in collegial action and not in the Chairman. This has resulted in inefficient management and contributed to the bureaucratic

jealousy and uncooperative attitude that exists between major NRC offices.

--The Executive Director for Operations, the chief executive officer under the Commission, lacks the authority to effectively manage or limit the powers of the five major NRC office directors. Thus, NRC basically consists of five separate organizations managing themselves--each able to bypass the Executive Director for Operations and report directly to the Commission.

We are basically in agreement with the findings of both the President's Commission and the NRC Special Inquiry as it relates to the past performance of the Commission. In a report issued in January 1980 on NRC's progress over its first 5 years, 1/ we reported similar problems with the Commission form of management. We did not agree, however, with the recommendations that have been proposed for solving the management ills of NRC, namely to eliminate the Commission in favor of a single administrator. Recognizing that a single administrator would probably provide the most efficient way of regulating nuclear power, we concluded that a Commission is clearly superior in deciding long-term nuclear safety policy questions and in providing continuity of regulation and independence from the policies and actions of the executive branch.

The President proposes an acceptable NRC reorganization plan

As stated earlier, on May 5, 1980, the President announced an amended reorganization plan for NRC. This plan, which is supposed to take effect on October 1, 1980, substantially strengthens the role of the NRC Chairman, while maintaining the overall authority of the Commission for such things as policy formulation, rulemaking, and adjudication--the areas where collegial deliberations are important.

The highlights of the President's NRC reorganization plan are that:

(1) The Commission would continue to be responsible for policy formulation, rulemaking, and adjudication--functions which should have collegial deliberation.

1/"The Nuclear Regulatory Commission: More Aggressive Leadership Needed," EMD-80-17, Jan. 15, 1980.

(2) The Commission would still be the ultimate authority in NRC and would set the overall framework within which the Chairman would operate.

(3) The Chairman would be the principal executive officer and spokesman for the Commission. His duties would include the authority to

--make most appointments to NRC staff positions, with only the upper-level officials subject to Commission approval;

--direct the Executive Director for Operations and the NRC staff as he considers necessary to carry out the requirements of the Commission;

--determine the use and expenditure of funds of NRC within guidelines approved by the Commission; and

--act for the Commission in an emergency, including the functions of declaring, responding, issuing orders, determining specific policies, advising the civil authorities and the public, and directing and coordinating actions relative to such emergency situations.

(4) The Executive Director for Operations would have increased authority and responsibility, subject to direction and supervision by the Chairman, to manage the day-to-day administrative and regulatory activities of NRC.

(5) The Chairman would conform to the policy guidelines of the Commission and keep it fully informed about matters within its functions and authority.

The plan makes it very clear that the Chairman and the Executive Director for Operations will run the day-to-day activities of NRC, within the overall guidelines and policies of the Commission. The five major Office Directors, will no longer routinely report to the Commission. Instead they will report directly to the Executive Director for Operations who, in turn, will be responsible to and supervised by, the Chairman. The head of any component organization within NRC can report to individual Commissioners or to the Commission only when that person believes a serious health and safety or security problem has not been properly addressed.

The Commission, on the other hand, will be freed of the burden of everyday administrative management and will be able

to concentrate its efforts on safety policy issues and on overseeing and directly participating in major licensing decisions--areas which it has neglected in the past.

We endorse this reorganization plan. It offers, in our opinion, an opportunity for an effective management structure that recognizes specific and well-defined roles for the Commission, the Executive Director for Operations, and the Chairman. The success of the plan, however, will depend on how forcefully it is implemented. The Chairman's responsibilities are very broad, requiring a manager who will assume responsibilities and make tough decisions. He must be capable of not only wresting the control of the agency away from the major staff offices but also keeping the Commission out of the day-to-day management functions for which he is now responsible. If this does not take place, the new organizational structure will, in effect, be no better than the old.

NRC'S STAFF MANAGEMENT AND METHODS OF REGULATION CAN BE IMPROVED

Some of the TMI investigation groups spent a large amount of time reviewing NRC's licensing and inspection programs, attempting to understand how they work and how they could be improved. For the most part, we found these reviews to be insightful and supportive of many of the recommendations that we have made over the past few years. Some of the more procedural-related findings of the TMI study groups and our past reports include the need for NRC to

- --establish realistic licensing criteria and goals on which its performance can be guided and evaluated;
- --eliminate the two-step licensing process in favor of mandatory, standardized designs coupled to a one-step licensing review;
- --review and strengthen the role of the Advisory Committee on Reactor Safeguards to better provide an independent check on safety matters;
- --create additional boards and offices to oversee NRC's performance and ensure that safety issues are properly addressed;
- --provide a more meaningful role for the public in the licensing process, even to the point of providing funding, and legal and technical counsel to potential intervenors; and

--eliminate the Atomic Safety and Licensing Appeal Board so that the Commissioners would have to rule on each licensing application that is appealed.

How safe is safe enough?

One of the major criticisms that has been leveled at NRC, particularly by the nuclear industry, is its refusal or inability to determine the desired level of safety in nuclear powerplant design and operation. Are the plants that have been operating safely for a number of years safe enough? If so, why is it necessary to continually place additional safety requirements on new plants? If not, how can NRC justify the continued operation of older plants without requiring the addition of the new safety features? These are questions that have plagued NRC over the past few years and which have not yet been answered to the satisfaction of either the industry or the public interest groups that oppose nuclear power.

The TMI investigations basically found this criticism of NRC to be justified. They reported that the statutes as well as NRC regulations and standards were absent of any specific criteria which set definitive safety goals or which specified an acceptable level of risk in nuclear power generation. Instead, NRC has been regulating by such vague phrases as "adequate protection," "reasonable assurance," and "no undue risk." This requires a large amount of judgment by the individual NRC staff reviewers and often results in the misapplication of priorities during the licensing reviews and the imposition of new regulatory requirements without knowing their true contribution to overall safety.

To solve this problem, the NRC Special Inquiry and the NRC Lessons Learned Task Force proposed that NRC place a high priority on establishing an acceptable safety goal of reactor regulation--in effect, to determine what level of safety is desirable. The NRC Special Inquiry thought that it might be possible to use probabilistic risk assessment techniques to establish quantifiable safety standards and to analyze reactor designs and operations against them. The NRC Lessons Learned Task Force agreed but also thought there were other acceptable ways and methods to establish safety goals.

The Lessons Learned Task Force was not as concerned about the type of safety goal established as it was about the need for specific guidance for the NRC staff to follow in the regulation of nuclear power. It described a situation where the staff has (without a prescribed safety goal or objective) charted its own course and, on an ad hoc basis, determined for

itself what level of safety is acceptable. Unfortunately, the Task Force reported that this level of safety has been inconsistently interpreted and applied by the staff, creating indecision and confusion about the safety objectives of the agency.

We agree with these findings and recommendations and believe that the establishment of precise safety goals or objectives should be a high-priority item at NRC. In our January 1980 report on NRC's progress over the past 5 years, we found that the lack of these goals and objectives was a major deficiency at NRC that precluded any measurement of the success of the regulatory process.

It does not appear, however, that NRC is making any concentrated effort to establish agencywide safety goals and objectives. Besides some research efforts to define what might be an acceptable level of risk, the NRC staff has been told by the Commission not to put any effort into this task. Likewise, a senior NRC official said that the development of safety goals was not an appropriate action for NRC to undertake. He felt that it would only be viewed by the public and intervenors as a self-serving process, permitting NRC to continue to license more plants. This official thought it more appropriate, from a public perception standpoint, for the Department of Energy, the National Academy of Sciences, or some other outside group to establish the goal.

While there is some logic to this concept, we believe that NRC, subject to review by the Congress, should be responsible for establishing an appropriate level of safety. No other agency, in our view, is more capable of establishing NRC goals and objectives than NRC itself. While it may need additional technical expertise from outside the agency to help in their development, NRC should be in charge of the effort and responsible for the outcome. Only NRC knows its own licensing capabilities and limitations, and it alone will be responsible for meeting that goal, when developed. In addition, it has the mechanisms in place to bring these issues before the public and to resolve substantial disagreements.

In this regard, the Senate Committee on Environment and Public Works included in NRC's fiscal year 1981 authorizing legislation, a provision directing NRC to develop a proposed safety goal for nuclear reactor regulation. This proposed goal, according to the draft legislation, would be reported to the Congress by June 30, 1981, and would include "clear subjective criteria, supplemented to the extent possible by quantitative criteria, necessary to assure protection of the public health and safety." We endorse this draft legislation

and believe that this type of congressional action is necessary to ensure that NRC gives proper attention to the development of a safety goal for nuclear regulation.

In commenting on this report, NRC noted that it is currently deciding on a staff proposal to develop NRC safety objectives. If this proposal is approved, NRC said that one of its first steps will be to determine the extent that such objectives could be developed in the near term. (See app. II.)

Can NRC conduct a licensing review in one step instead of two?

Currently, NRC's licensing process is divided into two stages: one before the plant is constructed and one before the plant is permitted to operate. In both stages, NRC reviews information relating to the plant's design and safety features, the proposed and alternative sites for locating the plant, the capabilities of the company to build and operate the plant, and other safety and environmental data related to the specific plant.

The difference between the two reviews is that the first only requires the utility to submit preliminary plant design and safety information. Final or detailed designs are not submitted and reviewed until the second, or operating license, phase of the process.

The TMI investigations found that this two-stage process was no longer desirable. It had been devised during the early stages of nuclear powerplant development. At that time, all plants were unique, and preliminary design information was all that was available before construction. Today, however, enough plants have been built so that it is possible to submit almost complete powerplant designs before construction begins.

The significance of a single-stage licensing review is that it would permit NRC to review the application for completeness and resolve all outstanding safety issues before construction begins. Under the present two-step process, safety items are often left open until the second step of the review. By this time, hundreds of millions of dollars may already have been spent and unnecessary pressures, real or imagined, are placed on NRC to take care of these items and issue a license. A one-step review would help eliminate these types of pressures and let NRC concentrate on the resolution of safety issues before construction begins.

One TMI study thought that the one-step licensing process would be particularly applicable when combined with formally

approved standardized designs. Under such a concept, a utility could match a standardized plant design with a site (possibly a site pre-approved by NRC) and with only a limitd NRC review, the utility could begin construction. NRC could then concentrate the majority of its efforts on inspecting the construction activities to ensure that the utility meets NRC requirements.

The study notes that NRC has been pursuing a plant standardization policy for several years but with limited success. It points out that the United States is the only major nuclear country in the world in which each nuclear plant is virtually custom-built and suggests that this situation is due to NRC's failure to make standardization mandatory.

NRC has not yet taken action on either of these proposals. It is not considered a very high priority because even if adopted, it would probably only be applicable to future powerplant applications--those not already under NRC staff review. At this stage of nuclear powerplant development, NRC does not expect any plant applications for several years, and it could even be argued that utilities will abandon the nuclear power option altogether. Thus, the bulk of NRC efforts, at this time, are being concentrated on those plants already built and under construction.

We agree with this priority. TMI highlighted many of the powerplant safety problems which were ignored by NRC in the past and which must now be reconsidered if the current plants are going to continue to operate safely. The importance of the one-step review/standardization program, however, should not be underestimated.

Besides TMI, one major reason that the utility industry has turned from nuclear power is the 10 to 12 years it takes to get a nuclear powerplant through the licensing process and constructed. If nuclear power is to make a comeback in this country, some system must be devised to reduce this schedule, while continuing to concentrate on and even improve safety. The one-step licensing/standardization concept offers one way to do this.

What should be the role of the Advisory Committee on Reactor Safeguards?

One of the major findings of the TMI studies was the licensing staff's (Office of Nuclear Reactor Regulation's) dominance over the entire licensing process. For instance, it was reported that many parts of the NRC organization, such as the Advisory Committee on Reactor Safeguards (ACRS), the

Atomic Safety and Licensing Boards, and even the Commission, lack the technical resources to seriously question staff decisions. These groups must largely "depend on the NRC staff for the information they need to appraise that very staff's judgement." Thus, reviews by these groups do not contribute seriously to the licensing process and for all practical purposes, safety decisions are made by the staff without substantial oversight by anyone. This was seen as a significant problem at NRC because of the staff's reluctance to make substantive changes to the licensing process and to recognize and consider several important safety matters. As a partial solution, the studies recommended that the authority of the ACRS be increased and that other safety offices and boards be created to oversee the licensing process and ensure that important safety issues are properly addressed and resolved.

The first thing that the studies thought could be improved was the role of the ACRS in reviewing reactor safety. The ACRS is an independent statutory committee of NRC, made up of 15 part-time members whose purpose is to review and advise the Commission on important safety issues. Its primary function (and one which takes up most of its time) is to review each powerplant application and advise the NRC staff of safety issues that should be addressed before a license is issued.

Unfortunately, however, the views of the ACRS are only advisory, and neither the staff nor the Licensing Boards are required to consider them during the licensing process. This is important when one considers the past issues raised by the ACRS which have now--since TMI--become top-priority items at NRC. These include (1) the need for instrumentation to follow the course of an accident, (2) the need to consider the potential for core-melt accidents and to design features into the plant to mitigate their effects, and (3) the need to use probabilistic risk assessment techniques in the licensing process. More than any other group, the ACRS thought that some TMI studies had the potential for effective, independent, technical scrutiny of the NRC staff position on reactor safety.

Thus, the studies made a variety of recommendations to improve the capabilities and authority of the ACRS. These include such things as:

--Eliminating the mandatory ACRS review of every powerplant application. This would eliminate a process that has not been very effective and permit the ACRS to concentrate its efforts on more important safety-related problems.

--Upgrading the technical staff of the ACRS to permit an increased capacity for independent safety analysis.

--Giving the ACRS the direct authority to intervene or participate as a party in licensing and rulemaking proceedings.

--Developing formal procedures to ensure that ACRS concerns are addressed by the NRC staff.

In general, we support these recommendations and believe their implementation could go a long way toward the development of a true advisory committee on reactor safety. We should point out, however, that permitting the ACRS to participate as a party in licensing and rulemaking proceedings might affect its "advisory" role within the NRC structure. This could have implications on its legal relationship to the NRC staff and to the Commission and may even reduce its effectiveness.

This is particularly important, we feel, because the ACRS could increase its contribution to effective regulation by developing a closer working relationship with the Commission. The Commissioners in office today generally lack the personal technical background to seriously question the licensing staff's opinions on reactor safety and licensing issues. They need the type of independent technical knowledge and expertise possessed by the ACRS to help make informed decisions and to keep from being dominated by the staff.

As it exists today, ACRS' relationship with the Commission is not very close. Communications are normally through formal letters and there is little, if any, free and open discussion of safety or regulatory issues. A change in this relationhip could add immeasurably to the capability of the Commission to make informed and timely decisions.

Will other proposed boards and offices improve reactor safety?

In addition to improvements suggested for the ACRS, the President's Commission and the NRC Special Inquiry both recommended that two new entities be created to oversee NRC's performance and ensure that safety issues are properly addressed. For instance, the President's Commission recommended that a committee be established (presumably outside of the NRC structure) to oversee the performance of NRC and the industry in addressing and resolving important safety issues. This committee, according to the recommendation, should include a maximum of 15 people from a wide spectrum

of backgrounds who report at least annually to the Congress and the President.

The NRC Special Inquiry endorsed this concept but calls it a "Nuclear Safety Board," puts it within the NRC organization, reduces its membership to five, and expands its functions. Besides overseeing NRC's regulatory process and operations, this Board would be given the added duty of investigating accidents and important safety-related events, independent of all other offices in NRC. This function was equated with the duties of the National Transportation Safety Board, which investigates aviation accidents independent of the Federal Aviation Administration.

The second special entity recommended by the study groups was an Office of Hearing Counsel (called an Office of Public Counsel by NRC's Special Inquiry). This office would, according to the President's Commission, participate in the formal hearing process as an objective party, seeking to assure that vital safety issues are addressed and resolved before the issuance of a license. Presumably, although not explained by the study, this office would include enough technical staff to know what is or is not a relevant safety issue and would not be tied to or supportive of the NRC staff of any group of intervenors.

The NRC Special Inquiry proposed a group with similar duties but which would also (1) administer and control a program to fund intervenors and (2) provide a source of legal and public counsel to the intervenors and other public interest groups. This would, according to the Special Inquiry, improve the quality of public participation in the hearing process and enhance NRC's credibility with both the industry and the public.

These additional entities are aimed at areas found to be major weaknesses at NRC. For instance, the TMI studies found that NRC was either slow in acting on or completely ignored important safety issues. They found an organization that was stagnant, that resisted new or innovative ways to improve the licensing process, that was poorly managed, and which had a technical staff that dominated the entire licensing process, including the public hearings.

The study groups did not think it enough, therefore, to recommend that these areas be improved. They also thought it necessary to create special groups to oversee NRC's performance and make sure that it deals effectively with important safety issues and with the public.

We agree with the purposes behind these recommendations and believe that, in some instances, independent oversight of NRC is needed, particularly in reviewing NRC's implementation of TMI-related recommendations. Much was found to be wrong at NRC, and some guarantees are needed to ensure that recommended changes are made or at least effectively considered before being rejected. An independent oversight group could help provide these guarantees.

We are not convinced, however, that the other recommended groups are needed at this time. Indeed, much additional study and debate should take place before a special Federal organization--either inside or independent of NRC--is created to legally represent intervenors in licensing or rulemaking proceedings. This alternative, in our view, might be necessary only after exhausting all other remedies to fund and improve public participation in the licensing process.

Likewise, the creation of a special "Nuclear Safety Board" to investigate accidents and other important reactor events needs additional study before implementation. In the past, NRC was clearly deficient in analyzing and learning from reactor mishaps. In fact, some investigations recommended that TMI might have been prevented if NRC had recognized the importance of similar reactor events and taken or required corrective actions. However, creation of a "Nuclear Safety Board" would directly overlap actions already taken or proposed by NRC to correct this situation. Such a "Board," therefore, might be advisable only if NRC's recent efforts fail to meet expectations.

Should the Government fund the public intervention of nuclear power

One of the more controversial issues that has been debated over the past few years is the value of public intervention in the nuclear regulatory process. Has it contributed to safety? Is it merely a ploy by anti-nuclear groups to delay and eventually kill nuclear power? Can or should public intervention be improved by Federal funding of individuals or groups that raise legitimate concerns about the safety of nuclear power? One of the TMI study groups addressed these questions and concluded that intervenor funding was necessary to promote effective citizen participation in the regulatory process. We agree with this assessment but believe that it would be a very difficult program to administer as proposed by the TMI study group.

As the licensing process works, it is not the NRC staff or the Commission that officially decides whether a license should be issued. Instead it is a group within NRC known as

the Atomic Safety and Licensing Board. This board, consisting of three members with legal and technical backgrounds, 1/ is convened only after the NRC staff has (1) substantially completed its safety and environmental reviews for a particular application and (2) decided that the issuance of a license will not adversely affect the public health and safety.

The purpose of the Licensing Board is to conduct public hearings; rule on any opposing contentions among the applicant, the NRC licensing staff, and the public; and make the initial decision as to whether the applicant should receive a license to either construct or operate a nuclear powerplant.

The primary problem with this process, which has been known for years, is that by the time the public hearings begin, NRC has already satisfied itself that the application is in order. Thus, at the hearings, the NRC staff often sides with the applicant and is preceived as being "on the side" of the utility. In short, the public intervenors in the hearings often view NRC as an adversary and not the protector of public interests.

In addition, the public intervenors rarely question the safety-related decisions of the NRC staff--decisions relating to the safety of the plant design or the adequacy of the regulatory review process. Instead, the intervenors normally concentrate on less technical issues such as environmental and siting decisions. They do not have the technical or financial resources to do otherwise.

To compensate for this problem, one of the TMI studies endorsed the concept of intervenor funding. The impetus for the concept comes from a long series of Comptroller General Decisions, holding that regulatory agencies have authority to fund intervenors under certain conditions, even without specific statutory authority.

Recognizing, however, that some intervenors might use this money to raise unimportant technical issues merely to stop a plant from being built, the TMI study suggested that strict requirements for funding be developed. These requirements would limit funding to those intervenors who needed the money to raise "nonfrivolous" issues.

1/Actually, there are 39 part-time and 13 full-time members on an Atomic Safety and Licensing Board Panel. The three member Licensing Board for each powerplant application is drawn from this Panel.

We favor the issue of intervenor funding but believe that it would be an extremely difficult program to administer. Indeed, giving money to intervenors based on subjective determinations of need or importance of ideas could lead to additional controversies and questioning of NRC motives.

In this respect, in NRC's fiscal year 1981 budget request, NRC proposed a trial program to fund intervenors. The program is intended to test the arguments for and against intervenor funding and to evaluate its contribution to the regulatory process. We support this approach and believe that such efforts are needed before committing to a full-scale intervenor funding program.

Possibly as important as intervenor funding, however, is the issue of when the public intervention takes place. It might be much more palatable for the public interest groups if they were involved at an earlier stage in the licensing process--before NRC has completed its review of the application and resolved all its questions with the utility. This might be hard to do, but it would certainly bring the focus of public issues into consideration at a more important point in the licensing process.

Should there be an Atomic Safety and Licensing Appeal Board?

The President's Commission on TMI and the NRC Special Inquiry both found that the Commission rarely involves itself in the decision to issue a powerplant construction permit or operating license. Instead, it has delegated substantially all of this authority to the Atomic Safety and Licensing Appeal Board. This is a special board administratively created by the Commission to review and rule on appeals from the Atomic Safety and Licensing Board.

The NRC Special Inquiry suggested, therefore, that if the commission form of organization is retained, the Appeal Board should be abolished and the Commissioners should be required to consider and approve every new reactor license. The Special Inquiry recognized that the Commission may not be able to handle this additional responsibility and suggests that this is one more reason why the Commission should be replaced by a single administrator.

We do not agree with this recommendation. Recognizing that the Atomic Safety and Licensing Appeal Board tends to insulate the Commission from the licensing process, we do not believe that the Board should be eliminated. Some insulation is necessary to keep the Commission focused on important safety issues and policy considerations. To make the Commission responsible for reviewing the appeal of every licensing application would, in our opinion, take up most of its time and detract from its other regulatory and public responsibilities.

Nevertheless, the findings of the TMI study groups are valid. The Commissioners, except for some rare cases, have refused to involve themselves in individual powerplant licensing decisions. Thus, they are generally unaware of the full impact of the safety issues under contention and are not as familiar as they should be with public and intervenor views on particular licensing applications.

In response to this criticism, NRC has recently completed a study of options to more directly involve the Commissioners in the appellate and decisionmaking process. These options range from eliminating the Atomic Safety and Licensing Appeal Board, as suggested by the NRC Special Inquiry, to having one or more Commissioners participate on each Appeal Board panel. The Commissioners currently have these options under consideration and are expected to reach a decision later this year on their proper role in the adjudication of powerplant applications.

CHAPTER 5

NRC ACTIONS SINCE TMI--

NEED FOR CONTINUED OVERSIGHT

Since TMI, NRC has initiated many actions to study the ills of nuclear power and to take corrective action. These actions have been impressive but much is yet to be done. To ensure that progress continues, we endorse action by the President to set up a special oversight group to follow the implementation of TMI-related recommendations. To provide further assurance and to keep the Congress informed, NRC should also periodically report to the Congress on its progress in implementing the TMI Action Plan, a document developed by NRC to address the numerous recommendations made after the TMI accident.

WHAT HAS NRC DONE TO RESPOND TO TMI?

Immediately following the TMI accident, NRC went into a phase of investigation and study that dominated a large portion of its resources. Agency priorities were reset and for almost a year the emphasis was taken off of licensing activities and put on finding deficiencies in the regulatory process and in the design and operation of nuclear powerplants. NRC is just now recovering from this phase, trying to ferret out, prioritize, study, and implement the important recommendations from the mass of the TMI studies and investigations.

Specific actions taken by NRC after the accident included:

--Creating several task forces and special studies to investigate the TMI accident and recommend changes not only in reactor designs and operations but also in the regulatory process and management structure of NRC.

--Reorganizing the licensing staff to concentrate on weaknesses found in the licensing process. Increased emphasis is being placed on the adequacy of (1) operator qualifications and training; (2) utility management, technical support, and commitment to safe plant operations; (3) emergency planning and procedures; (4) evaluation and dissemination of plant operating experience; (5) powerplant siting policies and criteria; and (6) reactor design features that might be needed to reduce or mitigate the effects of a core-melt accident.

--Initiating efforts to study weaknesses in existing reactor designs using probabilistic risk assessment techniques.

--Redirecting research efforts to analyze potential problems and design weaknesses identified by the TMI investigations.

--Redirecting inspection and enforcement programs to speed up the assignment of NRC resident inspectors to all reactor sites, to concentrate inspection efforts on important problem areas identified by the accident, and to increase NRC's power and authority to penalize utilities that fail to meet NRC requirements.

--Creating a special NRC group to summarize all the TMI recommendations and develop an agency plan for considering or implementing those recommendations.

Development of the TMI Action Plan

One of the major problems faced by NRC over the past few months has been how to deal with the hundreds of recommendations resulting from the TMI investigations. These recommendations dealt with almost every crevice of NRC, from its top-level management to requirements for very plant-specific design changes. Some recommendations had already been implemented, and others were scheduled for implementation, but most required additional study and deliberation.

To summarize and make sense of these recommendations, NRC created a special "TMI Action Plan Steering Group." This Group, over the past few months, has attempted to transform the TMI recommendations into a workable plan that describes the NRC and industry actions already taken or needed to implement and further study the recommendations. This "TMI Action Plan" includes about 175 discrete tasks along with their schedules and expected costs for implementation.

On May 27, 1980, at the request of the Chairman and Ranking Minority Member of the Subcommittee on Nuclear Regulation, Senate Committee on Environment and Public Works, we issued a separate report (EMD-80-76) on the TMI Action Plan. In that report we said that NRC had done an adequate job of preparing the Plan but cautioned that NRC was stretching its resources very thin and depending heavily on the nuclear industry to do most of the Action Plan tasks. If the industry does not perform as expected

or if NRC priorities are reshuffled because of other accidents, unforeseen licensing problems, or budget rescissions, it is unlikely that the Action Plan tasks can be completed on schedule.

We concluded, therefore, that an oversight mechanism was needed to give the Congress and the public periodic information on the status of the Plan. In this respect, we endorsed the President's creation of a "Nuclear Safety Oversight Committee" to oversee NRC's progress in improving reactor safety and implementing the recommendations of the "President's Commission on the Accident at TMI." This Committee, which was created on March 18, 1980, consists of five members and is expected to be in existence for 2 years. In addition, however, we recommended that NRC periodically report to the Congress on the status of the Action Plan, specifically describing the progress and resources spent on each Action Plan task as compared to the original Plan.

We reemphasize this recommendation because, in our view, congressional oversight of NRC's future actions is necessary to ensure that the agency does not, once again, become complacent. The TMI investigations performed the most thorough evaluations ever done on the regulatory process, and some very important recommendations were made to improve the process and upgrade reactor safety. The Congress should take steps to ensure that these recommendations are properly considered or implemented. The reporting mechanism we suggested will help in this effort.

This report, therefore, should be submitted at least annually and contain enough information not only to keep the Congress informed but also to serve as a basis (if considered necessary by congressional oversight committees) for special congressional oversight hearings involving the Commission, the new "Nuclear Safety Oversight Committee," the nuclear industry and other interested parties.

In commenting on this report (see app. II), NRC suggested that its annual report to the Congress should be used to convey the information on the TMI Action Plan. We agree with this approach as long as enough information is included to clearly describe for the Congress the progress that NRC has made in improving reactor safety and accomplishing the objectives of the TMI Action Plan.

A SYNOPSIS OF THE MAJOR STUDIES OF THE TMI ACCIDENT

A synopsis of the major studies of the TMI accident, their purpose, and the thrust of the reports follow.

AD HOC INTERAGENCY DOSE ASSESSMENT GROUP

In May 1979, an ad hoc group consisting of technical staff members of NRC; the Department of Health, Education, and Welfare; and the Environmental Protection Agency issued its preliminary assessment of the health effects of the TMI accident.

The ad hoc group concluded that the radiation dose during the period of March 28, to April 7, 1979, was small and that additional health effects would be minimal.

The group estimated the collective dose to the total population, within a 50-mile radius of the plant, to be 3300 person-rem. This was an average of four separate estimates that ranged from 1,600 to 5,300 person-rem, depending on the methods used to extrapolate data from dosimeter measurements. The group estimated the maximum dose that an individual, located off the plant site, might receive is less than 100 millirem.

The group evaluated milk and food sample data, analyzed by the Food and Drug Administration, to estimate the internal dose received. Iodine-131 was detected in milk, but no reactor-produced radioactivity was found in food samples. The group concluded that the maximum internal dose would be received by an infant who drank 1 liter of milk per day having the highest concentration of Iodine-131 found. The estimated total dose would be 5 millirem to the thyroid, which is well within the allowable dosage for milk.

The conclusions reached by the ad hoc group were generally in agreement with those of the President's Commission, the NRC Special Inquiry Group, and a licensee consulting firm.

NRC/OFFICE OF INSPECTION AND ENFORCEMENT INVESTIGATION

On April 20, 1979, NRC formally established its first investigation of the Three Mile Island accident. The investigation was done by the NRC Office of Inspection and Enforcement and its objectives were:

--to establish, in a comprehensive manner, the facts concerning the TMI accident and

--to evaluate the performance of the licensee in association with the TMI accident as a basis for corrective or enforcement action.

The investigation (1) did not include an evaluation of NRC or other agency actions during the course of the accident or recovery period nor (2) did it include an evaluation of NRC's regulatory process.

The investigation developed a reasonably detailed, well-supported operational and radiological sequence of events. Establishing the events of the accident was significant because they became the basis for other investigations.

The Inspection and Enforcement investigation was the only attempt to evaluate the performance of the licensee as a basis for corrective or enforcement actions. Civil penalties totaling $725,000 were proposed for 11 items. However, the Atomic Energy Act limits the total civil penalty, within any 30-day period, to $25,000; therefore, the proposed penalty was reduced to $115,000.

Broad observations and conclusions are cited in the Report's "foreword." However, some are misleading, generally not supported, and contradicted in the body of the report, or go beyond the stated objectives and/or scope of the investigations.

The report's foreword discusses an operator "mind set" or undue attention to the avoidance of a solid system without recognizing how the "mind set" was formed. These observations and conclusions received widespread news coverage. Since this was the first TMI investigation completed and publicized, proper emphasis was not given to NRC involvement, design problems, etc. Operator error was cited as the principal cause of the accident. Later investigators showed that operator error was only one of many causes.

NRC/OFFICE OF NUCLEAR REACTOR REGULATION LESSONS LEARNED

In May 1979, the Office of Nuclear Reactor Regulation formed an interdisciplinary team of engineers and scientists, from within NRC, to identify and evaluate safety concerns originating from the TMI accident. The task force issued two reports that are generally referred to as the Short-Term Lessons Learned and Long-Term Lessons Learned Reports.

APPENDIX I

Short-Term Report

The purpose of the Short-Term Lessons Learned Task Force was to identify and evaluate safety concerns that required immediate actions for operating reactors as well as reactors awaiting operating licenses or construction permits. The Task Force also had a responsibility to identify, analyze, and recommend changes to NRC's licensing requirements and the licensing process for nuclear powerplants.

Based on information available at the time, the Task Force accepted preliminary findings that the events that led to TMI involved equipment malfunctions, design deficiencies, and human error. Each contributed in varying degrees to the ultimate consequences of the accident. The 23 short-term recommendations, therefore, were geared toward quickly correcting the rather specific and narrow deficiencies that led to the Three Mile Island accident. Each of the recommendations was prioritized by establishing timetables for its implementation.

The NRC Advisory Committee on Reactor Safeguards reviewed the short-term recommendation and the proposed timetable for implementation. The Advisory Committee believed that a more flexible schedule and, in some instances, a longer time period would be necessary to accomplish the recommendations. With regard to the recommendations themselves, the Advisory Committee was in general agreement.

Long-Term Report

In contrast to the short-term recommendation, the long-term recommendations dealt with safety questions of a more fundamental nature such as nuclear plant operation and design and the regulatory process.

The principal conclusion of the Long-Term Lessons Learned Task Force was that inadequate attention was paid to the plant personnel and their role in preventing and responding to accidents. This general area of operational safety includes human engineering; qualification and training of operations personnel; integration of the human needs in the design, operation, and regulation of safety systems; and quality assurance of operations.

Another significant conclusion reached by the Task Force was that prior to this study, emphasis had generally been directed towards the prevention of accidents rather than the mitigation of their consequences. The Task Force found that before the TMI accident, NRC had thought that:

"* * * once severe core damage and consequent large releases of fission products from the fuel began to occur, there was only a small probability of arresting the course of an accident before substantial melting of the core occurred."

But, observing that the TMI accident was arrested after the core was severely damaged, the Task Force concluded that

--reducing the exposure of the public when an accident occurs has, until now, been provided by nuclear plant location and emergency response plans;

--designing to prevent an accident has reached a point of diminishing returns; and

--NRC should begin to formulate requirements for design features that could mitigate the consequences of a core-melt accident.

The task force made 25 recommendations in 13 general areas. The recommendations were prioritized or categorized into those requiring a decision to implement the recommendations in 3 months and those requiring further study for a decision on implementation.

Industry expressed some concern about the impact of the changes recommended by NRC, the planning behind some recommended changes, and whether the changes add to, or detract from, overall safety. NRC attempted to address these industry concerns during the development of the TMI Action Plan.

THE PRESIDENT'S COMMISSION

On April 11, 1979, by Executive Order, the President established an independent Commission to investigate and explain the accident at Three Mile Island. The Commission was composed of 12 persons appointed by the President, with Mr. John G. Kemeny, President of Dartmouth College, designated as Chairman.

The Commission was instructed to conduct a comprehensive study and investigation of the accident. Its primary objectives included:

(a) a technical assessment of the events and their cause, (this included an evaluation of the actual and potential impact of the events on the public health and safety, and on the health and safety of workers);
(b) an analysis of the role of the managing utility;
(c) an assessment of the emergency preparedness and

response of the Nuclear Regulatory Commission and other Federal, State, and local authorities;
(d) an evaluation of the Nuclear Regulatory Commission's licensing, inspection, operation, and enforcement procedures as applied to Three Mile Island;
(e) an assessment of how the public's right to information concerning the events at TMI was served, and of the steps which should be taken during similar emergencies to provide the public with accurate, comprehensible, and timely information; and
(f) appropriate recommendations based upon the Commission's findings.

On October 30, 1979, the President's Commission issued its report on the accident at Three Mile Island. The Commission concluded that equipment failures, inappropriate procedures, and human errors all contributed to the worst crisis ever experienced by the Nation's nuclear power industry. The Commission further concluded that fundamental changes were necessary in NRC's organization, procedures, practices and, above all, attitudes. With some qualification, the same changes were considered necessary for the nuclear industry.

The Commission received some criticism for limiting its investigation to only one accident at one nuclear plant. One point of controversy with the Commission report is the admitted limitation on scope (i.e., what happened at one nuclear plant) as a basis for applying many of its conclusions and recommendations to the entire nuclear industry.

The Commission categorized its recommendations in seven general areas. A significant recommendation called for restructuring of NRC as a new, independent agency in the executive branch. The report concludes that NRC in its present form does not have the organizational and management capabilities necessary for the effective pursuit of safety goals.

NRC/OFFICE OF INSPECTION AND ENFORCEMENT LESSONS LEARNED

The NRC Office of Inspection and Enforcement Lessons Learned Task Force was formed to look at how the accident could have been prevented and how NRC's response could have been improved. The report concludes that one of the primary lessons learned from TMI is the importance of evaluating and learning from experience.

Factors contributing to the accident were human error, system design, poor communications, an inspection program

with ineffective aspects, poor administrative controls, and poor personnel training and qualifications. While NRC's response to the accident was not considered ineffective, the task force recognized a need to improve the response effort.

THE NRC SPECIAL INQUIRY

On June 13, 1979, NRC entered into a contract with the Washington, D.C., law firm of Rogovin, Stern, and Huge to direct a special inquiry into the TMI accident. The principal objectives of the inquiry were to

--determine what happened and why it happened;

--evaluate the actions of the utility and NRC before and during the accident; and

--identify deficiencies where further investigation might be warranted.

The Special Inquiry Group issued its post-TMI report on January 24, 1980. The next day headlines blared that "Meltdown was near at TMI--disaster was an hour away, NRC Team finds."

The conclusion of the study claimed TMI was not so much a "hardware problem" as it was a "management problem" stemming from three factors: (1) the NRC's failure to assure the operational safety of existing plants; (2) a lack of coordination of responsibility between the utilities, the designers and manufacturers of the plants, and the Nuclear Regulatory Commission; and (3) a pervasive attitude of complacency based on a sense of reactor infallability. The need for fundamental change was stressed and 12 recommendations were advanced as remedies, including a programmatic and philososphical shift towards an awareness of risk and a non-avoidance of the "What if?" questions.

GOVERNOR'S COMMISSION

On May 14, 1979, Dick Thornburgh, Governor of Pennsylvania, by executive order, established a Commission to study and evaluate the consequences of the accident at Three Mile Island. The Commission was directed to

--ascertain the consequences of the incident;

--determine the adequacy of emergency preparedness and response of all parties and the adequacy of interaction with the Federal Government; and

--assess the nature and extent of physical or psychological health effects to the population, the environmental consequences, and the economic loss to the Commonwealth and its citizens.

The Commission accepted as reliable the estimated radiation dosage published by the Federal Government Ad Hoc Interagency Dose Assessment Group. They found no reason to disagree with the President's Commission finding that radiation releases will have only a negligible effect on the physical health of individuals. As for psychological effect, the Commission concluded that the accident had a demoralizing effect, but the effect passed quickly in all groups except TMI employees.

The Commission concluded that there was some short-term economic impact and that the effects over a long term are dependent upon many future decisions by Government, the courts, and the citizens.

In retrospect, the Commission believed that the State emergency response structure was capable of evacuating people in this instance because radiation exposure was small and the incident covered several days. If a response was necessary in a shorter time period, the outcome of an evacuation would be doubtful. The Commission concluded that the State had not adequately prepared for community health needs in a radiation emergency. Furthermore, no coordinated Federal response plan existed for meeting public health needs during such an emergency.

APPENDIX II

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

JUL 10 1980

Mr. J. Dexter Peach
Director, Energy and Minerals Division
General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Peach:

Subject: Draft GAO Report, "Three Mile Island: The Most Studied Nuclear Accident in History"

NRC Staff appreciates the opportunity to review this draft report.

We have a number of comments on the report, and they are enclosed. These comments are generally of a clarifying or editorial nature, save one. The one comment of significant disagreement with the draft report is number 13 in the enclosed list having to do with the functions of our Office for Analysis and Evaluation of Operational Data.

Sincerely,

William J. Dircks
Acting Executive Director
for Operations

Enclosure: NRC Staff Comments

ENCLOSURE

NRC STAFF COMMENTS

1. Page iv - 2nd paragraph - Suggest rewording to indicate that this recommendation is consistent with NRC plans as reflected in TMI Action Plan Item III.A.1.1 and III.A.2.1.

   GAO Note: Because of NRC's proposed actions to improve emergency planning and congressional action to make licensing contingent upon acceptable emergency plans, this recommendation was deleted from the draft report. (See p. 35.)

2. Page v - 5th paragraph - Suggest amendment to reflect TMI Action Plan item IV.E.1 wherein RES presently has an active acceptable risk criteria project to assess "How Safe Is It?", and ACRS effort started last year to develop quantitative safety goals.

   GAO Note: Reference was made in the body of the final report to reflect that NRC's Office of Research has started efforts to determine what risk might be acceptable to the general public. Such efforts are not, however, presently geared toward developing regulatory or licensing goals that would be used by the NRC staff when reviewing a powerplant licensing application.

   Likewise, according to the ACRS staff, the ACRS is not developing quantifiable safety goals. It is merely looking at the potential for doing so as a basis for determining whether to recommend that the NRC staff undertake such an effort. (See pp. 42-44).

3. Page vi - Safety goal recommendation - Suggest modification to indicate Commission plans pursuant to Chapter V, item V.1 of TMI Action Plan (as revised by SECY-80-230B) and Senate Nuclear Regulation Subcommittee amendment in FY 81 authorization bill setting June 1, 1981 deadline for a proposed safety goal. Also note that for uncontested OL proceedings the Commission is just as well informed as the hearing boards of current licensing and regulatory issues.

   GAO Note: The report was changed to reflect action taken by the Senate Subcommittee on Nuclear Regulation to require NRC to develop a proposed safety goal and report to the Congress by June 30, 1981.

We support this congressional action as necessary to ensure that such goals are established. (See p. 43.)

4. Page vii and later recommends a new special report to the Congress on progress in implementing TMI Action Plan - the Annual Report should be used for this purpose.

   GAO Note: The report was changed to reflect NRC's desire to combine the report we suggested with the annual report NRC already submitted to the Congress. (See p. 55.)

5. Page 2, 4th paragraph - This is not an accurate description of the release pathways for liquid and gas that occurred in the first several hours and days of the accident. Should be revised per NUREG-0600.

   GAO Note: Revisions were made as appropriate.

6. Page 20, middle paragraph - The "overall numerical risk assessment of reactor safety risk" was not "discredited." Its level of uncertainty was challenged and most agree that the level of certainity was overstated.

7. Page 21, second paragraph - Interim Reliability Evaluation (not Assessment) program.

8. Page 20, last paragraph - NRC endorsed the techniques in its response to the Lewis Committee report but never adopted them for systematic use in the regulatory process.

9. Page 21, 2nd paragraph - IREP plans are changing - suggest rewording to say "four or more plants by early next year."

10. Page 21, 2nd paragraph - there is no intention to stop IREP after the first few plants, only uncertainity about the most effective way to proceed. The TMI Action Plan deals with this in II.C.1 and II.C.2.

11. Page 25, 2nd paragraph - correctly states NRC intentions per item I.A.2.6 in Action Plan, but overstates them as decisions already made.

12. Page 26, last paragraph - overstatement. IE and NRR are already involved in qualifying nuclear powerplant operators, but not as much as they will be eventually, in conformance with Action Plan Items I.A.2.3, I.A.2.6, I.A.2.7.

GAO Note: The paragraph referred to was deleted from the report because it did not fully reflect NRC's proposed actions per the cited references.

13. Page 28 - major problem with 2nd and third paragraphs - it incorrectly implies that AEOD serves a coordinating function. Its function is more one of substantive, independent analysis and leadership in recommending means to correct operating deficiencies. The language should be revised to reflect the principal and specific responsibilities of AEOD for analysis and correction of operating deficiencies and that any coordination function is small by comparison.

GAO Note: The report was changed to delete indication that the new "Office of Analysis of Evaluation of Operating Data" will serve only a coordinating function. The Office will provide leadership in reviewing power plant operating experience, but its success or failure will depend on the cooperation and support given by the other NRC offices and top NRC management. (See p. 28.)

14. Page 32, 1st paragraph is in error - NUREG-0694, "TMI-Related Requirements for New Operating Licenses" at pages 19 and 25 require compliance with Action Item III.A.1.1 of the TMI Action Plan. That is, before issuing a new OL, licensee will be required to comply with 10 CRF Part 50, Regulatory Guide 1.101, NUREG-0654, the essential planning elements in NUREG-75/111, and Supplement 1 thereto, or receive a favorable finding by FEMA.

GAO Note: This paragraph was deleted and the report was adjusted to reflect NRC actions to upgrade emergency planning activities at nuclear powerplants in operation and under construction. (See pp. 34-35.)

15. See comment number 2.

16. Page 54, 2nd full paragraph - the TMI Action Plan contains about 175 discrete tasks; the new OL requirements number about 50.

17. Additional comments on Chapter 4 of the draft GAO report are attached.

GAO Note: NRC's page references were changed to reflect their position in the final report. Also, unless otherwise indicated, changes were made to the final report to reflect NRC's comments.

ADDITIONAL COMMENTS ON DRAFT GAO REPORT, CHAPTER 4: IMPROVEMENTS ARE NEEDED IN NRC'S ORGANIZATION, MANAGEMENT AND METHODS OF REGULATION

The criticism of NRC organization and management adduced by the TMI investigations are fairly summarized in the GAO report. However, the report would be more complete on this point if it were to note the Commission's work in late 1979 and early 1980 to better define and clarify the respective roles of the Commission, Chairman and the Executive Director for Operations (EDO) in carrying out the agency's mandated functions, including its executive and administrative functions.

GAO Note: Although the Commission took some actions following the TMI accident to clarify its role, the most important action in this area was the reorganization of NRC by the President. This is dealt with in the report and reflects the changes that have been made to address the management problems at NRC. (See pp. 39 to 41.)

The report also correctly notes that the NRC management and organizational picture is transformed by the President's Reorganization Plan No. 1 of 1980 which retains a "commission" structure for NRC but redefines the roles of the Commission, Chairman and the EDO. In letters to Senator John Glenn and Congressman Jack Brooks (copies attached) [See GAO note, p. 69.], the Commission expressed a belief that the organizational structure provided by the amended plan "is workable and should not hinder the agency's performance of its statutory responsibilities." This statement also fairly characterizes what will be the Commission's objective in implementing the plan when it becomes effective, viz., to develop an organizational structure that is workable and will foster the agency's performance of its mandated duties.

The GAO report also reasonably summarizes the recommendations of the TMI investigations for improving the Commission's regulatory process. As the report notes, most of these recommendations have been or are being addressed within the Commission. However, the authors of the report believe this is not the case with respect to (1) establishing goals and criteria which describe what level of safety and nuclear regulation is enough; and (2) developing systematic means to inform the Commission on current licensing and regulatory issues.

With respect to measureable safety goals, the Commission has before it for decision a staff proposal to formulate

a general plan for development and articulation of NRC safety objectives. If the Commission approves the proposal, one of the first steps will be to examine the extent to which articulation is possible and practical in the near term. The proposal would also pull together the current activities within NRC on this subject. A copy of the proposal (SECY-80-230B) is being made available to GAO so that its discussion of this important area can be as complete as possible.

GAO Note: A paragraph was added to the report to reflect these Commission actions. (See p. 44.)

Regarding Commission actions to keep informed on current licensing and regulatory issues it is useful to distinguish between general status information which the Commission receives about cases pending before the lower adjudicatory boards (i.e. Atomic Safety and Licensing Boards, Atomic Safety and Licensing Appeal Boards) and specific information and argument which the Commission receives as part of its decision whether to review a particular case. As to the former, monthly status reports are submitted to the Commission by the chairmen of the adjudicatory panels which summarize significant events in proceedings before the boards; also, the Office of General Counsel monitors and reports to the Commission on the status of a selection of proceedings before the lower boards. As to the latter, the Office of General Counsel prepares a paper for the Commission on each Appeal Board decision, which paper considers the issues in the case and recommends whether the Commission should undertake review. Parties to a proceeding may also file petitions seeking Commission review.

As presently drafted, the report is not entirely clear on the distinction but appears to address information and argument on the merits of issues in particular cases. As noted above, the Commission now receives the views of OGC on each Appeal Board decision, and the arguments of intervenors in the form of their petitions for Commission review of particular cases. The report would better reveal avenues for NRC reform if it were to identify the general types of information about issues and contentions in particular cases which the Commission should be, but is not now, receiving.

GAO Note: The report was changed to reflect actions taken by NRC to study options and decide on the future role, if any, on the Atomic Safety and Licensing Appeal Board. (See p. 52.)

APPENDIX II

CHAIRMAN

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

May 14, 1980

The Honorable John Glenn
Committee on Governmental Affairs
United States Senate
Washington, D. C. 20510

Dear Senator Glenn:

The Commission has completed its review of the amendments to Reorganization Plan No. 1 of 1980, submitted by the President to the Congress on May 5, 1980. In sum, the Commission recommends that the Congress not disapprove the amended Plan.

While varying reasons underlie each Commissioner's acceptance of the amended Plan, we all believe that the organizational structure it provides is workable and should not hinder the agency's performance of its statutory responsibilities. However, the Commission believes certain clarifications in the legislative record could offer additional protection against the Plan becoming a source of conflict for the agency.

The clarifications the Commission has in mind follow. I agree with (2) and (5), but disagree with the others.

(1) The ultimate agency authority to interpret and apply the Plan resides in the Commission, as exemplified in its authority to resolve doubt about its functions under subsection 1(a).

(2) Subsections 1(b), 1(c), 2(a) and 2(b)(4) which provide for authority to remove NRC officers and employees pertain only to the subject of who has authority to remove, and are not intended to affect other laws, such as those which relate to substantive and procedural rights for such officers and employees;

(3) No provision of the Plan authorizes the Chairman or the Executive Director for Operations (or any other employee of the Commission) to withhold information from the Commission and individual Commissioners;

(4) The provision in subsection 2(c) requiring the EDO to keep the Commission fully and currently informed "through the Chairman" is not intended to authorize the Chairman to prevent, hinder or control the substantive content or timing of the EDO's communications to the Commission under this subsection;

GAO note: Since the letters to Senator Glenn and Congressman Brooks are identical, the Glenn letter is the only one included in this report.

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(5) The provisions in subsection 4(a) which authorize direct communications to the Commission or a Commissioner by an NRC officer or employee are not intended to prevent the Commission from establishing other policies relating to direct communications such as its "open door" policy. These communications are to be encouraged, when necessary, and the Plan is not intended to erect barriers to them.

(6) Although the Plan does not explicitly so provide, its intent is that the Staff of the Commission (other than the officers and Staff referred to in sections 1(b)(4), 1(c) and 2(a) of the Plan) shall report to the EDO.

My comments are attached.

The Commission appreciates the careful scrutiny which the Congress has given to the NRC Reorganization Plan. If we may be of further assistance, please do not hesitate to call on us.

Sincerely,

John F. Ahearne

Attachment:
Separate comments of Chairman Ahearne

cc: The Honorable Jacob K. Javits

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Chairman Ahearne's Separate Comments

I personally agree that the Plan will assist the agency in the performance of its duties. I also agree that some legislative clarification may be helpful in guiding the NRC in its implementation. However, I do not believe that the Plan itself has any great inherent danger of becoming a stumbling block or source of conflict. The responsibility for the effective implementation of this Plan rests with the five members of this Commission. The intent of the President's Reorganization Plan is very clear: the Commission must devote its energies to the development of policy, handle rulemakings, and address adjudications. These policies and rules, and then interpretations through the adjudicatory process, provide guidance to the staff. It is equally clear that it is the intent of the Plan that the details of the management of the NRC staff in the implementation of Commission policy shall be the responsibility of the Chairman acting through the Executive Director. Any clarification in the legislative record should be consistent with these goals of the Plan.

My specific comments on the suggested clarifications follow:

1. While there is no argument that the Commission has the final authority to interpret the Plan within the NRC, the Plan places well defined limits on the scope of that authority in Section 1(a).

2. I agree with the Commission comment.

3. I do not believe there is any ambiguity in Section 1(d). The Commissioners shall have equal votes, authority and access to information pertaining to those areas for which they are responsible as described in Section 1(a) and 1(b). Commissioners should not as a matter of course be receiving information outside of these areas, and the Chairman would be justified in insisting that a Commissioner show why such a request related to his other Commission duties. Furthermore, the inclusion of the EDO or any other employee of the Commission in this paragraph implies that the Commission would make requests without going through the Chairman. This would be a clear violation of the intent and letter (Section 2(c)) of the Plan.

4. As principal executive officer of the Commission, the Chairman is ultimately responsible for the performance of the staff, including the EDO. There is adequate protection already in the Plan against the arbitrary suppression of safety related information (see next suggestion).

5. I agree with the Commission comment.

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6. The intent of the Plan is that the staff will report to the EDO, subject to the direction and supervision of the Chairman (Section 2(b)).

(302543)

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