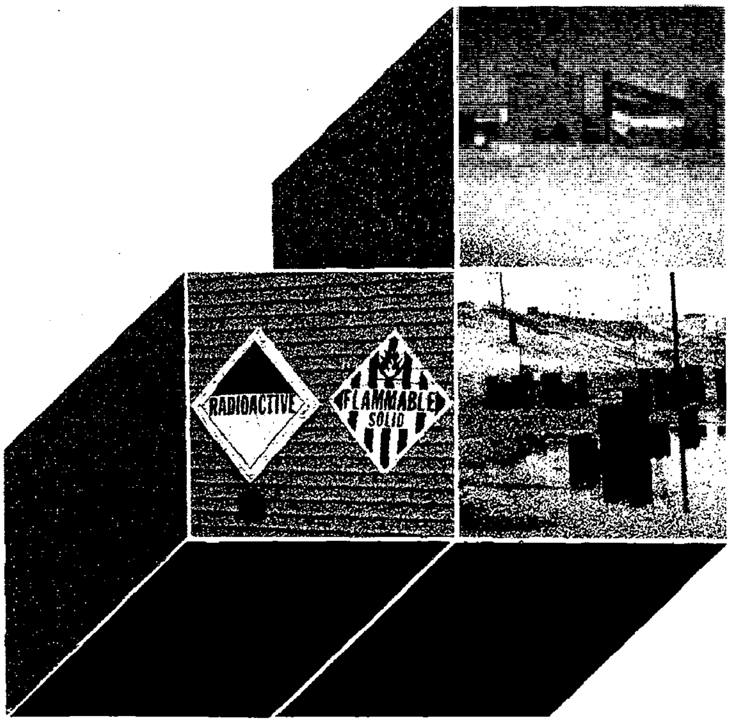
1979 Annual Report



U.S. NUCLEAR
REGULATORY COMMISSION

PREVIOUS REPORTS IN THIS SERIES

1975 NRC Annual Report, published April 1976
1976 NRC Annual Report, published April 1977
NUREG-0400, *1977 NRC Annual Report*, published April 1978
NUREG-0516, *1978 NRC Annual Report*, published February 1979
NUREG-0690, *1979 NRC Annual Report*, published March 1980
NUREG-0774, *1980 NRC Annual Report*, published March 1981
NUREG-0920, *1981 NRC Annual Report*, published June 1982
NUREG-0998, *1982 NRC Annual Report*, published June 1983
NUREG-1090, *1983 NRC Annual Report*, published June 1984
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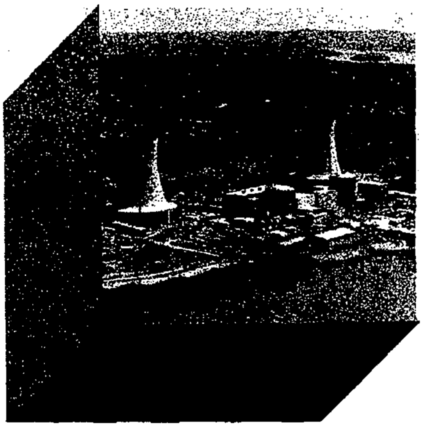


2
Accident at Three Mile Island

The accident at Three Mile Island in March was the focus of nearly all NRC activity in 1979.

Despite the fact that no one was killed and no physical injuries were sustained among the general public because of it, the accident at the Three Mile Island Nuclear (TMI) Station Unit 2 is unquestionably the most serious in the history of commercial nuclear power. It is also the most intensively studied and extensively reported incident in that history. This chapter can only attempt to cover the major investigative efforts devoted to the accident, only those whose results were available before the end of 1979 (the NRC's own Special Inquiry Group report was pending, as were the results of several Congressional studies), and only the most salient findings and recommendations or actions issuing from them. Other chapters of this report cover many aspects and effects of the TMI accident in connection with the particular NRC activities under discussion. These references are cited in the Index under "Three Mile Island accident."

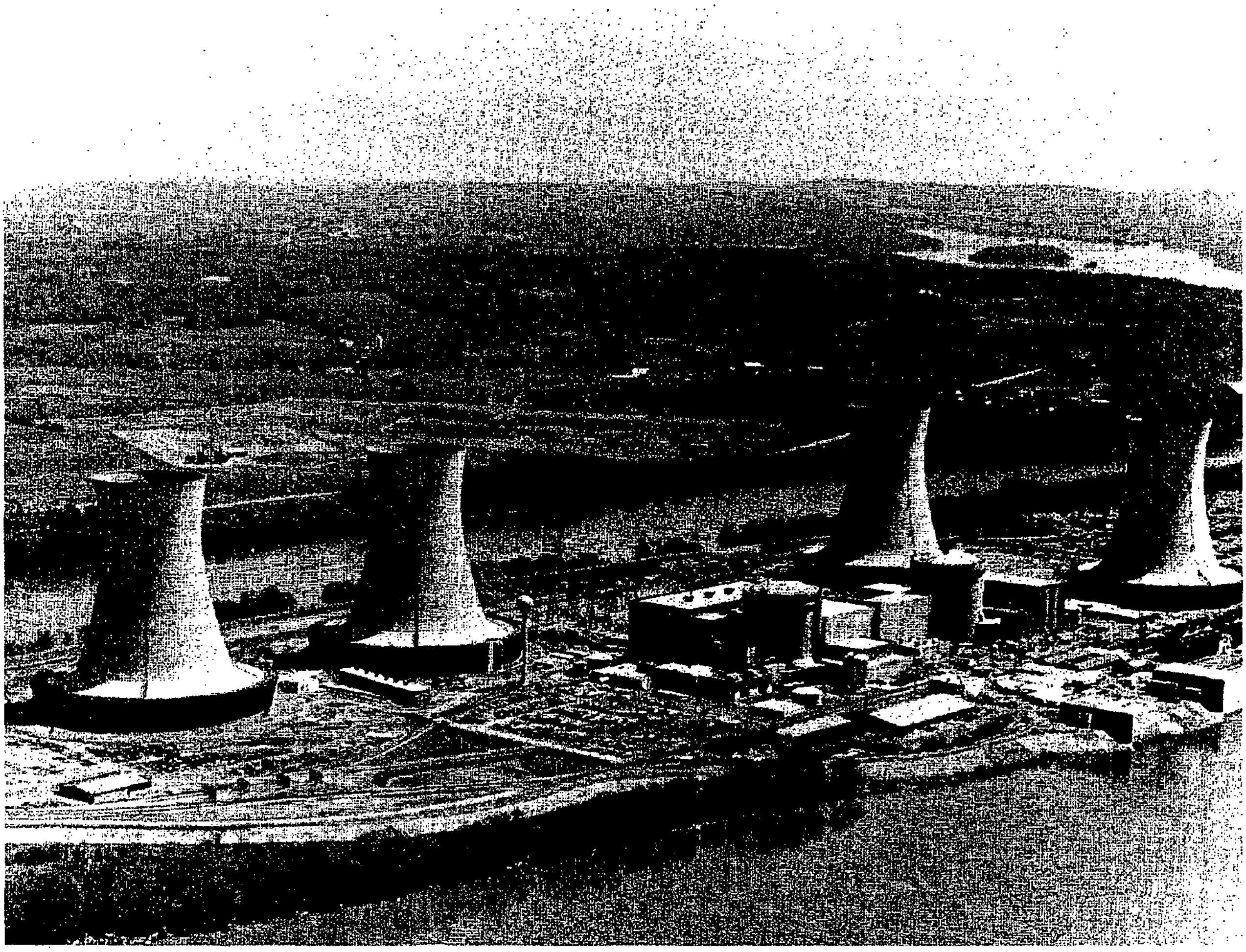
The full reports of the various NRC investigations and other documents cited in this chapter are available from the GPO Sales Program, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, and from the National Technical Information Service, Springfield, Va., 22161. The titles and catalogue numbers are listed in the box below. The report of the President's Commission on the Accident at Three Mile Island, which is discussed at length, is available from the U.S. Government Printing Office.

WHAT HAPPENED

Located in Dauphin County, Pa., about 10 miles southeast of Harrisburg on an island in the Susquehanna River, the Three Mile Island Nuclear Station (TMI) consists of two pressurized water reactors and associated equipment, each one with two large steam generators and each employing two 370-ft. cooling towers—part of the system which condenses the steam after it has passed through the turbines to generate electricity. The utility licensed to operate the facility is the Metropolitan Edison Company, a subsidiary of General Public Utilities, Inc., of New Jersey. Unit 1 at TMI was licensed for operation in 1974, at a net capacity of 819 MWe; Unit 2 was licensed in February 1978 and went into commercial operation in December 1978. Each unit has its own reactor containment building, control room and auxiliary building. Each containment building houses a reactor, a pressurizer, and two steam generators; the turbine and electric generator are outside the containment.

NRC REPORTS ON TMI CITED IN THIS CHAPTER

NUREG-0558:	"Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station"
NUREG-0560:	"Staff Report on the Generic Assessment of Feedwater Transients in Pressurized Water Reactors Designed by the Babcock & Wilcox Company"
NUREG-0578:	"TMI-2 Lessons Learned Task Force: Status Report and Short-Term Recommendations"
NUREG-0585:	"TMI-2 Lessons Learned Task Force: Final Recommendations"
NUREG-0596:	"The Non-Radiological Consequences to the Aquatic Biota and Fisheries of the Susquehanna River from the 1979 Accident at Three Mile Island Nuclear Station"
NUREG-0600:	"Investigation into the March 28, 1979 Three Mile Island Accident by [NRC] Office of Inspection and Enforcement"



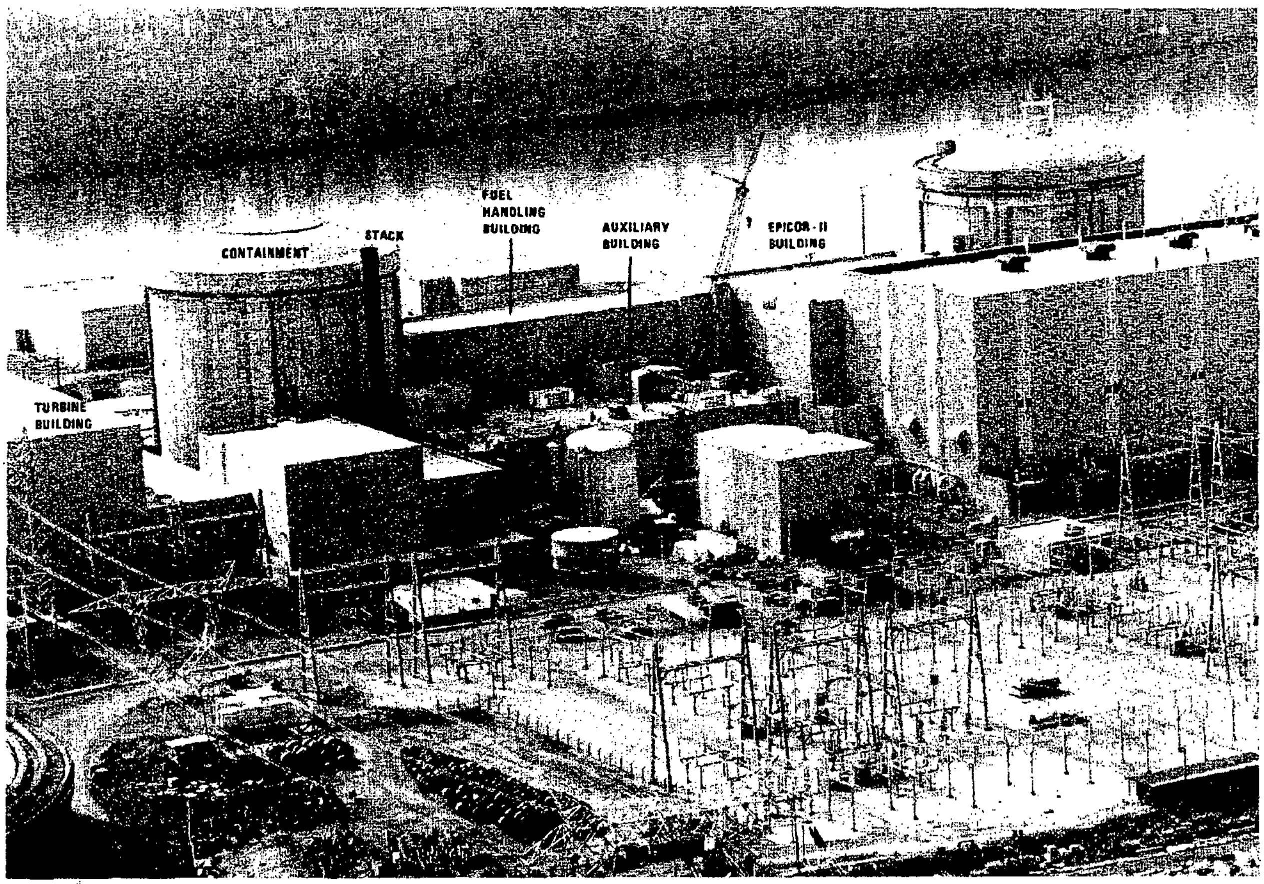
The Three Mile Island Nuclear Station. The four large towers cool the steam generator water used in the production of electricity by the two reactor units at the station, located in the cylindrical domed structure shown at right center in the photo. The Unit 2 reactor, scene of the accident, is housed in the cylindrical containment building farthest to the right.

Wednesday—March 28

At about half a minute past 4:00 a.m., on Wednesday, March 28, 1979, a "condensate" pump and the main "feedwater" pumps connected with one of the Unit 2 steam generators shut down, causing an almost simultaneous and automatic shutdown of the Unit 2 turbine (Unit 1 was shut down at the time for refueling.) The initiating cause of the shutdown is not definitely known but may have been an alteration in the pressure in the feedwater system brought about by a maintenance procedure taking place at the time. An unexpected pump shutdown is not unusual or, in itself, serious. With the feedwater flow stopped, the steam generators stopped removing heat from the primary system, i.e., from the closed system of pressurized water which passes through the reactor, carries heat to the secondary system, and returns to the reactor. The buildup of heat in the primary system caused the pressure of the water to rise and a "pressurizer relief valve" to open. The reactor automatically shut down in response to the increase in primary coolant pressure. This reactor "scram" took place eight seconds after the condensate pump shut down on the secondary side of the system. Instantly the output of heat from nuclear fission in the reactor core was stopped, but a substantial amount of "decay heat" continued. The production of decay heat, like the momentum of a large ship at sea, cannot be ended by turning off the power source, and it is essential that sufficient primary coolant and pressure be maintained even after the reactor has shut down.

Through the first seconds of the accident, the performance of the equipment went according to design and the sequence of responses to the unexpected interruption of heat transfer from primary to secondary systems was "normal." After the reactor scrammed and the relief valve lifted, the primary coolant pressure dropped back to the point where the pressurizer relief valve was supposed to close, restoring a closed, fully pressurized primary system with coolant flowing through the reactor core and removing its decay heat (about 7 percent of its normal operating heat production). The relief valve did not close. At this same time, several pumps came on automatically on the secondary side to restore feedwater flow and remove heat through the steam generators. This action was thwarted by closed valves, a condition which was not corrected until eight minutes into the accident.

Because the pressurizer relief valve was stuck open, the pressure in the primary system did not level off at the proper point but continued to decrease. As the pressure of the coolant goes down so does its boiling point, and the danger arises that it may begin to turn into steam. Since steam cannot carry off decay heat effectively, the primary system could heat up to dangerous levels. When the pressure had decreased to about 75 percent of normal, an emergency core cooling system (ECCS) automatically came on, injecting cold water under high pressure into the reactor. Believing that the pressurizer relief valve was closed and seeing the level of coolant in the pressurizer rise with the injection of ECCS water into the reactor, the operators in the control room feared that the pressurizer would fill up with coolant and the system would lose the pressurizing bubble of steam that is normally maintained at the top of the pressurizer. Consequently, they shut off one ECCS pump and throttled back the ECCS flow from the other pump into the reactor. Ordinarily the level of coolant in the pressurizer is an accurate indicator of the volume of coolant in the entire primary system, so the operators were confident that the system was full, the reactor core was covered, and the heavy injection of ECCS coolant was unnecessary and was, in fact, making the system too full. As the four licensee personnel then present in the control room later testified, they were not aware that the level of coolant in the pressurizer is not necessarily an index to the amount and level of coolant throughout the system. As it happened, the drop in pressure following the failure of the relief valve to close and the failure of the auxiliary feedwater



The major buildings making up the Three Mile Island Nuclear Station Unit 2 are shown, including the Epicor-II building at right which houses the system used to decontaminate the radioactive water held in the auxiliary building tanks. The containment building at the left houses the Unit 2 reactor, pressurizer and steam generators. The Unit 1 building is at the far right.

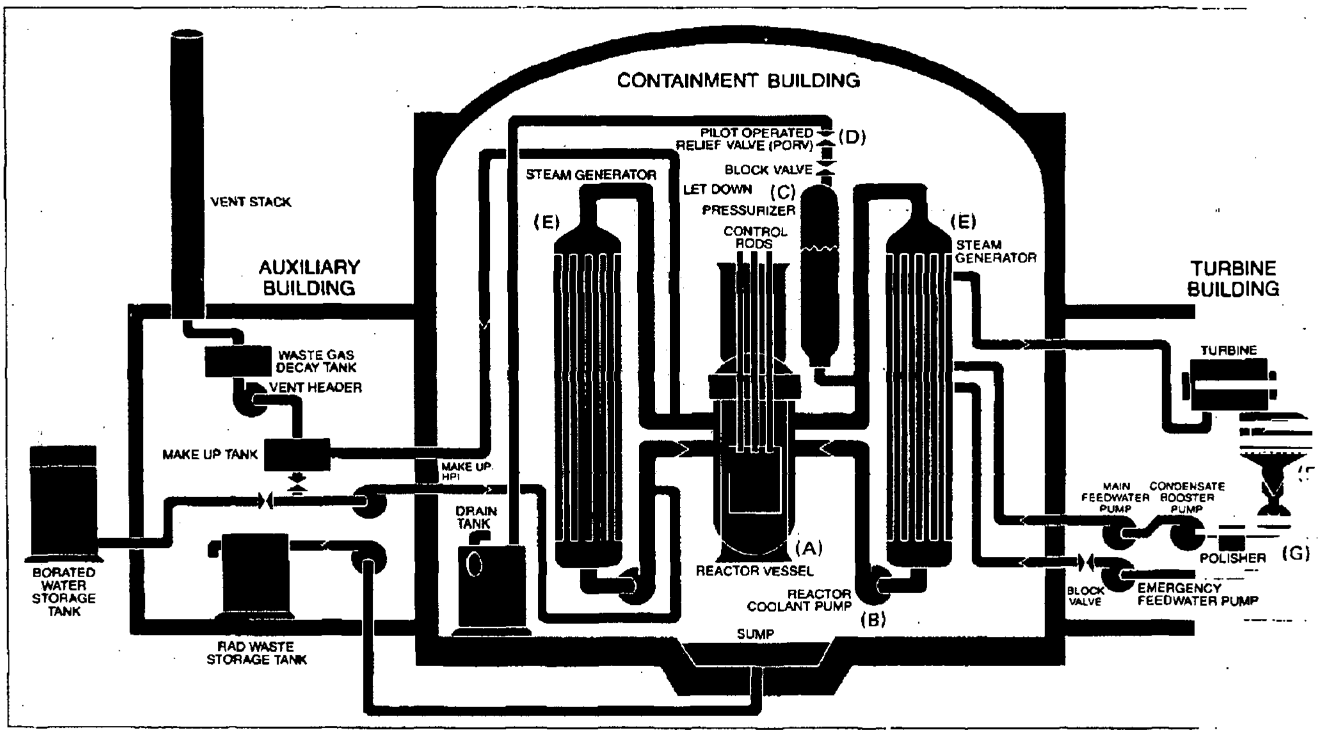
allowed the coolant going out of the core to boil, and steam voids or bubbles had formed within the primary system between the reactor core and the coolant in the pressurizer. Under such conditions, the level of coolant in the pressurizer would not disclose the amount of coolant in the primary system as a whole.

The pressurizer relief valve remained open for about two hours and 20 minutes, permitting the escape from the primary coolant system of more than 30,000 gallons of slightly radioactive water. Early in the accident, the operators were also letting coolant out through a "letdown" system, in the belief that the system was close to filling up. In fact, more coolant was leaving the primary system than coming into it, and this led eventually to "uncovering" of the upper portion of the reactor core resulting in sharp increases in temperature, damage to the fuel rods and releases of radioactive fission products. Just how extensive the damage was to the core and fuel cannot be determined until technicians are able to open the reactor vessel. Estimates of the damage are based on analyses of samplings taken from the atmosphere inside and from coolant standing on the floor of the containment, and they tend to indicate extensive damage to the fuel.

At 4:08 a.m., a sump pump came on automatically and began moving the slightly radioactive coolant—which had come down from the drain pipe for the relief valve and from the letdown system—into sump tanks located in the Unit 2 auxiliary building. It was at this point that radioactive material first left the containment; some of it was eventually vented to the outside air (though the more serious releases came later). At 4:11 a.m., the reactor building sump overflowed. Some minutes later the control room crew was apprised of this and, at 4:39, turned off the sump pumps in the containment. By that time, something over 8,000 gallons of water had been pumped to tanks in the auxiliary building, which was not sealed off from the outside air as the containment building was. At 4:50 a.m., the superintendent of technical support for Unit 2 arrived, but he too found a situation he had never experienced: a high level of primary coolant in the pressurizer but low pressure in the coolant system.

At 5:14 a.m., reacting to vibrations in the four pumps circulating coolant through the reactor (caused by steam in the coolant), the operators shut down two of them. Twenty-seven minutes later, for the same reason, they shut down the other two, cutting off all flow of coolant to the reactor core. The expectation at this stage was that the primary system could now work by "natural circulation" with the coolant heated by decay heat expanding and moving upward to the steam generators (whose feedwater was now restored and would carry off heat from the primary system) and with the cooler water flowing down and back to the reactor. The operators did not succeed, however, in establishing natural circulation.

Schematic of the TMI-2 facility.

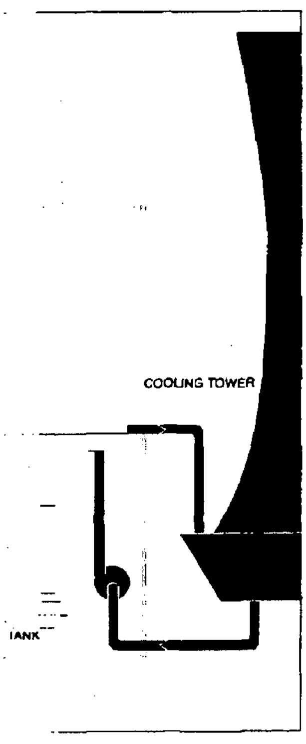


By 6:00 a.m., there was evidence, from radiation alarms, of radioactive gas in the containment. Primary coolant continued to escape through the relief valve, now containing non-condensible radioactive gas and hydrogen generated by a reaction between the zirconium cladding on the overheated sections of the fuel rods and the steam in the system. Finally the relief valve was sealed when a block valve on the pressurizer was closed at 6:20 a.m. That action ended the loss of coolant from the primary system, but the flow of coolant was not resumed until 6:45, when a reactor coolant pump was reactivated; vibrations again caused the operators to turn off the pump.

A conference telephone call took place beginning about 6:00 a.m., involving officials of the licensee company and a representative of the reactor manufacturer. About the same time, radiation readings at various points on the island began to show abnormal increases and instruments in the reactor core registered abnormally high temperatures. At 6:50 utility officials publicly declared a "site emergency," a procedure prescribed in the facility's emergency plans whenever an event posed the possibility of an "uncontrolled release" of radiation to the immediate environment. Local and State authorities were notified of the potential impact on public safety, beginning with the 7:02 a.m. notification of the Pennsylvania Emergency Management Administration (PEMA). The licensee tried to contact the NRC Region I office near Philadelphia starting at 7:10, but the switchboard there did not open until 7:45. The TMI station manager arrived on the scene shortly after 7:00 and at 7:24, he declared a "general emergency," signifying a situation with the potential for "serious radiological consequences" for public health and safety.

At 7:45 a.m., the NRC regional office was made aware of the situation at TMI and established an open line with the Unit 2 control room within a few minutes. By 8:00, the NRC headquarters was alerted and the Operations Center in Bethesda, Md., was activated. The regional office dispatched a first team of inspectors to the site about this time, and other agencies mobilized in response to communiques from NRC and State authorities.

Radiation monitoring on and near the island had begun before 8:00 a.m. and was to broaden and intensify throughout this and subsequent days of the accident. A helicopter engaged by the utility was taking samples above the plant by midday and another aircraft detailed from the Department of Energy (DOE) was in action by mid-afternoon of the first day. From the beginning, the level of radioactivity around the TMI site was in the range of one or two millirem-per-hour (thousandths of a rem) on the ground, though readings above the island and at some points on the plant grounds or just across the river were much higher and inside the containment ran up to thousands of rem-per-hour. The radioactive coolant which had overflowed the sump tanks in the containment building was automatically pumped over to the aux-



At left is a schematic drawing of the Three Mile Island Unit 2 facility. Some of the major components are labeled as follows:

(A) REACTOR VESSEL: A cylindrical vessel made of steel—40 feet high and 8½ inches thick—which contains the reactor (core and control rods) and through which the reactor coolant flows, carrying heat away from the core to the steam generators. The TMI-2 reactor contains 177 fuel assemblies with 208 fuel rods in each assembly.

(B) REACTOR COOLANT PUMP: One of four pumps which move the reactor coolant through the core to the steam generators and back to the core in a closed system (the primary system) of what is normally only slightly radioactive water. About one hour into the TMI accident, the operators shut down two of these pumps because they were vibrating severely, the result of the steam in the primary system. Half an hour later they shut down the other two pumps for the same reason. At that point, damage to the fuel in the core began, causing releases of radioactive material into the coolant.

(C) PRESSURIZER: A large vessel connected to the primary system between the reactor and the steam generators which is normally a little more than half full of water, with a steam bubble in the upper portion of the vessel. It is designed to keep the pressure in the reactor coolant relatively constant.

(D) PILOT OPERATED RELIEF VALVE: The pressurizer relief valve located at the top of the pressurizer and designed to open automatically when primary system pressure rises to a preset level and it becomes desirable to let off steam. When pressure is back to normal, the relief valve is supposed to close by itself. At TMI-2 it failed to do so, and reactor coolant flowed through the relief valve and down to a drain tank on the floor of the containment building. This valve remained open for more than two hours.

(E) STEAM GENERATOR: The large vessel in which the transfer of heat from the reactor coolant to the feedwater takes place. The transfer results in the conversion of the feedwater into steam, as it flows around tubes carrying the pressurized, core-heated coolant from the reactor. This steam is conveyed to the turbine which powers the electrical generator.

(F) CONDENSER: The vessel in which the steam which has passed through the turbine is condensed to a liquid state again. The heat is removed by pipes carrying condenser water which flows to the cooling towers and back to the condenser.

(G) CONDENSATE PUMP: The pump which moves the feedwater (the condensate) from the condenser to the polisher or demineralizer which cleanses the water before it flows back to the steam generator. The TMI accident began at this point in the feedwater system when plant personnel were trying to clear a line associated with the polisher and the condensate pump automatically shut down, followed by a similar "tripping" of the feedwater pump and subsequently of the turbine and the reactor.

Above is a photo of the conference room at the NRC Operations Center in Bethesda, Md., taken during the course of the TMI accident. Other rooms of the center are equipped and staffed to gather and analyze data and maintain secure communications with NRC regional offices and the accident site. Numerous technical experts from the NRC were at the center to inform and advise senior NRC officials on the Executive Management Team. Personnel from other Federal agencies involved in or assisting with management of the accident were officed in areas adjoining the Operations Center. In the foreground, at left, is Lee V. Gossick, NRC Executive Director for Operations.

iliary building tanks where it again overflowed. Since the auxiliary building is not isolated from the outside environment, some radioactive gases carried over in the coolant were vented to the outside. The reactor containment building was not sealed off from the auxiliary building until about 9:00 a.m., after more than eight thousand gallons of coolant had been transferred.

This transfer of coolant was not, however, the main cause or source of the release of radioactivity to the environment during the TMI accident. The transfer actually took place prior to any major fuel damage in the reactor. It was between one and two hours following the turbine trip, when the operators turned off the reactor coolant pumps to save them from vibration damage, that damage to the nuclear fuel began. For the next several hours, there was a large temperature difference between the coolant entering and exiting the nuclear core, indicating inadequate flow of coolant through the core. As a result of fuel damage, the concentration of radioactivity in the reactor coolant increased by several orders of magnitude. A flow of this highly contaminated reactor coolant was maintained from the primary coolant system through the letdown system and returned to the primary system via the makeup system. This flow, maintained for several days following the accident, was necessary to ensure adequate cooling of the reactor coolant pump bearings. Normally the gases evolving from the reactor coolant in the letdown and makeup systems are of little radiological significance. During this period, however, these gases caused very high radiation levels inside the auxiliary and fuel-handling buildings and resulted in much higher than normal environmental releases via the ventilation exhausts from these buildings. This flow was the principal pathway by which radioactivity passed from the damaged reactor core to the auxiliary building, fuel-handling building, and to the environment.

At about 8:00 a.m., the station superintendent and other officials on the site decided to try again to activate the reactor coolant pumps. After some difficulty, two of the four pumps (one in each loop) were restarted. By 8:30, there was new coolant entering the primary system from the ECCS.

At 9:15, the White House was notified of the accident by the NRC. The team dispatched by NRC Region I arrived at the site by 10:15. It was shortly afterwards that the radiation level in the Unit 2 control room required that personnel there don respiratory masks. These proved to be a hindrance to clear communication. At 11:00 a.m., all non-essential personnel were ordered off the island. It was about this time that the NRC and State radiation protection officials asked the Department of Energy (DOE) to send a team from the Brookhaven National Laboratory to help with radiation monitoring.

About 11:30 there began an attempt to depressurize the reactor coolant system so as to be able to activate the low-pressure decay heat removal system. The pressure, however, remained too high for this purpose because of the volume of hydrogen gas and steam in the primary coolant system. Hence, the decay heat removal sysyem could not be initiated, and the attempt at repressurization was terminated about 3 p.m. Repressurization began at about 5:30 and was completed at about 6:45.

Sometime around noon, three licensee employees entered the Unit 2 auxiliary building and found radiation levels of from 50 to 1,000 rem-per-hour; each of the three incurred radiation doses of 800 millirem. At 1:50 p.m., a hydrogen explosion or "burn" took place in the Unit 2 containment building. Personnel on hand later remembered hearing a thud about this time and the computer chart showed a sudden pressure surge in the containment up to 28 pounds-per-square-inch, but the meaning of the spike on the chart was not immediately recognized.

By evening of the 28th, NRC had 11 people on the TMI site and a mobile laboratory van for analysis of the radiation content of environmental samples. A team from the Brookhaven National Laboratory had been assisting with the radiation monitoring since mid-afternoon, as had the aerial survey aircraft from DOE. About 8:00 p.m., a reactor coolant pump was activated and coolant flow was established, carrying heat out of the reactor through one of the steam generators to the condenser, bypassing the turbine. The primary system remained essentially in this mode for a month, until natural circulation was finally achieved on April 27.

Thursday—March 29

On Thursday morning, a team of seven specialists from NRC headquarters arrived at the site. At that time the radiation readings at and near the plant were not negligible but also were not alarming. No significant iodine releases were detected. These would be considered especially hazardous because radioactive iodine, should it enter the human food chain, tends to accumulate in the thyroid and can cause cancer of that gland. The Congress evinced immediate and urgent interest in events at the plant: Chairman Hendrie was called to explain the situation before the House Subcommittee on Energy and the Environment, and Senators Heinz and Schweiker and Congressmen Ertel and Goodling—all of Pennsylvania—were briefed by the utility and the NRC. During the afternoon, some waste water from the plant was discharged by the licensee into the Susquehanna River. Because it contained only slightly radioactive material, the release did not constitute a violation of NRC regulations, but, with all the uncertainties still surrounding the scene at TMI, the NRC Chairman ordered the discharges stopped. Late in the day, analyses of coolant samples confirmed the presence and showed something of the extent of the core damage that took place during the periods that the core was uncovered on Wednesday. (It was later determined that there had been three periods when a significant portion of the core was being cooled by steam rather than fluid coolant.) First concerns about the presence of a hydrogen bubble in the reactor vessel arose on Thursday, and the fact that there had been a hydrogen explosion outside the vessel in the containment building early Wednesday afternoon was brought to light.

Friday—March 30

Friday was the day when it became clear to all concerned that the event was far from over; that radiation releases from the auxiliary building were not under control and were increasing; that there was a large gaseous bubble in the reactor vessel which could conceivably expand, forcing the level of coolant below the top of the core, uncovering it again; that, according to some analyses and expert judgments, the bubble might become flammable as oxygen evolving from the decomposition of water by radiation made its way into the upper part of the vessel; that radiation was emanating from the facility in a manner neither planned nor controlled.

Early in the day, reports of a 1200 mr/hr reading above TMI-2 precipitated serious discussion at the NRC Operations Center in Bethesda of the possibly urgent need to evacuate the residents of Goldsboro, Middletown and other communities and areas around the plant, even out as far as Harrisburg. The fact that there was a consensus favoring such a recommendation at the Operations Center was relayed to State officials in Pennsylvania, occasioning considerable anxiety and confusion, since the judgment was not shared by people at the plant site. The NRC position was clarified when Chairman Hendrie spoke with Governor Thornburgh about 10:00 a.m., and counseled against full-scale evacuation of the population, suggesting instead that the Governor recommend that people stay indoors for awhile until the true situation could be better defined. The Governor did so. About 40 minutes later, President Carter contacted Chairman Hendrie and directed that a senior NRC official be dispatched to the TMI site as his personal representative; the President also assured that the White House staff would see to it that an adequate and dependable communications system would be set up as soon as possible between the site, the White House and the NRC. Prior to this, communications between the plant and the NRC had been unreliable and had even been lost for a time. The Director of NRC's Office of Nuclear Reactor Regulation, Harold Denton, left NRC headquarters for the TMI site with a support staff of 12 to serve as the President's representative and as the primary NRC official on the scene. Shortly after noon, Chairman Hendrie indicated to Governor Thornburgh by telephone that a recommendation by the Governor that pregnant women and pre-school aged children within five miles of the plant leave the area temporarily was advisable. The Governor made this recommendation soon afterwards.

Discussions and assessments of the possible need for total evacuation of the population near TMI continued throughout the day among NRC, other Federal and State officials. About an hour after the former's arrival at TMI and a first assessment of conditions in and around the plant, NRR Director Denton and Chairman Hendrie reviewed various possible courses the accident might take—or that licensee personnel might take in their effort to gain control of events—and the implications of each for a judgement on whether and when to move people out of the area. Within an hour of their conversation, Chairman Hendrie was in contact with Governor Thornburgh, at which time he advised the Governor that, though the bubble in the reactor vessel could cause trouble later in keeping the core cooled, there was no appreciable amount of oxygen in it and the chance of a hydrogen explosion such as took place in the containment on Wednesday was "close to zero." The Chairman also appraised the chance of a core meltdown as being extremely low, but the possibility of a significant radiation release as being somewhat higher.

Additional contingents of NRC personnel were sent to TMI during the day and by 4:00 p.m. there were 83 NRC staff people at the site. Other Federal agencies—DOE, EPA, FDAA and others—and State officials responsible for emergency management and radiation protection were also present in force. In a press release issued around 6:00 p.m., the NRC Chairman declared that there was "no imminent danger of a meltdown" of the reactor core. By 8:30 on Friday evening, Governor Thornburgh decided, having consulted with NRC officials on the site, to lift the advisory that people within five miles of the plant should stay indoors but, with NRC concurrence, continued to recommend that pregnant women and young children leave and/or stay out of the area.

By day's end, there was deep uncertainty among all concerned as to the potential hazard represented by the hydrogen bubble in the reactor vessel. National laboratories and industrial experts, as well as NRC research personnel, were at work calculating how long it might be until the amount of oxygen finding its way into the hydrogen bubble would produce a flammable mixture in the upper portion of the vessel. Preliminary estimates of that time-frame varied. Later on it was realized that there was no appreciable build-up taking place because the oxygen resulting from the radiolytic decomposition of water was combining with free hydrogen in the reactor coolant.

Saturday—March 31

On Saturday the focus of concern had shifted from periodic uncontrolled radiation releases to potential explosion of the hydrogen in the reactor vessel. Radiation readings were very low everywhere but inside the containment. The NRC and other Federal presence at the site was expanding. The NRC Commissioners meeting in Washington, D.C., continued discussions of what changes in the situation might warrant a recommendation that people leave the TMI area, or whether such a recommendation should be made immediately, as a precaution. The conditions at TMI-2 were improved in virtually every respect, except for the hydrogen problem, and the Commissioners were

The control room for TMI Unit 2 is shown above. The instruments and controls are deployed in a U-shaped pattern in a design intended to permit one operator to supervise operations under normal, stable conditions. During abnormal situations, it is expected that additional operators would be available to give any needed assistance.

conscious of the hardships an evacuation would impose upon the population. There was also the matter of range to consider, whether to evacuate out to five miles or 10 miles or more, and of how much time would be available, if core conditions began to deteriorate, before the defensive barriers of the plant would be breached.

Around noon the NRC Chairman and NRR Director at the site discussed the situation at length, considering both the kinds of events that would signal a need to begin moving people out and also various means by which to reduce the hydrogen hazard. Soon afterwards, estimates were received from various research teams that the conditions necessary for hydrogen combustion or explosion in the reactor vessel were perhaps days away, and it appeared that there would be amply sufficient time to vent the vessel into the containment or otherwise defuse the danger. In mid-afternoon, Chairman Hendrie held a press conference at the NRC Operations Center in Bethesda, Md., at which he affirmed that a precautionary evacuation of the TMI area was still a possibility, especially if it were decided to try to force the hydrogen bubble out of the reactor vessel. Soon after, the Chairman and the Governor conferred by phone. Responding to the latter's query, the Chairman advised that, since some low-level releases of radiation were still coming from the auxiliary building, it would be prudent to continue the recommendation on pregnant women and pre-school aged children and to keep emergency planning personnel and resources in readiness.

Sunday—April 1

Following a brief meeting with the staff at Bethesda, Chairman Hendrie left Washington to go to the TMI site. President Carter was to arrive there in the early afternoon for a tour of the scene and briefings on the status of the reactor. During the morning, the NRC personnel at the site had augmented the radiation monitoring equipment by placing 37 thermoluminescent dosimeters within a 12-mile radius of the plant. By mid-afternoon the bubble in the reactor vessel seemed to be dissipating and the system stabilizing, though intense discussion of the evacuation question continued among Commissioners and staff in Washington. Chairman Hendrie communicated the favorable change in the situation to the group in Washington and characterized the next phase in management of the accident as a choice between moving at once to activate decay heat removal from the reactor or moving slowly and letting the reactor cool at its own rate.

Reactor cooling was maintained by the action of one of the main coolant pumps providing the flow through the reactor core, and heat removal through one of the steam generators to the condenser, until about 2:00 p.m. on April 27 when the reactor coolant pump was intentionally shut down and core cooling by natural circulation was achieved.

Governor Thornburgh and President Carter are escorted into the TMI Unit 2 control room by a Metropolitan Edison employee on Sunday, April 1, 1979.

A bulletin was transmitted Sunday afternoon to all NRC licensees operating reactors of the B&W design to make an immediate review of plant conditions and to implement a number of precautionary measures derived from the TMI experience. NRC inspectors were also sent out to confirm that the prescribed actions were taken. The bulletin was the first in a series issued by NRC to licensees as analyses of the TMI accident revealed both necessary and prudential actions to be taken to prevent recurrence of the event (see "Bulletins and Orders Task Force," below).

Later in April, licensees for the other nuclear power plants employing B&W nuclear steam supply systems indicated that they would voluntarily shut down until prescribed alterations in design and procedures were completed. Confirmatory orders to that effect were subsequently issued by NRC for several of these units.

By the end of May, "dedicated" telephone lines had been established between the NRC Operations Center in Bethesda and 68 of the 70 licensed nuclear power plants and 14 licensed fuel cycle facilities. The lines make it possible for operations personnel in these facilities to communicate immediately and directly with members of the NRC's technical staff any time of the day or night on any day of the year. The system also provides for instant communication with any one of the five NRC regional offices.

The accident at TMI-2 generated investigations, reports, findings and recommendations literally too

Water from the industrial waste treatment systems of the plant (TMI), designed to be non-radioactive, is checked to insure that is has not been contaminated.

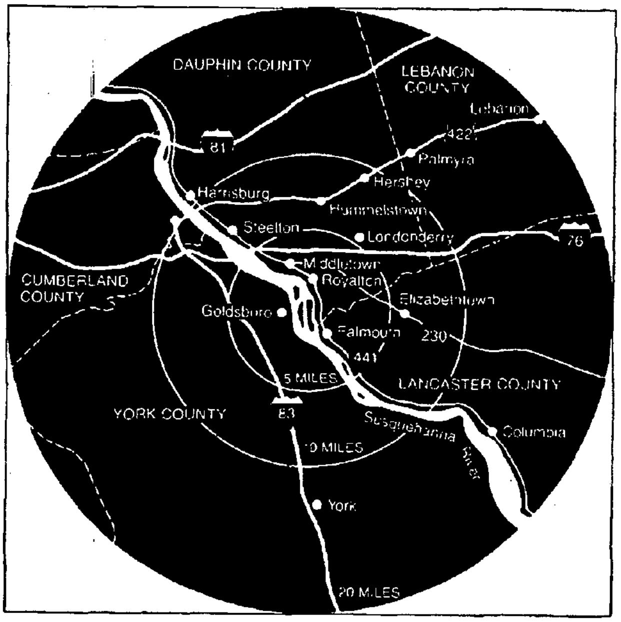
•Plotting wind direction to assist in monitoring operations.

numerous to mention. The balance of this chapter attempts only to describe the major NRC undertakings in the matter and to cover the findings and recommendations of the commission appointed by President Carter to conduct an independent investigation of the accident and its implications, together with NRC's responses to those recommendations. At the time this report was prepared, the work of the NRC Special Inquiry Group—an investigatory body set up by the NRC under independent directorship—was not yet complete, nor had the various Congressional reviewers reported their results.

RADIOLOGICAL CONSEQUENCES TO PERSONS AND THE ENVIRONMENT

Individual and Collective Doses. NRC staff members participated in an interagency study to determine the individual and population doses associated with the TMI accident. The results of the study are presented and discussed in the NRC report, "Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station" (NUREG-0558). Based on environmental measurements performed during the accident, it was estimated that the maximum individual off-site whole body dose was about 83 millirem, which is approximately one-sixth the NRC's allowable maximum whole body dose of 500 millirem-per-year. The population within 50 miles of the TMI site received an estimated integrated dose of 3,300 person-rem. This population dose is expected to result in less than one additional fatal cancer among the exposed population, in which 325,000 fatal cancers can be expected to occur as a result of other causes.

Radiation doses to licensee employees have also been estimated. Occupational whole-body doses accumulated from the date of the accident through May 31, 1979, totaled 225 person-rem. These doses were received by employees in performing recovery operations after the accident, such as changing filters in the cleanup systems for air leaving the auxiliary building and fuel-handling building, sampling of air and primary coolant, decontamination and radioactive waste processing operations, and routine inspection and maintenance activites. In the days immediately following the accident, four persons received exposures exceeding NRC regulatory standards. Two persons involved in taking a primary-coolant sample received doses substantially in excess of the standards. One person received a total body dose of 4.1 rem (the regulatory limit is 3.0 rem), an extremity (finger) dose of 147 rem (the limit is 18.75 rem) and skin dose to the top of the head of 13 rem (the limit is 7.5 rem). The second person received extremity doses of 54 rem. Two other persons received whole body exposures of 3.2 rem and 3.1 rem, which are slightly higher than the NRC limit of 3.0 rem.



Map of the TMI area showing 5-, 10- and 20-mile evacuation zones.

Environmental Protection at Three Mile Island. During the accident at Three Mile Island there was concern that a core meltdown might occur. This could have led to the contamination of the groundwater of the island and ultimately of the Susquehanna River and beyond. The staff developed contingency plans to mitigate the effects of groundwater contamination by isolating the immediate plant area from the regional water supplies. The plans provide for blocking groundwater movement, for withdrawing the potentially contaminated water, and for monitoring and temporarily storing the contaminated water. Working with the U.S. Army Corps of Engineers, the NRC staff formulated a plan to construct a bentonite-cement cut-off wall, dewatering wells, and a pumping system. Availability of equipment needed to carry out the plan was verified. Plans for monitoring and on-site storage were also completed. It did not prove necessary to implement planned isolation of the area.

Another problem encountered in the accident was the need for the staff to produce estimates of the transport or diffusion of gaseous releases, in order to plan for possible evacuation of the population and for assessment of the consequences thereof. These estimates were made by staff meteorologists assigned to the NRC Operations Center. Well into the accident, the staff ascertained that meteorological data were available from the TMI meteorological tower by remote access and made use of this information. In addition, the staff arranged for National Weather Service (NWS) to provide supplementary meteorological instrumentation at the site. The staff established communications with and utilized the forecasting services of the NWS Harrisburg River Forecast Center and NWS Philadelphia Area Weather Forecast Center. The staff's estimates of the transport and diffusion of TMI releases were used in estimating doses for the locations of dose-rate instrumentation both on the TMI site and off. Because the magnitude of the release was unknown during the early stages of the accident, data from environmental monitors and meteorological estimates were used to calculate releases. Atmospheric transport estimates were used to advise evacuation planners.

In further protection of the environment, the possible non-radiological consequences to the aquatic biota and recreational fisheries of the Susquehanna River from the accident at Three Mile Island Nuclear Station in late March of 1979 were investigated up through the post-accident period (through June). Data used in the investigation included site-specific biological and water quality information collected by the license under the Environmental Technical Specifications and National Pollutant Discharge Elimination System monitoring programs, and also information from State and Federal agencies, knowledgeable persons, and

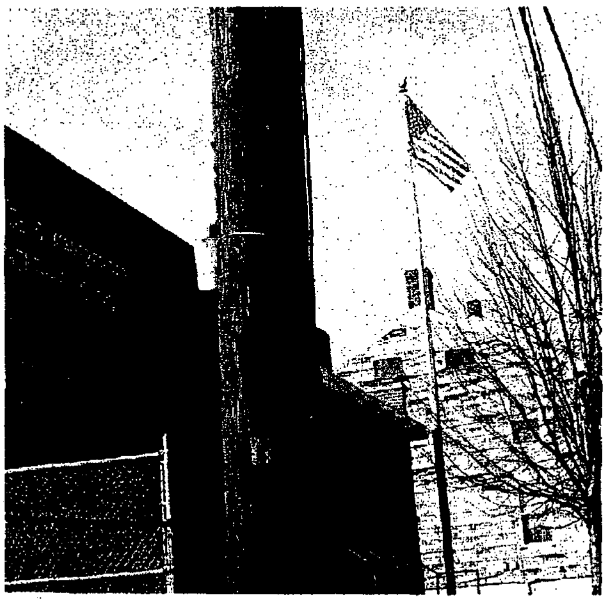
Samples of grass from the area surrounding the plant and the Susquehanna River are shipped out by the EPA to be checked for radioactive contamination.

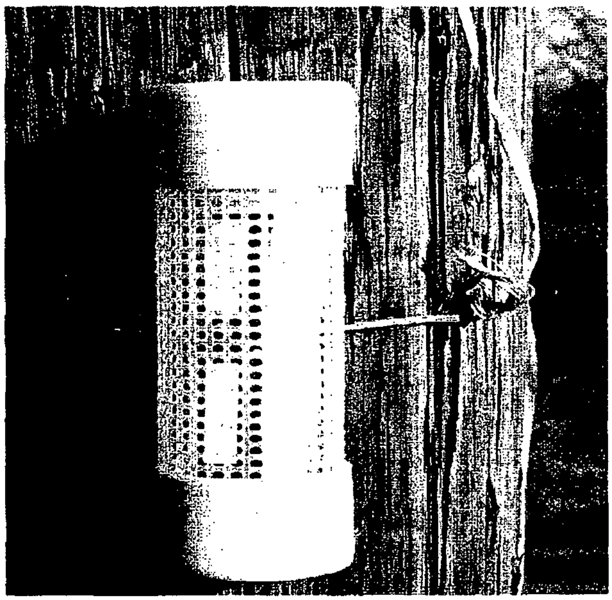
studies conducted in other upstream and downstream areas of the river. Thermal and chemical discharges during and following the accident did not exceed the effluent limitation established to protect the aquatic environment. Although several million gallons of treated industrial waste effluents were released into the river, these discharges were not of unusual volume compared with normal operation and were a very small portion of the seasonally high spring river flows. The extent and relative location of the effluent plume were defined and the fish species known to have been under its immediate influence were identified—including rough, forage, and predator/sport fishery species. Impacts to benthic invertebrates or fishes were not detected. No unusual conditions of fish disease or mortality were noted in the river following the accident. The normal spring increases in abundance and species-composition of riverine fauna occurred, as did the onset of the fish spawning season in April with peaks of ichthyoplankton abundance in May and June.

Nevertheless, post-accident recreational fishing in the Three Mile Island vicinity underwent significant departures from historical trends. Fishing activity appeared to shift away from the Susquehanna River waters near the nuclear station to other areas, especially downstream. Anglers returned greater proportions of their catches than during any comparable period within the previous five years. This was most notable during April when anglers fishing near the plant returned an unprecedented 100 percent of their catches. Thus, in the waters receiving station effluents during the month following the accident, the liquid radiological pathway leading to man via fin fish consumption could have been absent entirely. With the passage of time following the accident, the normal pattern of recreational fishing was approached. The investigation defined several generic aspects of the accident and lessons applicable to other facilities: the time of the accident with respect to the biological season, and to the ability to detect an impact; data availability and data needs for adequate monitoring; and the application of the non-radiological findings for radiological assessment. This investigation is described in an NRC report: "The Non-Radiological Consequences to the Aquatic Biota and Fisheries of the Susquehanna River from the 1979 Accident at Three Mile Island Nuclear Station" (NUREG-0596).

TMI RECOVERY OPERATIONS

Following the accident of March 28, a substantial effort was mounted to provide technical assistance, regulatory guidance and review of the licensee's operations procedures and system addition and modification activities. A team began to form with the arrival of the Office of Inspection and Enforcement Region I inspectors shortly after the accident and continued to expand with the arrival of the first contingent from the Office





Thermoluminescent dosimeter (enlarged at right), used by the NRC to measure the amount of airborne radiation delivered to a specific place, is shown mounted on a utility pole near a school in Middletown, Pa. Similar devices were installed both on the TMI site and at various locations around the plant up to 15 miles away by NRC, the Environmental Protection Agency, Metropolitan Edison Co., and an independent contractor. In addition to making independent evaulations, each group sent the data collected to both the NRC and EPA for analysis.

of Nuclear Reactor Regulation (NRR) on March 29 and additional inspectors from all five regional offices. On March 30, the Director of NRR and additional NRR staff arrived on the site to assist in the recovery operation. A Public Affairs Office was also established in Middletown, PA, and staffed on a 24-hour-per-day basis to handle the flow of information to the public and the media.

NRR staff analysts in many of the major disciplines were brought to TMI to provide needed technical resources. The specific activities engaged in by the staff can be broken down into four major areas:

(1) A review was initiated of the system modifications and system additions (proposed by the licensee, the industry review group, or the NRC) as contingency measures to mitigate the consequences of the accident and to provide assurance for continued safe shutdown and long-term safe shutdown.

(2) Substantial effort was given to the review of all procedures, both emergency and normal operation and maintenance, which were necessary to post-accident activities. In many cases, because of changes in the use of normal systems and the addition of new ones, new operating procedures were necessary. Further, the facility license and technical specifications, which defined the limits for operating parameters and surveillance requirements, were no longer fully applicable to the post-accident facility, though existing facility procedures provided a mechanism for establishing specific operability limits and surveillance requirements. It was necessary, from a regulatory point of view, to have NRC's review and approval of any new procedures that might be in conflict with the pre-accident license.

(3) NRR provided close and continuous monitoring of the operations in progress to assure that system parameters stayed within expected limits and to provide prediction of future system performance and the capability of plant systems to maintain safe conditions.

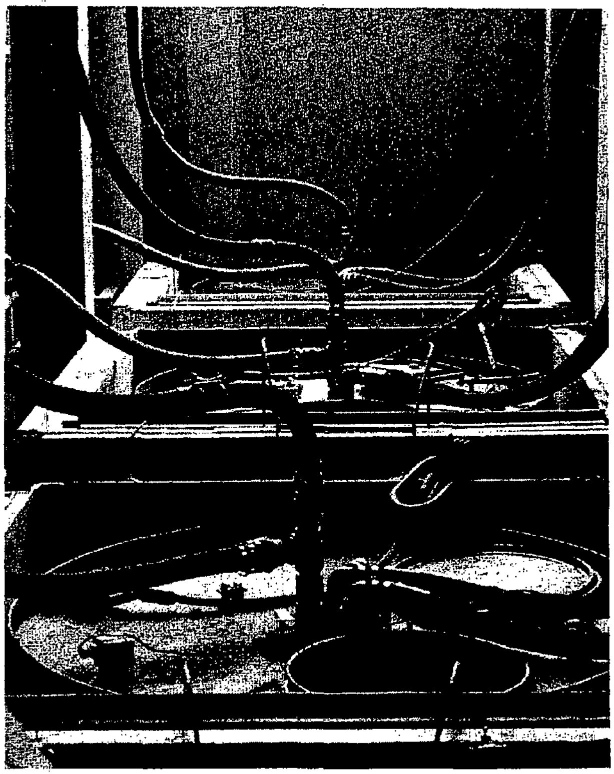
(4) Lastly, substantial NRR effort was committed to providing consultation, review and analysis of the ongoing radwaste, cleanup, and health physics activities. The accident generated a significant amount of contaminated water which, in turn, contaminated substantial portions of the facility and its systems. This made it difficult to have normal access to systems important to safety and also constituted a threat of further fission product release and occupational exposure. In addition, the radiological makeup of the contamination was different from that normally encountered in operating reactors, in terms of its airborne intensity as well as its ratio of beta and gamma activity. It was therefore an important concern—particularly in view of the intensive work activity needed to continue safe operation—that operator exposures be maintained within acceptable limits and the environment protected from undue radiological effluents.

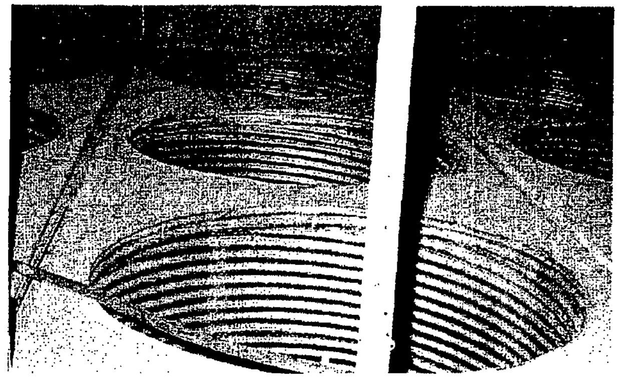
Examples of the system review activity undertaken by the NRR on-site staff were design reviews and evaluations of the following sytems:

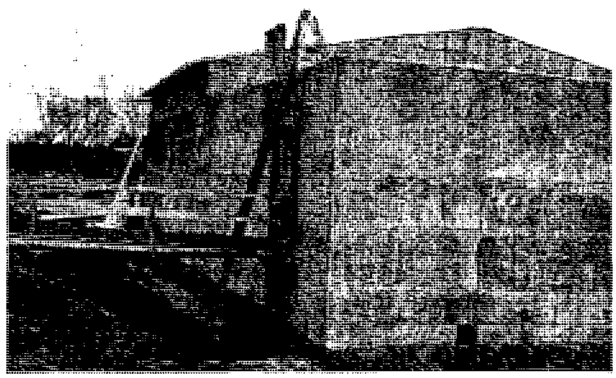
(a) Supplementary diesel generators
(b) Supplementary filtration systems
(c) Long-term cooling systems
(d) Alternative decay heat removal system
(e) Pressure volume control system
(f) Tank farm for storage of radioactive liquids
(g) EPICOR-II system for processing of contaminated liquids
(h) Many monitor modifications in existing systems which allowed operability in the post-accident environment.

Besides the systems reviews, approximately 250 procedures were reviewed and approved by the on-site staff. This activity was particularly important in the first two months following the accident because a serious shortage of personnel familiar with the facility existed; the NRC review constituted not only a regulatory approval of the intended operation, but also served as a quality assurance check on adequacy and operability. The review of procedures is continuing as the licensee rewrites emergency and operating procedures to reflect the changing status of the facility. It is anticipated that such procedure review will be necessary until a new set of facility technical specifications, which reflect the post-accident facility configuration, is implemented.

A substantial amount of staff effort was expended on the review and approval of the EPICOR-II operation, intended for use in decontaminating the 380,000 gallons of intermediate-level contaminated water held in the auxiliary building tanks and in the tank farm constructed following the accident. EPICOR-II was designed and constructed following the accident because it was clear that storage of water would be a significant problem and could not be accommodated with existing facility equipment. EPICOR-II is a three-stage demineralization system, constructed in an existing on-site building. EPICOR-II was provided with sufficient shielding and remote-handling capability to accommodate the processing of radioactive water up to a level of about 100-microcuries-per-milliliter. When facility operation was near, court actions were initiated to prevent operation of EPICOR-II or disposal of the decontaminated water. In response to these actions, the Commission directed that an environmental assessment for the use of







The "EPICOR-II" system being used to decontaminate some 380,000 gallons of intermediate-level radioactive water held in the auxiliary building tanks at the TMI-2 site is shown above. It consists of three process vessels (steel liners) shielded by four-inch lead enclosures located in the chemical cleaning building. Each vessel contains ion-exchange resin. The vessel at the top of the photo at the left is the system prefilter/demineralizer, the center vessel is a cation ion-exchanger, and the third vessel is a mixed-bed polishing ion-exchanger. Each is fitted with three quick-disconnect hoses: a liquid waste influent line, a processed waste effluent line, and a vent line with attached overflow hose. Vented air from each vessel passes through a special filter and charcoal adsorber. "Spent" ion-exchange resin liners containing radioactive material removed from the water are transferred by crane to cells (shown at top right) which are housed in modular concrete storage structures (above). The cells are concrete-shielded, galvanized corrugated steel cylinders seven feet in diameter and 13 feet high. The storage module shown under construction has 4-foot thick walls and will be 57 feet wide and 91 feet long. The modules, each holding about 60 storage cells, will be built on an as-needed basis. Shipment of the radioactive liners away from the site will depend on approval of a disposal facility and availability of shipping casks.

EPICOR-II be prepared, followed by the environmental assessment for the alternatives of disposal of decontaminated water. Both of these environmental assessments would be provided to the public for comment before any actions would be initiated. Environmental assessment for the use of EPICOR-II in the decontamination of the intermediate level of contaminated water in the auxiliary building was prepared and sent out for public comment on August 14, 1979. The assessment evaluated various alternatives to the proposed cleanup and concluded that the use of the already constructed system was the best alternative, and that the processing of water would constitute a negligible environmental impact.

Based on these evaluations, the Commission, on October 16, 1979, issued a Memorandum and Order directing the use of EPICOR-II.

BULLETINS AND ORDERS TASK FORCE

The accident at TMI-2 involved a feedwater transient coupled with a small break in the reactor system (the open relief valve). Because of the severity of the ensuing events and the potential generic implications of the accident for other operating reactors, the NRC staff initiated prompt action to: (1) assure that other reactor licensees, particularly those with plants similar in design to TMI-2, took the necessary action to substantially reduce the likelihood for TMI-2 type events, and (2) start comprehensive investigations into the potential generic implications of this accident on other operating reactors.

The Bulletins & Orders Task Force was established within the Office of Nuclear Reactor Regulation (NRR) in early May 1979. This task force was responsible for reviewing and directing the TMI-2 related staff activities regarding loss-of-feedwater transients and small break loss-of-coolant accidents for all operating reactors. The task force concentrated its efforts in the areas of: assessments of auxiliary feedwater system reliability; review of the analytical predictions of plant performance for both feedwater and small LOCA-induced transients; evaluations of generic operating guidelines; the review of emergency plant operating procedures; and the review of operator training.

The task force worked with operating plant licenses, and, for the review of generic items, with owners' groups for plants of each nuclear steam supply vendor (Babcock and Wilcox, Westinghouse, Combustion Engineering, and General Electric) and with the individual vendors. Initial priority was placed on plants of the Babcock and Wilcox (B&W) design, but as short-term actions on these plants were completed, priority was shifted to other pressurized water reactor (PWR) plants, i.e., those manufactured by Westinghouse and Combustion Engineering. Activities related to boiling water reactors, a significantly different light water reactor type manufactured by the General Electric Company, were pursued as a third priority.

The task force, which was composed of approximately 30 technical professionals of widely varying disciplines and areas of expertise, evaluated licensees' responses to NRC Bulletins; the issuance and subsequent lifting of Orders to the B&W operating reactors; system reliability and predicted plant performance for each of the reactor vendors, with regard to feedwater transients and small break loss-of-coolant accidents; and related follow-on activities.

Bulletins

The preliminary review of the accident chronology identified several events that occurred during the accident and contributed significantly to its severity. As a result, all holders of operating licenses were subsequently instructed to take a number of immediate actions to avoid repetition of these errors. These instructions were specified in a series of bulletins issued by the NRC's Office of Inspection and Enforcement (IE).

The initial bulletins defined actions by operating plants using the B&W reactor system, but as staff evaluations determined that additional actions were necessary, these bulletins were expanded, clarified, and issued to all operating plants for action. For example, as a result of staff evaluations, holders of operating licenses for B&W designed reactors were instructed by IE Bulletins to take further actions, including immediate changes to decrease the reactor high pressure trip point and increase the pressurizer pilot-operated relief valve settings. A chronology of bulletins issued by IE is shown below.

The task force directed the evaluations of each licensee's response to the IE Bulletins. This process involved an inter-office review group, which included representatives from IE and from the NRR Division of Operating Reactors. When it was concluded that a licensee had understood and had provided an acceptable response to the bulletins, the bulletin review was completed and the evaluation issued as a staff report.

The prompt action taken by licensees in response to the IE Bulletins was considered an important contributor to the assurance of continued safe plant operation. The bulletins and related evaluations also provided substantial input to other staff activities, such as those associated with the generic study efforts and the Lessons Learned Task Force (see below). Thus, many of the subjects addressed by the bulletins were studied in greater depth through other staff activities and studies. Further, the bulletins and the associated responses were used as a basis for IE inspection activities and for auditing of reactor operator training.

Orders on Babcock and Wilcox Plants

Soon after the TMI-2 accident, the NRC staff began a reevaluation of the design features of B&W reactors to determine whether additional safety corrections or improvements were necessary. This evaluation involved numerous meetings with the vendor and the affected licensees.

The conclusion of these preliminary staff studies was documented in an April 25, 1979 status report to the Commission. It was found that B&W designed reactors appeared to be unusually sensitive to certain transient conditions originating in the secondary system. The features of the B&W plants that contributed to this sensitivity were: (1) design of the steam generators which operate with relatively small liquid volumes in the secondary side; (2) lack of direct initiation of reactor trip upon the occurrence of off-normal conditions in the feedwater system; (3) reliance on an integrated control system (ICS) to automatically regulate feedwater flow; (4) actuation before reactor trip of a pilot-operated relief valve on the primary system pressurizer (which, if the valve sticks open, can aggravate the event); and (5) a low steam generator elevation (relative to the reactor vessel) which provides a smaller driving head for natural circulation (except for the Davis-Besse plant).

Because of these features, B&W design relies more than other PWR designs on the reliability and performance characteristics of the auxiliary feedwater system, the integrated control system, and the emergency core cooling system (ECCS) performance to recover from certain anticipated transients, such as loss of off-site power and loss of normal feedwater. This, in turn, can require greater operator knowledge and skill to safely manage the plant controls during such anticipated transients. As a result of the work supporting the April 25, 1979 report, the NRC staff concluded that certain other short-term design and procedural changes at operating B&W facilities were necessary in order to assure adequate protection to public health and safety.

After a series of discussions between the NRC staff and licensees of operating B&W plants, the licensees agreed to shut down these plants and keep them shut down until the actions identified to the Commission in the April 25, 1979 report could be completed. This agreement was confirmed by a Commission Order to each licensee (see "Actions Directed by Orders," below). Authorization to resume operation was issued in the period late May through early July, as individual plants satisfactorily completed the short-term actions and the NRC staff completed an on-site verification of the plant's readiness to resume operation. In addition to the modifications to be implemented promptly, each licensee also proposed to carry out certain additional long-term modifications to further enhance the capability and reliability of the plant systems to respond to transient events (see "Longer Term Actions," below).

Since some of the long-term modifications involve the design, procurement, and qualification of safety-grade hardware, not all of the actions of the long-term portion of the Orders were completed in 1979. Staff involvement will continue to assure that licensees complete each long-term action of the Order "as promptly as practicable" and that the Orders are closed out by a prompt staff acceptance review.

Specific Plant and Generic Studies

For B&W operating reactors, an initial staff study has been completed and published in a staff report (NUREG-0560). This study considered the particular design features and operational history of B&W operating plants in light of the TMI-2 accident and related current licensing requirements. As a result of this study, a number of findings and recommendations resulted which are now being pursued.

Generally, the activities involving the B&W reactors are reflected in the actions specified in the Orders. Consequently, as noted earlier, a number of specific actions have been specified in the areas of transient and small break analyses, upgrading of auxiliary feedwater reliability and performance, procedures for operator action, and operator training.

Similar studies are now well underway for the Westinghouse and Combustion Engineering operating plants. These studies focus specifically on the predicted plant performance under different accident scenarios involving small break loss-of-coolant event and feedwater transients. Based upon analytically predicted system behavior, recommended guidelines for emergency operating procedures were developed and reviewed in the study. In addition, these studies include engineering assessments of the reliability of individual plant auxiliary feedwater systems and identification of dominant failure contributors and recommendations for corrective action. A similar study of the operating boiling water reactors is also in progress, but is at an earlier stage.

As the above studies developed firm conclusions and recommendations, implementing action was initiated. For example, the results of the Westinghouse and Combustion Engineering auxiliary feedwater system reliability assessments concluded that certain improvements were necessary. Individual plant licensees were then requested by letter to initiate corrective action or to propose design solutions for NRC staff review. Additional instructions were to be issued to licensees upon completion of other aspects of these reports.

Follow-On and Interfacing Activities

It was planned that the task force would terminate its activities in late 1979, and therefore some of its activities were transferred prior to completion. Consequently, the task force concentrated on lead plants and established review guidelines and acceptance criteria that could be implemented by other NRR organizational elements.

As a result of the work performed in modeling small break and feedwater transients, longer range efforts were identified dealing with the procedures and systems available for core cooling under certain accident conditions, and with confirming analytical models through experiment or research programs. For example, plans are being implemented to conduct some small break loss-of-coolant tests at the Semiscale and LOFT facilities to obtain a better understanding of small break phenomena and to use the results to verify calculational techniques (see Chapter 11). Other recommendations in this regard are expected to result from the task force activities.

As noted previously, the task force concentrated on the immediate and near term actions necessary to assure the safe operation of operating plants. However, based on actions already completed, a number of items have been identified which warrant careful additional study. These actions have been and are continuing to be, documented for detailed assessment within the NRR organization.

IE BULLETINS ISSUED: APRIL—JULY 1979

Bulletin	*Date Issued*	*Issued to*
79-05	April 1, 1979	B&W plants
79-05A	April 5, 1979	B&W plants
79-06	April 11, 1979	W and CE plants
79-06A	April 14, 1979	W and CE plants
79-06B	April 14, 1979	CE plants
79-08	April 14, 1979	BWR plants
79-06A (Rev. 1)	April 18, 1979	W plants
79-05B	April 21, 1979	B&W plants
79-05C	July 26, 1979	B&W plants
79-06C	July 26, 1979	W and CE plants

Actions Directed by NRC Orders

(for immediate implementation)

(1) Reviewing and upgrading, as appropriate, auxiliary feedwater reliability and performance.

(2) Implement operating procedures for initiating and controlling feedwater independent of ICS.

(3) Implement hard-wired control grade reactor trip on loss of main feedwater and/or turbine trip.

(4) Complete analyses for potential small breaks and implement appropriate instructions for operator action.

(5) Provide at least one senior reactor operator, having TMI-2 training on B&W simulator, in control room.

Longer-Term Actions Required by Orders

(1) Continue to review and upgrade performance of auxiliary feedwater system.

(2) Submit a failure mode and effects analysis of the integrated control system to the NRC.

(3) Improve the quality of the reactor trip following loss of main feedwater and/or turbine trip by upgrading to safety-grade design.

(4) Give continued attention to transient analysis and procedures for management of small breaks.

TMI-2 LESSONS LEARNED TASK FORCE

In May 1979 an interdisciplinary team of engineers from the NRC Offices of Nuclear Reactor Regulation, Nuclear Regulatory Research, Inspection and Enforcement, and Standards Development began work on the identification and evaluation of safety concerns originating from the TMI-2 accident that required licensing actions. This team, the TMI-2 Lessons Learned Task Force, concentrated on issues separate from those specified in IE Bulletins and Commission Orders issued to operating plants early after the accident. The areas of interest to the Lessons Learned Task Force were applicable not only to operating plants but also to pending operating license (OL) and construction permit (CP) applications.

The task force was charged to review and evaluate investigative information, Commissioners' recommendations, ACRS recommendations, staff recommendations from NUREG-0560 ("Staff Report on the Generic Assessment of Feedwater Transients in Pressurized Water Reactors Designed by the Babcock & Wilcox Company"), and recommendations from outside the NRC. In addition, the task force was charged to identify, analyze and recommend changes to licensing requirements and the licensing process for nuclear power plants based on the lessons learned. The scope of the task force assignment covered the following general technical areas:

(1) Reactor operations, including operator training and licensing.

(2) Licensee technical qualifications.

(3) Reactor transient and accident analysis.

(4) Licensing requirements for safety and process equipment, instrumentation, and controls.

(5) On-site emergency preparations and procedures.

(6) NRR accident response role, capability and management.

(7) Feedback, evaluation, and utilization of reactor operating experience.

Two Phases of Work

The work of the task force proceeded in two phases. The first was the development of recommendations for short-term actions which, when combined with the requirements associated with implementation of the IE Bulletins on TMI-2—including the generic status reports issued by the task force and certain other changes in emergency preparations by licensees and operator training and licensing requirements—would ensure the safety of plants already licensed to operate and those to be licensed for operation in the near future. The first phase culminated with issuance in July 1979 of a report entitled "TMI-2 Lessons Learned Task Force: Status Report and Short-Term Recommendations" (NUREG-0578). The implementation of 23 short-term licensing requirements was directed for operating reactors by the Director of NRR in September 1979 based on a favorable ACRS review received in August.

Metropolitan Edison staff members work in a room adjacent to the TMI control room to coordinate communication between the plant and local officials such as State police and fire departments.

In the second phase of its work, the task force considered more fundamental questions in the design and operation of nuclear power plants and in the licensing process. The issues were grouped in four general categories: general safety criteria, system design requirements, nuclear power plant operations, and nuclear power plant licensing. A report entitled "TMI-2 Lessons Learned Task Force: Final Recommendations" (NUREG-0585) was issued in October 1979 to complete this phase.

The completion of these reports terminated the formal activities of the Lessons Learned Task Force, and its members returned to other duties. Two small groups among them, however, remained intact to make up the nuclei of interdisciplinary review teams which will see to the implementation of task force recommendations for new operating licenses and for operating reactors.

Short-Term Recommendations

The decisionmaking process followed by the task force in determining which safety issues required short-term licensing action versus those that could be deferred for further evaluation by the task force or others was based on engineering evaluation and qualitative professional judgment of the safety significance of the various issues. In this regard, the task force selected items for "short-term action" if their implementation would provide substantial, additional protection required for the public health and safety. The task force recommendations presented in NUREG-0578 comprised 23 specific requirements. Each of these is discussed in detail in NUREG-0578, and a proposed two-stage implementation schedule is included as an appendix to that report. The 23 recommendations are briefly stated below.

(1) *Emergency Power.* For PWRs (pressurized water reactors), provide emergency power for the minimum number of pressurizer heaters required to maintain natural circulation conditions in the event of loss of off-site power, for power-operated relief valves and associated block valves, and for pressurizer level instrument channels.

(2) *Valve Tests.* For BWR (boiling water reactors) and PWR relief and safety valves, perform full-scale performance verification tests.

(3) *Valve Position Indication.* Provide direct position indication for PWR and BWR power-operated relief valves and safety valves.

(4) *Instrumentation for Inadequate Core Cooling.* Perform analyses and implement procedures and training for prompt recognition of low reactor coolant level and inadequate core cooling using existing or modified instrumentation; analyze and describe instrumentation for detection of low reactor vessel water level.

(5) *Containment Isolation Signals.* Provide containment isolation on diverse signals, review isolation provisions for non-essential systems and revise as necessary, and modify containment isolation designs as necessary to eliminate the potential for inadvertent reopening upon reset of the isolation signals.

(6) *Recombiner and Purge Penetrations.* For plants that have external hydrogen recombiners or purge systems, provide dedicated penetrations and isolation systems that meet the redundancy and single failure requirements of the Commission regulations.

(7) *Inerting BWR Containments.* Provide inerting for all Mark I and Mark II BWR containments. (Rulemaking required.)

(8) *Hydrogen Recombiner Capability.* Provide the capability to add, within a few days after an accident, a hydrogen recombiner system for post-accident hydrogen. (Minority view; rulemaking required.)

(9) *Systems Leakage.* Perform leakage rate tests on systems outside containment that process primary coolant and could contain high level radioactive materials. Develop and implement periodic testing and preventive maintenance programs.

(10) *Shielding Review.* Perform a design review of the shielding of systems processing primary coolant outside containment and assure that access to vital areas will not be unduly impaired due to radiation from these systems.

(11) *Automatic Initiation of the Auxiliary Feedwater System.* Provide means for automatic initiation

of all auxiliary feedwater systems; manual capability to initiate the auxiliary feedwater system from the control room must be retained.

(12) *Auxiliary Feedwater Flow Indication.* Provide indication in the control room of auxiliary feedwater flow for each steam generator.

(13) *Post-Accident Sampling.* Review and upgrade the capability to obtain and analyze samples from the reactor coolant system and containment atmosphere under high radioactivity conditions.

(14) *High-Level Radiation Monitors.* Provide high-range radiation monitors for noble gases in plant effluent lines and a high-range radiation monitor in the containment. Provide instrumentation capable of measuring and identifying radioiodine and particulate radioactive effluents in effluent lines under accident conditions.

(15) *Improved In-Plant Iodine Instrumentation.* Provide instrumentation for accurately determining in-plant airborne radioactive concentrations to minimize the need for unnecessary use of respiratory protection equipment.

(16) *Analysis of Transients and Accidents.* Provide the analysis, emergency procedures, and training to improve operator performance during a small break loss-of-coolant accident, to assure that the reactor operator can recognize and respond to conditions of inadequate core cooling, and to improve operator performance during transients and accidents, including events that are caused or worsened by inappropriate operator actions.

(17) *Shift Supervisor Responsibilities.* Promptly issue an operations policy directive that emphasizes the duties, responsibilities, and authority and lines of command of the control room operators, the shift supervisor, and the person responsible for reactor operations command in the control room.

(18) *Shift Technical Advisor.* Provide a shift technical advisor at each nuclear power plant who has a bachelor's degree or equivalent in a science or engineering discipline and with specific training in the plant response to off-normal events and in accident analysis of the plant.

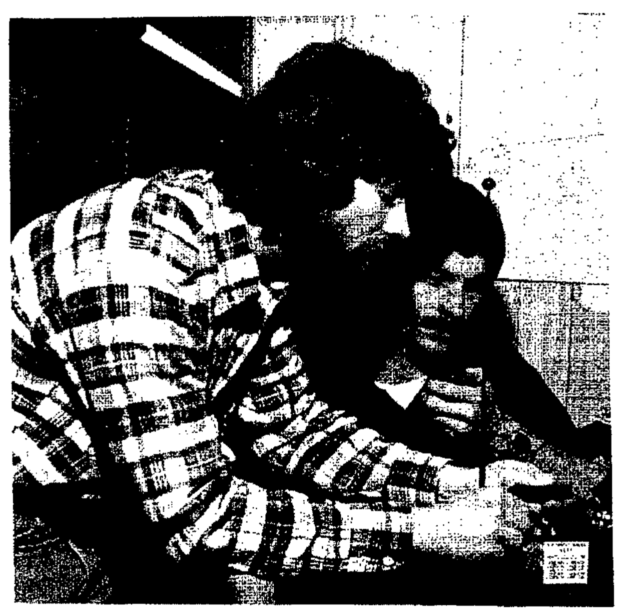
(19) *Shift and Relief Turnover Procedures.* Review and revise plant procedures as necessary to assure that a shift turnover checklist is provided and required to be completed and signed by the oncoming and offgoing individuals responsible for command of operations in the control room.

(20) *Control Room Access.* Revise emergency procedures as necessary to assure that access to the control room under normal and accident conditions is limited to those persons necessary to the safe command and control of operations.

(21) *On-site Technical Support Center.* Provide an on-site technical support center, separate from the control room, for use by plant management, and technical and engineering support personnel in an emergency. This center shall be used for assessment of plant status, support of the control room command and control function, and in conjunction with implementation of on-site and off-site emergency plans. Communications links shall be established and the center shall be equipped as necessary for emergency engineering support activities.

(22) *On-site Operational Support Center.* Establish and maintain an on-site operational support center to which shift support personnel (e.g., auxiliary operators and technicians) other than those required and allowed in the control room report for further orders and assignment during an emergency.

(23) *Loss of Safety Function.* Require that a reactor be shut down if human errors lead to a complete loss of safety function (e.g., loss of emergency feedwater, high pressure ECCS, low pressure



Portable communication units provided by the U.S. Forest Service were used to communicate between the TMI control room and various staff activities at the site. One such unit was manned on a 24-hour basis while periodic checks were made with the control room to record the status of the reactor.

ECCS, containment, emergency power or other prescribed safety function), and allow the facility to return to power only after a public meeting and NRC approval of the remedial changes proposed by the licensee. (Rulemaking required.)

After considering comments on NUREG-0578 by various NRC offices, the Advisory Committee on Reactor Safeguards (ACRS), the industry and the public, the Director of Nuclear Reactor Regulation, with the approval of the Commission, added four requirements as follows:

(1) *Containment Pressure Indication (ACRS).* Provide wide-range continuous indication of containment pressure in the control room.

(2) *Containment Hydrogen Indication (ACRS).* Provide continuous indication in the control room of hydrogen concentration in the containment atmosphere.

(3) *Containment Water Level Indication (ACRS).* Provide continuous indication in the control room of containment water level.

(4) *Reactor Coolant System Vents.* To provide means for removing noncondensible gases, install reactor coolant system and reactor vessel head high point vents remotely operated from the control room.

Implementing Short-Term Recommendations

The Commission directed that the staff proceed as soon as possible with implementation of all of the short-term recommendations, except those which were modified as set forth below, on the two-stage, 16-month schedule recommended by the task force.

In view of ACRS comments, the Director of Nuclear Reactor Regulation decided to delay any rulemaking action concerning inerting of BWR Mark I and II containments and provisions of hydrogen recombiner capability at operating plants until the final report of the task force had been issued. Final resolution of these matters is discussed in the section below covering the long-term recommendations of the Lessons Learned Task Force.

With respect to the recommendation to add a Shift Technical Advisor at each plant, the ACRS endorsed the concept but suggested that flexibility be maintained in implementation so that the objective could be reached through innovative approaches by individual licensees. For guidance, the task force prepared a statement of functional characteristics for the Shift Technical Advisor to be used in evaluating alternatives proposed by licensees.

The recommendation to review limiting conditions of operation to incorporate mandatory shutdown if human error causes loss of a safety function stimulated much interest inside and outside the staff. The Office of Standards Development has prepared a paper proposing such a new rule, but setting forth alternatives for achieving the same objectives as the task force recommendation.

On September 13, 1979, letters were sent to all operating nuclear power plants advising them that they should proceed with implementation of the recommendations of the Lessons Learned Task Force and the additional items resulting from ACRS comments and review by the Director of Nuclear Reactor Regulation. During the week of September 24, 1979, regional briefings were held to apprise reactor owners of these requirements. These meetings were followed by a 3-day series of meetings at NRC headquarters in Bethesda, Md. on some of the specific short-term requirements. Letters were also sent to applicants for construction permits and operating licenses instructing them to implement the short-term lessons learned.

All of the short-term "Category A" requirements deriving from conclusions of the Lessons Learned Task Force were conveyed to licensees of operating reactors by the end of 1979. It was expected that about two-thirds of these licensees would have met the Category A requirements by the end of January 1980, and the rest by May at the latest.

The approach adopted by NRC staff in seeking swift implementation of the short-term requirements allowed licensees to fulfill those requirements prior to NRC staff review. The approach necessitated a careful clarification of each requirement, and this was provided by means of regional as well as topical meetings and numerous discussions among NRC staff, the vendor-oriented owners' groups, and licensees.

The small number of action items that were not completed by the deadlines prescribed by NRC mainly involved problems of equipment availability. Some slippage is also permitted where it can be demonstrated that a severe impact on regional power supply would otherwise result.

Long Term Recommendations

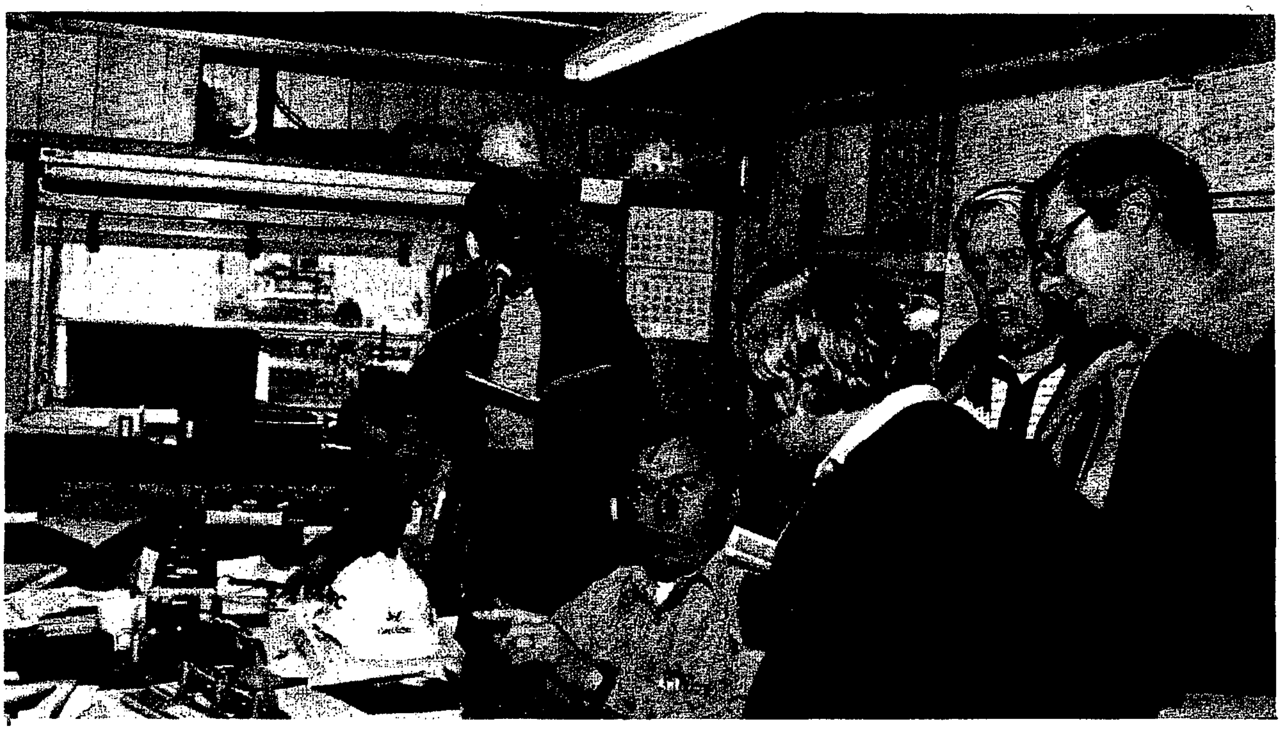
In contrast to the short-term recommendations in NUREG-0578, which were of a more narrow, specific, and urgent nature, the final report of the task force (NUREG-0585) dealt with safety questions of a more fundamental policy nature regarding nuclear plant operations and design and the regulatory process.

To stimulate discussion and speed the deliberative process, the task force developed a number of specific, final recommendations toward accomplishing the policy objectives and safety goals described in the report. The task force considered the modifications it outlined to be of fundamental importance to nuclear safety, and urged that immediate steps be taken to complete the deliberative process and initiate implementation of the recommendations.

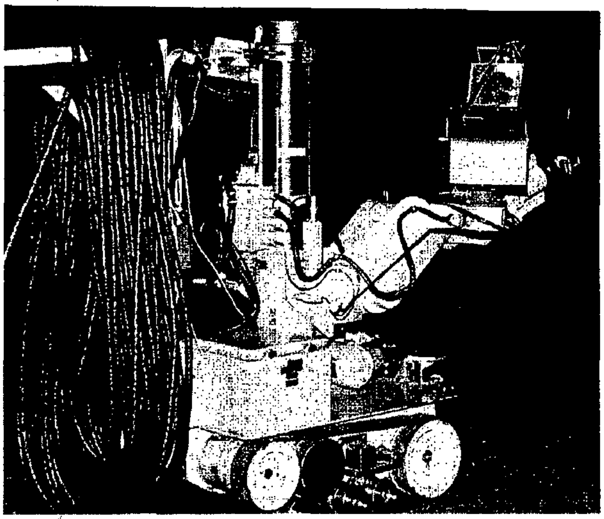
Although the accident at Three Mile Island stemmed from many sources, the most important lessons learned fall in a general area the task force chose to call operational safety. This general area included the topics of human factors engineering; qualification and training of operations personnel; integration of the human element in the design, operation, and regulation of system safety; and quality assurance of operations. Specifically, the primary deficiency in reactor safety technology identified by the task force's review of the accident was the inadequate attention that had been paid by all levels and all segments of the technology to the human element and its fundamental role in both the prevention of accidents and the response to accidents. Thus, the policy recommendations and specific ideas in NUREG-0585 for stimulating and accomplishing change concentrated heavily on operations reliability and the associated design and licensing review measures that support or augment operations reliability.

The task force also devoted considerable attention to the basic mission of reactor regulation after Three Mile Island. It was not alone in these efforts; many people called for a clearer articulation of NRC's role and mission after March 28, 1979. The task force found that prescriptive and narrow licensing requirements only add to the quiltwork of regulatory practice and do little to directly address the nation's heightened concern for the safety of nuclear power plants. The task force called for the development of an articulate and widely noticed national nuclear safety policy with which to bind together the narrow and highly technical licensing requirements. Although the NRC and the President's Commission alluded to a more definitive safety policy by taking actions that in effect say, "no more Three Mile Islands," the task force urged that the feasibility and the adequacy of such a policy be critically examined and an opportunity provided for thorough and widespread public input.

More than 30 recommendations in 13 different areas were made by the TMI-2 Lessons Learned Task Force. In its review of these recommendations, the ACRS supported them in all 13 areas, offered advice on details of implementation and criteria employed in some of those areas, and added comments and recommendations on areas not addressed in the task force reports. Final recommendations of the task force and of the ACRS were being factored into the development of the NRC Action Plan for TMI-2 matters, which was in preparation at the end of 1979.



Activity in the trailer office of NRC's Office of Inspection and Enforcement shortly after the accident, where personnel kept track of the environmental monitoring of radioactivity. At far right is Richard H. Vollmer of NRC's Office of Nuclear Reactor Regulation, who was designated in June to direct NRC's support activities related to recovery and cleanup operations at the TMI site.



"Herman," a mobile manipulator borrowed from the Oak Ridge National Laboratory, proved too awkward for use at TMI-2. It was hoped that the robot could retrieve samples of radioactive water in the No. 1 Auxiliary Building, thereby reducing exposure to workers. The idea was abandoned when testing showed Herman's lack of pressure sensitivity presented the risk of flasks of contaminated water being dropped or crushed.

Inspection and Enforcement Lessons

The NRC Office of Inspection and Enforcement (IE) also undertook an intensive investigation of the TMI accident but limited the scope of its inquiry to two sharply defined aspects of it: (1) the operational activities of the licensee from before the initiating event, about 4 a.m. on March 28 up to about 8 p.m. that evening, when primary coolant flow was reestablished by the starting of the reactor coolant pump; and (2) steps taken by the licensee to control the release of radioactive material to off-site environs and to implement its emergency plan, from the initiating event until midnight on March 30. These periods were selected for scrutiny because, in the judgment of IE, they encompassed those licensee actions which most significantly affected the course of the accident and its consequences.

In its report on this investigation, issued August 3, 1979, IE confirmed that the collective radiation dose to the general public resulting from the TMI accident constituted—as reported by the Ad Hoc Dose Assessment Group (made up of various Federal agencies) in its May 10, 1979 report—minimal risk to the health of the off-site population. At the same time, IE reported several inadequacies in the licensee's radiation protection activities inside the plant, as well as in the measuring of off-site radiation levels. These flaws, however, were not such as would cast doubt on or call for alterations in the conclusions of the ad hoc group.

The IE investigation also substantiated earlier conclusions regarding the underlying causes of the TMI accident and the factors that contributed to its severity. The six distinct areas of deficiency earlier identified as causative or complicating elements and confirmed by IE comprised equipment performance; licensee analysis of past transients and accidents; operator training and performance; equipment and systems design; the transmission of information (especially in the early phase of the accident); and the implementation of emergency planning. But what the IE report called "perhaps the most disturbing result" of the investigation was "confirmation of earlier conclusions that the Three Mile Island Unit 2 accident could have been prevented, in spite of the inadequacies" cited. The design, equipment, analyses, and procedures in place and in effect at TMI were, IE concluded, sufficient "to have prevented the serious consequences of the accident" if they had been allowed to function or had been adhered to as intended. For example, had the TMI operators permitted the ECCS to have its full effect, the damage to the core would most likely have been prevented (other examples were adduced in the report where a right action taken or a wrong one avoided could have significantly mitigated the consequences of the accident).

On the other hand, the IE report concedes, had certain equipment been designed differently it too could have prevented or diminished the effects of the accident. The investigation made it "difficult to fault only the actions of the operating staff." An undue preoccupation with the hazards of overfilling the reactor coolant system (that it was to be avoided "at almost any cost") was also evident in the decisions and actions of the operators, leading them to ignore prescribed procedures and to fail to respond to indications that the core was not properly cooled. Retraining of all licensed operators has now been required by NRC as well as an upgrading of procedures.

Causes and Contributing Factors. Soon after the shift came on at TMI-2 at midnight of March 27, 1979, the shift foreman and two auxiliary operators were engaged in transferring resin from a "condensate polisher" tank to a "resin regeneration" tank, on the secondary side of the plant. The chore was a carryover from the previous shift and was one with which plant personnel had encountered some difficulty. The staff thought the problem was a resin blockage in the transfer line and the foreman and auxiliary operators were trying to clear it. The IE report concluded that, "probably as a result of their efforts to clear the line," the plant underwent a total loss of feedwater flow, initiated by a loss of condensate flow and bringing about an almost simultaneous shutdown of the main turbine, at 37 seconds after 4 a.m., on March 28.

Ensuing events were found to be as described earlier in this chapter with certain noteworthy additions and conclusions. Among these was the finding that, about six minutes after the start of the accident, the pressurizer was completely filled with water and the reactor coolant system was, in fact, "solid," the condition which the control room crew strived to avoid throughout the crucial early hours of the accident by actions which delayed cooling of the core and compounded the consequences of the event. The IE report also indicated that "substantial fractions of the core were uncovered" by about 6:30 a.m. on March 28, although the fact went unrecognized by the operators and officials on the scene, and the high temperature readings in the core and the loops were considered too high to be realistic. The report also found that the operators interpreted the failure of the core flood tanks to inject a substantial portion of their volume into the reactor coolant system to be an indication that the core was covered, even though these tanks cannot be used for that purpose and are designed to supply water in the event of a large loss-of-coolant accident, which was not happening. With respect to the hydrogen explosion in the containment, the report observed that the release of this noncondensible gas from the reactor coolant system may have contributed to the later apparent success of the staff in collapsing the voids in the "A" loop of the reactor. That appearance of success in establishing natural circulation, despite the continued high temperatures in portions of the system, led the operators to believe that they had attained a reasonably stable condition by early afternoon of March 28.

Specific actions cited by the IE report as bringing about the extensive core damage that took place included: throttling the high pressure injection (ECCS) to a minimum during the first three and one-half hours of the accident; operating the reactor coolant pumps at pressures below procedural requirements (which led to greater loss of coolant through the stuck-open pressurizer relief valve); failure to isolate the relief valve after pressure continued to fall in the reactor coolant system, the drain tank disc had blown, and the sump pump operation all indicated that a large discharge of water from the system and the building was taking place; and failure to establish the conditions necessary for natural circulation in the system.

The report made note of other licensee actions which, while they did not directly affect the course of the accident as it actually unfolded, could have severely impaired the response of safety-related equipment if that course had taken another direction. Specifically, the disabling of the automatic startup features of the emergency diesel generators and the isolating of the core flood tanks early in the event constituted these kinds of lapses. The report was also critical of the communications provided during the event by the licensee, pointing out that persons assigned to furnish information off-site had concurrent duties related to management of the emergency. At the root of this and other problems, the report concluded, lay the misconception that even major accidents would be short-term events and that plans for mobilizing and communicating with off-site technical support over time, as an accident progresses, was not warranted as part of the emergency planning.

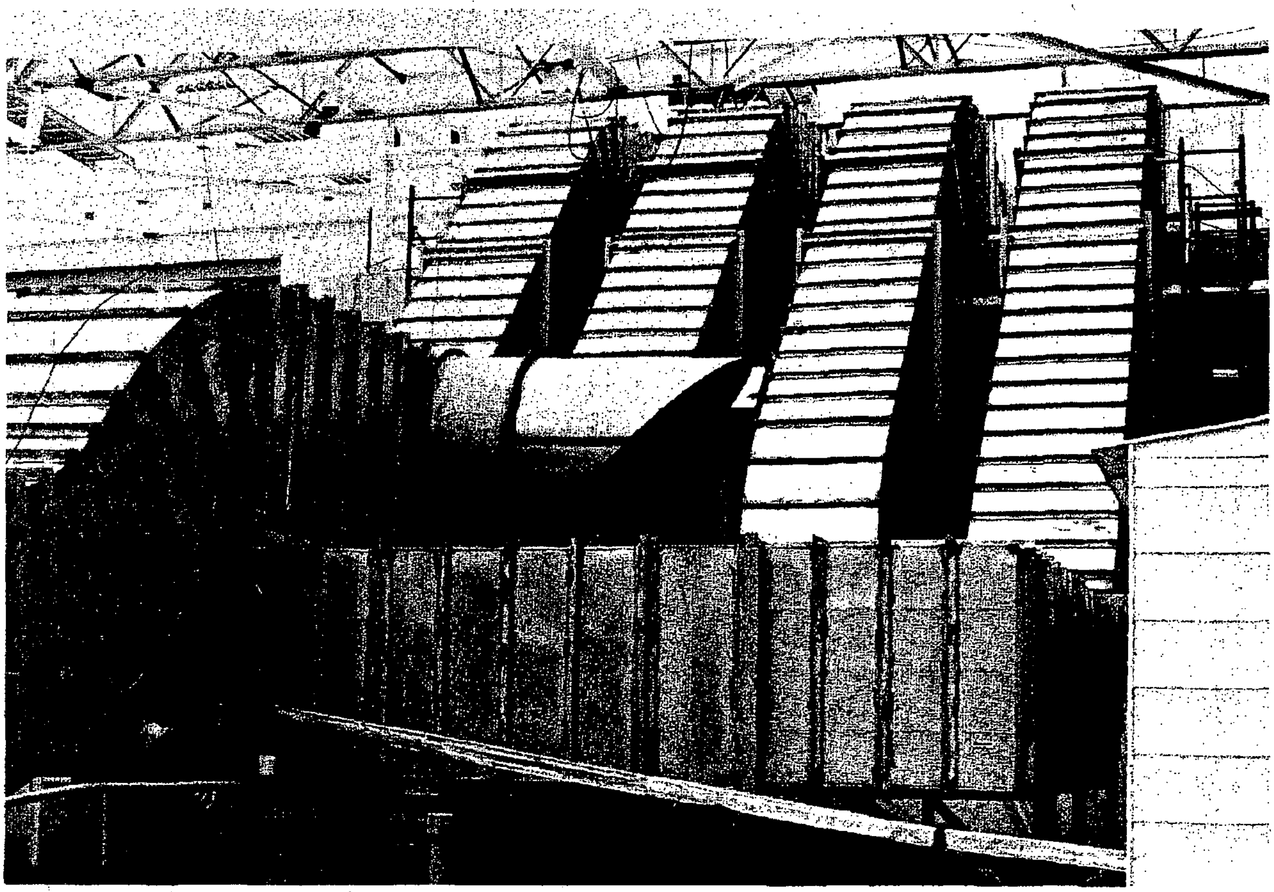
Enforcement Action Proposed. On October 25, 1979, the Director of Inspection and Enforcement notified the licensee for TMI that the IE investigation had revealed "numerous items of noncompliance" with NRC regulations on the part of the licensee. Six "violations"—the most serious breach of regulatory requirements—were alleged by IE, including serious weaknesses in the licensee's health physics program; control of maintenance activities; development and review of procedures; adherence to prescribed procedures; and audit activities. The licensee was cited for failure to operate the facility in accordance with the technical specifications approved and adopted for that particular plant, and for authorizing a surveillance procedure which placed certain valves in a status which rendered emergency feedwater unavailable on three separate occasions—including the last on March 28, when it was needed. Personnel training was also found insufficient, and record maintenance and in-house inspections as well.

The licensee was called upon to correct each of these deficiencies and departures from requirements and was notified that civil penalties were being proposed in the amount of $155,000, the legal maximum (although an assessment of $725,000 was justified for all violations identified).

Task Force Urges Statutory Mandate on Lead Role. The IE task force on leassons learned from TMI urged that IE be assigned, by statutory mandate, the lead role in NRC's emergency response in the future. Such a role flows from IE's *de facto* activity as the "principal contact with operating licensees," it was argued. It was also recommended that intra-office training be expanded and tightened surveillance of licensees be adopted. In the lead role for NRC emergency response, IE could give assistance to licensees in its response to an incident, as well as coordination to all NRC acitivities. It would also undertake training of other NRC offices regarding emergency preparedness and the respective responsibilities of those offices.

The task force also recommended that NRC create a new office to oversee training programs to upgrade the quality of inspectors and operations personnel, especially in the area of emergency response.

ACRS Comment on IE Findings. In a letter to Chairman Hendrie dated November 14, 1979, the Advisory Committee on Reactor Safeguards (ACRS) registered its view of the IE investigation and conclusions based on that investigation. Taking note of the limitation in scope of the IE study, the ACRS felt that the emphasis put by IE on the licensee's departure from technical specifications prior to the accident and from approved procedures during it resulted in too lit-



A new ventilation filtration system was installed on top of the auxiliary building of Unit 2 when the NRC determined that the existing system was not functioning satisfactorily after the accident. This system filters out airborne radioactive iodine and particulates before air is released to the environment.

tle consideration of other relevant factors. Examples of such factors taken from other investigations by NRC and others might be the peculiarities of a nuclear steam supply system that tended to inhibit recovery from interruption of normal operation or to confuse the operators by producing conditions and instrument readings not anticipated in the written procedures and, in general, by failing to convey clear, complete information to those in the control room. The ACRS concluded that the limited scope of the IE report tended to lead to a catalogue of violations and expressed its concern that the rationale behind the IE report would be perceived to be that a licensee's failure to follow accident procedures is automatically a violation. The ACRS noted that the procedures are prepared by the licensee and are not approved by NRC (although the licensee is required by NRC to follow them) and affirmed that such procedures cannot be so detailed as to allow for every accident situation. On the contrary, the ACRS declared, a deviation from conditions assumed in the framing of procedures may make it necessary to depart from those procedures. There is a question as to whether an operator who, using his best judgment, consciously takes an action at variance with procedures which in themselves may contain confusing or incorrect guidance is guilty of a violation. If this is the case, the ACRS affirmed its belief that it is "the wrong approach to protecting the public health and safety" in an emergency and that an operator, guided by written procedures, should be allowed to use his best judgment to deal with a problem. That judgment would be subject to *post-factum* appraisal by responsible parties, but it should not necessarily be deemed an error or a violation of regulations.

The ACRS found the IE report "less than satisfactory" for these reasons and recommended issuance of a consolidated report on the findings of the several NRC task forces investigating the TMI accident.

The President's Commission

On April 11, 1979, President Carter issued an executive order (#12130) creating the President's Commission on the Accident at Three Mile Island and charging its members to "conduct a comprehensive study and investigation of the recent accident involving the nuclear power facility on Three Mile Island in Pennsylvania" and to include in their study the following elements:

- A technical assessment of the events and their causes.
- An analysis of the role of the managing utility.
- An assessment of the emergency preparedness and response of the NRC and other Federal, State and local authorities.
- An evaluation of the NRC's licensing, inspection, operation and enforcement procedures as applied to this facility.
- An assessment of how the public's right to information concerning the events at Three Mile Island was served and of the steps which should be taken during similar emergencies to provide the public with accurate, comprehensible and timely information.
- Appropriate recommendations based upon the Commission's findings.

The President appointed John G. Kemeny, the President of Dartmouth College and former chairman of the Mathematics Department at that institution, to the chairmanship of the Commission. Eleven other members were appointed, including a State Governor, a resident of Middletown, Pa., a labor union president, an industrialist, the president of a national society, an attorney, and five unversity professors. A full-time staff was engaged which eventually numbered over 60 persons; more than 30 separate staff reports were prepared and many of them published along with the report of the Commission, which was issued on October 30, 1979. In the course of its investigation, the Commission conducted 12 days of public hearings, and its staff compiled more than 150 separate depositions.

The report of the President's Commission was divided into three major sections: an overview, together with the principal specific findings of the Commission with respect to the causes of the accident; recommendations flowing from the findings and addressed to (1) the NRC, (2) the utility and nuclear industry, (3) the training of nuclear plant personnel, (4) certain technical considerations, and (5) the health and safety of plant workers and the general public; and a chronology of the accident with some further attribution of causality. Highlights of each section are provided below, together with the NRC's response to the Commission's recommendations and the President's statement about them.

Findings and Judgments

The Commission affirmed at the outset of its report its basic conclusion that to prevent accidents as serious as TMI in the future it will be necessary to effect "fundamental changes" in the organization, procedures and practices, and, "above all, in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical, of the nuclear industry." The need for a change in attitude in NRC and in the industry is emphasized throughout the Commission's report. The Commission also declared at the start that its findings do not, "standing alone," require a conclusion that nuclear power plants are inherently too dangerous to continue in operation or that new ones should not be built, but neither would the Commission propose that the nation "move forward aggressively" in expanding commercial nuclear power uses.

In its discussion of causality, the Commission identified the root problems as being "people-related," rather than related to deficiencies in plant design or equipment (though these too were present and involved in the accident). The weaknesses identified were not only the "shortcomings of individual human beings," but problems of structure and communication "among key individuals and groups." The Commission asserted outright that the equipment involved at TMI was good enough that, "except for human failures, the major accident . . . would have been a minor incident." There was, the Commission found, a preoccupation with regulations as such, rather than with the safety they are supposed to promote, and that regulations as voluminous and complex as those in current effect were actually a negative factor with respect to safety. A particular distortion cited by the Commission was the concentration on large-scale or "worst case" hazards to the neglect of less consequential but more probable scenarios. Thus "the break of a huge pipe . . . [is] studied extensively and diligently," reflecting the attitude that if the worst accidents can be controlled there is little to fear from lesser events. The Commission pointed out that TMI was the result of a combination of minor equipment failures which is "likely to occur much more often than the huge accidents," and that successful handling of minor failures is usually going to depend more on quick and appropriate human reaction, in contrast to the necessarily automatic and extremely fast response of equipment to sudden, large-scale accidents. The Commission urged on the NRC and industry a newfound recognition that "human beings who manage and operate the plants constitute an important safety system."

On the subject of operator error at TMI, the Commission noted that the training of TMI operators (and that of reactor operators in general) was "greatly deficient" in that it did not prepare them for dealing with the extraordinary, with "something as confusing" as the conditions created by multiple equipment failures. Moreover, the TMI- 2 control room design was lacking in many ways, "the control panel is huge, with hundreds of alarms, and . . . some key indicators placed . . . where the operators cannot see them." (More than 100 alarms were in fact activated in the early stages of the accident, and, while the pressure and temperature in the reactor coolant registered in the control room, there was no indication to the operators that the combination of the two meant steam was forming.) Altogether the design of the room and its gauges and equipment gave little attention to "the interaction between human beings and machines" and "ignored the needs of operators during a slowly developing small break accident." Some members of the Commission favored a complete modernization of the control rooms of a TMI design, and all of them agreed that "a relatively few and not very expensive improvements in the control room could have significantly facilitated management of the accident." Thus the Commission found that, while inappropriate operator action was a major factor in the TMI accident, a number of deficiencies on the part of the utility, its suppliers, and the NRC—in training, in procedures, in control room design—and the failure to recognize these deficiencies and to learn from previous experience were among major contributing causes. Despite its findings as to the proximate and contributing causes of the TMI accident, and its judgment that the potential for such lapses could and should have been anticipated by various principals involved, the Commission expressed its conviction that, given all the deficiencies cited, "an accident like Three Mile Island was eventually inevitable."

Regarding the severity of the accident's impact on public health, the President's Commission determined that actual releases of radiation at TMI "will have a negligible effect on the physical health of individuals," and that the major health effect of the accident was mental stress. As to the possibility of an eventual TMI-radiation-induced cancer occurring among the exposed population, it found that there will be "either no case of cancer or the number of cases will be so small that it will never be possible to detect them." The mental stress experienced by people near the facility was "quite severe," however. The Commission ascribed this to several factors, especially the extensive speculation by public officals during the first week of the accident on how serious it could become and whether evacuation of the population should or would take place. Concerning the effect of news media coverage during this time—its speculations, selections of items to cover, and general tone—the Commission decided that there was "overall, a larger proportion of reassuring than alarming statements in the coverage," and the news media "did not present only 'alarming' views, but rather views on both sides," although a "few newspapers . . . did present a more frightening and misleading impression of the accident." The severe stress was short-lived, the Commission concluded, and was worst among people living within five miles of the plant and in families with young children.

The damage to the facility itself was very extensive and, in the words of the report, the "ongoing cleanup operation at TMI demonstrates that the plant was inadequately designed to cope with the cleanup of a damaged plant. The direct financial cost of the accident is enormous. Our best estimate puts it in a range of $1 to $2 billion, even if TMI- 2 can be put back into operation. (The largest portion of this is for replacement power estimated for the next few years.) And since it may not be possible to put it back into operation, the cost could be much larger."

The Commission felt it an important part of their task to ascertain not only how bad the TMI accident was but how bad it might have been. It posed the question to itself, "What if one more thing had gone wrong?" Among the possibilities considered was whether a hydrogen or steam explosion could have breached the reactor vessel and also the containment. (That a nuclear explosion might have done so was not considered because, with the slightly enriched fuel used in a reactor, such an explosion is not a possibility.) Several scenarios potentially leading to the rupture of containment and release of massive amounts of radiation from the plant were studied. Of particular concern was the potential release of radioactive iodine which might enter the food chain. (There was only a trace off-site release of iodine from the actual TMI accident.) Some scenarios led to a better outcome than the actuality, and two or three would have resulted in more severe core damage than occurred and even a melting of the core. However, the Commission reported that—within the limits of current engineering knowledge of the interaction of molten reactor fuel with concrete, steel and water—its calculations show "that even if a meltdown occurred, there is a high probability that the containment building and the hard rock on which the TMI- 2 containment building is built would have been able to prevent the escape of a large amount of radioactivity." Being less than absolutely sure of this conclusion, the Commission urged more research into this vital but murky area of severe core damage and its worst plausible effects. The Commission averred that, whether or not TMI came close to becoming catastrophic, "accidents as serious as TMI should not be allowed to occur in the future," although "we must not assume that an accident of this or greater seriousness cannot happen again, even if the changes we recommend are made." The latter fact argues strongly for the need to be prepared to deal with the aftermath of such accidents.

The next focus of Commission scrutiny, closely related to its last cited observation, was the matter of emergency preparedness among the various governmental elements involved at TMI. The Commission judged that the plans made by these agencies were not adequate and that their responses to the emergency were not satisfactory. It found problems associated with having multiple jurisdictions respond to a radiation emergency and an "almost total lack of detailed plans" in the local communities around TMI. The report noted that when "prompt defensive steps are necessary within a matter of hours, insufficient advance planning could prove extremely dangerous." The Commission advocated centralization of emergency planning and response in a single Federal agency which would maintain close coordination with State and local authorities and draw upon Federal and other expertise as the need arose. The report also criticized the NRC siting policy with respect to nuclear facilities and its requirement that reactors be located in a "low population zone," or LPZ, where protective action could be taken in the event of an accident. The Commission found "this concept implemented in a strange, unnatural and roundabout manner," with dimensions predicated on only a very serious hypothetical accident accompanied by very large doses to the population. (The NRC discontinued use of the LPZ in its siting requirements prior to publication of the Commission report.) The Commission proposed that a variety of possible accidents be considered in site evaluation—particularly the smaller scale accident with the higher probability of occurring—and protective action appropriate to each sector of the affected public be built into emergency plans for a facility. Also, State and local agencies must be ready to respond "once information is available on the nature of an accident and its likely levels of releases."

At TMI the emergency response "was dominated by an atmosphere of almost total confusion," the report stated, with "lack of communication at all levels."

On the subject of public and worker health and safety, the Commission noted that, in setting standards for worker exposure to radiation in licensed facilities, in its plant siting and other health-related decisions, the NRC "is not required to, and does not regularly seek" advice or review from other Federal agencies, such as HEW or EPA, concerned with health and radiation. Emergency plans did assign responsibilities to these agencies, as well as to DOE and NRC, in their response to the TMI accident, but, the Commission indicated, the plans were so poor that ad hoc arrangements had to be made and coordination improvised. In addition, the Commission found that the State agencies with responsibilities for public health did not have adequate resources "for dealing with radiation health programs related to the operation of TMI." Its recommendations on these matters appear later in this chapter.

On the issue of whether the public's right to information during the accident was well served, the Commission concluded that it was not. It found "serious problems with the sources of information, with how this information was conveyed to the press, and also with the way the press reported what it heard." Early in the accident the utility tended to minimize the hazards, according to the report, while later on the NRC "was the source of exaggerated stories." In particular, the Commission noted, "official sources would make statements about radiation already released... that were not justified by the facts—at least not if the facts had been correctly understood. And NRC was slow in confirming good news about the hydrogen bubble. On the other hand, the estimated extent of the damage to the core was not fully revealed to the public."

A separate problem concerned the way facts were presented to the press. It seemed that those who briefed the press either lacked the technical knowledge to explain the events transpiring or, when they did understand what was happening, they tended to speak in a technical jargon the press could not understand. Moreover, the report stated, "The press was further disturbed by the fact that, in order to cut down on the amount of confusion, a number of potential sources of information were instructed not to give out information. While this cut down on the amount of confusion, it flew in the face of the long tradition of the press checking facts with multiple sources." As mentioned, the Commission concluded that, with a few notable exceptions, the media "generally attempted to give a balanced presentation which would not contribute to an escalation of panic." (The Commissioner who was residing in Middletown, Pa., during the accident did not concur in that judgment; see "Supplementary Views," below.) A serious impediment in the conveying of accurate and complete information to the public was that "even personnel representing the major national news media often did not have sufficient scientific or engineering background to understand thoroughly what they heard, and did not have avail-

NRC trailers at Three Mile Island used by the investigation team of the Office of Inspection and Enforcement and by the TMI support staff of the Office of Nuclear Reactor Regulation. Staff from these and many other NRC offices were on duty from time to time—many on a voluntary basis—during the first few weeks after the accident. Later, plans were made for office space in Middletown, Pa., for a long-term stay of some NRC staff.

able to them people to explain the information." This applied particularly to the reporting of radiation releases, when numbers told the public nothing of the severity—or insignificance—of the releases. "Many of the stories were so garbled as to make them useless as a source of information."

Turning to an assessment of the NRC, the Commission took note that "when NRC was split off from the old Atomic Energy Commission, the purpose... was to separate the regulators from those who were promoting the peaceful uses of atomic energy." But the Commission found "evidence that some of the old promotional philosophy" persists in the regulatory practices of the NRC, and "evidence... that the NRC has sometimes erred on the side of the industry's convenience rather than carrying out its primary mission of assuring safety." In both the NRC's licensing and its inspection and enforcement activities, the Commission found "serious inadequacies."

The NRC licensing criteria and general approach were found exceptionable in several key respects:

- The application of a "single failure" criterion in the licensing process and the failure to analyze the consequences of a breakdown in two systems occurring independently (as happened at TMI).
- The inappropriately sharp distinction between "safety-related" components and "nonsafety-related," and the exemption of the latter from the stringent requirements applied to the former. (The report proposes instead "a system of priorities as to how significant various components . . . are for the overall safety of the plant.")
- The apparent assumption that plants can be made "people proof," and insufficient attention to operator training and operating procedures.
- The licensing of plants when relevant safety issues remain unresolved.
- Insufficient attention to the "ongoing process of assuring nuclear safety," as exemplified by NRC's categorization of a safety issue as a "generic problem," thereby relieving the licensee of responsibility for resolving the issue before licensing. (The report suggests there is evidence that "the labeling of a problem as generic may provide a convenient way of postponing decision on a difficult question.")
- A reluctance to apply new safety standards to previously licensed plants. (The report cites this as an instance of the "old AEC attitude" influencing NRC judgments and finds no evidence that "the need for improvement of older plants was systematically considered prior to Three Mile Island.")
- The tendency of a detailed and voluminous body of regulations "to focus industry attention narrowly on the meeting of regulations rather than on a systematic concern for safety." (The Commission felt that, in some instances, certain regulations may—because of the way rate bases are decided—have served to deter utilities and suppliers from initiating safety improvements.)
- The voluminous NRC inspection and enforcement manual, so extensive that "many inspectors do not understand precisely what they are supposed to do." The Commission also found that sometimes inspectors have had difficulty getting their superiors "to concentrate on serious safety issues," and also that incidents reported by licensees "tended to concentrate on equipment malfunction" while "serious operator errors have not been focused on."
- The lack of a systematic method for evaluating industry experience and to look for patterns that could warn of the presence of a basic problem, and a failure to use monetary fines to full effect.
- A heavy preoccupation in NRC with the safe operation of equipment to the neglect of "people-oriented" concerns, resulting in lack of attention to the operating procedures and "an almost total lack of attention" to the interaction between human beings and machines.

With respect to the NRC's response to the TMI accident, the Commission stated that it was "extremely critical of the role the organization played," citing the "serious lack of communication among the commissioners, those who were attempting to make the decisions about the accident in Bethesda, the field offices, and those actually onsite." The Commission questioned the suitability of the collegial structure of NRC, with five equipollent Commissioners, to manage an emergency and it found the "precise role" of the Commissioners unclear. In addition, the President's Commission observed that the "huge bureaucracy [NRC]... is highly compartmentalized with insufficient communication among the major offices," and it saw no "effective managerial guidance from the top," but rather "some of the old AEC promotional philosophy in key officers below the top." The Commission also cited the unnecessarily strict procedural rules within NRC which inhibited free communication among the NRC Commissioners and between them and the staff.

In conclusion, the President's Commission determined that, despite in-depth studies and critiques from within and outside the agency, there is "no well thought out, integrated system for the assurance of nuclear safety within the current NRC." For all of the reasons discussed, the Commission recommended a "total restructuring of the NRC," making the agency part of the executive branch, headed by a single administrator chosen from outside the NRC, with the freedom to "reorganize and bring new blood into the . . . staff. This new blood could result in the change of attitude that is vital for the solution of the problems of the nuclear industry." This and other Commission recommendations are treated below (see "Recommendations and Responses"), together with the NRC's response to each, as well as the President's statement on the Commission report.

With regard to the utility, the President's Commission felt that the necessary "management qualifications and attitudes" for conducting nuclear power operations were not given sufficient attention by the parent corporation whose subsidiary ran TMI. The Commission found "a divided system of decision-making within [the parent company, General Public Utilities Corporation] and its subsidiaries. While the utility has legal responsibility for a wide range of fundamental decisions, from plant design to operator training, some utilities have to rely heavily on the expertise of their suppliers and on the Nuclear Regulatory Commission. Our report contains a number of examples where this divided responsibility, . . . [as] in the case of TMI, may have led to less than optimal design and operating practices." The report notes that the design of the TMI control room "seems to have been a compromise among the utility, its parent company, the architect-engineer, and the nuclear steam system supplier (with very little attention from the NRC)." Operator training afforded the best example of the effects of divided responsibility, however. The utility has the legal responsibility for training operators and supervisors, but the TMI licensee did not have the expertise to conduct training by itself, so it contracted with the supplier of the nuclear steam system to do some portions of the training. The latter company had no responsibility for the quality of the total program, and coordination between it and the licensee was "extremely loose." The simulator employed in the program given by the reactor supplier differed "in certain significant ways" from the actual control console at TMI and, in any case, it was not programmed to reproduce the conditions faced by the TMI operators on March 28. The Commission believed that "the role that the NRC plays in monitoring operator training contributes little and may actually aggravate the problem." The NRC's "fairly routine licensing examinations" and limited spot-checking of requalifications exams (administered by the utility) "may be perpetuating a level of mediocrity," since the utility tends to equate the passing of the NRC exam with satisfactory operator training. The report was again very critical of operating procedures at TMI and the corresponding deficiencies they produce in the operators' training. Commission analysis of TMI management "raises the serious question of whether all electric utilities automatically have the necessary technical expertise and managerial capabilities for administering such a dangerous high-technology plant." Concluding that they do not, the Commission recommended higher standards of organization and management that a company must meet before receiving an operating license.

Recognizing that "recommendations as sweeping as ours will take a significant amount of time to implement," the Commission unanimously voted that "the NRC or its successor should, on a case-by-case basis, before issuing a new construction permit or operating license: (a) assess the need to introduce new safety improvements recommended in this report, and in NRC and industry studies; (b) review, considering the recommendations set forth in this report, the competency of the prospective operating licensee to manage the plant and the adequacy of its training program for operating personnel; and (c) condition licensing upon review and approval of the State and local emergency plans."

Expressing its "overwhelming concern about some of the reports" from other TMI investigations, and warning that proposed improvements carried out in a "business as usual" atmosphere will not suffice, the President's Commission concluded the Overview, stating:

"We believe that we have conscientiously carried out the mandate of the President of the United States, within our limits as human beings and within the limitations of the time allowed us. We have not found a magic formula that would guarantee that there will be no serious future nuclear accidents. Nor have we come up with a detailed blueprint for nuclear safety. And our recommendations will require great efforts by others to translate them into effective plans."

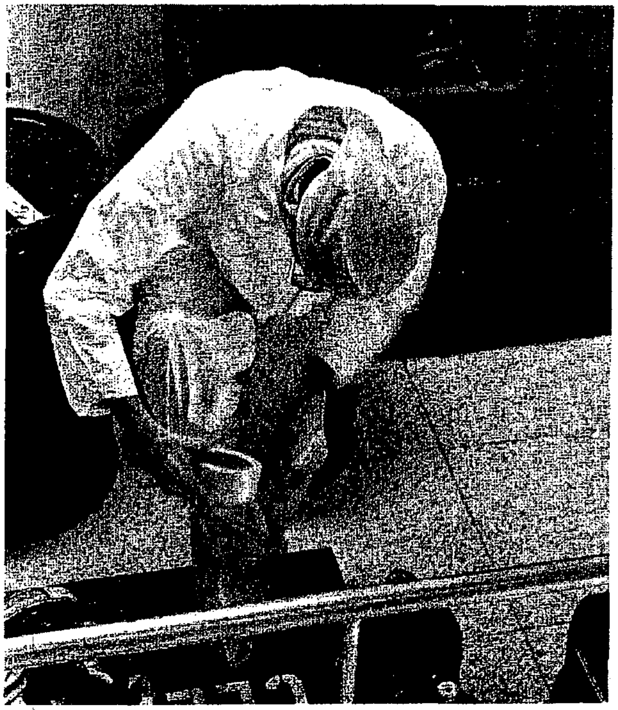
The Commission reaffirmed the need for fundamental change, charging that "unless portions of the industry and its regulatory agency undergo fundamental changes, they will over time destroy public confidence and hence, *they* [emphasis theirs] will be responsible for the elimination of nuclear power as a viable source of energy."

Supplemental Views

A number of Commissioners published comments of their own as supplements to the overall report of the President's Commission.

The Chairman and five other Commissioners cosigned a statement taking note of the fact that they had supported a recommendation, which failed of adoption by the full Commission, that "no new work authorization permits or constructions permits should be issued until such time as the NRC or its successor had adopted siting guidelines" consistent with the recommendation, which was adopted (unanimously), calling upon NRC to review its siting criteria (see "Recommendations and Responses," recommendation number 6, below).

Governor Bruce Babbitt of Arizona took up the matter of utility capability to operate nuclear power plants and gave his view that, while the "Commission



Here a workman prepares to enter a contaminated area by donning a suit of protective clothing. He is careful to tape his ankles to seal the area where the pant leg of the suit joins the overshoes.

Workmen about to leave the plant are carefully monitored with a pancake-type Geiger counter to insure that they have not been contaminated.

has clearly addressed the institutional shortcomings of the Nuclear Regulatory Commission, it has not addressed the institutional problems of the industry." The Governor expressed his belief that "this is one area where fewer entities with more depth and expertise might be justified for sake of public health and safety." The Commissioner also mentioned the possibility that certain facts known to TMI management on the first day of the accident had not been conveyed in timely fashion to the NRC and State officials, an issue which merits further investigation.

Commissioner Russell W. Peterson, President of the National Audubon Society, reaffirmed his endorsement of the recommendation noted above as having the support of six Commissioners, namely, that no new limited work authorizations or construction permits should be issued until the NRC siting requirements were changed. The Commissioner also felt that the President and Congress should "involve highly technically qualified critics of nuclear energy safety" in the continuing appraisal of nuclear safety called for by the Commission. He also urged serious study of nuclear waste disposal. Commissioner Peterson finally stated his conviction that a "much more serious accident" than TMI was going to occur somewhere at some time, because of the complexity of the technology and human limitations, and therefore he called for the development by the government of a "strategy which does not require nuclear fission energy."

Commissioner Thomas H. Pigford, Chairman of the Department of Nuclear Engineering at the University of California (Berkeley), issued a lengthy supplement to the report, setting forth, among others, the following observations:

- The report's stress on the need for more emphasis on people and less on equipment has obscured the "very important fact" that, despite the crucial errors of people, the safety equipment did indeed function to achieve its purpose; and despite the failures of equipment—the stuck valve and the leaks in the gas vent system—the overall system was good enough that, absent the effects of human error, the accident would have been a minor incident. Staff analyses show that even if all the fuel cladding had oxidized and even if fuel melting or meltdown had occurred, the containment would have stood up and the public would have been protected.
- Systems of equipment at TMI performed better than expected; earlier assumptions would have led to far greater core damage and radiation release to the containment than what actually occurred.
- TMI has revealed to all a number of remedies and improvements to be made, but there "seems to be some unwillingness to recognize that many of these remedies are already being implemented.

The NRC and the nuclear industry have taken and are taking steps . . . The problem with 'attitudes' emphasized in the Commission's report must refer largely to pre-TMI attitudes."

- More emphasis is needed on analysis of and planning for small break accidents, but "the possibility of an accident of this type was known and had been analyzed and predicted prior to the TMI-2 accident." Thus the facts of the present investigation provide no basis for concluding that reactors are unsafe.
- Since the attitudes of various persons and groups were not directly examined prior to the TMI-2 accident, valid conclusions can only be drawn on "actions taken, i.e., problems addressed and not addressed, regulations issued and complied with, and the occurrence of events that reflect upon the adequacy of these processes." It is "more constructive to assume that attitudes are symptomatic of . . . forces at work in the system, and it is those forces which must be addressed." It is the apparent failure of the system to assimilate lessons from plant experience and to incorporate up-to-date technology—in control room design, for example—that constitute "a more manageable and appropriate focus for the overall conclusion of this Commission. I believe that such technology is . . . or will be used by the industry and that changes . . . will be effected, not merely to satisfy critics or to demonstrate attitudinal penitence, but on the basis of sound judgment resting on sound data."
- The NRC must deal with the question of how much cost and delay is justifiable to realize a given increment in safety, and efforts to balance costs and benefits should not be considered evidence per se of a promotional philosophy. Both overreaction and inaction in this area carry social costs which must be weighed.
- While it is "confusingly" referred to as a "single failure" criterion, the NRC licensing process applies a criterion which assumes at least three failures: any credible component failure (1) in which all internal or all external power supply is lost, with (2) the additional failure of a single active component which (3) is the component whose failure causes the most serious aggravation of the accident.
- In the analysis of postulated accidents, there is no assumption that an active "nonsafety-related" item will not fail; it was not a preoccupation with a safety-related item list that proved inadequate in the analysis of TMI, but a failure to take into account lack of operator training and deficient operating procedures and practices.
- The finding that there is no systematic backfitting review of older plants "appears to take too little account" of NRC's Systematic Evaluation Program (SEP), initiated more than three years ago; progress in some areas, such as upgrading emergency plans, does appear to have been somewhat slow.
- The Commission's appraisal of NRC inspection and auditing of licensee compliance "calls for NRC to do more of what it already does and to do it better." Resident inspectors have been at some plants for more than a year, and unannounced on-site inspections "appear to be so frequent as to be commonplace." It is "clearly impractical" for the NRC to undertake substantial independent testing of construction work and cease to rely on testing done by the utility.
- A lack of quantified safety goals is a major problem in the NRC regulatory rationale, and its failure to set priorities leads to a disproportionate commitment of resources and efforts to sometimes marginal concerns. A large portion of the NRC management and staff are lacking practical experience in designing and operating the equipment they regulate, and too many requirements are unsupported by valid technical backup and value-impact analysis (an "overwhelming emphasis on conservative models and assumptions"). There is an insufficient exchange of information between NRC and industry because of the "adversary approach" existing between them, and NRC does not carry out the kind of systematic analysis of operating data that would disclose significant trends and patterns.
- There was not sufficient time allowed for a careful review of the President's Commission staff reports on which Commission findings were based (some were still incomplete when the final report was issued), and there were "several parts of some key staff reports with which I cannot agree, particulary the staff report on the NRC." There was unqualified acceptance in that report of testimony which was unconfirmed and uncorroborated, "an indicator of insufficient balance" in the staff investigation of the NRC. The staff report also "relies to a considerable extent upon excerpts from a book," without establishing the author's qualifications or taking his testimony. The Commissioner stated, "In my view, the . . . book does not express a comprehensive, accurate and balanced knowledge of the NRC and of the nuclear industry."
- Criticism of the NRC "should not obscure the central issue that primary responsibility for nuclear safety lies with the utility, shared to a large extent with the equipment suppliers and the architect-engineers. This also reflects my view of the responsibilities for the TMI-2 accident."

Commissioner Anne D. Trunk, a resident of Middletown, Pa., located about three miles from the TMI station, took exception to the Commission finding regarding the news media's treatment of the accident and its effect on the mental state of the people living near the facility. (Mental stress was identified by the Commission as the "major health effect" of the accident.) Commissioner Trunk, affirming that she spoke for herself "and a majority of her circle of citizens who lived through the TMI accident," stated:

"The report concluded that the errors and sensationalism reported by the news media merely reflected the confusion and ignorance of the facts by the official sources of information. It further concluded that the press did a creditable ('more reassuring than alarming') job of news coverage.

"In fact, these conclusions are not generally supported by the staff reports. There were reliable news sources available. Too much emphasis was placed on the 'what if' rather than the 'what is.' As a result, the public was pulled into a state of terror, of psychological stress."

The Commissioner called for a self-evaluation on the part of the news media. She also noted that she could not support a moratorium on the issuance of new construction permits because "it was not shown how this could result in a safer plant at TMI nor attain higher standards of safety and performance by the industry." Instead, the Commissioner recommended a defined period within which the parties concerned would be charged to act upon the Commission's recommendations, and a separate probationary operating period for the licensee at TMI.

Recommendations and Responses

Starting below and in the pages that follow, the specific recommendations of the President's Commission—concerning the NRC, the utility and its suppliers, the training of operating personnel, a technical assessment, and both worker and public health and safety—are set forth in the left-hand column, with the response of the NRC to each recommendation set forth in the right-hand column.

Stacks of lead ingots were sent to the TMI accident site from industry groups and national laboratories responding to a general request from the NRC. The lead was used in various parts of the plant for radiation shielding during observation and measurement taking. In the weeks following the accident, however, it was determined that site radiation levels did not require all of the lead and much of it was returned to the donors.

In forwarding the NRC comments to Dr. Frank Press, Director of the Office of Science and Technology Policy, Executive Office of the President, Chairman Joseph Hendrie expressed a number of general comments on behalf of the Nuclear Regulatory Commission. (Two NRC Commissioners added supplementary remarks, cited at the close of this section.) The Chairman stated that, from NRC's own reviews of the accident, "we have generally found that the actions recommended by the President's Commission in the areas of human factors, operational safety, emergency planning, nuclear power plant design and siting, health effects, and public information are necessary and feasible." He affirmed that changes taken and intended by the NRC are in conformity with the recommendations of the President's Commission, and that some changes under consideration would go beyond those recommendations. Of particular importance, the Chairman noted, was the need for "prompt and positive assurance that the technical and management competence of all licensees is sufficient to operate nuclear power plants safely and to respond effectively to emergencies." Expeditious action would be taken in this area. Reporting that four of the five NRC Commissioners felt that effective reform could and should be accomplished within the existing agency, the Chairman also conveyed disagreement "with the overall thrust of the President's Commission recommendations to lessen the role of NRC in responding to emergencies and providing emergency information to the public." Estimating that it would take several months to develop the new or improved safety objectives and detailed criteria for implementing them, the Chairman disclosed that "we have decided that new plants will not be licensed until we have developed the required criteria."

PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON THE NRC

PC RECOMMENDATIONS	NRC RESPONSES
(1) NRC SHOULD BE RESTRUCTURED AS A NEW INDEPENDENT AGENCY IN THE EXECUTIVE BRANCH. The present five-member Commission should be abolished, and a single administrator appointed by the President, with advice and consent of the Senate, to serve at the pleasure of the President. The administrator should be from outside NRC and should be given substantial discretionary authority in managing the agency.	(1) Four of the five Commissioners felt that the objectives of the President's Commission could be accomplished by reforms effected within the existing structure. It is desirable to have the statutory authority to delegate management responsibilities to a single Commissioner in event of an emergency. Clarifications in the law could remove ambiguity of the Chairman's authority, as well as that of the Executive Director for Operations. NRC has adopted a new "policy planning program guide" mechanism and is studying new modes of Commission involvement in developing key safety policy.
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(2) AN OVERSIGHT COMMITTEE ON NUCLEAR REACTOR SAFETY SHOULD BE ESTABLISHED. Its purpose would be to examine, on a continuing basis, the performance of the agency and the industry in resolving important public safety issues related to nuclear power plants and in exploring the overall risks of nuclear power. Membership—up to 15 in number—would be drawn from the fields of public health, environmental protection, emergency planning, energy technology and policy, nuclear power generation, and nuclear safety; one or more State governors and members of the general public would serve on the committee, which would report to the President and Congress annually.	(2) Although this call for an oversight committee is tied to the recommendation for a new executive branch agency, this proposal should be examined on its own merits. Such an oversight or public advisory committee might contribute to the interaction among the Federal Government, States, utilities, public interest groups. and the general public on the controversial issues related to nuclear power.
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PC RECOMMENDATIONS	NRC RESPONSES
(3) THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) SHOULD BE RETAINED, IN A STRENGTHENED ROLE, TO CONTINUE PROVIDING AN INDEPENDENT TECHNICAL CHECK ON SAFETY MATTERS. The staff of the ACRS should be augmented, and its public health expertise especially improved. The ACRS would choose which licensee applications to review, and it would have a statutory right to intervene in hearings as a party. It should be authorized to raise any safety issue in a proceeding, give reasons and arguments for its views, and require formal response by the agency to its submissions. Any ACRS member would be exempt from subpoena in any proceeding in which he has not previously appeared voluntarily or made an individual written submission. ACRS should have similar rights in rulemaking proceedings and power to initiate such a proceeding to resolve any generic safety issue it wishes.	(3) NRC endorses a strengthened role for the ACRS and the recently initiated ACRS Fellows Program should reinforce its analytic resources. But the strength and value of the independent ACRS reviews derives from the collegial interaction of its members; adding staff beyond reasonable needs will not contribute much to that strength. NRC has supported legislation which would enable the ACRS to choose applications for review. The proposed right to intervene may not be appropriate for a part-time advisory body; it would require a new ACRS legal staff and active involvement in hearings could severely compromise the independence and collegial nature of the committee. The ACRS can now recommend rulemaking to the NRC, but whether it should be able to mandate a proceeding needs and will be given further consideration. In general, NRC agrees that ACRS views warrant prompt response by the NRC staff. Comments on the matter have been requested from the ACRS.
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(4) INCLUDED IN THE AGENCY'S GENERAL SUBSTANTIVE CHARGE SHOULD BE THE REQUIREMENT TO ESTABLISH AND EXPLAIN SAFETY-COST TRADE-OFFS. Where additional safety improvements are not clearly outweighed by cost considerations there should be a presumption in favor of the safety change. The agency should be relieved of "any unnecessary responsibilities that are not germane to safety." In particular, operator and supervisor licensing should be upgraded, and accreditation of training centers required; a definition of "safety matters" should be formulated which is broader than the present inventory of "safety-related items"; an emphasis on examination of overall plant design and performance, from a systems engineer's standpoint, is needed, with attention to multiple failure potential, control room design, instrumentation; research with a broad scope that includes public health and which exploits all scientific knowledge available should be coordinated with the regulatory process.	(4) NRC has not, in the past, clearly articulated its policy on the effect of costs on safety decisions. Some safety-cost tradeoffs are presently authorized, e.g., value-impact analyses performed for proposed regulatory requirements or in research planning. A better articulation of NRC policy is needed. It is believed that benefits and detriments can be sufficiently quantified to aid in decision-making, and it is agreed that, in general, some sort of safety-cost tradeoffs are at least implicit in a regulatory system that concedes that a goal of zero risk is impossible of attainment. The reality should be made explicit. But NRC is in complete accord that in all comparative judgments of this kind there should be a presumption in favor of safety. NRC will seek views of the Congress, other agencies and the public in developing an explicit policy statement. Legislation may eventually be desirable for the definitive policy expression. Legislation would be required to divest NRC of its non-safety responsibilities, and the prospect raises problems in the area of nuclear exports. The Commissioners are not in agreement now on the best course of action. As to operator and supervisor training, a study is under way as to the options for NRC involvement and operator licensing requirements are being upgraded. The broadening of the definition of safety-related matters is a priority, including both equipment and human factors, and the interaction of safety- and non-safety grade equipment is under study. Control room design, overall plant design, and safety research are all undergoing reevaluation, and flexibility in assuring maximum application of scientific knowledge will be pursued.
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PC RECOMMENDATIONS

(5) RESPONSIBILITY AND ACCOUNTABILITY FOR SAFE POWER PLANT OPERATIONS, INCLUDING THE MANAGEMENT OF A PLANT DURING AN ACCIDENT SHOULD BE PLACED ON THE LICENSEE IN ALL CIRCUMSTANCES. Thus the competence of licensees to meet this obligation must be assured, and the agency should impose higher standards or organizational and managerial capability, especially confirming the "integration of decisionmaking" in the company licensed to construct or operate a plant; the necessary range of expertise; financial capability; quality assurance; operator and supervisor performance; surveillance and maintenance practices; and thorough analysis and reporting of unusual events.

* * *

(6) THE AGENCY SHOULD BE REQUIRED, TO THE MAXIMUM EXTENT FEASIBLE, TO LOCATE NEW POWER PLANTS IN AREAS REMOTE FROM CONCENTRATIONS OF POPULATION. Siting determinations should be based on technical assessments of various classes of accidents that can take place, including those involving releases of low doses of radiation.

* * *

(7) THE AGENCY SHOULD BE DIRECTED TO INCLUDE IN ITS LICENSING REQUIREMENTS PLANS FOR THE MITIGATION OF THE CONSEQUENCES OF ACCIDENTS, including the cleanup and recovery of the contaminated plant. The agency should be directed to review existing licenses and to set deadlines for accomplishing any necessary modifications.

* * *

(8) BEFORE ISSUING A NEW CONSTRUCTION PERMIT OR OPERATING LICENSE, THE NRC SHOULD DO THE FOLLOWING ON A CASE-BY-CASE BASIS: assess the need to introduce the safety measures recommended by the President's Commission and in NRC and industry studies; review the competence of the prospective licensee to manage the plant and the adequacy of operating personnel training; and make licensing contingent upon review and approval of State and local emergency plans.

* * *

NRC RESPONSES

(5) NRC fully agrees and has begun actions to upgrade standards and requirements to assure technical competence of licensees. The objective will be "to minimize accident occurrence and maximize proper response to accidents." Licensee performance will be subject to more frequent periodic reviews, involving licensee's top management. More immediate and decisive action is being contemplated (see response to recommendation 2 under "Commission Recommendations on the Utility," below).

* * *

(6) The NRC Siting Policy Task Force report under current review by the Commissioners recommends similar changes and goes beyond those proposed. Radiation releases from small accidents will be considered in appraising these recommendations. For the past five years, the Standard Review Plan has excluded sites with high population densities, but operating plants built before then may call for added design features, power reduction, or shutdown.

* * *

(7) The NRC Lessons Learned Task Force recommends similar action but goes beyond that proposed. The staff has already implemented new requirements for system leakage and shielding and has recommended operator training in core-melt accident mitigation, as well as NRC rulemaking on required design features to provide such mitigation.

* * *

(8) NRC has decided that new plants will not be licensed until the required criteria have been developed. The NRC will: (a) review and correlate recommendations of the President's Commission, the ACRS, the Congress, its own inquiries and others; (b) draw up safety objectives corresponding with those recommendations; (c) develop plans by which to realize those objectives by action affecting NRC structure and procedure or by requirements placed on licensees; (d) impose such requirements on operating plants; and (e) impose such requirements on plants under construction. Deadlines will be associated with the last two steps. Operator training will, as noted, be upgraded, and a rule requiring approval of State and local emergency plans prior to plant operation is being considered.

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PC RECOMMENDATIONS

(9) THE AGENCY'S AUTHORIZATION TO MAKE GENERAL RULES AFFECTING SAFETY SHOULD INCLUDE THE FOLLOWING REQUIREMENTS: that a public agenda be developed according to which rules will be formulated; that the agency set deadlines for resolving generic safety issues; that existing rules be reevaluated periodically and systematically; that rulemaking procedures be adopted which give interested persons a meaningful opportunity to participate, which ensure careful consideration and explanation of proposed rules, and which provide for the application of new rules to existing plants. In particular, proposed rules should be accompanied by analyses of the issues involved and identification of relevant technical material. Interested parties and organizations should have sufficient opportunity to assess and refute technical evidence and findings, and final rules should be fully explained, with responses for principal comments received. If needed, interim safeguards for operating plants affected by generic safety rulemaking should be imposed, and the possible need for retroactive application of new safety requirements to operating plants should be examined.

NRC RESPONSES

(9) NRC publishes an agenda of rulemaking petitions, a report of regulations under development, advance notices of proposed rulemaking in major actions, and proposed rules for comments. Analyses and discussions of these are made public, and public meetings or hearing are held in cases of special importance. The means for the public to petition NRC to issue, revise or withdraw a rule are provided, and proposed and final rules sent to NRC Commissioners for consideration are accompanied by a staff paper dealing with the relevant concerns, alternatives, benefits and detriments, and comments received and their resolution. The process is being reevaluated for clarity, sufficiency of public attention, effectiveness in resolving safety issues. In practice all new rules call for a judgment on backfitting to existing plants, but NRC is now considering including the practice in the regulations. Deadlines for the resolution of unresolved safety issues were set more than a year ago, and these issues are, by definition, the most significant of the generic issues. Other such issues will be addressed by priority based on safety significance. The review of NRC regulations usually has followed some specific event, such as a research result, a petition for rulemaking or new technology, with some exceptions in the area of transportation and safeguards. This will now change, with plans for an initial review of regulations by June 1980, completion of relevant rule changes by 1982, and completion of a systematic review of all safety regulations by 1984. The review cycle will be repeated thereafter every five-to-seven years.

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(10) LICENSING PROCEDURES SHOULD FOSTER EARLY RESOLUTION OF SAFETY ISSUES BEFORE MAJOR FINANCIAL COMMITMENTS IN CONSTRUCTION CAN OCCUR. The Commission recommends: (a) the reduction of duplicative consideration of issues in the several stages of a plant's licensing history by assignment of particular issues (such as need for power) to some single stage of the proceedings; (b) resolution of issues that recur in many licensing actions by rulemaking; (c) combining construction permit and operating license hearings whenever plans can be made sufficiently complete at the construction permit stage; (d) an initial adjudication of a license application and appeal to a board whose decision would be final, with no provision for subsequent appeal within the agency. Both adjudicators and appeal boards would have a clear mandate to pursue any safety issue it wished to; (e) the creation of an "Office of Hearing Counsel" in the agency to participate in formal hearings as "an objective party, seeking to assure that vital safety issues are addressed and resolved," and empowered to appeal

(10) The objective underlying this recommendation is shared by NRC, but it cannot make specific comment on it at present. A report is pending from a special advisory committee on its study of an NRC rule which permits plant construction during adjudication. The report may also have a bearing on the NRC practice of permitting discrete, specific issues to remain open up to the operating license stage and even beyond. (It can happen that a safety issue cannot be settled without additional information, but that such information can be obtained by research, even as construction proceeds.) On November 2, 1979, the NRC suspended its rule by which reactor licenses become immediately effective following a favorable initial decision by a licensing board. No license will become effective until the Commission itself has had the opportunity to determine the relevance of TMI-related issues to the case. The assignment of single issues to specific stages of the process, and possibly combining construction permit and operating license hearings, are matters in which NRC's authority is unclear (the latter step would require new

PC RECOMMENDATIONS

"any adverse licensing board determination to the appeal board;" and (f) a deadline on the resolution of any specific safety issue left open in a licensing proceeding.

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(11) THE AGENCY'S INSPECTION AND ENFORCEMENT FUNCTIONS MUST RECEIVE INCREASED EMPHASIS AND IMPROVED MANAGEMENT. The Commission recommends: (a) an improved program for the systematic safety evaluation of plants to assess compliance with requirements, to determine whether new requirements should apply, and to identify new safety issues; (b) systematic assessment of reactor operating experience to reveal any pattern of abnormal activilty and provide a measure of overall rises or declines in safety and a base for specific improvements; (c) substantial penalties be levied on licensees who fail to report new safety-related information or violate rules proscribing unsafe practices; (d) improved inspection and auditing of licensee compliance with regulations and unannounced onsite inspection; (e) periodic intensive and open review of each licensee's performance in meeting license requirements and regulations; and (f) agency adoption of criteria for revocation of licenses, for sanctions short of revocation (e.g., probation), and for requiring immediate plant shutdown or other operational safeguards.

NRC RESPONSES

statutory power). Even though it may be possible to combine the two kinds of hearings, there must still be a vehicle for verifying the design details, and that must necessarily be done late in construction when engineering of the design is complete. Also, new information affecting the early construction permit decision can arise at any time. It is current NRC practice to segregate recurrent issues for generic resolution whenever possible. The recommendation that appeal board decisions be made final NRC dispositions of applications for licenses would have the effect of removing the Commissioners (or Administrator) entirely from a major dimension of nuclear regulation. As to the mandate to pursue safety issues, the boards already have independent authority to pursue "serious matters" and the exercise of the right is no longer qualified by "sparingly" or "in extraordinary circumstances." The proposal that a new Office of Hearing Counsel be created has a purpose which is not entirely clear, but it might serve as an alternative to other devices for broadening public participation, such as intervenor funding, and merits consideration. Plant-specific safety issues left open at the time of licensing are now carried forward with clear deadlines as conditions on the operating license; NRC will consider whether it should also be conditioned with deadlines for resolution of relevant unresolved safety issues.

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(11) In 1977, NRC set up a Systematic Evaluation Program (SEP) whose first phase called for review of conditions at 11 older plants. Extension of this program to all operating plants is being considered. The Interim Reliability Evaluation Program (see recommendation 4 under "Technical Assessment," below) is also under consideration. In July 1979, NRC created the Office for Analysis and Evaluation of Operational Data to give broad coordination to major program offices' assessment of operating experience; licensees have also been required to establish operating experience evaluation groups and to assess experience of other facilities than their own. The industry has created similar groups. The inspection and enforcement staff is being augmented with plant systems analysts to conduct independent technical evaluations and followup of licensee events, transients, and inspection findings. Potential generic problems and operating experiences will be conveyed promptly to licensees through Bulletins, Circulars, and Information Notices. Legislation to increase civil penalties imposed by NRC is pending before Congress, and the possible use of probation status is under review within NRC. The resident inspector program begun in 1977 has been expanded; at least two resident inspectors will be assigned to each site in fiscal year 1981. Licensee performance evaluations combined with

PC RECOMMENDATIONS

NRC RESPONSES

assessments of licensee management control systems by the Performance Appraisal Team will identify marginal utility operations and provide prompt correction. Unannounced inspections are carried out by NRC, but the need for these in light of the expanded resident inspector program is problematic.

PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON THE UTILITY AND ITS SUPPLIERS

PC RECOMMENDATIONS

(1) THE NUCLEAR INDUSTRY MUST DRAMATICALLY CHANGE ITS ATTITUDES TOWARD SAFETY AND REGULATIONS; IT MUST SET AND POLICE ITS OWN STANDARDS OF EXCELLENCE, to ensure the effective management and safe operation of nuclear power plants. It should develop standards for management, quality assurance, and operating procedures and practices, and it should conduct independent evaluations (perhaps through the Institute of Nuclear Power Operations). It should gather and analyze all power plant operating experience systematically, communicate information speedily to affected parties, and make needed changes on realistic deadlines.

* * *

(2) ALTHOUGH RESPONSIBILITY FOR SAFETY LIES WITH THE TOTAL ORGANIZATION OF THE PLANT, EACH NUCLEAR POWER PLANT COMPANY SHOULD HAVE A SEPARATE SAFETY GROUP THAT REPORTS TO HIGH-LEVEL MANAGEMENT. The group's assignment would be to evaluate procedures and general operations regularly from a safety perspective, to assess quality assurance programs, and to develop continuing safety programs.

NRC RESPONSES

(1) NRC agrees that improvements and maintenance of operational safety is a fundamental responsibility of licensees. The NRC role should be to provide acceptance criteria, detailed guidance where necessary, and any incentives needed to attain and sustain operational safety. NRC agrees with the other parts of recommendation 1 as well and feels the Institute of Nuclear Power Operations may well be the right vehicle for independent evaluation, especially with regard to important human factors. A statement of understanding between the Institute and the NRC should be executed within six months. In addition to creating the Office of Operational Data Analysis and Evaluation, the NRC has required each licensee to establish an engineering staff capability to assess and feed back pertinent operating experience. The intent is that programs of NRC, industry, and vendors will be complemented by and integrated with each licensee's program to assure that intelligible analyses of operating experience reach all reactor operators and plant technical support staff. A proposed rulemaking by NRC would require plant shutdown by a licensee upon discovery of human or operational errors that cause important safety systems to be inoperative.

* * *

(2) Although NRC has taken action to augment on-site technical support capability with shift technical advisors and operations evaluators at each plant, it is considering a requirement that would expand the staff for on-site safety surveillance by all licensees. A group of technical specialists would be assembled with no direct operating responsibilities to distract them from day-to-day attention to safety; it would report to senior management independently of the power production staff. NRC is also considering a requirement for licensees to improve their systems for independent verification of operational safety by means of automatic system status monitoring and personal verification as well.

PC RECOMMENDATIONS

(3) INTEGRATION OF MANAGEMENT RESPONSIBILITY AT ALL LEVELS MUST BE ACHIEVED CONSISTENTLY THROUGHOUT THIS INDUSTRY. There must be a single accountable organization with the requisite expertise to take responsibility for the integrated management of the design, construction, operation, and emergency response functions of nuclear power plant operation. Without such demonstrated competence, a company should not qualify for an operating license. At the design stage, the utility can either contract for a "turn-key" plant, a fully operational plant delivered by the vendor or architect-engineer, or the company can assemble expertise capable of integrating the design process. In either case, it is critical that knowledge gained during design and construction of the plant be transferred effectively to those responsible for operating the plant. Clear procedures, responsibilities, and communication serve to ensure accountability and are especially important in the event of a crisis.

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(4) IT IS IMPORTANT TO ATTRACT HIGHLY QUALIFIED CANDIDATES FOR THE POSITIONS OF SENIOR OPERATOR AND OPERATOR SUPERVISOR. Pay scales should be high enough to attract such candidates.

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(5) SUBSTANTIALLY MORE ATTENTION AND CARE MUST BE DEVOTED TO THE WRITING, REVIEWING, AND MONITORING OF PLANT PROCEDURES. Clearer wording, sound and practical content, clear diagnostic instructions for identifying abnormal occurrences, and insistence on the part of utility and vendor management on the early cure of safety questions (with deadlines, sanctions for delays, dissemination of results) are all recommended.

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(6) STATE RATE-MAKING AGENCIES SHOULD GIVE EXPLICIT ATTENTION TO THE SAFETY IMPLICATIONS OF RATE-MAKING WHEN THEY CONSIDER COSTS ON "SAFETY-RELATED" CHANGES.

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NRC RESPONSES

(3) NRC has recently surveyed and is studying the technical resources available to each power reactor licensee. It is developing new criteria by which to judge the competence of licensees to operate nuclear facilities and expects to promulgate them by April 1980. NRC agrees emphatically that there is a need for clear definition of roles and responsibilities and has required that licensees for operating plants provide these kinds of well-defined procedures, for both normal and emergency conditions, by January 1, 1980. NRC needs to develop new criteria for determining acceptable technical qualifications to design and construct nuclear power plants.

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(4) NRC has taken actions and will do more to substantially increase the qualifications of operating plant personnel (see next heading). NRC agrees it will be necessary for utilities to increase their pay scales.

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(5) NRC believes that licensees must evaluate and incorporate operating experience into their procedures, has ordered detailed analyses of small break loss-of-coolant accidents for all B&W operating reactors, and has ordered new analyses and procedures by all operating reactor licensees for responding to off-normal events which can be aggravated by operator action. Procedures which assist the operator in responding to inadequate core cooling have also been prescribed. Studies of the effects of stress on operator actions are underway and human factors will be afforded a prominence equal to that given equipment in NRC systems safety evaluations.

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(6) NRC agrees and will consider further its role in the resolution of the problem and examine whether other financial considerations, such as deadlines for rate-making purposes or tax exemptions, affect the safety of a nuclear power plant.

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PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON THE TRAINING OF OPERATING PERSONNEL

PC RECOMMENDATIONS

(1) AGENCY-ACCREDITED TRAINING INSTITUTIONS FOR OPERATORS AND SUPERVISORS SHOULD BE ESTABLISHED. Highly qualified instructors, high standards, and an emphasis on fundamentals of nuclear power plants and possible health effects thereof are recommended, and the training of operators to respond to emergencies. The institutions could be national, regional, or specific to nuclear steam systems; reactor operators should be required to graduate from one of them, with exemptions only when there is documented evidence that the candidate has equivalent training; the institutions should be subject to periodic reaccreditation by NRC; candidates must meet entrance requirements.

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(2) INDIVIDUAL UTILITIES SHOULD BE RESPONSIBLE FOR TRAINING OPERATORS WHO ARE GRADUATES OF ACCREDITED INSTITUTIONS IN THE SPECIFICS OF A PARTICULAR PLANT. The operators should be examined and licensed by the NRC both at initial licensing and at relicensing; operators must pass every portion of the examination, and supervisors of operators should have, at a minimum, the same training as operators.

* * *

(3) COMPREHENSIVE ONGOING TRAINING MUST BE GIVEN TO MAINTAIN OPERATORS' LEVEL OF KNOWLEDGE. The training must be continuously integrated with operating experience, with emphasis on diagnosing and controlling complex transients, and on fundamental understanding of reactor safety. Each utility should have ready access to a control room simulator, and operators and supervisors should be required to train regularly on it. Retention of operator licenses should be made contingent upon simulator performance.

* * *

NRC RESPONSES

(1) Although it agrees with the objective underlying the recommendation, NRC is not convinced that accreditation by NRC is the best way to proceed (although it does not object, in the long term, to having operators trained in a few, high-quality, accredited institutions closely controlled by NRC). But NRC's approach to date has aimed at upgrading the training requirements while leaving the choice of where to conduct training to the utility. The Institute for Nuclear Plant Operations established by the industry intends to give training to utility management and to instructors involved in operator training, and if the Institute can become the accrediting authority for reactor operator training, it might be preferable, although NRC will certainly be more deeply involved in auditing and monitoring training than ever before.

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(2) Utilities are now responsible for training operators in the specifics of a particular plant. Operators are initially examined and licensed by NRC, but licenses are renewed every 2 years afterward without NRC examination. NRC is taking action to reexamine operators for license renewal, to increase the overall passing grade and require it for each portion of the test (effective now), and will continue to require supervisors to have at least the same training as operators and be licensed as senior operators, as before. Managers at certain levels may also be required to be licensed as senior operators.

* * *

(3) NRC requires ongoing training and requalification of operators with annual examinations conducted by the utility. Requalification programs are being revised to give more emphasis to diagnosing and controlling complex transients, improving the fundamental grasp of reactor safety, and taking account of operating experience. In the future, NRC will administer requalification exams. The use of simulators will be required in operator training and retraining and for recertification. NRC is considering a requirement that utilities upgrade training for all plant personnel, over and above the recommendation cited.

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PC RECOMMENDATIONS

(4) RESEARCH AND DEVELOPMENT SHOULD BE CARRIED OUT ON IMPROVING SIMULATION AND SIMULATION SYSTEMS, to bring a higher level of realism to operator training, including simulated transients, and to improve diagnostics and general knowledge of nuclear plant systems.

NRC RESPONSES

(4) NRC believes that different types of simulators are needed to upgrade training, on the one hand, and refine diagnostic techniques, on the other. Explicit requirements are being readied for the simulator exercises to be included in operator training, covering normal and abnormal situations and response to multiple and concurrent failures. NRC will undertake extensive research in this area.

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PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS BASED ON ITS TECHNICAL ASSESSMENT

PC RECOMMENDATIONS

(1) EQUIPMENT SHOULD BE EVALUATED ACCORDING TO THE EXTENT TO WHICH IT INFORMS AND ASSISTS OPERATORS TO HELP THEM PREVENT ACCIDENTS AND DEAL WITH THOSE THAT DO OCCUR. Instruments should give both monitory and precursory information, e.g., indications of the full range of temperatures in the reactor under normal or abnormal conditions, and indication of the actual position of valves. Computer technology should be used to furnish clear displays to operators and supervisors of measurements relevant to accident conditions and advance warnings of developing conditions. In the interim, for TMI and similar plants, grouping of key measurements should be considered, with distinct warning signals on a single panel available to a specific operator and a duplicate panel to the supervisor.

NRC RESPONSES

(1) NRC agrees with all PC recommendations on improved control room designs and believes that the need for improved design is one of the most important of TMI lessons. Actions have been taken to improve the ability of operators to prevent or cope with accidents by improving the information available to them. Revised procedures and operator training in recognizing inadequate core cooling are required to be completed by the end of 1979 at all operating reactors. Instrumentation to monitor water level in the reactor and pressure, water level, radiation and hydrogen in the containment will be required by the end of 1980, as will other safety items designed to inform the operators clearly and fully. The most important new requirement is the year-long review of control rooms employing experts in human factors and person-equipment interaction. In the long term, NRC is encouraging completion of an industry standard on control room design and will carry out research in this entire area.

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(2) EQUIPMENT DESIGN AND MAINTENANCE INADEQUACIES AT TMI SHOULD BE STUDIED WITH A VIEW TO MITIGATING THE CONSEQUENCES OF ANY SIMILAR FUTURE OCCURRENCE. Iodine filters, the hydrogen recombiner, the vent gas system, containmnet isolation, reporting of water and radiation levels in containment, and the fast analysis of containment samples all merit review and correction.

(2) The NRC staff has required all licensees to fix six of the seven types of components cited by January 1, 1981. Iodine filtration is the subject of ongoing study and criteria development which includes other post-accident radiation control and treatment matters. Requirements for design changes redressing other equipment and maintenance deficiencies have also been imposed.

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(3) MONITORING INSTRUMENTS AND RECORDING EQUIPMENT SHOULD BE PROVIDED TO RECORD CONTINUOUSLY ALL CRITICAL PLANT MEASUREMENTS AND CONDITIONS.

(3) NRC is in complete accord. General criteria for such a requirement were developed by the Lessons Learned Task Force in the form of instrument readings which characterize the plant's safety status. NRC has required that recording equipment and instrumentation be present in the new on-site technical support centers by January 1, 1981.

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PC RECOMMENDATIONS

(4) CONTINUING IN-DEPTH STUDIES SHOULD BE INITIATED ON THE PROBABILITIES AND CONSEQUENCES OF NUCLEAR POWER PLANT ACCIDENTS, including the consequences of meltdown. The studies should cover both onsite and offsite effects and encompass a variety of small break loss-of-coolant and multiple failure accidents, with particular attention to human failures. Such studies should be useful in planning for recovery and cleanup after a major accident and in modifying plant design to help prevent or mitigate accidents (e.g., venting hydrogen from the reactor coolant system); they could be carried out by industry or other organizations under NRC or other Federal sponsorship.

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NRC RESPONSES

(4) NRC agrees and has increased or redirected its current program, requiring licensees to analyze small break loss-of-coolant accidents assuming multiple equipment failures. These are complete and revisions of procedures and training have been effected. Crystal River Unit 3, a B&W operating plant, is included in the Integrated Reliability Evaluation Program, as well other operating plants and possibly new operating plant licensees. NRC is also redirecting its research program to take in more probable transients and small break accidents, and is investigating core melt phenomena, including data from TMI relevant to recovery and cleanup after a major accident. Some specific deficiencies revealed at TMI and present elsewhere will be, as recommended, corrected before the end of 1980, but NRC believes that, since the deficiencies existed because this kind of TMI accident had not been considered in design and evaluation of the plant, mitigatory design features addressed to core damage and core melting may be required.

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PC RECOMMENDATIONS

(5) STUDY SHOULD BE MADE OF THE CHEMICAL BEHAVIOR AND THE RETENTION OF RADIOACTIVE IODINE IN WATER, which resulted in the very low release of radioiodine to the atmosphere in the TMI accident. The information should be taken into account in the studies of the consequences of other small break accidents.

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NRC RESPONSES

(5) NRC agrees that more information is needed on the realistic behavior of iodine, other radioisotopes and chemicals in the primary coolant systems of severely damaged reactors, and will conduct the necessary research.

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PC RECOMMENDATIONS

(6) BECAUSE OF HEALTH HAZARDS ASSOCIATED WITH THE CLEANUP AND DISPOSAL PROCESS, CLOSE MONITORING OF THE CLEANUP PROCESS AT TMI AND OF THE TRANSPORTATION AND DISPOSAL OF THE RADIOACTIVE MATERIAL THERE IS RECOMMENDED. As much data as possible should be preserved and recorded about the conditions within the containment building for future safety analyses.

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NRC RESPONSES

(6) NRC agrees and has had a continuing presence at the site to monitor, audit and review the cleanup underway. As much important data as possible will be preserved and recorded for future use. NRC has also decided to prepare a programmatic environmental impact statement on the decontamination and disposal of wastes from the TMI accident.

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PC RECOMMENDATIONS

(7) AS PART OF THE NORMAL SAFETY ASSURANCE PROGRAM, EVERY ACCIDENT OR NEW ABNORMAL EVENT SHOULD BE SCREENED TO ASSESS ITS IMPLICATIONS for the existing system design, computer models of the system, equipment design and quality, operations, operator training, training simulators, plant procedures, safety systems, emergency measures, management and regulatory requirements.

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NRC RESPONSES

(7) NRC agrees on the need for thorough investigation of accidents and abnormal events and believes that the initiatives on operating experience evaluation, in close coordination with inspection and enforcement activities for the especially significant events, will meet the intent of this recommendation.

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PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON WORKER AND PUBLIC HEALTH AND SAFETY

PC RECOMMENDATIONS	NRC RESPONSES
(1) EXPANDED AND BETTER COORDINATED RESEARCH INTO HEALTH-RELATED RADIATION EFFECTS SHOULD BE ESTABLISHED, and should include, among others, study of the biological effects of low levels of ionizing radiation; acceptable levels of ionizing radiation to which the general public and workers may be exposed; means for mitigating the adverse health effects of exposure to ionizing radiation; and the genetic or environmental factors which predispose individuals to incurring adverse effects. The research should be coordinated with the National Institutes of Health and other Federal agencies.	(1) NRC agrees with the recommendation. During 1978–79, the NRC staff worked in an interagency project chaired by the Department of Health, Education and Welfare, which also concluded that there was need for this kind of research. Thus, the interagency committee on radiation research, chaired by the National Institutes of Health, was established in early 1979, with NRC as a member. Topics cited by the PC will be introduced by NRC as agenda items for action by the committee.
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(2) NRC POLICY STATEMENTS OR REGULATIONS CONCERNING RADIATION-RELATED HEALTH EFFECTS, INCLUDING REACTOR SITING ISSUES, SHOULD BE SUBJECT TO REVIEW AND COMMENT BY THE SECRETARY OF THE DEPARTMENT OF HEALTH AND HUMAN SERVICES. A time limit should be placed on such review to assure expeditious treatment.	(2) NRC agrees with the value of Federal oversight of NRC activities that affect public health. But NRC believes that a more effective and balanced result would be achieved through the role envisioned for the Federal Radiation Policy Council that the President has decided to establish.
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(3) AN INCREASED PROGRAM, AS A STATE AND LOCAL RESPONSIBILITY, FOR EDUCATING HEALTH PROFESSIONALS AND EMERGENCY RESPONSE PERSONNEL IN THE VICINITY OF NUCLEAR POWER PLANTS SHOULD BE CREATED.	(3) NRC agrees with this recommendation and, although the suggestion is for a State and local program, NRC intends to give guidance and help in meeting their needs. In particular, NRC will supplement NRC/EPA guidance already available to States on the preparation of emergency response plans to provide more detailed guidance on the education and training of personnel who will respond to emergencies at nuclear power plants. In addition, NRC has offered and will continue to offer technical assistance to the States in the preparation or upgrading of emergency response plans.
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(4) UTILITIES MUST MAKE SUFFICIENT ADVANCE PREPARATION FOR THE MITIGATION OF EMERGENCIES, by having radiation monitors available for normal or off-normal conditions; by having the emergency control center for health physics operations and analytic laboratory in a well-shielded area with its own air supply; by having enough instru-	(4) The recommendation of the NRC Task Force on Emergency Preparedness to expand coverage and improve offsite monitoring capability for accidents is being implemented by all operating plant licensees, and NRC has increased its capability in this area. Requirements for onsite monitoring for accident diagnostics and health physics purposes recommended by

PC RECOMMENDATIONS

ments, respirators, and other equipment for normal or off-normal conditions; and by performing adequate maintenance on all such health-related equipment.

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(5) AN ADEQUATE SUPPLY OF POTASSIUM IODIDE FOR PROTECTION AGAINST RADIATION EFFECTS ON THE THYROID SHOULD BE AVAILABLE REGIONALLY FOR DISTRIBUTION TO THE GENERAL POPULATION AND WORKERS AFFECTED BY A RADIOLOGICAL EMERGENCY.

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NRC RESPONSES

the Lessons Learned Task Force are also being implemented. Requirements for emergency health physics control centers and health physics equipment are being upgraded. These actions should substantially improve utility capability.

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(5) NRC agrees and will require licensees to have adequate supplies of this agent available for nuclear power plant workers. For the general population, NRC expects to make its availability a necessary part of an acceptable State emergency response plan. Plans are not complete as to how and how much of the agent should be stockpiled and distributed; studies are underway.

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PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON EMERGENCY PLANNING AND RESPONSE

PC RECOMMENDATIONS

(1) EMERGENCY PLANS MUST DETAIL CLEARLY AND CONSISTENTLY THE ACTIONS PUBLIC OFFICIALS AND UTILITIES SHOULD TAKE WHEN OFFSITE RADIATION DOSES OCCUR. The State within which a prospective nuclear power plant will be sited should have an emergency response plan reviewed and approved by the Federal Emergency Management Agency (FEMA) before an operating license is granted. FEMA should have the Federal responsibility for radiological emergency planning and should consult with other agencies, including the NRC and health and environmental agencies. The State should coordinate its planning with the utility and local officials, and States with plants now operating should upgrade, without delay, their plans to conform with FEMA requirements.

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(2) PLANS FOR PROTECTING THE PUBLIC FROM OFFSITE RADIATION RELEASES SHOULD BE BASED ON TECHNICAL ASSESSMENT OF VARIOUS CLASSES OF ACCIDENTS THAT CAN TAKE PLACE AT A GIVEN PLANT. No single plan based on fixed distances and responses can suffice; planning should involve the identification of several different kinds of accidents with different radi-

NRC RESPONSES

(1) NRC agrees with the substance of the recommendation and has moved to upgrade plans in States with operating plants. Rulemaking has been initiated to raise emergency preparedness standards and an extensive review of all aspects of response capability is underway. A joint letter has been issued by FEMA and NRC confirming the former's lead role in Federal emergency planning and declaring joint responsibility for concurring in State emergency response plans prior to NRC's issuance of an operating license. NRC is considering a rule that would make such issuance contingent upon approval of State plans within a fixed time frame.

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(2) The basis for emergency response planning has been under examination at NRC for some time. An NRC/EPA task force published the results of an extensive study in December 1978 and its conclusions were consistent with this recommendation. In October 1979, the NRC Commissioners endorsed the concept of a flexible planning base, including emergency planning over much larger areas than before. The base re-

PC RECOMMENDATIONS

ation effects. For each kind there should be clear criteria for the appropriate response at various distances, such as instructing people to remain indoors for a time, providing special medication, or ordering an evacuation. Response plans should be keyed to various possible scenarios and activated when the nature of the potential hazard is clear. Plans should exist for protecting the public from radiation levels lower than those in current NRC-prescribed plans. And all local communities should have funds and technical support adequate for preparing the plans recommended.

NRC RESPONSES

quires that specific scenarios be used to test the adequacy of plans and that the activation of emergency response be keyed to various plant conditions according to revised emergency action guidelines published in September 1979. NRC currently uses the EPA protective action guides, but will give greater emphasis in the new action level guidance on the potential for exposure as distinct from the actual exposure levels. An NRC staff study on funding problems of State and local governments was recently published and is under consideration by NRC; it discusses the need for and possible sources of such funding.

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(3) RESEARCH SHOULD BE EXPANDED ON MEDICAL MEANS FOR PROTECTING THE PUBLIC AGAINST VARIOUS LEVELS AND TYPES OF RADIATION. This research should include exploration of appropriate medications that can protect against or counteract radiation.

(3) NRC agrees that such research is needed and will encourage the Department of Health and Human Services to take steps in this area.

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(4) IF EMERGENCY PLANNING AND RESPONSE TO A RADIATION-RELATED EMERGENCY IS TO BE EFFECTIVE, THE PUBLIC MUST BE BETTER INFORMED. A program is needed to educate the public on how nuclear power plants operate, on radiation and its health effects, and on protective actions required in an emergency.

(4) NRC agrees but believes that a broad public information program would be more appropriately handled by other agencies. Better information on radiation risks is among the subjects to be addressed by the planned Federal Radiation Policy Council. NRC will require, however, that licensees keep the public informed on a continuing basis of the nature of hazards in a radiation emergency and of actions that might have to be taken. Periodic response drills on the part of local and State organizations should contribute to this awareness.

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(5) COMMISSION STUDIES SUGGEST THAT DECISION-MAKERS MAY HAVE OVERESTIMATED THE HUMAN COSTS, IN INJURY AND LOSS OF LIFE, IN MANY MASS EVACUATION SITUATIONS. Further study is needed into the human costs of mass evacuation and into the question of whether radiation-related evacuations differ from those occasioned by other events. Such studies should take into account the effects of improved emergency planning, public awareness of the planning, and costs.

(5) NRC agrees that further study should be done on this and other protective actions.

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(6) PLANS FOR PROVIDING FEDERAL TECHNICAL SUPPORT, SUCH AS RADIOLOGICAL MONITORING, SHOULD CLEARLY SPECIFY THE RESPONSIBILITIES OF THE VARIOUS SUPPORT AGENCIES AND THE PROCEDURES BY WHICH THEY PROVIDE ASSISTANCE. Existing plans, expecially those of the Interagency Radiological Assistance Plan and the various memoranda of understanding among the agencies, should be reexamined and revised by Federal authorities in the light of TMI and better coordination and more efficient Federal support provided for.

(6) NRC agrees that improvements are needed and has efforts underway to reexamine and revise Federal interagency agreements on emergency assistance.

PRESIDENT'S COMMISSION (PC) RECOMMENDATIONS ON THE PUBLIC'S RIGHT TO INFORMATION

PC RECOMMENDATIONS

(1) FEDERAL AND STATE AGENCIES, AS WELL AS THE UTILITY, SHOULD MAKE ADEQUATE PREPARATION FOR A SYSTEMATIC PUBLIC INFORMATION PROGRAM, so that when a radiation emergency occurs, they can provide timely and accurate information to the news media and the public in a form that is understandable. Assignments of briefing responsibility and availability of informed sources are necessary to reduce confusion and inaccuracy. The utility has primary responsibility for providing information on the status of the plant to the news media and the public, as it has for the management of the accident. The NRC should also be available to provide background information and technical briefings. A designated State agency should convey all information related to State decisions on protective actions (including evacuations) and to offsite radiation releases. This agency should set up the means to keep local officials informed and to coordinate briefings to discuss Federal involvement in any evacuation measures.

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NRC RESPONSES

(1) The procedure used before TMI was that NRC public affairs staff would be sent to an accident site to support NRC personnel in communicating with the media, but not to take charge of information activities. At TMI, the NRC in fact took over public information responsibilities on March 31. Although this recommendation prescribes a background role for NRC, it seems more realistic that the Federal regulator be in a position to talk about an emergency situation, since NRC would expect the State and the public to look to NRC for authoritative information on the situation. NRC believes it would be more effective to have Federal, State, and utility personnel operate out of a single press center and, whenever possible, give a unified view of the situation.

* * *

(2) BECAUSE THE OFFICIAL SOURCES OF INFORMATION MUST MEET THE NEEDS OF THE MEDIA FOR INFORMATION WITHOUT COMPROMISING THE EFFORT OF OPERATIONAL PERSONNEL TO MANAGE THE ACCIDENT, it is recommended that those who brief the news media have direct access to informed sources of information, that technical liaison people be designated as contacts for the briefers and the media, and that primary official news sources have plans for promptly setting up press centers fairly close to the site, properly equipped and staffed.

* * *

(2) NRC agrees with the recommendations and will consider requirements to assure that licensee plans will achieve them. Licensees are now required to identify offsite emergency control centers where the utility, Federal, State, and local officials can gather. A press center would be established either at the off-site emergency control center or nearby, which will facilitate State activities set forth in the preceding recommendation.

* * *

(3) SPECIAL RESPONSIBILITIES ON THE NEWS MEDIA TO PROVIDE ACCURATE AND TIMELY INFORMATION REQUIRE THAT all major media hire and train specialists familiar with reactors and radiological language, and all other media in the area of nuclear power plants should have plans for securing such services in an emergency; reporters try to place complex information in an understandable context and allow the public to decide the hazard to their health and safety; reporters try to avoid raising "what if" questions needlessly and try to understand expressions of uncertainty and probability from the sources of information.

* * *

(3) NRC agrees and will urge the professional societies, such as the American Nuclear Society or the Health Physics Society, to sponsor seminars for the news media where reporters can learn how nuclear power plants operate and about radiation effects. NRC will consider in ongoing rulemaking whether the training program required to be developed by the licensee for local officials could be extended to include local news media personnel.

* * *

PC RECOMMENDATIONS	NRC RESPONSES
(4) STATE EMERGENCY PLANS SHOULD INCLUDE PROVISION FOR CREATION OF LOCAL BROADCAST MEDIA NETWORKS FOR EMERGENCIES THAT WILL SUPPLY TIMELY AND ACCURATE INFORMATION. Arrangements should be made to have knowledgeable people available to go on the air and clear up rumors and explain conditions. Communications between State officials, the utility, and the network should be prearranged to handle the possibility of an evacuation announcement.	(4) NRC agrees the proposal has merit and will incorporate recommendations accordingly in guidance to the States. It will also consider in the ongoing rulemaking on emergency preparedness whether there is a need to include requirements for licensee planning and coordination to disseminate information to the public on these local broadcast networks and to provide information to such networks in the event of an accident.
* * *	* * *
(5) THE PUBLIC IN THE VICINITY OF A NUCLEAR POWER PLANT SHOULD BE ROUTINELY INFORMED OF LOCAL RADIATION MEASUREMENTS THAT DEPART APPRECIABLY FROM NORMAL BACKGROUND RADIATION, whether from normal or abnormal operation of the nuclear power plant, from a radioactivity cleanup operation such as that at TMI, or from other sources.	(5) NRC agrees with this recommendation, which is consistent with its current practice, in which public announcements are made on any releases to the environment from licensed facilities that appreciably exceed NRC limits (which are small in comparison with normal background, but are in addition to normal background). Most licensees also issue such announcements.

In addition to providing the Executive Office of the President with responses to each of the President's Commission's recommendations, the NRC cited several examples of considerations and actions it had taken as a result of TMI which were outside the scope of the PC recommendations. Seven such examples were given.

(1) **Generic Requirements for Design Features for Core Melt Consequence Mitigation.** Severe core damage did occur at TMI, but significant exposure of the public was prevented because radiation releases were, for the most part, successfully kept in the containment building. There is substantial evidence that the residual risks of core melt accidents can be significantly reduced if some of the potential modes of containment failure can be prevented or controlled. The NRC Lessons Learned Task Force has recommended that this issue—whether to require additional design features and training for core melt accidents—be revised through the rulemaking process.

(2) **Expanded Reactor Safety Goals, Including Quantification of Reliability.** The President's Commission endorsed the conservative use of safety-cost tradeoffs, but did not confront the fundamental question as to just what level of safety is desired and acceptable. The Advisory Committee on Reactor Safeguards and the NRC Lessons Learned Task Force have recommended that policy guidance be developed within NRC on what is an acceptable safety goal of reactor regulation, reflecting a synthesis of views and priorities and setting forth an objective sufficiently clear for the staff to employ in day-to-day decisionmaking. This regulatory safety goal should comprise both evaluative and quantified reliability criteria, applicable to the development of any new regulatory requirements and to a decision on backfitting requirements to existing plants.

(3) **NRC Emergency Response Capabilities.** Events at TMI demonstrate that NRC has an important role in auditing and monitoring the licensee's actions, and NRC is strengthening the crisis management and technical capabilities of its emergency management staff. The emergency response teams of the NRC Office of Inspection and Enforcement are being tested and actually dispatched to various sites. NRC is also specifying the content and transmission requirements for a nuclear data link from all operating plants to its Operations Center.

(4) **Compensating Features for Plants with High Population Density Sites.** NRC is considering the need for additional protective action—such as shutdown, reduced power or additional design features—for currently operating plants located in densely populated areas.

(5) **Licensing of Operations Personnel in Addition to Reactor Operators and Their Supervisors.** NRC is considering making it a requirement that certain nuclear power plant personnel other than reactor operators and supervisors be licensed. TMI indicated in various ways that plant safety can be affected by persons in many positions, including managers, engineers, auxiliary operators, maintenance personnel, and technicians. The Institute of Nuclear Power

Operations, recently established by the nuclear industry, may have a role to play in this area.

(6) Plant Security During an Emergency. A need for clear instructions for plant security during an emergency was brought home by TMI, particularly to ensure that access control measures remain effective but do not hamper recovery operations.

(7) Worker Protection. Significant deficiencies in the worker protection program at TMI have been disclosed and, concerned that the problems may be widespread, NRC is developing new generic requirements in this area.

Two of the five NRC Commissioners made separate supplemental responses to the President's Commission findings and recommendations. These are summarized below.

Commissioner Bradford's Views. Commissioner Peter A. Bradford expressed his judgment that, while the PC report was helpful and insightful in a number of areas (including recommendations on the NRC, on operating personnel training, technical assessment, and emergency planning), it was "a flawed document" in three respects. First, the major recommendation for a restructuring of the nuclear regulatory process "does not make good sense." Second, there are a number of areas to which the report could have spoken but did not. Third, there is "no clear relationship between the narrative, the findings, and the recommendations, with the result that some important findings do not result in recommendations while some of the recommendations find little support elsewhere in the report."

On the first flaw, the Commissioner felt that the concept of an independent agency headed by a "single administrator appointed by the President . . . to serve at the pleasure of the President" presented a "contradiction in terms," since an agency cannot be independent if its head is removable at the pleasure of the President. Further, the "more this point is corrected by the granting of true independence to the agency the more undesirable it will be to vest what will become quite sweeping powers in a single individual."

The problems within NRC to which the recommendation is addressed are of two kinds: an "attitudinal" problem, which shows up in the agency's failure to pursue the questions which would have led it to discover the vulnerabilities now revealed by TMI; and the diversity of views among the NRC Commissioners which may make it difficult for the agency to correct itself. While the Commissioner agreed that the second problem was curable by setting up a single administrator, as recommended by the President's Commission, "it is also curable through changes within the current Commission structure" which would constitute a "potentially faster and certainly wiser" course of action. The Commissioner pointed out that the only real benefit of the single-administrator proposal (or proposals to reinforce the authority of the Chairman or the Executive Director for Operations) is "that it provides a shortcut away from the perceived stalemate at the current Commission." He felt that these proposals "ignore the fact that collegial agencies are perfectly capable of moving rapidly and innovatively in new directions *as long as they have a coherent and predictable majority that includes the Chairman and that supports the chief operational officers.*"

A number of items were cited by the Commissioner on which he believed the President's Commission "could usefully have taken a position had time permitted."

- On the question of whether and when evacuation was warranted at TMI, he notes that the PC report "said nothing about the validity of the actual recommendation that was made. This seems to me to be an oversight of some magnitude, for such decisions are often likely to involve the allocation of unquantifiable uncertainties. It would be very useful to know whether these twelve citizens . . . feel that a greater or lesser set of evacuation advisories were in order at different times during the accident."
- The report does not discuss "the pros and cons of intervenor funding . . . an essential tool to enable the proposed Public Counsel to guarantee effective outside skeptical participation in the licensing process."
- The PC report is "blurred as to what the fundamental standard for the safety of nuclear power should be. . . . [T]he considered view of twelve laymen on this subject would have been extremely valuable. Instead, one finds statements to the effect that 'accidents as serious as TMI should not be allowed to occur in the future.' . . . [S]ome statement as to how this group regarded the acceptability of risks from nuclear power plants in the context of other technologically imposed risks would have been a helpful guidance." The NRC is going to have to "fill the void with a rulemaking."
- There is no acknowledgment in the PC report of "the strides already achieved since Three Mile Island by the Nuclear Regulatory Commission. . . . This oversight would be easier to understand if it were explicitly acknowledged and explained. It would also be easier to understand if the TMI Commission had not gone out of its way to pat the nuclear industry on the back for having recently created the Institute of Nuclear Power Operations."
- The report speaks repeatedly of examples of AEC promotional attitudes and practices within the NRC but gives no specifics. The statements "tend to tar everyone with the same brush, and they are

not helpful in setting a clear course of corrective action."

- While the report criticizes the NRC's "single failure criterion," it makes no specific recommendation on the subject. If the criterion is to be abandoned, the implications for the nuclear licensing process "are considerable and would almost certainly result in extensive redesigning and backfitting to plants already under construction or in operation." If this is the recommendation of the report, it should have been made explicit.
- The PC report "lays a gentle and indecipherable hand on the state ratesetting process." In the relation between financing and safety, there are "at least two areas of much greater significance . . . the timing of state decisions that create an incentive to rush a plant into service (this allegation was specifically made in regard to TMI) and the Internal Revenue Service's practice of assuming for tax purposes that the plant was in service for the full calendar year if it is in commercial operation by midnight on December 31." Both questions are under study by NRC and "it might be well to ask the Internal Revenue Service and the National Association of Regulatory Utility Commissioners to have a look at them as well."
- On the subject of worker and public health and safety, the report "contains nothing on the vital subject of making sure that workers are adequately informed and trained with regard to radiation and its hazards. It also says nothing about the need to assure that workers who raise safety- or radiation-related concerns are adequately protected against reprisals by their management."
- The report fails to note that the Atomic Energy Act "currently preempts the States from setting most radiological health and safety standards involving nuclear power plants. . . . [I]f the states had a role in this area, they would no longer find themselves excluded from nuclear power plant radiation regulatory matters until the moment at which something really goes wrong and they are expected to step in and cope effectively with the offsite consequences."
- The report "says nothing about the effect of the attitudes of the Congressional Oversight Committees on the quality of the nuclear regulatory process." The approach of the former Atomic Energy Commission cited so often and so critically by the President's Commission "was shaped by the demands that were laid on the AEC by the Joint Committee on Atomic Energy. Anyone trying to understand where nuclear regulation went astray must realize that the AEC was responding not solely to its own or to Executive Branch notions of desirable Atomic Energy policy, but also to the continuing pressure for results from the one congressional committee to which it was answerable. The relationship as I understand it was a mutually reenforcing one, but the continuing role of the Congress setting the tone for nuclear regulation should not be overlooked."

Commissioner Gilinsky's Views. Commissioner Victor Gilinsky also put on record certain personal views on the report of the President's Commission. On the basic finding of a need for fundamental change, the Commissioner was in agreement, noting that publication of the report and the attention it received, especially from the President, strengthens the hand of "those concerned with improving nuclear safety and further shifts the burden of proof to those who would do less rather than more." The Commissioner expressed agreement with "almost all" of the findings and recommendations of the report, but stated, "I feel compelled to add that when we get below the general level, down to the nitty-gritty of reactor regulation, the report is less helpful."

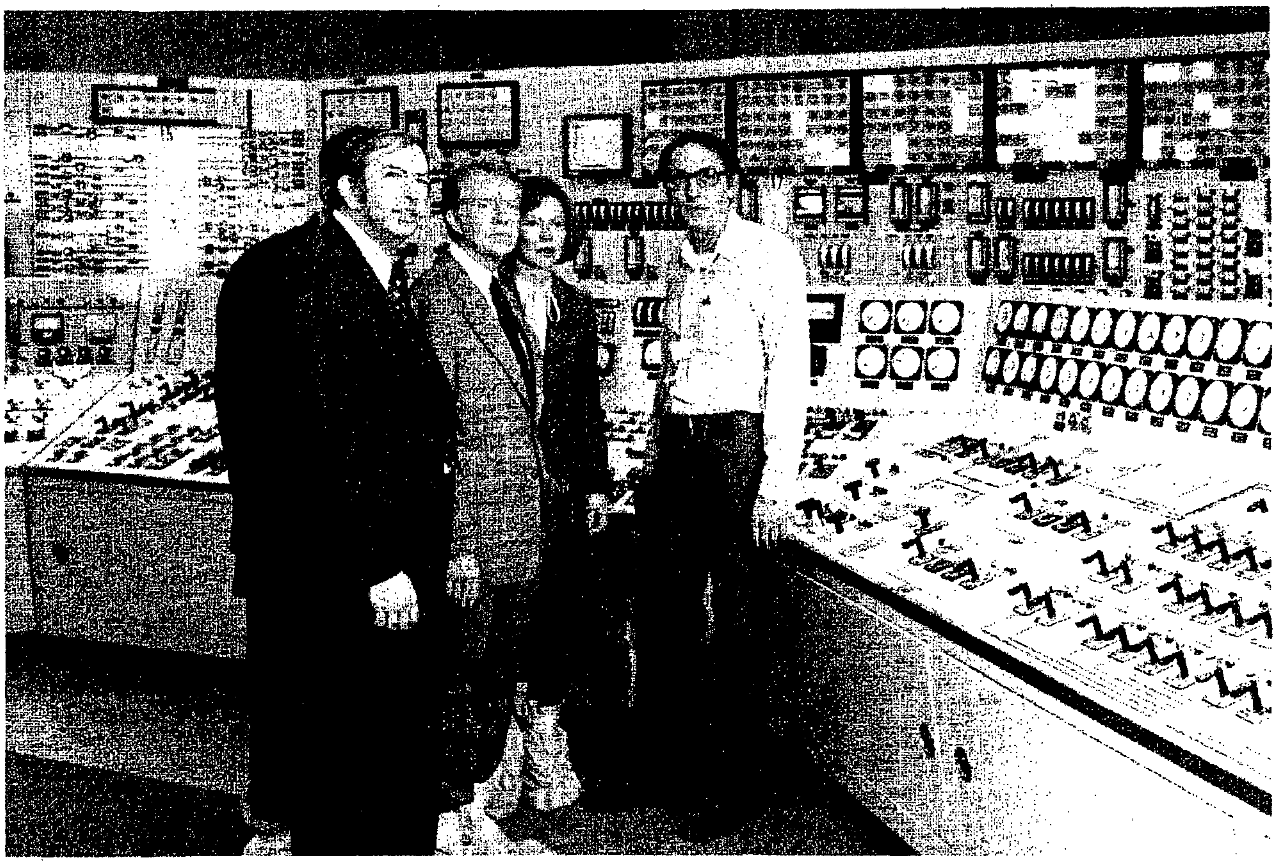
The inventory of items that need fixing—operator training, emergency planning, improved use of operating information, etc.—are "almost all . . . the subjects of major NRC actions which were initiated before the report's publication." The more difficult questions "in each case are: What precisely needs to be done? Are NRC actions sufficient?" The President's Commission decided that the present NRC is unable to fulfill its responsibility for providing an acceptable level of safety, but the PC report "is silent on what an acceptable level is." It is up to the NRC, the Commissioner concludes, to "get more specific about overall standards for nuclear safety—on what is safe enough."

The section of the PC report dealing with utility management deficiencies carries "no attempt to judge whether these deficiencies are characteristic of the industry. Without such a determination, it is impossible to judge the overall system for public protection."

The report also fails to deal with the adequacy of the TMI licensee's communication to government authorities of plant conditions—high core temperatures and the containment hydrogen explosion—on the first day of the accident. "I regard this as a vital question," the Commissioner declared. "Given the dangers inherent in nuclear plants we have to be confident that the utilities will report promptly any conditions that require public protection."

The report "never comes to grips with the question of whether an evacuation should or should not have been ordered," a decision which "is critical to forming a judgment on the [Nuclear Regulatory] Commission's responses and to planning further response."

On the subject of NRC Commissioners' isolation from the licensing process, the Commissioner suggests that the single administrator called for in the PC report "would be even more removed from the licensing proceedings" because, as the report proposes it, the



President and Mrs. Carter toured the TMI site on Sunday, April 1, 1979, and are seen above in the TMI-2 control room. At left is NRC's Director of Reactor Regulation, Harold Denton, who was designated the President's personal representative at the site for the duration of the accident.

appeal board decisions would not be reviewable by the administrator. The Commissioner indicates that the experience of NRC is that "leaving all appeals to the Appeal Board leads to loss of policy control over the licensing process." He urges that "[t]he Commissioners need to be more involved in the adjudicatory reviews rather than less."

The PC report recommends, "after seemingly streamlining the NRC for emergencies by shifting to a single administrator," that the NRC "stay out of dealing with emergencies altogether" and leave emergency planning to FEMA and the handling of any accident—and public information related thereto—to the utility. The Commissioner does not think it "wise or realistic to downplay the NRC role to this extent."

The Commissioner also observes that the report, by emphasizing the human failures and "thereby vindicating the equipment," does not stress enough that the equipment "could have been designed to avoid this kind of trouble."

The President's Response

On October 30, 1979, the President's Commission on the Accident at Three Mile Island presented its final report to the President. Following a period of study by a panel appointed from his staff, the President issued his response to the recommendations of the PC report on December 7, 1979. (The President's statement is reprinted on page 62 in its entirety.)

Among the salient points of the statement were the announcements that:

- A reorganization plan for the NRC would be sent to Congress in the next session which will strengthen the role of the Chairman to lead the Commission in the development of a unified and more reliable nuclear safety regulatory program.
- The President would appoint a new Chairman of the NRC from outside the agency.
- A five-member expert advisory committee would be established to monitor the progress of the

NRC, other Federal agencies, the States, and the utilities in improving the safety of nuclear reactors and in implementing recommendations of the President's Commission. The committee would report periodically to the President and the public.

- The President was asking the NRC and other agencies to accelerate placement of a resident Federal inspector at every reactor site and was asking the NRC to evaluate the need for a Federal presence in the control room of operating reactors.

- The President was directing that the Federal Emergency Management Agency (FEMA) assume responsibility for all offsite nuclear emergency planning and response. A supplemental appropriation of $8.9 million would be submitted to Congress to enable FEMA to complete the review of State emergency plans in all States with operating licenses by June 1980.

- The President was urging the industry to build on the progress it had made since the TMI accident to provide enhanced analysis and evaluation for safety of the design, construction, and operation of plants and a greatly strengthened training, retraining, and evaluation program for operators and supervisors. He asked the NRC to appraise and reinforce these efforts.

- To assure that the lessons of TMI were expeditiously absorbed and applied, the President was submitting a supplemental appropriation to Congress of $49.2 million for the NRC and $7 million for the DOE. These funds would allow the collection and evaluation of data and speed the implementation of reforms.

Affirming that he "agrees fully with the spirit and intent" of all recommendations of the PC report, the President chose to strengthen the NRC organization through enhanced executive powers for the Chairman, rather than by creation of a new agency. Since the collegial Commission, representing diverse and complementary views, would be retained, the President chose not to create a 15-member oversight committee. He did, however, announce his intention of establishing a smaller advisory committee to report to him on the progress of the NRC and others, as noted above. The President urged the NRC to complete its work of defining and effecting the reforms dictated by analyses of TMI as quickly as possible and, in any event, no later than May 1980. In doing so, the President observed that "we must resume the licensing process promptly so that the new plants which we need to reduce our dependence on foreign oil can be built and operated." He concluded by stating that "nuclear power has a future in the United States—it is an option that we must keep open. I call on the utilities and their suppliers, the NRC, the Executive Departments and agencies, and the State and local governments to assure that the future is a safe one."

Statement by President Carter on the Kemeny Commission Report

I have reviewed the report of the Commission I established to investigate the accident at Three Mile Island nuclear power plant. The Commission, chaired by Dr. John Kemeny, found very serious shortcomings in the way that both the government and the utility industry regulate and manage nuclear power.

The steps I am taking today will help ensure that nuclear power plants are operated safely. Safety has always been, and will remain, my top priority.

As I have stated before, in this country, nuclear power is an energy source of last resort. By this I meant that as we reach our goals for conservation, direct use of coal, development of solar power and synthetic fuels and enhanced production of American oil and natural gas, we can minimize our reliance on nuclear power.

Many of our foreign allies must place greater reliance than do we on nuclear power, because thay do not have the vast natural resources that give us many alternatives. We must get on with the job of developing alternative energy sources—by passing the legislation I proposed to the Congress, and by making an effort at every level of society to conserve energy.

We cannot shut the door on nuclear energy.

The recent events in Iran have shown us the clear, stark dangers that excessive dependence on imported oil holds for our Nation. We must make every effort to lead this country to energy security.

Every domestic energy source, including nuclear power, is critical if we are to free our country from its overdependence on unstable sources of high-priced foreign oil. We do not have the luxury of abandoning nuclear power or imposing a lengthy moratorium on its further use. A nuclear plant can displace up to 35,000 barrels per day.

We must take every possible step to increase the safety of nuclear power production. I agree fully with the spirit and intent of the Kemeny Commission's recommendations, some of which are within my power to implement, others of which rely on the Nuclear Regulatory Commission or the utility industry itself.

To get the government's own house in order I will take several steps. First, I will send to Congress a reorganization plan to strengthen the role of the Chairman of the NRC and provide this person with the power to act on a daily basis as the chief executive officer, with authority to put needed safety requirements and procedures in place. The Chairman must be able to select key personnel, and act on behalf of the commission during an emergency.

Second, I will appoint a new Chairman of the NRC—someone from outside that agency, in the spirit of the Kemeny Commission's recommendation. In the meantime, I have asked Commissioner Ahearne, now on the NRC, to serve as Chairman. Dr. Ahearne will stress safety and the prompt implementation of the needed reforms. In addition, I will establish an independent advisory committee to help keep me informed of the progress the NRC and the industry are achieving in making nuclear energy safer.

Third, I am directing the Federal Emergency Management Agency to head up all off-site emergency activities, and complete a thorough review of emergency plans in all states with operating reactors by June.

Fourth, I have directed NRC and other agencies to accelerate our program to place a resident federal inspector at every reactor site.

Fifth, I am asking all relevant government agencies to implement virtually all of the other recommendations of the Kemeny Commission.

A detailed fact sheet is being issued to the public, and a more extended briefing will be given to the press.

With clear leadership and improved organization, the Executive branch and the NRC will be better able to act quickly on the critical issues of improved training and standards, safety procedures, and the other Kemeny Commission recommendations.

But responsibility to make nuclear power safer does not stop with the federal government. In fact, the primary day-to-day responsibility for safety rests with utility company management and suppliers of nuclear equipment. There is no substitute for technically qualified and committed people working on the construction, operation and inspection of nuclear power plants. Personal reponsibility must be charged both at the corporate level and at the plant site. The industry owes it to the American people to strengthen its commitment to safety.

I call on the utilities to implement the following changes:

First, building on the steps already taken, the industry must organize itself to develop enhanced standards for safe design, operation, and construction of plants.

Second, the nuclear industry must work together to develop and to maintain in operation a comprehensive training, examination and evaluation program for operators and supervisors. This training program must pass muster with the NRC through accreditation of training programs.

Third, control rooms must be modernized, standardized and simplified as much as possible to permit better informed decision-making during an emergency.

I challenge our utility companies to bend every effort to improve the safety of nuclear power.

Finally, I would like to discuss how we manage the transition period during which the Kemeny recommendations are being implemented. There are a number of new nuclear plants now awaiting operating licenses or construction permits.

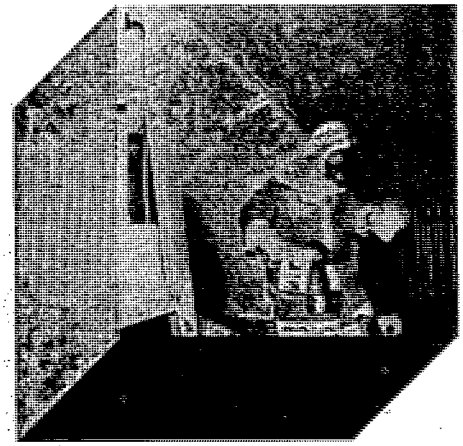
Licensing decisions rest with the NRC and, as the Kemeny Commission noted, it has the authority to proceed with licensing these plants on a case-by-case basis, which may be used as circumstances surrounding a plant dictate. The NRC has indicated, however, that it will pause in issuing new licenses and construction permits in order to devote its full attention to putting its house in order. I endorse the approach the NRC has adopted, but I urge the NRC to complete its work as quickly as possible, and in any event no latter than six months from today.

Once we have instituted the necessary reforms to assure safety, we must resume the licensing process promptly so that the new plants which we need to reduce our dependence on foreign oil can be built and operated.

The steps I am announcing today will help assure our country of the safety of nuclear plants. Nuclear power has a future in the United States—it is an option that we must keep open. I call on the utilities and their suppliers, the NRC, the executive Departments and agencies, and the State and local governments to assure that the future is a safe one.

1980
Annual Report

U.S. NUCLEAR
REGULATORY COMMISSION



2
Aftermath of the Accident at Three Mile Island

The second chapter of the *1979 NRC Annual Report* (pp. 11-62) gave a detailed account of the events of March 28, 1979, and the period immediately thereafter at the Three Mile Island Nuclear Station in Pennsylvania. That treatment covered major phases of the accident and responses to it on the part of the NRC, the Administration, the Congress and others, up through the issuance of the report of the President's Commission on the Accident at Three Mile Island (Kemeny Commission) on October 30, 1979, and concluding with the President's response to the recommendations of that report, issued on December 7, 1979.

The present chapter attempts to update the specific situation at Three Mile Island through the current report period (ended September 30, 1980) and also to take cognizance of generic aspects of the TMI aftermath, as reflected in the findings and recommendations of reports issued since the President's Commission finished its work, and in policies and requirements developed by NRC in the wake of TMI. The aggregate of tasks which correspond to recommendations of the various TMI investigators and which the NRC has committed itself to undertake is designated the TMI Action Plan. This plan comprises over 150 separate tasks in a number of broad categories and embraces a time frame extending more than five years into the future. Some portions of the plan are touched upon in this chapter, but a fuller discussion of its implications for NRC licensing activities in general will be found in Chapter 4. A tabulation of each of the tasks in the plan can be found in Appendix 7.

The chapter is made up of two sections and discusses the following subject areas: the events and actions that have taken place at the TMI-2 facility from the time of the last annual report to the end of fiscal year 1980, with an assessment of the environmental and socioeconomic impact of the TMI accident after 18 months; a discussion of the findings and recommendations contained in certain TMI investigative reports issued during the current report period, dealing with causes, effects and lessons, and also actions associated with decontamination and cleanup at TMI-2.

STATUS OF THE TMI-2 FACILITY

On the afternoon of April 27, 1979, the reactor coolant pump which had been providing the flow through the core of the TMI-2 reactor and bearing away the decay heat for removal through a steam generator was intentionally shut down and natural circulation cooling was achieved. The reactor was thus brought to a stable condition which could be sustained without dependence on the functioning of electrically activated equipment.

Decontamination of Water—EPICOR II

After the accident, about 450,000 gallons of contaminated water with intermediate levels of radioactivity (i.e., concentrations between one and 100 microcuries-per-milliliter) were held in various tanks and sumps in the auxiliary and fuel-handling buildings at TMI-2. In addition, contaminated water from system leakage, flushing and draining was accumulating at the rate of about 400 gallons-per-day. To decontaminate this water, the licensee for TMI proposed to install a three-stage demineralization system called EPICOR-II, which uses resins to adsorb radioactivity. Following the NRC Memorandum and Order of October 16, 1979, which directed that the EPICOR-II system be used, the licensee began processing the contaminated water at an average rate of

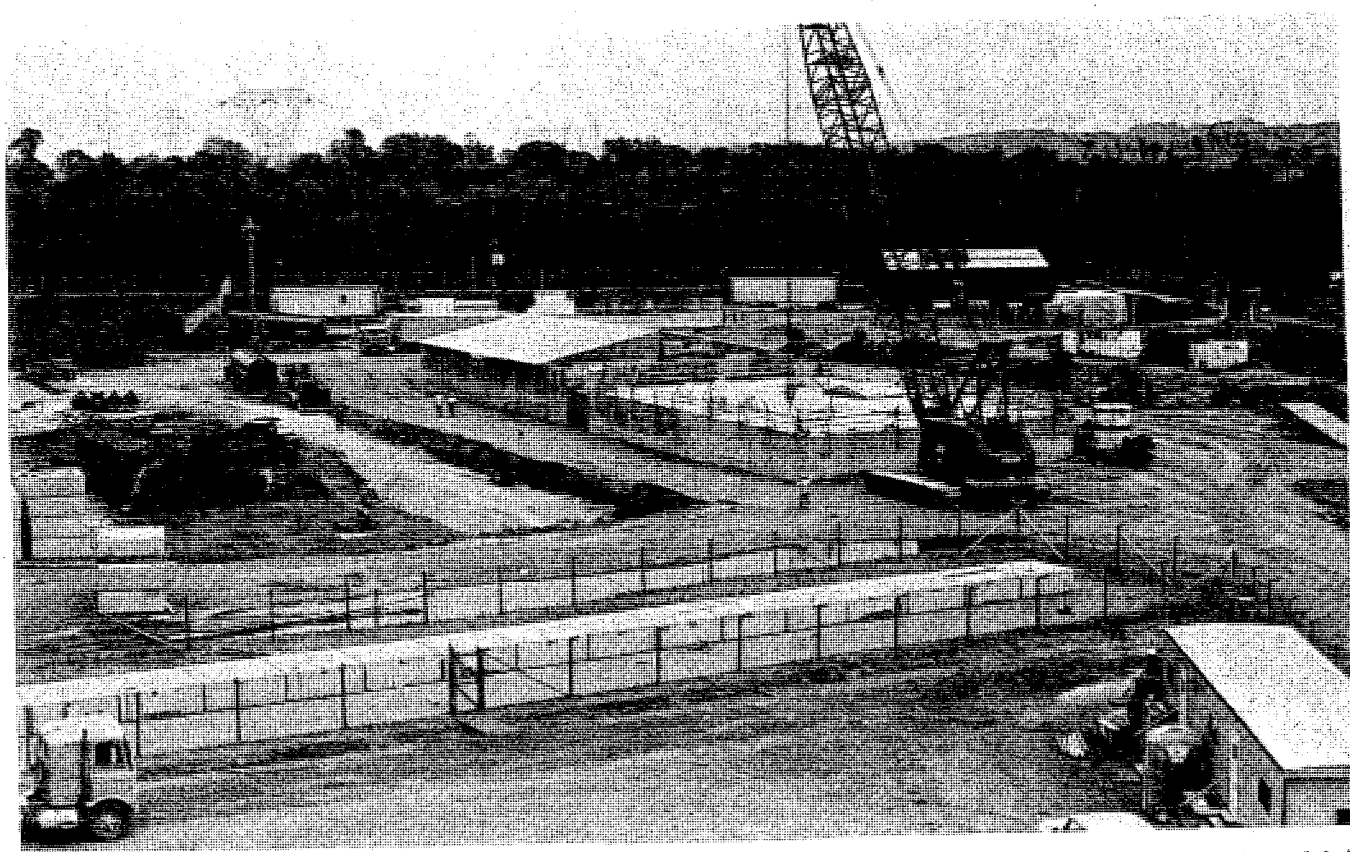
10 gallons-per-minute. As of August 1980, about 500,000 gallons of water (including some recycling) had been processed and about 55,000 curies of radioactivity removed. The processed water contains concentration levels of less than 0.00001 microcuries-per-milliliter, except for tritium. The latter is not affected by the processing and remains at a concentration of about 0.2 microcuries-per-milliliter.

The decontaminated water is being held in storage tanks at the site. The spent resins are dewatered and stored in steel liners, which are placed in massive concrete structures with concrete walls four feet thick and 15-ton concrete caps over each cell. The structures provide environmental protection and radiation shielding which allows personnel to work alongside and on top of the cells. (See the *1979 NRC Annual Report*, pp. 22-24.) Alternatives for the final disposition of the processed water and of the liners were being evaluated at the close of the report period. The more highly contaminated water in the reactor containment building had not yet been processed at that time.

Decontamination of Atmosphere

Before workers could begin the job of cleaning up the containment building, maintaining instruments and equipment, and eventually removing the damaged fuel from the reactor core, the radioactive gas krypton-85 which had been released into the reactor building during the accident had to be removed. Although the gas was only thinly diffused throughout the building atmosphere (in a concentration of about one microcurie-per-milliliter), it nevertheless posed a danger to personnel who would have to work in the building for prolonged periods. In February 1980, two incidents occurred involving small inadvertent releases of krypton-85: one was associated with the leak of up to 1,000 gallons of primary coolant from the makeup system to the TMI-2 auxiliary building on February 11, and the other on the following day, when a small leak went undetected for about 17 hours. These releases represented a psychological health hazard calling for timely decontamination of the plant.

In March 1980, the NRC staff issued for public comment a draft environmental assessment of a



Storage area at Three Mile Island for "spent" ion-exchange resin liners containing radioactive material removed from the contaminated water in the auxiliary building tanks at the TMI-2 site. One modular storage structure is shown at left center of photo, while construction of a new facility next to it is underway. The facilities have 4-foot thick concrete walls and hold concrete-shielded, galvanized corrugated steel cylinders in which the spent resin liners are placed. Shipment of liners from the site will depend on approval of a disposal facility and availability of shipping casks.

number of alternatives for the decontamination of the reactor building atmosphere. Approximately 800 responses were received from various Federal, State and local agencies and officials, as well as from non-governmental organizations and private individuals. Following appropriate revisions, responding to the comments received, and additional reviews and analyses by NRC staff, the "Final Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere" (NUREG-0662) was issued in May 1980. The statement discussed several alternatives and the potential environmental impacts associated with each.

Having reviewed the staff assessment and recommendations, together with the comments of the public, the Governor of Pennsylvania, and many others, the Commission issued a Memorandum and Order which authorized the licensee to clean the reactor building atmosphere by means of a controlled purge or release of contaminated air through filter systems. On the same day, the Commission issued a modification of the TMI operating license setting off-site dose limits for the purge.

The purging operation was carried out under detailed procedures approved by the NRC staff; it began on June 28, 1980, and by July 11 was essentially complete. Measurements showed that about 43,000 curies of krypton-85 was released during this period. Samples from the release flow were analyzed to ascertain the presence of radionuclides other than krypton, and the amounts were determined to be insignificant. During the entire operation, members of the NRC staff were on-site to monitor the licensee's activities. In addition, off-site radiation monitoring programs were conducted by the licensee, the NRC, the Environmental Protection Agency, the Department of Environmental Resources of the Commonwealth of Pennsylvania, and also by private individuals— through the Community Radiation Monitoring Program set up by the Department of Energy and the Commonwealth of Pennsylvania. The maximum cumulative radiation dose and the maximum dose rate measured at off-site locations were a fraction of the limits allowed under NRC regulations.

Reactor Building Entry

Personnel entry into the reactor building at TMI-2 was an important first step toward acquiring technical data by which to assess radiation levels and equipment damage and plan for decontamination and defueling. On July 23, 1980, after completion of the purging of krypton-85, two engineers in the employ of the licensee entered the reactor building through an airlock. They were wearing protective clothing and carried self-supply air-breathing apparatus. The initial entry lasted for 20 minutes; the engineers took 29 photos and six radiation swipes, and made a general survey of the area for beta and gamma radiation.

A second entry was made on August 15, 1980, by four workers; two of them stayed for 20 minutes and the others for 40 minutes. All were physically exhausted by working at temperatures of 85° to 90°F inside the building while wearing several layers of protective clothing and full-face respirators. The team managed to energize the bulding's lights. They observed that the sump water was murky with floating debris, and that electric wiring had become so brittle it crumbled when touched. A standard black telephone had partially melted. A 55-gallon drum with the top cover still attached was crushed. Numerous rusted surfaces were observed, but the reactor head appeared to be in good condition.

Programmatic Environmental Impact Statement

Responding to a directive of the Commission issued on November 21, 1979, the NRC staff prepared a draft programmatic environmental impact statement dealing with the decontamination and disposal of radioactive waste resulting from the TMI accident. The statement (NUREG-0683) was released for public comment on August 14, 1980. It discussed four fundamental activities necessary to the cleanup: treatment of radioactive liquids; decontamination of the building and equipment; removal of fuel and decontamination of the coolant system; and packaging, handling, storing and transporting nuclear waste. The statement addresses the principal environmental impacts that can be expected to occur as a consequence of cleanup activities, including occupational and off-site radiation doses and resultant health effects, socioeconomic effects, and the effects of psychological stress (see "Special Reports on TMI," below). Off-site doses of radiation from normal cleanup operations were considered, together with those from postulated accidents. The NRC staff concluded that methods exist or can be adapted to perform the cleanup operations at TMI with minimal releases of radioactivity to the environment. It was anticipated that the Final Programmatic Environmental Impact Statement—incorporating comments from other agencies of government and from the public as well as responses to those comments by the NRC staff—would be ready for issuance by early 1981, following an extensive comment period.

Advisory Panel on TMI Cleanup

While the draft environmental statement on the TMI cleanup was out for comment, the NRC

A milestone in the post-accident cleanup at TMI-2 was reached on July 23, 1980, with the first entry into the reactor building since the accident on March 28, 1979. The licensee's personnel are shown in protective clothing with communications and radiation detection equipment as they prepare to enter the inner door of the personnel access hatch.

announced the creation of a 12-member advisory panel to consult with the Commission and give advice on major stages of the cleanup. The panel was headed by the Chairman of the Dauphin County (Pa.) Commissioners, and includes other officials from State and local government, scientists and citizens from the area. NRC Chairman John F. Ahearne, in making the announcement, noted that "the NRC Special Task Force on the Three Mile Island Cleanup recommended that the Commission develop a formal means to obtain input and views from the residents of the Three Mile Island area on the cleanup plans. Subsequently . . . provision was made for the establishment of a Three Mile Island Advisory Panel . . . . We believe this group can provide the Commission with valuable counsel on the actions to be proposed and taken by the NRC regarding cleanup of Three Mile Island Unit 2."

NRC Policy Statement on State Requirements at TMI

On September 23, 1980, the TMI licensee sought a temporary stay of a cease and desist order of the Pennsylvania Public Utility Commission under which the licensee was ordered not to use revenues for cleanup and restoration at TMI-2 which were not provided by insurance. The licensee took the position that it could not comply with the State Commission's order without violating Federal law requiring it to comply with directives of the NRC. The NRC's policy statement declared: "This Commission strongly emphasizes that all the health, safety and environmental requirements applicable to TMI 2 must be fully complied with by the TMI licensee. In the event of any such conflict [between an order of the State's Public Utility Commission and an NRC requirement]. . .NRC requirements must supersede State agency requirements that result in a lesser degree of protection to the public. In short, the Commission will not excuse [the TMI licensee] from compliance with any order, regulation or other requirements by the Commission" which serves the purpose of protecting public health and safety or the environment.

Six TMI Workers Incur Radiation Overexposure

During the very early phases of post-accident activities at TMI, an accidental overexposure to radiation affecting six individuals took place. On August 29, 1979, the six men entered a room in the TMI-2 fuel-handling building to inspect and tighten leaking valves preparatory to decontamination of the area. Reactor coolant water, highly contaminated from the March 28 accident, was leaking from the valves. The radiation survey instrument used by the workers showed a gamma dose rate in the room of 10-15 rem-per-hour in general and, in one small zone, of 25 rem-per-hour. It was decided that the time limit on the presence of each worker in the radiation area was four minutes. What the survey instrument failed to disclose was the beta radiation rates in the room, which were running as high as 2500 rem-per-hour.

It was later ascertained that the workers had received doses in excess of regulatory limits from the beta radiation. The doses were as high as 166 rem to the whole body, in one instance, and 161 rem in another. No indication of medically significant effects in the personnel was identified by medical examination. The causes of the accident were determined to be inadequate instrumentation for radiation detection and a failure to require adequately protective clothing for the workers. Corrective action was taken under NRC direction.

SPECIAL REPORTS ON THREE MILE ISLAND

The *1979 NRC Annual Report* carried detailed treatment of the major investigations into the TMI-2 accident available during 1979 (see Chapter 2 of that report). Following are discussions of the findings and recommendations coming out of continuing research into the causes and consequences of the accident, from the final reports of major investigative bodies issued in 1980, and from an inquiry into financial problems related to the TMI cleanup.

Psychological Stress Resulting from The Three Mile Island Accident

One of the significant findings of NRC research into TMI-2 was the lingering psychological stress which the accident imposed. Recognizing that psychological and emotional distress would probably be present in the community during the long period of decontamination and cleanup, the NRC staff, in collaboration with consulting psychologists, developed a program to delineate the nature and level of such stress. The first product of this collaboration was a discussion of stress in the final environmental assessment for decontamination of the TMI reactor building atmosphere, published in May 1980 for public comment. In that document, the staff concluded that atmospheric purging of krypton-85 from the TMI containment would result in less psychological impact than alternative decontamination procedures. The staff acknowledged, however, that this recommendation would be unpopular with a segment of the local community. Preliminary observation by the consultants during the venting operation indicated that the more expeditiously the purging operation was conducted, the lower the stress induced by the activity would be.

The complete process of decontamination was addressed in the draft programmatic environmental impact statement on decontamination of TMI, published in August 1980. The conclusion set forth in that issuance was that, although low levels of stress would persist during the cleanup period, no long-term psychological effects on the majority of the community should be expected. Moreover, the general level of stress associated with decontamination subsequent to the purging of the containment atmosphere would be well below that already experienced by residents during the accident.

Socioeconomic Impacts of the TMI Accident

As part of its documentation of post-accident effects at TMI, the NRC developed a research program on the socioeconomic impact on the area. The first element of this program took the form of a telephone survey covering 1,500 households within 55 miles of TMI and seeking information on the activities of household members during and after the accident, their attitudes toward TMI and nuclear power in general, their demographic characteristics, and both the short-term and continuing socioeconomic effects of the accident. This survey constitutes the broadest and most detailed of the studies undertaken in the wake of the TMI accident, as of the end of fiscal year 1980. The survey results were published in October 1979 in a preliminary report, "Three Mile Island Telephone Survey" (NUREG/CR-1093).

The survey results disclosed that the impact of the TMI accident affected large numbers of people, both socially and economically, and that some effects continued long after the accident. The magnitude of public anxiety during the period of the accident can be gauged by the fact that 144,000 persons living within 15 miles of the plant temporarily left their homes, some of them for as long as two months. Those who relocated travelled an average distance of 100 miles, to a total of 21 States. These evacuees stayed mainly with friends and relatives. The economic cost of the accident for evacuated and non-evacuated households was estimated to be $18 million—including evacuation costs, lost pay and other income losses, and other expenses. The emotional stress (see discussion above, under "Psychological Stress") was such as to disrupt the social routines of residents and to cause a large number of them to consider moving out of the area.

To study the short-run impact of the accident on the real estate market, the NRC contracted with the Institute for Research on Land and Water Resources at the Pennsylvania State University in April 1980. The specific objective of the contracted study is the isolation—through the use of statistical and non-statistical techniques—of the accident's impact on real estate prices, number of sales, delay in sales, and changes in mortgaging policies. Research design incorporating a sample of all single family houses and lot sales from 1975 through 1979, for an area within 25 miles of TMI and for three control areas, has been prepared. The researchers also expected to interview a number of mortgage lenders, realtors, and developers. Results of the study were expected in late 1980.

A second report, expanding upon the telephone survey, was prepared with the cooperation of the Governor of Pennsylvania's Office of Policy and Planning and published in January 1980. It is entitled "The Social and Economic Effects of the Accident at Three Mile Island: Findings to Date" (NUREG/CR-1215). The report deals with impacts of the accident on the regional economy, the business community, local government agencies, churches, schools, hospitals, prisons, and homes for the elderly. It also appraises the impacts on agriculture and tourism, both economic sectors adversely affected in the short run by the accident. Finally, the report estimates the long-term effects of the accident on persons, business firms, the value of real estate, and political institutions.

Impact of Three Mile Island on Biota

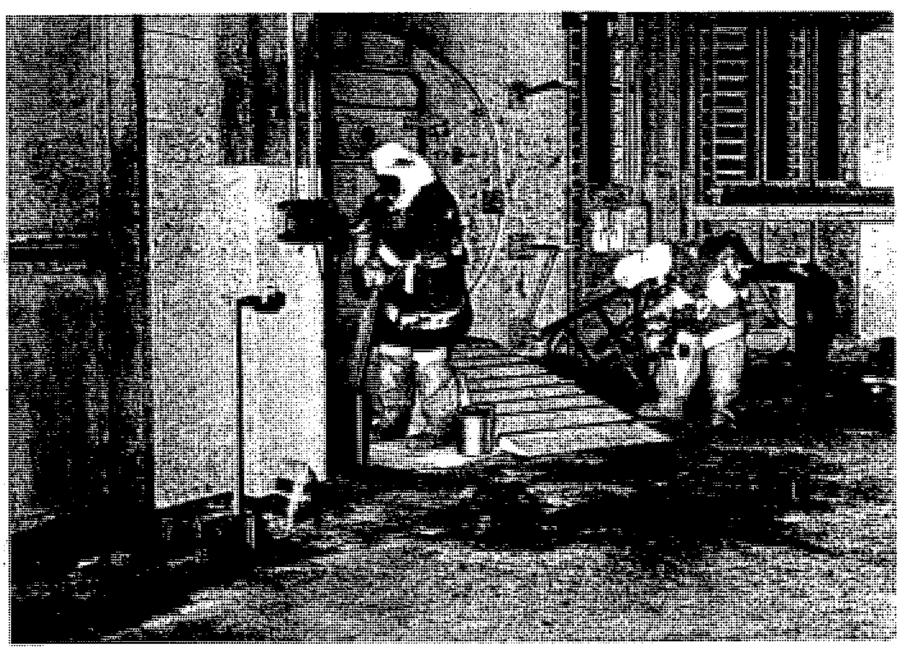
A number of residents near the TMI power plant maintained that there was a causal connection between the operation of the facility—and the accident there—and problems in the region with the health of animals and plants. The NRC staff investigated the claims, with participation by a veterinarian from the Environmental Protection Agency, a radiobiologist from the Argonne National Laboratory, and a veterinarian from the Pennsylvania Department of Agriculture. Their findings, published as an NRC technical report (NUREG-0738), indicated that, while some local residents were in fact having problems with animals and plants, no causal connection could be established between events at TMI and those problems.

With respect to recreational fishing on the Susquehanna River near TMI, comparisons were drawn up between the period after the accident and the period of 1974-1978. The monthly levels of fishing activity were found to be about average during 1979, but harvests, and indices of harvest success, were at record low levels for five months following the accident, though they improved with time until normal levels were attained again in the sixth month. The depressed harvests did not result from degraded water quality or other ecological or radiological causes attributable to the accident, but rather from the fact that many local anglers did not retain their catch, or retained less than normal, because of their concern about the quality of the fish after the accident. The gradual recovery of retained fish harvests followed the same general pattern as the decreasing perception of threat and concern with radioactive emissions among the local populace.

Groundwater Monitoring at TMI

Because of the potential for leaking of radioactive water from TMI into the groundwater and subsequently into the Susquehanna River, the NRC staff requested that the TMI licensee install a series of monitoring wells around the auxiliary and reactor buildings. The wells were completed and monitoring begun in early 1980. Initial tests showed tritium levels below the maximum permissible concentrations, but several readings were higher than normally occurring background levels. The latter fact caused some concern, because if a leak from the reactor

Metropolitan Edison personnel are shown carrying out a radiation mapping program inside the containment building of TMI-2. The levels of radiation are recorded on a building floor plan. This necessary step preparatory to developing a comprehensive plan for decontamination began in the summer of 1980.



building had occurred, the first radionuclide to be detected in the groundwater would most likely be tritium.

The NRC staff then requested a program of monitoring, sampling, analysis, and testing to determine the actual cause of the high tritium readings. After several months of testing, no significant increases were observed, and it was decided that the likeliest cause of the concentration first detected was a leak from the borated-water storage tank, and not from the reactor building.

The program has been continued and expanded to provide a close monitor of groundwater quality on the island and to identify any further contamination of the groundwater at the TMI site.

NRC Special Inquiry Group

Within weeks of the accident at Three Mile Island, the Nuclear Regulatory Commission decided to establish a Special Inquiry Group to carry out, under independent directorship, a thorough analysis of the causes and assessment of the implications of the accident. Although the work of the group was not intended to be a duplication of the efforts of the President's Commission (see Chapter 2 of the *1979 NRC Annual Report*) or any other investigative body, there was a good deal of overlap between its coverage and that of the President's Commission, including a number of similar or identical recommendations in the final reports of both.

In mid-June of 1979, the Commission contracted with the law firm of Rogovin, Stern, and Huge to have the firm assume directorship of the group and responsibility for its work. Most of the people eventually assembled to assist in the inquiry were drawn from the NRC professional staff, carefully screened to avoid any conflict of interest. A number of technical consultants in the areas of accident investigation and safety management were also engaged to assist in the inquiry, as were some lawyers with investigative experience. Also contributing to the study—mainly by providing specialized technical expertise—were some of the national laboratories of the Department of Energy, the National Academy of Public Administration (in the area of emergency response), and a private firm experienced in human factors engineering.

In the course of the inquiry, the group took about 270 formal depositions under oath, including those of the five NRC commissioners, dozens of other NRC officials, the management of the company licensed to operate the TMI facility and of the company which made the reactor, control room personnel from TMI, and persons responsible for emergency preparedness at the State and county levels of government. Besides these formal statements, the group carried out on the order of a thousand interviews not under oath. In addition, the group had access to the transcripts of interviews and depositions taken by the President's Commission, other NRC investigators, and others.

Finally, in an effort to optimize the quality of the finished report and to guard against inadvertent bias on the part of NRC staff participating in the inquiry or from any other source, the judgments of 21 outside experts were solicited both during the planning stage and while the report was in final preparation. These consultants—associated with universities, national laboratories, industry, and public-interest groups—were selected with a view to eliciting informed judgment from a broad spectrum of interests and approaches.

The results of the special inquiry were published in January 1980 under the title, "Three Mile Island - A Report to the Commissioners and to the Public" (NUREG-CR/1250, Vols. I and II). A summary of the principal conclusions and recommendations offered in that report follows.

Findings and Recommendations. Many of the conclusions and recommendations of the NRC Special Inquiry Group were, as noted, closely congruent with those of the President's Commission on the Accident at Three Mile Island, which were made public in October of 1979, and with those of other studies, including those of NRC offices. A major proposal of both the President's Commission and the Special Inquiry Group was that the NRC be replaced by an executive branch agency headed by a single administrator, based on the conviction that the TMI accident had demonstrated that authority was too diffuse in a five-member commission for quick, clear and effective decision-making in an emergency. The recommendation was not adopted in the Administration's reorganization plan for the NRC, though the office of the Chairman was, under that plan, greatly strengthened with respect to managerial prerogatives and emergency powers.

A fundamental finding of the group was that the TMI accident did not expose hardware problems so much as it revealed management deficiencies both in the nuclear power industry and the NRC. Of the latter, the group affirmed that "the Commission is incapable, in its present configuration, of managing a comprehensive national safety program . . . adequate to ensure the public health and safety." The group ascribed an "attitude of complacency" to both industry and the NRC prior to TMI, but took note of the fact that the "defense-in-depth" concept did in fact serve to protect the public health and safety during and after the accident, and that "less attention than is deserved will be given to what 'went right'" at TMI. The group's technical analyses showed that the accident "did not result in radioactive release levels that posed any threat to public health, even in the long run."

Among the changes prescribed by the group in response to lessons learned at TMI were these:

- A shift in resources within NRC from the sphere of reviewing facility design to the monitoring of actual operating reactors, with new emphases on the evaluation of operating experience and inspection of operating reactors.
- A strengthening of on-site technical capability and utility management at reactor sites, with new emphasis on reactor-operator training, together with new NRC requirements regarding the qualifications of supervisors of reactor operations.
- A policy of remote siting for new reactor plants and clear definition of a minimum evacuation planning zone for existing plants, with upgraded emergency planning. Plants that could not meet the criteria for the minimum zone were to be closed unless (1) additional safety systems for mitigation of accidents were installed, or (2) the President determined that their operation was vital to national interests.
- Increased use of quantitative risk assessment methods in the NRC licensing process.
- Greater application of human factors engineering, including better instrumentation display and overall design of the control room.
- An overhaul of the NRC licensing process, increased standardization, increased use of rule-making procedures, and funding for intervenors in the licensing hearings.

The group also called for renewed efforts to educate the public concerning the risks and benefits associated with nuclear power generation, as compared with those deriving from other kinds of power plants, and with such risks as a continued dependence on foreign oil imports.

Without attempting to decide "how safe is safe enough," the group concluded that the "generation of nuclear power can never be risk-free. It will inevitably present certain risks. . . ." Their report affirmed that the defense-in-depth concept and other strengths in the reactor safety system do not detract from the urgent need to make changes "where important weaknesses have been revealed."

Special Senate Investigation Report

The report of the Special Senate Investigation of the TMI accident—undertaken at the behest of the Subcommittee on Nuclear Regulation of the Senate Committee on Environment and Public Works—was published in July 1980. The investigation focused on three discrete aspects of the TMI accident:

(1) Events of the first day, especially with respect to what the utility management and the NRC officials knew and did not know about the condition of the reactor core and the implications of their knowledge or lack of it for decisions on evacuating the population or taking other protective action.

(2) Cleanup activities at the TMI site, including safety, legal, financial and social problems associated with those activities.

(3) Events prior to the initiation of the TMI accident which may have contributed to the severity of the outcome of that accident.

Regarding the first area of inquiry, the investigation sought to answer the question of whether the known condition of the plant during the early hours of the accident warranted a precautionary evacuation of the surrounding community, and of whether there was willful concealment of the true situation by plant operators and managers. Noting that by 8:30 a.m. on March 28, 1979, some four hours into the accident, the reactor core had been uncovered for a prolonged period, the investigators cited the uncertainty of the operating personnel at the site as a fact which "should itself be deemed a plant condition" sufficient to warrant consideration of a precautionary evacuation. As to whether the utility offical in charge of emergency planning and response was also uncertain about the condition of the core, the investigators found that factual record unclear. They concluded that if the official had been unsure, and had understood his proper role in recommending protective actions, he should have advised State officials to consider a precautionary evacuation of the population in close proximity to the plant. The report concluded that the utility management was remiss in not clearly communicating its uncertainty on the morning of the first day to the NRC and to the State, and, for their part, the NRC and the State were remiss in not pursuing the matter and ascertaining the condition of the reactor and the plant, including the uncertainty about whether the core was covered. Although the factual record is not clear, the lesson is, according to the report: it is that when there is prolonged and substantial uncertainty about whether a reactor core is covered or uncovered, the affected State should consider the need for evacuation of the population near the reactor plant.

On the subject of willful concealment, the investigators found that the evidence reviewed by them does not disclose any intentional concealment by the utility on the first day of the TMI accident. Conflicting statements were made as to whether the utility offical in charge of emergency operations was made aware of major evidence of an uncovered and severely damaged core, but the investigators affirmed that the weight of the evidence does not support a judgment that there was intentional concealment of such information by the utility. In that respect, the Senate investigation finding resembled that of the President's Commission and the NRC Special Inquiry Group, with the conclusion that human error was the principal contributor to the severity of the accident. The Senate report added the caveat that it would be "inappropriate and unfair" simply to blame control room personnel for the accident at TMI-2. The utility, the reactor vendor, the architect-engineering firm that built the plant, and the NRC all share responsibility for the deficiencies that together constitute the underlying cause of the accident—in operator training, control room design, instrumentation and equipment, and in emergency procedures. The investigators also found insufficient attention on the part of the industry and the NRC to the importance of human factors in the designing and operating of nuclear facilities. Such factors, they proposed, were so serious that they had consequences equivalent to those that could be brought about by major mechanical failures or design defects.

Beyond the human factors, the investigation identified some major weaknesses in the design of the facility that made it difficult to understand and deal with the off-normal condition and concluded that TMI control room personnel did not have the benefit of guidance based on similar accidents in the past because neither the reactor vendor nor the NRC had carried out an effective review of potentially recurring problems.

Because of the many measures taken since the accident which are responsive to these deficiencies, and because of continuing policy studies by its investigative staff, the Subcommittee did not put forward specific recommendations at the time the report was made public.

GAO Report to Congress on TMI

The General Accounting Office issued its report to the Congress on the TMI-2 accident on September 9, 1980, in a document entitled "Three Mile Island: The Most Studied Nuclear Accident in History." Some of the principal findings and judgments set forth in that report are discussed below.

- The "defense-in-depth" concept—resulting in multiple backup systems for safety-related equipment and successive protective barriers to mitigate the impact of any accident—caused the NRC to ignore signs of certain design or operating weaknesses in nuclear power plants. The NRC tended to assume that if an important system failed and plant operators did not know how to deal with the situation, the plant would automatically correct the problem or shut itself down safely. For the same reason, emergency planning by State and local government had not been made mandatory.
- Management direction provided by NRC was particularly deficient.
- The President's reorganization plan for NRC, greatly expanding the role and authority of the Chairman but leaving the Commissioners responsible for setting policy, will, if properly carried out, offer the opportunity for an effective management structure. The GAO endorses this reorganization.
- While the NRC has taken or planned action responsive to most of the recommendations offered in major investigations of TMI, it has made little progress in establishing goals and criteria which describe what level of safety is enough. The GAO endorses the directive of the Senate Committee on Environment and Public Works (in the draft authorizing legislation for NRC for fiscal year 1981) that a safety goal for nuclear reactor regulation be developed by June of 1981. Only the NRC knows its own licensing capabilities and limitations, and it alone will be responsible for meeting the safety goal, so the NRC—subject to review by the Congress—should be responsible for establishing it.
- The NRC appears to have recognized past inadequacies and to be taking corrective action.
- The NRC seems to have recognized the value of probabilistic risk assessment and to be moving in the right direction.
- The GAO endorses action by the President to set up a special oversight group to follow the implementation of TMI-related recommendations.

Potential Impact of Bankruptcy of TMI Licensee

In a report to the Commission by the NRC Director of Nuclear Reactor Regulation (NRR) in September 1980, the possibility and potential consequences of bankruptcy on the part of the TMI licensee were explored at length. The TMI power plant is owned by the Metropolitan Edison Company (Met Ed) and Penelec Company in Pennsylvania, and the Jersey Central Company in New Jersey. Met Ed is the licensee for TMI and owns 50 percent of the facility; the other two utilities own 25 percent each. Shares in the holding company for these utilities, General Public Utilitlies, Inc. (GPU), are publicly held.

At the end of the report period, the TMI-2 reactor was in stable shutdown condition and decontamination and cleanup operations were under way. The key phases in decontamination and defueling—which must be carried out, regardless of economic or other considerations—are these: (1) reactor core cooling; (2) decontamination of auxiliary and fuel-handling buildings; (3) decontamination of the containment and reactor coolant system; (4) reactor inspection and defueling; (5) radioactive waste processing; (6) solid radioactive waste management; (7) construction of needed support facilities; and (8) installation of radiological controls. Work in most of these areas was in progress by September 1980.

The cost of these operations was estimated in fiscal year 1980 by the TMI owner to range from $690 million to $1,150 million. In making its assessment, the NRC staff has assumed a cost of $900 million. The plant was insured for $300 million, and it is expected that this sum will have been expended by the end of 1981. The NRC concern is that the source of the $600 million balance necessary to carry out the cleanup of TMI-2 has not been identified by the licensee. Since the fixed costs of maintaining and operating the TMI power station are running $150 million per year (including servicing the debt and preferred stock and depreciation cost), and the plant is not part of the rate base for any of the three utilities of GPU, bankruptcy of the TMI owners before a cleanup is accomplished has to be considered a possibility. In September 1980, Med Ed reduced its overall work force by 20 percent (mainly contract personnel) after it was denied an emergency rate increase, resulting in a tightening of credit from the banking consortium providing short term credit to the utility. It was estimated that this action could extend the recovery period for Unit 2 into 1986.

The NRR report noted that experts on the subject do not regard bankruptcy as a desirable solution for a company in GPU's situation. The problems which have led to finacial distress, the need to buy power from outside and the costs of cleaning up TMI-2, are going to continue, and there is no way to predict how much of the licensee's funds would go to creditors and how much to cleanup activities. The consultants felt that the events which could precipitate bankruptcy for the TMI owners are within the control of three forces: State public utility commissions in Pennsylvania and New Jersey, the consortium of banks providing credit to the owners, and the NRC.

If the State public utility commissions provide rate increases adequate to cover cleanup, the banks continue to extend short-term credit, and the NRC licenses the restart of TMI-1, then bankruptcy could be avoided. Alternatively, the Federal government can extend financial assistance in the form of loan guarantees or grants, or can establish a system for assessing other utilities or the nuclear industry the costs of cleaning up TMI-2. That action could also enable the TMI owners to avoid bankruptcy.

Should a default take place, however, action would have to be taken to protect the public health and safety and maintain TMI-2 in a safe condition while completing decontamination.

Two possible approaches to dealing with licensee default were considered by the staff: (1) a Federal agency would engage a contractor—possibly the TMI owners, or a Federal or State agency—to do the work; or (2) a Federal agency would, by whatever means, take over the plant and complete the cleanup itself. The first approach is feasible, but only with substantial funding by Congress. With regard to the second approach, it is doubtful that any Federal agency has either the personnel to take over the cleanup operation or the funding—although it might, with sufficient Congressional authorization and funding, hire the needed personnel. In addition, the staff concluded that, except in a situation of extreme importance for the health and safety of the public, direct NRC involvement in and assumption of cleanup activities are not clearly authorized under existing law (and are without precedent in the exercise of regulatory functions). The NRC does have statutory authority to revoke licenses, take possession of special nuclear material, and operate a facility; and it has the final say as to who may assume the responsibility of a license.

Finally, the chief recommendation of the staff was that the NRC encourage the Executive Branch to initiate discussions among State and Federal agencies and representatives of the financial community with regard to the financial ability of the licensee to continue cleanup. Such discussions would help disclose common goals in the public interest and help define what each party involved is trying to accomplish and is willing to accept.

Appendix 7

Status of TMI Action Plan Items

	ITEMS IMPLEMENTED DURING FY 1980 TITLE (LEAD OFFICE)	DATE
I.A.1.2	Operational safety — Shift Supervisor admin. duties (NRR)	01/80
I.A.2.1	Immediate upgrading of operator and Senior Operator training and qualifications (NRR)	05/80
I.A.3.1	Revise scope and criteria for licensing exams (NRR)	05/80
I.B.2.1	Revision of IE inspection program (IE)	04/80
I.C.2	Shift and relief turnover procedures (NRR)	01/80
I.C.3	Shift Supervisor responsibilities (NRR)	01/80
I.C.4	Operating procedures — Control room access (NRR)	01/80
I.C.5	Procedures for feedback of operating experience (NRR)	01/80
I.D.6	Control room design — Technology transfer conference (RES)	06/80
I.E.1	Establish Office for Analysis and Evaluation of Operational Data (AEOD)	09/80
I.E.2	Program office — Operational data evaluation (AEOD)	09/80
II.E.3.1	Decay heat removal — Reliability of power supplies for natural circulation (NRR)	01/80
II.G.1	Power supplies for pressurizer relief valves, block valves, and level indications (NRR)	05/80

	THESE ACTION ITEMS WERE BEING WORKED ON AT THE END OF THE FY 1980 PERIOD: TITLE (LEAD OFFICE)
I.A.1.1	Operational safety — Shift technical advisor (NRR)
I.A.1.3	Operational safety — Shift Manning (NRR)
I.A.1.4	Operational safety — Long-term upgrading (SD)
I.A.2.2	Training and qualification requirements for Operations personnel (NRR)
I.A.2.6	Long-term upgrading of training and qualifications (SD)
I.A.3.2	Operator licensing program changes (NRR)
I.A.3.4	Licensing of additional Operations personnel (NRR)
I.A.4.1	Training simulator improvements — Initial (NRR)
I.A.4.2	Training simulator improvements — Long-term (SD)
I.A.4.3	Feasibility study for procurement of training simulator (RES)
I.A.4.4	Feasibility study to evaluate potential value of NRC engineering computer (RES)
I.B.1.1	Management for Operations — Long-term improvements (NRR)
I.B.1.2	Management for Operations — Evaluation for NTOL applicants (IE)
I.B.2.2	Inspections at operating reactors — Resident inspector (IE)
I.B.2.3	Inspections at operating reactors — Regional Evaluations (IE)
I.B.2.4	Overview of licensee performance (IE)
I.C.1	Short-term accident analysis and procedures revision (NRR)
I.C.6	Procedures for verification of correct performance of operating activities (NRR)
I.C.7	NSSS vendor review of operating procedures (NRR)
I.C.8	Pilot monitoring of selected emergency procedures for NTOL applicants (NRR)
I.C.9	Long-term plan for upgrading of procedures (NRR)
I.D.1	Control room design reviews (NRR)
I.D.2	Control Room Design — Plant safety parameter display console (NRR)
I.D.4	Control room design standard (SD)
I.D.5	Control room design — Improved instrumentation Research (RES)
I.E.3	Operational safety data analysis (RES)

I.E.4	Coordination of licensee, industry, and regulatory programs (AEOD)
I.E.6	Reporting requirements for analysis and dissemination of operating experience (AEOD)
I.E.7	Information for analysis and dissemination of operating experience — Foreign sources (IP)
I.E.8	Human error rate analysis (RES)
I.F.1	Quality assurance — Expand QA list (SD)
I.G.1	Training requirements — Preoperational and low-power testing (NRR)
II.A.1	Siting policy reformulation (SD)
II.B.1	Safety review consideration — Reactor coolant system vents (NRR)
II.B.2	Safety review consideration — Plant shielding to provide post-accident access to vital areas (NRR)
II.B.3	Safety review consideration — Post-accident sampling (NRR)
II.B.4	Safety review consideration — Training to mitigate core damage (NRR)
II.B.5	Safety review consideration — Research on phenomena associated with degraded core (RES)
II.B.6	Safety review consideration — Risk reduction for operating reactors in high-population density areas (NRR)
II.B.8	Safety review consideration — Rulemaking proceeding on degraded-core accidents (SD)
II.C.1	Interim reliability evaluation program (IREP) (RES)
II.C.2	Continuation of IREP (RES)
II.C.3	Risk assessment — Systems interaction (NRR)
II.D.1	Coolant system valves — Testing requirements (NRR)
II.D.2	Coolant system valves — Research on test requirements (RES)
II.D.3	Coolant system valves — Valve position indication (NRR)
II.E.1.1	Auxiliary feedwater system evaluation (NRR)
II.E.1.2	Auxiliary feedwater system automatic initiation and flow indication (NRR)
II.E.1.3	Update standard review plan and develop regulatory guide (NRR)
II.E.2.1	Reliance on the emergency core cooling system (ECCS) (NRR)
II.E.2.2	Research on small break locas and anomalous transients (RES)
II.E.3.2	Decay heat removal — Systems reliability (NRR)
II.E.3.4	Decay heat removal — Alternate concepts research (RES)
II.E.3.5	Decay heat removal — Regulatory guide (SD)
II.E.4.1	Containment design — Dedicated penetrations (NRR)
II.E.4.2	Containment design — Isolation dependability (NRR)
II.E.4.4	Containment design — Purging (NRR)
II.E.5.1	Design evaluation of B&W Reactors (NRR)
II.E.5.2	B&W reactor transient response task force (NRR)
II.F.1	Additional accident monitoring instrumentation (NRR)
II.F.2	Identification of and recovery from conditions leading to inadequate core cooling (NRR)
II.F.3	Instrumentation for monitoring accident conditions (Reg. Guide 1.97) (SD)
II.F.5	Classification of instrumentation, control, and electrical equipment (SD)
II.H.1	Maintain safety of TMI–2 and minimize environmental impact (NRR)
II.H.2	Obtain technical data on the conditions inside the TMI–2 containment structure (RES)
II.H.3	Evaluate and feedback information obtained from TMI (NRR)
II.H.4	Determine impact of TMI on socioeconomic and real property values (RES)
II.J.1.1	Establish a priority system for conducting vendor inspections (IE)
II.J.1.2	Modify existing vendor inspection program (IE)
II.J.2.1	Reorient construction inspection program (IE)
II.J.2.2	Increase emphasis on independent measurement in the construction inspection program (IE)
II.J.2.3	Assign resident inspectors to all construction sites (IE)
II.J.3.1	Organization and staffing to oversee design and construction (NRR)
II.J.4.1	Revise deficiency reporting requirements (IE)
II.K.1	Measures to mitigate small-break locas and loss of feedwater accidents — IE bulletins (NRR)
II.K.2	Commission orders on B&W plants to mitigate accidents (NRR)
II.K.3	Final recommendations of B&O task force to
III.A.1.1	Upgrade emergency preparedness (NRR)
III.A.1.2	Upgrade licensee emergency support facilities (NRR)
III.A.1.3	Maintain supplies of thyroid blocking agent (KI) (NRR)
III.A.2.1	Amend 10 CFR 50 and Appendix E (to Part 50) (SD)
III.A.2.2	Development of guidance and criteria (NRR)
III.A.3.1	Emergency preparedness — NRC role in responding to nuclear emergencies (EDO)

III.A.3.2	Emergency preparedness — Improve operation centers (IE)
III.A.3.3	Emergency preparedness — Communications (IE)
III.A.3.4	Emergency preparedness — Nuclear data link (IE)
III.A.3.5	Emergency preparedness — Training, drills, and tests (IE)
III.A.3.6	Emergency preparedness — NRC and other agencies (EDO)
III.B.1	Transfer of emergency preparedness responsibilities to FEMA (EDO)
III.B.2	Implementation of NRC's and FEMA's responsibilities (EDO)
III.C.1	Public information — Provide to news media and public (OPA)
III.C.2	Public information — Provide training (OPA)
III.D.1.1	Primary coolant sources outside the containment structure (NRR)
III.D.1.3	Ventilation system and radioiodine adsorber criteria (NRR)
III.D.2.2	Radioiodine, carbon-14, and tritium pathway dose analysis (NRR)
III.D.2.3	Liquid pathway radiological control (NRR)
III.D.2.4	Offsite dose measurements (IE)
III.D.2.6	Independent radiological measurements (IE)
III.D.3.1	Radiation protection plans (NRR)
III.D.3.2	Health physics improvents (SD)
III.D.3.3	Inplant radiation monitoring (NRR)
III.D.3.4	Control room habitability (NRR)
III.D.3.5	Radiation worker exposure data base (SD)
IV.A.1	Seek legislative authority in enforcement process (OGC)
IV.A.2	Revise enforcement policy (IE)
IV.D.1	NRC staff training (ADM)
IV.D.1	Expand research on quantification of safety decision-making (RES)
IV.E.2	Plan for early resolution of safety issues (NRR)
IV.E.4	Resolve generic issues by rulemaking (SD)
IV.E.5	Assess currently operating reactors (NRR)
IV.F.1	Increased IE security of power ascension test program (IE)
IV.F.2	Evaluate the impacts of financial disincentives to the safety of nuclear power plants (NRR)
IV.H	NRC participation in the radiation policy council (SD)

THESE ITEMS FROM THE ACTION PLAN WERE NOT BEING WORKED ON AT THE END OF FY 1980:

	TITLE (LEAD OFFICE)
I.A.2.3	Administration of training programs (NRR)
I.A.2.4	NRR participation in inspector training (IE)
I.A.2.5	Training and qualification of operating personnel — Plant drills (NRR)
I.A.2.7	Accreditation of training institutions (NRR)
I.A.3.3	Establish requirements for operator fitness (SD)
I.A.3.5	Licensing of personnel — Statement of understanding with INPO and DOE (NRR)
I.B.1.3	Management for Operations — Loss of safety function (SD)
I.D.3	Control room design — Safety system status monitoring (NRR)
I.E.5	Nuclear plant reliability data system (SD)
I.F.2	Quality assurance — Develop more detailed QA criteria (SD)
I.G.2	Scope of test program — Preoperational and low-power testing (NRR)
II.A.2	Site evaluation of existing facilities (NRR)
II.B.7	Safety review consideration — Analysis of hydrogen control (NRR)
II.C.4	Risk assessment — Reliability engineering (NRR)
II.E.2.1	Reliance on the Emergency Core Cooling System (ECCS) (NRR)
II.E.2.3	Uncertainties in ECCS performance predictions (NRR)
II.E.3.3	Coordinated study of shutdown heat removal requirements (NRR)
II.E.4.3	Containment design — Integrity check (NRR)
II.E.6	In situ testing of valves — Test adequacy study (NRR)
II.F.4	Study of control and protection action design requirements (NRR)
II.J.1.3	Increase regulatory control over present nonlicensees (IE)
II.J.1.4	Assign resident inspectors to reactor vendors
II.J.3.2	Management for design and construction — Issue Reg. Guide (SD)

III.D.1.2	Radioactive gas management (NRR)
III.D.1.4	Radwaste system design features to aid in accident recovery and decontamination (NRR)
III.D.2.1	Radiological monitoring of effluents (NRR)
III.D.2.5	Offsite dose calculation manual (NRR)
IV.B.1	Revise practices for issuance of instructions and information to licensees (IE)
IV.C.1	Extend lessons learned from TMI to other NRC programs (NMSS)
IV.E.3	Plan for resolving issues at construction permit stage (NRR)
IV.G.1	Develop a public agenda for rulemaking (ADM)
IV.G.2	Periodic and systematic reevaluation of existing rules (SD)
IV.G.3	Improve rulemaking procedures (SD)
IV.G.4	Study alternatives for improved rulemaking process (SD)

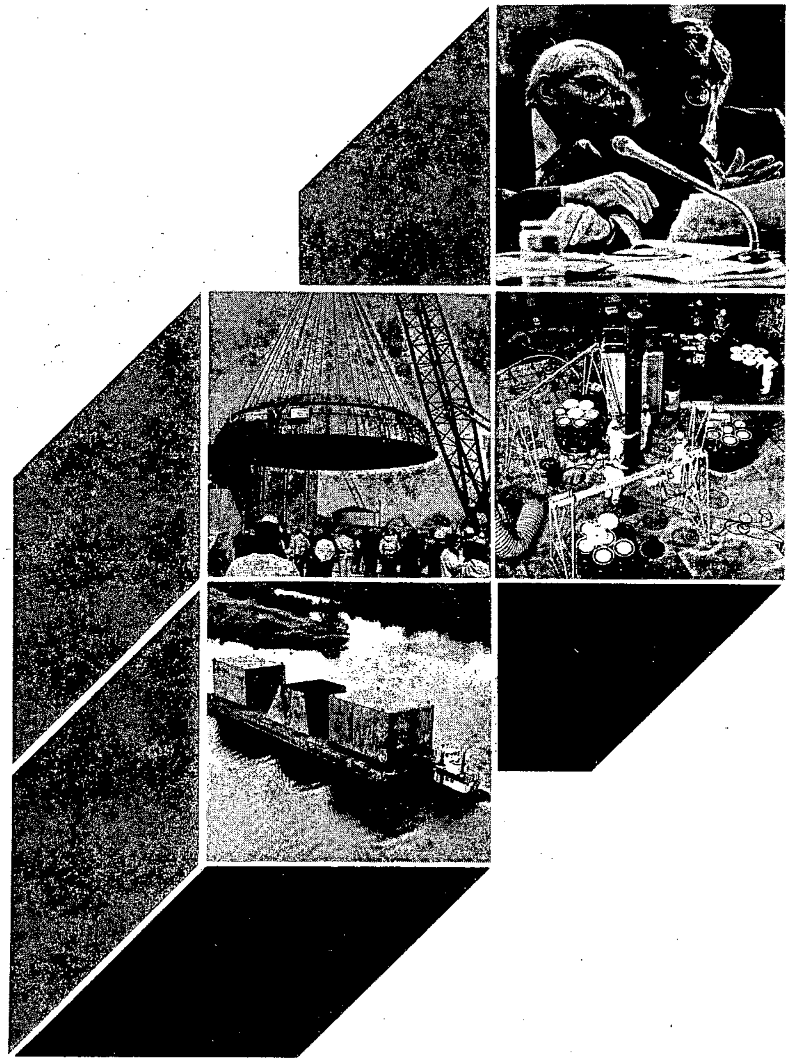
NOTE: Additional information on current status of the action plan items may be obtained from the TMI Action Plan Tracking System maintained by the Office of MPA.

THESE ACTION ITEMS WERE DEVELOPED AS ITEMS IN WHICH THE COMMISSION HAD LEAD RESPONSIBILITY:

NRC POLICY, ORGANIZATION AND MANAGEMENT

V.1	Develop NRC policy statement on safety
V.2	Study elimination of nonsafety responsibilities
V.3	Strengthen role of ACRS
V.4	Study need for additional advisory committees
V.5	Improve public and intervenor participation in hearing process
V.6	Study construction-during-adjudication rules
V.7	Study need for TMI-related legislation
V.8	Study the need to establish an independent nuclear safety board
V.9	Study the reform of the licensing process
V.10	Study NRC top management structure and process
V.11	Reexamine organization and functions of NRC offices
V.12	Revise delegations of authority to staff
V.13	Clarify and strengthen the respective roles of Chairman, Commission, and EDO
V.14	Authority to delegate emergency response functions to a single commissioner
V.15	Achieve single location—long-term
V.16	Achieve single location—interim
V.17	Reexamine commission role in adjudication

1981
Annual Report



U.S. NUCLEAR
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hazard severity and frequency of occurrence from site to site and from event to event. In view of the difficulty in establishing reasonable standoff distance criteria, alternate concepts are being considered. Currently, an effort has been started, in support of the proposed rulemaking, to provide a technical base for defining and characterizing off-site hazards and risk acceptance criteria. This will permit the consideration of including specific requirements within the revised 10 CFR Part 100 with respect to each principal type of hazard.

STATUS OF TMI-2 FACILITY

Since the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979, the NRC has continued to monitor the situation there. Activities related to that facility during fiscal year 1981 are summarized below.

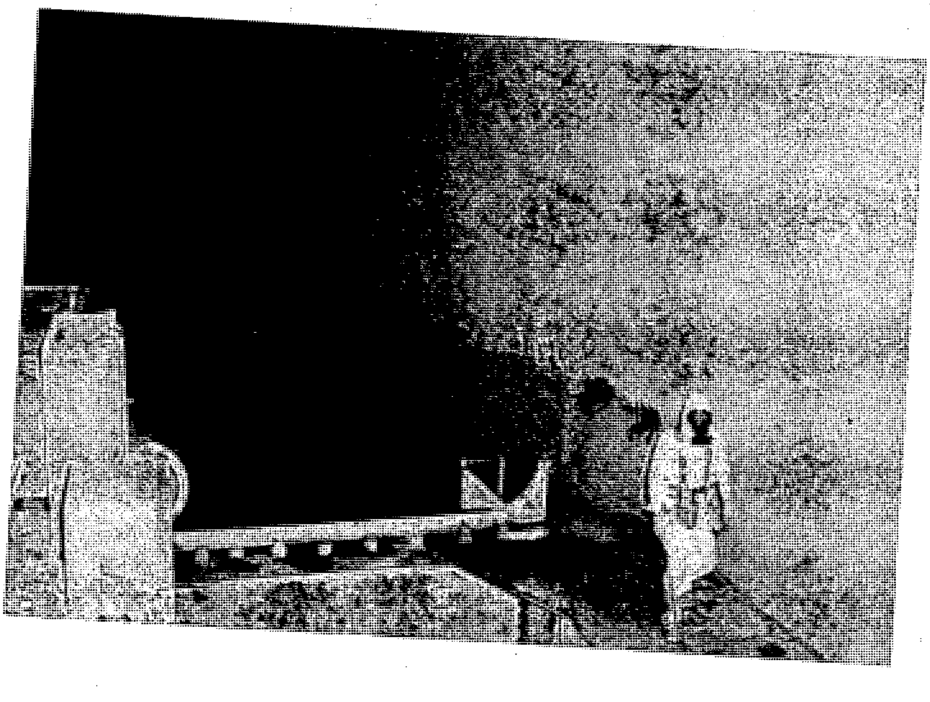
On-Site Situation

Coolant System. As noted on page 15 of the *1980 NRC Annual Report*, the TMI-2 reactor coolant system was placed in natural circulation, with decay heat removal to the condenser via sub-atmospheric boiling in the "A" steam generator, on April 27, 1979. This cooling mode was maintained with gradually decreasing flow and eventually only cyclic flow in the reactor coolant system until November 6, 1980, when a test was initiated to determine if the TMI-2 reactor would be adequately cooled only by heat losses to the reactor building ambient ("loss-to-ambient" cooling mode). The reactor building ambient is being maintained by the reactor building fan coolers. The test was completed on December 9, 1980, when the reactor cooling mode was returned to cyclic natural circulation with heat rejection to the condenser. Evaluation of the test data showed that the reactor's decay heat (presently approximately 30 kw) could be safely and adequately removed by operating in the loss-to-ambient cooling mode, which was resumed on January 5, 1981, and has continued since. This is a particularly desirable mode for removing the reactor decay heat since operating in this cooling mode permits several previously required cooling systems to be de-energized (e.g., circulating water system, main steam system and the "A" generator, condensate and feedwater systems, main condenser and auxiliary boiler), thus decreasing the plant's dependence on electrically activated equipment.

Reactor Building Entries. A total of 15 manned post accident entries have been made into the Unit 2 reactor building. To date, activities inside the reactor building have focused primarily on gathering post-accident data.

The entries have permitted identification of the physical and radiological conditions inside the reactor building. However, decontamination and repair work has been limited to testing specific critical components. An overall detailed plan and schedule for reactor building decontamination and fuel removal has not been established pending analysis of data obtained from inside the reactor building and resolution of licensee fiscal problems.

The reactor building entries have not identified any major mechanical damage. Surface contamination and electrical problems, particularly on the polar



Survey in progress of the polar crane inside the reactor building of Three Mile Island Unit 2.

crane, appear to be the most troublesome for future TMI-2 cleanup operations. It has been demonstrated that industry-proven decontamination methods may be used to decrease contamination and radiation levels inside the reactor building. The existing radiation levels on the upper floor (refueling floor) of the reactor building are not prohibitive (in the range of 50 - 100 millirem per hour as of the end of fiscal year 1981), in terms of worker accessibility for reactor vessel head and fuel removal.

Once an adequate level of TMI cleanup funding is established, the licensee will begin refurbishing the polar crane. This activity is a prerequisite to removal of the missile shield athe eactor head and to reactor disassembly. Some degree of processing and decontamination of reactor building sump water will have to be performed before other recovery work can proceed. The physical condition of the fuel—perhaps the most crucial issue in the recovery process—will not be determined until the reactor vessel head is removed and the core region is inspected visually.

Containment Integrity. Because there is a potential for leakage of radioactive water from TMI into the groundwater and eventually into the Susquehanna River, the NRC staff requested the licensee to conduct a monitoring program to detect any leakage. This program has continued since early 1980 (see the *1980 NRC Annual Report*, p. 20) and consists primarily of periodic sampling, analysis and testing of water from a series of monitoring wells strategically located around the TMI facility. An increase of radioactive nuclide concentrations above those normally occurring as background levels would indicate a possible source of leakage from the TMI facility.

Since the spring of 1981, the licensee has instituted an expanded program to assess the containment integrity. In addition to groundwater monitoring, the Containment Integrity Assessment Program includes radiation monitoring of the reactor building tendon access gallery, the cork seals between building structures and the containment outer wall, and the measurement of sump water levels in the containment.

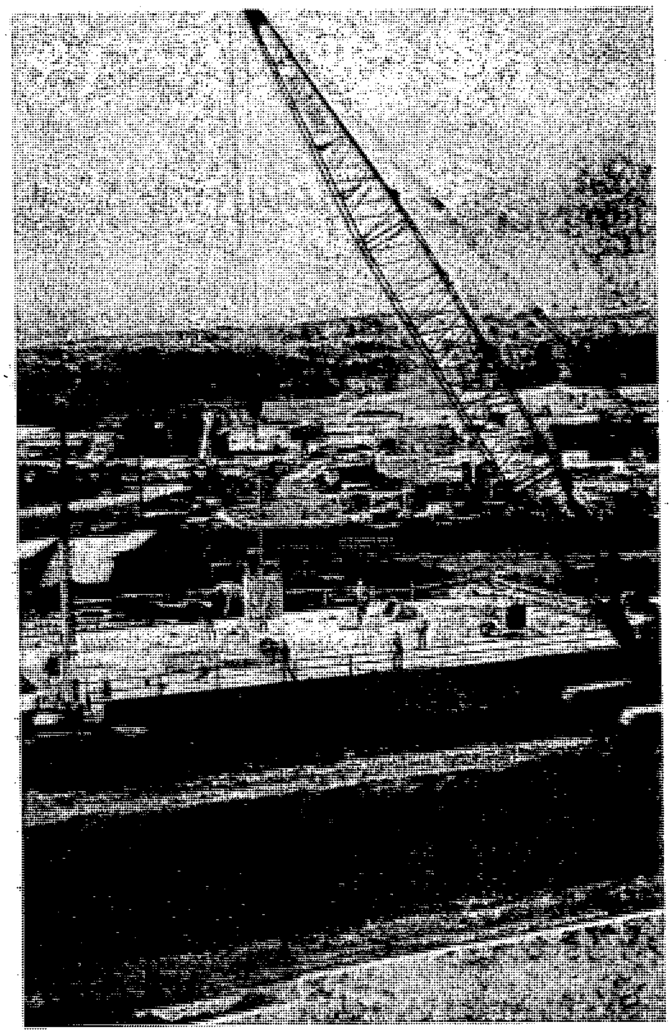
During 1980, several groundwater sample readings indicated higher than normal background levels of radioactive nuclide concentrations (i.e., tritium, cobalt and cesium). Followup investigations, including the identification of radioactive nuclides with potential leakage sources, determined that the source of leakage was probably from the borated water storage tank (BWST), and not from the reactor building. The licensee has acted to prevent further leaks from the BWST and has constructed a catch basin to collect any that should occur. Subsequent samples showed reduced concentrations of cesium and cobalt, trending down to background levels. Other parts of the containment integrity assessment program have also confirmed that there is no indication of radioactive water leakage from the containment.

EPICOR-II Spent Resin Liners. The Commission's October 6, 1979 Memorandum and Order directing the use of the EPICOR-II system for decontaminating the intermediate-level contaminated water (*1979 NRC Annual Report*, pp. 23-24) included a provision requiring that spent EPICOR-II resins not be shipped off-site unless solidified. The requirement for solidification of the EPICOR-II spent resins was based on the understanding that solidification of resin wastes:

(1) would help immobilize the radionuclides after disposal,

(2) would eventually be required by all the burial sites.

(3) would be a practical way to meet the then existing burial site requirement that the wastes contain no free liquids, and



Removal from waste storage of a liner from the first stage of EPICOR-II for shipment to the Battelle Columbus Laboratories for examination.

(4) would help ensure there were no leaks or spills during the shipment of the wastes.

However, on February 19, 1981, the licensee requested that the requirement for solidification of spent EPICOR-II resins be waived and that those spent resin liners which are similar to normal reactor resin wastes be disposed of by shallow land burial at a commercial disposal site. The NRC staff reviewed the licensee's request and concluded that 22 second and third stage EPICOR-II spent resin liners could be safely disposed of by burial at a commercial burial facility in an unsolidified but dewatered condition. NRC approval to dispose of these 22 liners in this manner was issued on March 25, 1981. The last of these liners was shipped from the TMI site to the U.S. Ecology burial site at Richland, Wash., on June 27, 1981, where all 22 liners were successfully disposed of.

The remaining EPICOR-II spent resin liners consist of 50 prefilters (first stage liners), most of which are unique and unlike those routinely generated and disposed of by other nuclear power plants. The requirement to solidify the resins in these liners was also waived and a Department of Energy (DOE) program of research and development on waste characterization is underway to examine and characterize the condition of one of these liners and its contents at a DOE contractor facility. It was decided that not solidifying the resins in these 50 liners would also be appropriate, so as not to foreclose future options for handling and eventual disposal of these wastes.

The liner (PF-16) selected for examination was shipped from TMI to the DOE contractor laboratory (Battelle Columbus Laboratories in West Jefferson, Ohio) on May 19, 1981. PF-16 was one of the older and more heavily loaded of the 50 first stage EPICOR-II liners used to process the accident-generated water collected in the Unit 2 auxiliary building. Examination of PF-16 was initiated immediately upon receipt and will continue for approximately two years. This research and development effort, which is designed to fully identify the conditions in the EPICOR-II liners, will aid in the development of technology for safely processing highly contaminated organic and inorganic resins. Specific program work includes analysis of resin degradation and gas generation, radioactivity loading profiles, corrosion of liner internals, characterization and radioactivity elution studies on resin core samples and cement solidification testing.

Decontamination of High-Activity Water. As a result of the March 28, 1979, accident at Three Mile Island Unit 2, over three quarters of a million gallons of high-activity waste water (i.e., radionuclide concentrations greater than 100 microcuries-per-milliliter) were generated. This water is currently contained in the reactor building sump (approximately 700,000 gallons) and the reactor coolant system (approximately 95,000 gallons). In order for the cleanup to proceed, a method was needed to reduce the radionuclide concentrations in the water contained in the reactor building sump and reactor coolant system. In a letter dated April 10, 1980, the licensee formally submitted its Technical Evaluation Report (TER) and requested permission to operate an underwater demineralization system. The Submerged Demineralizer System (SDS) described in the licensee's TER was designed to provide controlled handling and treatment of the highly contaminated waste water generated during the accident.

The SDS is designed to operate underwater in one of the spent fuel pools of TMI Unit 2. It consists of a liquid waste treatment subsystem, a gaseous waste treatment subsystem and a solid waste handling subsystem. The liquid waste treatment subsystem is designed to decontaminate the high-activity waste water by filtration and ion exchange. The primary components of the liquid waste treatment subsystem include two filters, and two parallel trains of four identical inorganic zeolite-filled ion exchange vessels. In the event that additional cleanup of the effluent from SDS is required, it can be recycled through SDS or polished with the EPICOR-II system.

The volume of solid waste generated during system operation (spent ion exchange media) is expected to be minimized by loading the inorganic zeolite resin to high levels (up to 60,000 curies or higher). Solid waste generated during SDS operation will be stored underwater in the same spent fuel pool while awaiting offsite shipment. Due to the unique character and nature of the zeolite wastes, the Department of Energy will take possession of and retain these wastes to conduct a research, development and testing program on waste immobilization. Other solid wastes generated during SDS operations are expected to be suitable for commercial land disposal.

The NRC staff review of the SDS formally started when the licensee submitted the TER on April 10, 1980. Due to a number of design changes and technical questions from the staff, formal NRC approval of the SDS was not given until June 1981. On June 18, 1981, the licensee was directed to promptly commence and complete processing of the remaining intermediate level contaminated water (less than 100 microcuries-per-milliliter) in the auxiliary building tanks and the highly contaminated water in the reactor building sump and the reactor coolant system.

As of August 9, 1981, the remaining 100,000 gallons of intermediate level water was completely processed. The licensee started processing the high activity water in September 1981. The approval to operate SDS does not include water disposal. All processed water will be stored in existing onsite tanks. Decisions related to the disposition of processed water will be made by the Commission at a future date.

NRC - DOE Memorandum of Understanding. On July 15, 1981, the NRC and DOE signed a Memorandum of Understanding (MOU) which formalized the working relationship between the two agencies with respect to the removal and disposition of solid nuclear wastes generated during the cleanup of TMI-2. This action represents a significant step toward assuring that the TMI site does not become a long-term waste disposal facility. This MOU covers only solid nuclear wastes; it does not cover liquid wastes resulting from the cleanup activities.

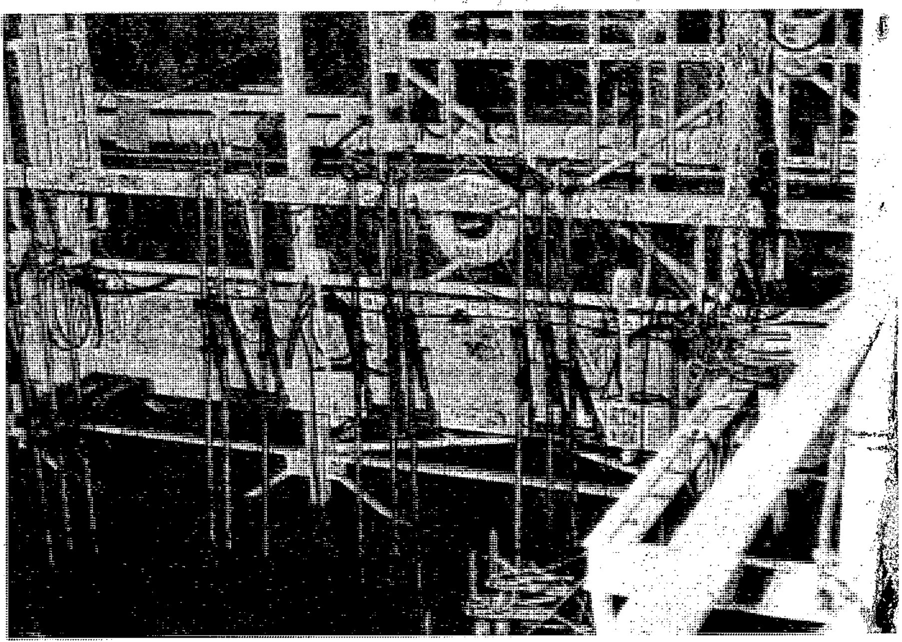
The MOU addresses the following three basic categories of TMI-2 wastes: (1) Wastes determined by DOE to be of generic value in terms of beneficial information to be obtained from further research and development activities (the MOU calls for DOE to perform such activities at appropriate DOE facilities); (2) wastes determined to be unsuitable for commercial land disposal because of high levels of contamination, but which DOE may also undertake to remove, store and dispose of on a reimbursable basis from the licensee; and (3) wastes considered suitable for shallow land burial which are to be disposed of by the licensee in licensed, commercial low-level waste burial facilities.

The MOU specifically highlights currently identified TMI-2 wastes, e.g., EPICOR-II system wastes, submerged demineralizer system wastes, reactor fuel wastes, etc. However, the agreement also anticipates future modifications in the MOU may be necessary to cover radioactive waste materials which are identified as the cleanup progresses.

NRC Activities

The Final Programmatic Environmental Impact Statement. On February 27, 1981, the NRC staff issued, on schedule, the Final Programmatic Environmental Impact Statement (PEIS) related to decontamination and disposal of radioactive wastes resulting from the TMI accident. The issuance of the final statement (NUREG-0683) followed an extensive 90-day comment period during which comments were received from the public and from other agencies of the government on the Draft Programmatic Environmental Impact Statement issued on August 14, 1980. The final statement considered all of those comments, as well as the questions and comments raised by members of the public during the 31 meetings with the public, media and local officials held by the NRC staff. These meetings were held in the vicinity of the TMI site in Pennsylvania and Maryland to discuss cleanup issues and the draft PEIS. The final PEIS includes the NRC staff's responses to nearly 1,000 comments the staff received on the draft statement. The final PEIS has the benefit of additional data obtained from several containment entries as well as additional evaluations on cleanup alternatives. The final PEIS reaffirms the major conclusions of the draft statement that the decontamination of the TMI-2 facility, including the removal of the nuclear fuel and radioactive wastes from the TMI site, is necessary for the long-term protection of public health and safety, and that methods exist or can be suitably adapted to perform the cleanup operations with minimal releases of radioactivity to the environment. Further, the final PEIS concludes that the only environmental impact that may be of significance would be the cumulative radiation doses to the cleanup workers (see page 17 of the *1980 NRC Annual Report* for discussion of the draft PEIS).

On April 27, 1981, the Commission issued a policy statement endorsing the final PEIS and concluded



The Submerged Demineralizer System for decontamination of highly radioactive water was installed at Three Mile Island Unit 2 in the spent fuel pool, which was filled with water for shielding from radiation.

that the PEIS satisfies the Commission's obligations under the National Environmental Policy Act. The policy statement also stated that, as the licensee proposes specific major decontamination activities, the staff will determine whether these proposals, and associated impacts that are predicted to occur, fall within the scope of those already assessed in the PEIS. With the exception of the disposition of processed accident-generated water (the Commission will decide this issue), the staff may act on each major cleanup activity if the activity and associated impacts fall within the scope of those assessed in the PEIS. The staff will keep the Commission informed of staff actions prior to staff approval of the major activity. In addition , the Commission's policy statement declared that the cleanup should be expedited and activities carried out in accordance with the criteria in Appendix R of the PEIS which limits the doses to off-site individuals from radioactive effluents resulting from cleanup activities. These effluent limits are numerically identical to those design objectives of radioactive effluents for operating power reactors contained in Appendix I of 10 CFR Part 50. The criteria of Appendix R of the PEIS for TMI-2 cleanup activities are more restrictive than those for the operating power reactors, since the Appendix R values are limits that cannot be exceeded, whereas, for operating power reactors, they are design objectives to be met on the "as low as reasonably achievable" principle. On June 26, 1981, the NRC staff amended the Environmental Technical Specifications of the TMI-2 license to incorporate the criteria in Appendix R of the final PEIS as limiting conditions of the cleanup operations.

Advisory Panel on TMI Cleanup. The NRC's Advisory Panel for the Decontamination of Three MIle Island Unit 2 was formed by the Commission in October 1980 to provide advice on major stages of the cleanup. The 12-member Panel has been headed since its creation by the Chairman of the Dauphin County (Pa.) Commissioners, and includes local citizens, local and State governmental officials and scientists. In 1981, the Panel provided recommendations related to radioactive waste processing, storage and disposal to the Commission. The Commission subsequently concurred in these recommendations. In addition to soliciting views from members of the public, the Panel has been interacting with Congress and other federal agencies to assure the safe and expeditious cleanup of TMI-2.

Site Office. The NRC has continued its on-site presence at the Three Mile Island Site. The Three Mile Island Program Office in Middletown, Pa., physically located in offices on-site and in Middletown proper, is comprised of 15 full-time technical personnel, three full-time secretaries, a part-time clerk and supportive cooperative students and summer interns. The personnel are detailed mainly from two NRC staff offices and are supported by region-based inspectors and by other NRC technical staff. Part-time assistance has also been provided by foreign assignees from Italy and Taiwan.

Day-to-day review of all licensee activities that pertain to the cleanup of Unit 2 is provided by this staff. Review and direction of the overall Unit 2 cleanup and review of all detailed implementing procedures are provided. From October 1, 1980, to September 30, 1981, a total of approximately 750 procedures were prepared by the licensee and submitted to the NRC for review and approval, with an average turnaround time of less than three working days.

Information flow is a major responsibility of the Site Office. A Weekly Status Report, containing pertinent reactor and radiological and environmental information, is prepared and distributed to all NRC offices. This report is also distributed to the public, with copies available at the Middletown office. The Middletown office is open and staffed on a regular basis, including evening hours, to provide the public an opportunity to remain informed of the cleanup progress. Information is also supplied to the public by press releases, television and radio interviews and direct response to both written and oral public concerns. Information exchange meetings are also held periodically with officials of the Department of Energy and the Environmental Protection Agency.

Financial Aspects of Cleanup

Funding by GPU. There are several actual or potential sources of funds available to GPU companies for TMI-2 cleanup. The first is insurance proceeds. The availability of these funds has been accelerated in time by the insurers, and the total coverage of $300 million was available as of late August 1981. Based upon a reduced pace of cleanup activity, this coverage will probably be exhausted by the end of 1983. The second source, potentially, is revenues allowed through rates set by the Pennsylvania Public Utility Commission (PaPUC) and the New Jersey Board of Public Utilities (NJBPU). The PaPUC, however, at this point has prohibited Metropolitan Edison Company (Met Ed) from using funds from its customers for TMI-2 cleanup purposes. A third source is short-term credit under a revolving credit agreement with a consortium of banks. Since GPU and its subsidiaries are unable to issue any stocks or bonds, bank credit constitutes its only outside source of credit. However, amounts available from this source of funds are becoming increasingly limited and are dependent upon the amount of progress in other developments affecting the GPU companies.

As of August 1981, all three GPU operating subsidiaries have pending rate increase cases before their respective public utilities commissions. Each of the companies has applied for a two-stage increase. The stage I requests are intended to recover amounts for the future operation and capital costs of TMI-1. From the viewpoint of assisting in the cleanup of TMI-2, TMI-1's return to service would constitute a significant milestone. The combination of the financial effect of this unit's operation with adequate rate relief would partially restore Met Ed's net income to pre-accident levels. Met Ed also anticipates that the return of TMI-1 to a normal generating level would result in savings of energy costs.

A substantial portion of the amounts requested for stage II of the GPU companies' rate increase petitions seek recovery of TMI-2 capital and cleanup costs. The PaPUC and the NJBPU have consistently denied the companies' recovery of costs for this purpose.

(As of October 1, 1981, the banks and GPU renegotiated the terms and conditions of the revolving credit agreement. While the agreement is renewed to December 31, 1982, severe limitations and conditions on credit availability are also expected should certain events favorable to GPU not occur.)

Proposals for Sharing Costs. Several proposals have been made for the sharing of costs necessary to clean up the damaged TMI-2 facility. On July 9, 1981, Governor Richard Thornburgh of the Commonwealth of Pennsylvania proposed that the estimated $760 million in additional funds necessary to clean up TMI-2 be shared as follows: 25 percent by the nuclear industry; 25 percent by the Federal Government; GPU contributing 32 percent; remaining insurance accounting for 12 percent; and the Commonwealth of Pennsylvania and the State of New Jersey participating at 4 percent and 2 percent, respectively. The NRC and other Federal agencies are reviewing these cost sharing proposals. The NRC is also continually monitoring the financial condition of the GPU companies.

GAO Report. In August 1981, the General Accounting Office (GAO) issued a report entitled "Greater Commitment Needed to Solve Continuing Problems at Three Mile Island." The principal findings set forth in the report are summarized below:

- Replacement power for the TMI units is available, but future system reliability is questionable unless funds are made available to increase construction and maintenance above present restricted levels.

- The financial condition of GPU continues to deteriorate, and unless sufficient rate relief is granted to restore its financial credibility, its future as a provider of electric power is in doubt.

- Cleanup of TMI-2 is technologically feasible, but the uncertainties surrounding the source of the funds needed for the task and the regulatory environment in which it must be done have yet to be resolved.

- The expeditious cleanup of TMI-2 and the benefits that can be derived are significant enough to warrant the financial participation of several parties, rather than putting the entire burden on any one entity.

- State officials in Pennsylvania and New Jersey should take the leadership role in assembling the financial assistance needed for the cleanup.

- On-site property insurance coverage needs to be increased to levels that the Nuclear Regulatory Commission (NRC) determines to be adequate if other utilities are to avoid the financial and operational stress suffered by GPU in the event of another major accident.

- Better defined regulatory guidelines for nuclear accident recovery efforts are needed to minimize the delays and added costs that have occurred at TMI-2.

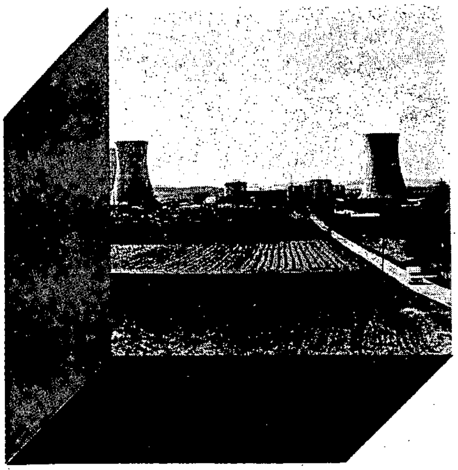
Based on the above findings, the GAO made two recommendations to the NRC which are listed below:

- Because another nuclear accident at an underinsured utility company could seriously affect public health and safety, GAO recommends that NRC closely follow the current efforts of the insurance and utility industries to increase insurance coverage to what it determines to be an acceptable level. GAO further recommends that no later than December 31, 1981, NRC assess the progress being made. This assessment should include an evaluation of the insurance available in the private sector and a determination as to whether a mandated insurance coverage program is necessary. (Regarding this recommendation, the Nuclear Regulatory Commission approved publication of a proposed rule for public comment on August 18, 1981, that, if approved as a final rule, would require power reactor licensees to provide the maximum amount of property insurance available.)

- To mitigate future regulatory constraints on nuclear accident cleanup activities, GAO recommends that NRC establish a set of guidelines that would facilitate the development of recovery procedures by utility companies in the event of other nuclear reactor accidents.

1982 Annual Report

U.S. NUCLEAR REGULATORY COMMISSION



3
Cleanup at Three Mile Island Unit 2

At the close of the report period, i.e., the end of September 1982, conditions at the Three Mile Island Nuclear Power Station (TMI) near Harrisburg Pa., were stable and the cleanup of the damaged Unit 2 was proceeding. The pace of progress in decontaminating the plant and removing the damaged reactor fuel was less than hoped for during 1982. NRC Chairman Nunzio J. Palladino made repeated allusion to the situation at TMI in various public statements during the year. The Chairman deplored the "disturbingly slow pace of the project" and the "prospect that funds may run down or run out before the job is done." Some aspects of the future of the cleanup campaign became clearer during the period, such as the agreement by the Department of Energy to take custody of the entire core of TMI-2 when that becomes possible. But other uncertainties persist, both fiscal and technical, and costs continue to mount. (See Chapter 9 for discussion of cleanup costs.)

Meanwhile the Commission set forth explicit positions and intentions regarding TMI in its annual policy and planning guidance for the NRC staff. In this document, the Commission affirms that the "expeditious cleanup" of the Unit 2 containment and reactor is "one of the NRC's highest safety priorities." The NRC's TMI Program Office will continue to monitor cleanup activities from the actual TMI site, and the NRC will generally provide oversight, support and, if necessary, direction to ensure the prompt decontamination of the facility and the safe removal of radioactive materials from the site. The licensee will be directed to submit updated plans and schedules for cleanup activities in 1983 and these will be reviewed by NRC staff, who will report on them, with recommendations, to the Commission within three months of licensee submittal.

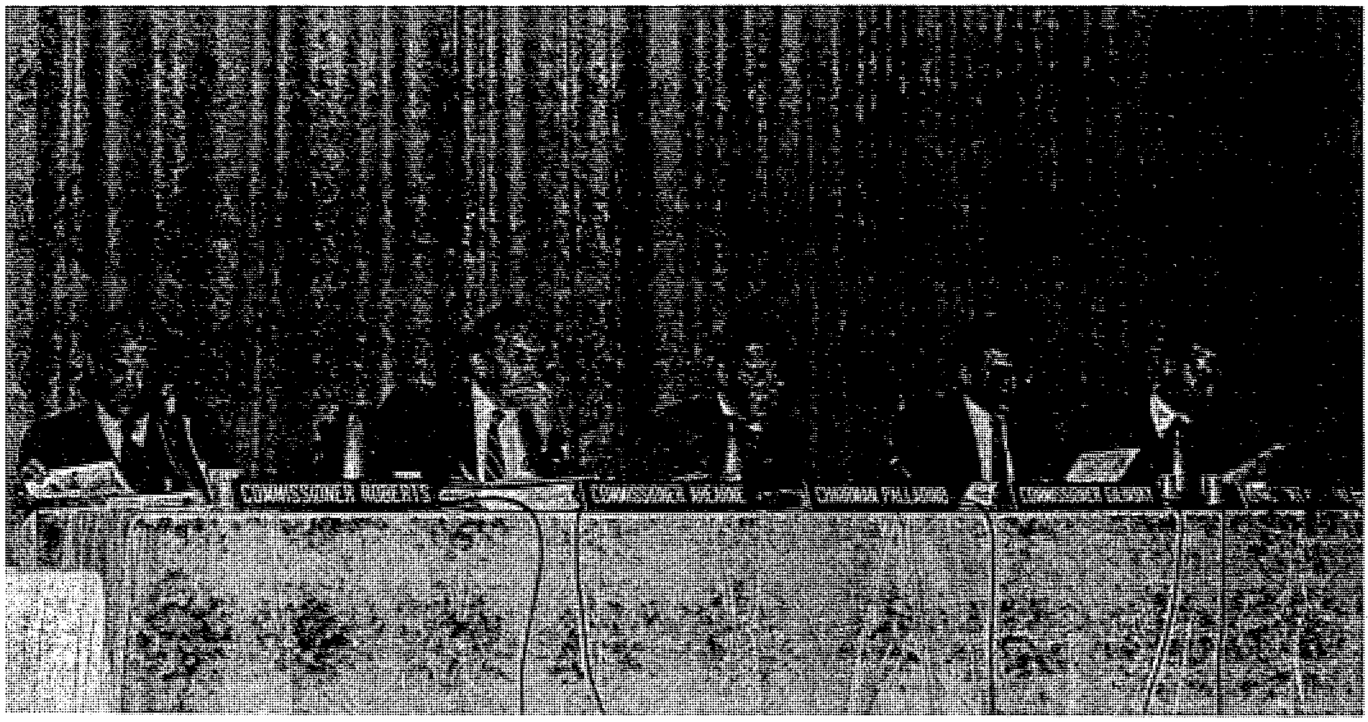
Memorandum of Understanding

In July 1981, the Nuclear Regulatory Commission and the Department of Energy (DOE) signed a Memorandum of Understanding (MOU) that formalized the working relationship between the two agencies with respect to removal and disposal of solid nuclear waste from Three Mile Island Unit 2 (TMI-2), which was damaged in the accident of March 1979. This was a significant step towards ensuring that the TMI site would not be permitted to become a long-term waste disposal facility.

Besides working closely with the NRC, the DOE agreed to carry out research and development and to conduct tests on solid wastes taken from the plant whenever DOE determines that they may have generic information value. With costs reimbursable by General Public Utilities Nuclear, the operator of TMI-2, the DOE may also assume responsibility for removal, storage, and disposal of other wastes that are too highly radioactive for disposal in commercial facilities. Low specific- activity wastes associated with decontamination (such as some ion-exchange media, boots, gloves, and trash) will be disposed of by the utility in licensed commercial low-level burial facilities.

In March 1982, the NRC and the DOE agreed to a revision of the MOU. Instead of taking only samples of the damaged fuel of TMI-2, the DOE agreed to accept the entire core for research and development and for storage at a DOE facility. The terms of ultimate disposal of the core will be negotiated between DOE and the utility operating the TMI facility. The DOE also agreed to take possession of highly radioactive resins from the purification system, again on the basis of future reimbursement by the utility.

The DOE also plans to take possession of zeolite wastes from the submerged demineralizer system and



The five NRC Commissioners participated in an all-day public hearing in Harrisburg, Pa. on November 9, 1982, at which residents and community groups in the Three Mile Island area were invited to express their views and concerns regarding the future of the TMI unit involved in the accident of 1979. Shown at table, left to right, Commissioners Roberts and Ahearne, Chairman Palladino, and Commissioners Gilinsky and Asselstine.

retain them for research and testing with regard to waste immobilization. Experiments are being conducted by DOE on several of the 49 high-specific-activity resin liners from the EPICOR-II system for decontaminating water, and this program may be extended to include other liners as well. An alternative approach being investigated by DOE is the development of a high-integrity container, which may allow these liners to be acceptable for commercial burial. Waste contaminated with transuranic elements at levels of radioactivity comparable with those acceptable for commercial disposal will be considered by the DOE on a case-by-case basis for possible use in research, archiving, temporary on-site storage, or disposal in a permanent repository off-site.

Status of Cooperative Efforts

On May 21, 1982, the first waste vessel from the submerged demineralizer system was shipped from TMI to DOE facilities at Hanford, Wash., for disposal. This vessel was used to process waste water from the reactor-coolant bleed tanks and contained approximately 12,000 curies of radioactive material on zeolite ion-exchange media. Subsequent shipments will include liners containing more than 50,000 curies of radioactive material removed from reactor-building sump water. The DOE will be conducting research on glass vitrification (solidification) of this type of solid waste at Hanford.

On July 27, 1982, one of the 49 high specific-activity EPICOR-II liners stored on-site was sampled for gas composition at TMI and was shipped on August 17 to the Battelle Columbus Laboratories in West Jefferson, Ohio, for radiation and chemical characterization tests. The liner contained approximately 1,800 curies of radioactive material and was shipped in a special cask designed to withstand severe transportation accidents. On August 25, a second liner was shipped from TMI to the Idaho National Engineering Laboratory in Scoville, Ida., for characterization tests. Eleven more shipments of these liners from TMI by the end of calendar year 1982 have been tentatively scheduled by the utility.

Cleanup of Cooling Water

The reactor coolant system of TMI-2 remained in the loss-to-ambient cooling mode during fiscal year 1982, and this mode was found to be reliable and adequate for the present level of decay heat, which is approximately 30 kilowatts. On May 17, 1982, the first "feed-and-bleed" cycle for the cleanup of the reactor coolant system began, and the cycle was repeated for several batches. Water processing was interrupted on July 11 to allow for preparatory activities in support of the core inspection program. Through fiscal year 1982, the submerged demineralizer system has processed approximately 708,000 gallons of water from the reactor building sump (including 50,000 gallons of flush water), 277,000 gallons of water from the reactor-coolant bleed tanks, and 250,000 gallons of water from the reactor coolant system.

Groundwater Monitoring Program

On January 13, 1982, a leak was discovered in a 3/8-inch instrument line connected to the borated water storage tank. In February, the groundwater monitoring program found that samples of several test borings indicated increased tritium levels, but they were still below the maximum permissible concentration for unrestricted areas. Increased surveillance indicated that the source of radioactivity in the groundwater on the TMI-2 site was probably from the borated water storage tank. Staff of the NRC located at the site and utility staff have continued to follow the results of the groundwater monitoring program

Reactor Building Entries

During fiscal year 1982, workers entered the TMI-2 reactor building 73 times. Their activities continued to focus on gathering post-accident data, decontamination efforts, and equipment refurbishment.

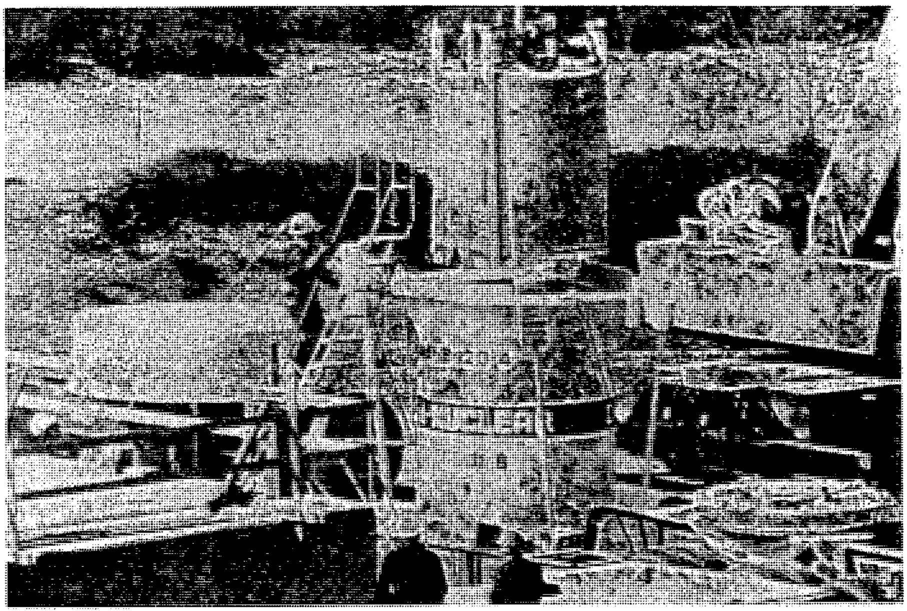
In March 1982, a large-scale decontamination experiment was initiated. One objective was to evaluate the safety, effectiveness, and efficiency of various methods and equipment for performing large-scale decontamination of extensive, complex, contaminated surfaces within the reactor building. The other objective was to reduce the contamination present on selected surfaces within the reactor building. Post-experiment surveys indicated that decontamination of loose material could be achieved by using both low-pressure and high-pressure water sprays and various mechanical and chemical techniques. But fixed sources of radiation, which are the apparent cause of exposure to gamma rays, were evidently not decontaminated by methods tried. Further efforts will be required to decontaminate the reactor building.

The polar crane in the reactor building, which will be needed to remove the reactor vessel head and plenum, was inspected during the report period. No structural damage of the crane was observed, but it is anticipated that replacement of all electrical cables, control components, and brake shoes — and the addition of a pendant control — will be required.

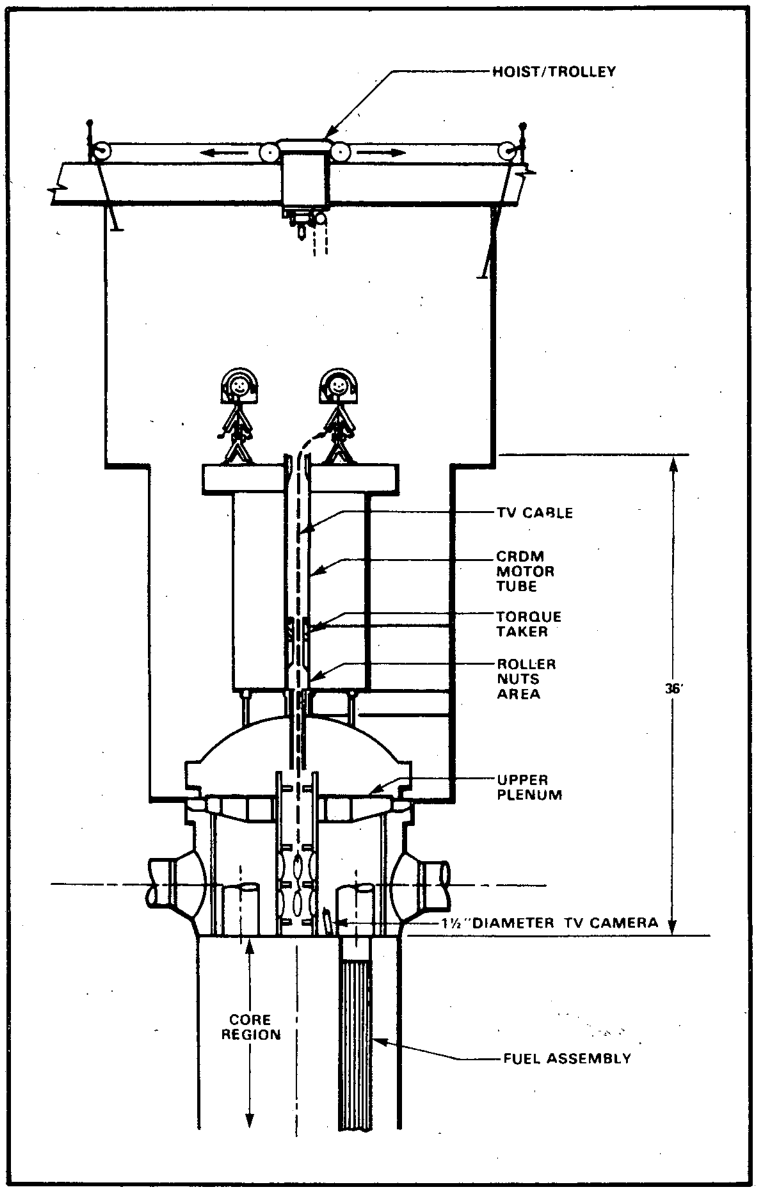
During reactor-building entries in August 1982, attempts were made to uncouple the leadscrews from all 61 control rods and the eight axial powershaping rods. Uncoupling of the leadscrews is a prerequisite to removal of the reactor vessel head. The uncoupling was successful in all but three cases, where the leadscrews will probably have to be cut to disconnect them from the reactor vessel head.

Inspection of the Reactor Core

The first closed-circuit television inspection of the reactor core was performed on July 21, 1982. A



EPICOR-II liners at TMI-2 are transferred from site storage areas in the cask shown at top, and lowered into shipping casks beneath to maintain shielding of radioactive material. During 1982, several shipments of the casks were made to various laboratories for study and tests.



Schematic showing the technique by which a tiny TV camera was lowered into the reactor at TMI-2 for inspection of the damaged core. The first such inspection took place on July 21, 1982.

camera 1-1/2 inches in diameter and 12 inches long was inserted through the central control-rod guide tube As the camera was lowered into the core region, it revealed a bed of rubble approximately five feet below the normal location of the top of the fuel assembly. It is believed that the rubble bed contains oxidized Zircaloy cladding, fuel fragments and/or pellets, poison material, and core structural components. No evidence of melted uranium-oxide fuel pellets was found. Another inspection, on August 4, midway between the periphery and the center of the core also revealed a rubble bed approximately five feet below the top of the core region. Intact pellets, which may be fuel or poison material, were visible on the top of the rubble. During a third inspection, which took place on August 12, a probe was poked through the rubble and it penetrated approximately one foot below the surface, indicating that the rubble in this region is composed of loose material.

Advisory Panel on TMI Cleanup

An Advisory Panel for the Decontamination of Three Mile Island Unit 2 was formed by the NRC in October 1980 to provide advice on major stages of the cleanup. The 12 members of the panel include local citizens, local and state government officials, and scientists (see Appendix Two for list of members). The Panel held several open meetings during fiscal year 1982 and members of the general public were invited to express their views. The NRC has asked the panel to address the issue of final disposition of treated water from the accident.

NRC

U.S. NUCLEAR REGULATORY COMMISSION

1983 Annual Report

Cleanup at Three Mile Island Unit 2

CHAPTER 3

At the end of September 1983, conditions at the Three Mile Island Nuclear Power Station (TMI) near Harrisburg, Pa., remained stable, and cleanup of the damaged Unit 2 by the operator, General Public Utilities Nuclear Corporation, was proceeding. The cleanup continues to be controlled by funding limitations and the lack of firm funding commitments for future activities. (See discussion at the end of Chapter 9.) In addition, in March of 1983, public allegations were made by several former and current licensee and contractor employees about inadequate testing of the reactor-building polar crane to be used in lifting the reactor vessel head and other cleanup-related issues. The NRC Office of Investigations and the Office of Inspector and Auditor undertook to evaluate the merits of the allegations. The end of cleanup, now projected to be mid-1988, may be affected by these new complications.

Meanwhile the Commission set forth explicit positions and intentions regarding TMI in its annual policy and planning guidance for the NRC staff. In this document, the Commission affirms that the "expeditious cleanup" of the Unit 2 containment and reactor is "one of the NRC's highest safety priorities." The TMI Program Office will continue to monitor cleanup activities from the site, and the NRC will generally provide oversight, support and, if necessary, direction to ensure the prompt decontamination of the facility and the safe removal of radioactive materials from the site.

The licensee submitted updated plans and schedules for the cleanup activities in December 1982, and the NRC staff reviewed these plans and provided recommendations to the Commission.

Reactor Building Entries

During fiscal year 1983, workers entered the TMI-2 reactor building 191 times. Their activities continued to focus on gathering post-accident data, decontamination and dose reduction efforts, and repair of the reactor-building polar crane. Other important tasks accomplished were the removal of the neutron shield tanks, decontamination of the reactor building air coolers, closed-circuit television inspection of the 282 ft. elevation, raising and parking of all eight axial-power-shaping rod leadscrews, and first steps toward a complete characterization of radiological conditions of the reactor-vessel underhead. As part of the underhead characterization task, the NRC has contracted with Battelle Pacific Northwest Laboratories to review such major elements as radiation measurements, cesium plate-out on the plenum, and related chemistry phenomena. Preliminary analysis of sonar mapping data from the underhead characterization study indicates that few, if any, of the 177 fuel assemblies remain intact.

Waste Management

The existing Memorandum of Understanding (MOU) dated March 15, 1982, between the NRC and the Department of Energy (DOE) for TMI-2 solid radioactive wastes specifies the interagency procedures for the removal and disposition of such wastes resulting from the cleanup of TMI-2. The MOU covers six categories of solid wastes including: (1) EPICOR-II system wastes, (2) submerged demineralizer system (SDS) wastes, (3) reactor fuel, (4) transuranic contaminated waste materials, (5) makeup and purification system resins and filters, and (6) other solid radioactive wastes (i.e., normal low-level solid waste which is acceptable for burial in licensed commercial low-level waste burial facilities).

The MOU provides that any materials with transuranic levels above those acceptable at commercial low-level waste burial facilities will be considered by DOE on a case-by-case basis. As stated in the MOU, the alternatives for such material could include archiving, research and development, temporary storage on-site at a DOE facility to await further processing and/or disposal in a permanent off-site repository. Recent more definitive guidance specifies that DOE may accept abnormal wastes from General Public Utilities (GPU) for storage and/or disposal on a cost reimbursable basis. (Abnormal wastes are defined as those which are significantly dissimilar in form, content, and/or quantity to wastes generated at other licensed nuclear facilities and which cannot be made acceptable for disposal in commercial low-level waste burial facilities at reasonable cost.) The guidance does not apply to the reactor core which is covered by a separate agreement with GPU, consistent with the MOU. The recent development by DOE of definitive guidance for the removal and disposition of TMI-2 abnormal transuranic contaminated waste is significant, because now there is clear direction for the removal and disposition of essentially all existing and anticipated TMI-2 solid radioactive waste.

Cooperative efforts between DOE and NRC have been essential to resolving the problem of disposing of abnormal waste from TMI-2 to DOE facilities. The last two of the 50 EPICOR-II prefilters of high specific activity were shipped from TMI-2 on July 12, 1983, and the last of the 13 highly contaminated SDS liners left the TMI site on August 30, 1983. The 50 EPICOR-II prefilters contained approximately 60,000 curies of primarily cesium radionuclides and the 13 SDS liners contained approximately 360,000 curies of primarily cesium and strontium radionuclides. These achievements are significant in that they represent the off-site disposition of the bulk of the radioactivity that was dispersed throughout the plant as liquid radioactive waste generated by the accident.

Polar Crane

Repair of the damaged polar crane is indispensable to progress on the major cleanup efforts, which are lifting the head of the reactor pressure vessel and removing the plenum prior to extracting the damaged core.

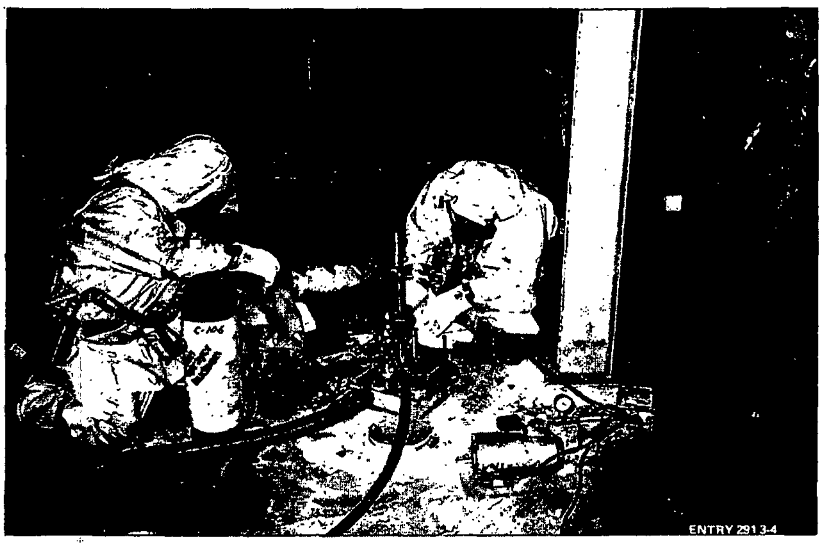
On February 18, 1983, GPU submitted a safety evaluation report (SER) for the polar crane load test and the NRC staff initiated a safety review of the proposed activity. The staff's review included the detailed load test and operating procedures for the polar crane as well as an SER addendum, dated March 15, 1983, submitted in response to the staff's initial review. The staff's safety review of the load test was in progress when, on March 22, 1983, a GPU contractor employee assigned to TMI-2 made allegations about the safety of the polar crane and other cleanup-related issues. Shortly thereafter, the investigation of the matter by the Office of Investigations and the Office of Inspector and Auditor was initiated. To avoid possible interference with this inquiry, the staff was requested to stop its safety review of those polar crane load test issues associated with the allegations and limit the use of the polar crane by GPU to lifts of five tons or less. By mid-July 1983, the staff's load test safety review was resumed. The report from OI regarding the evaluation of the allegations was dated September 1, 1983; it cited deficiencies in the administrative and procedural aspects of the polar crane repair.

On the basis of information from GPU related to the requalification of the polar crane, information exchanged in numerous discussions with GPU and its contractors, information provided in related correspondence, and the results of the OI investigation, the staff, with the assistance of an expert consultant, expects to complete the safety review of the polar crane load test early in the first quarter of fiscal year 1984.

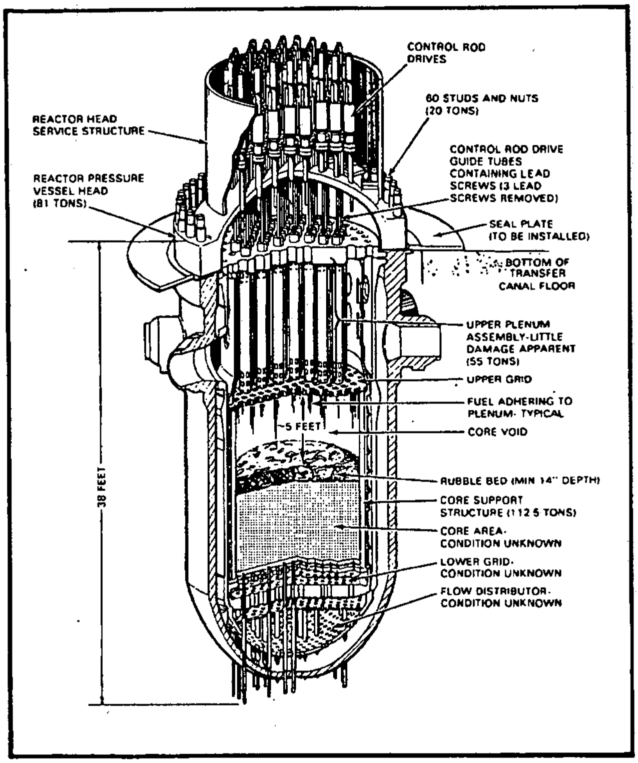
The report from OIA dated September 6, 1983, addressed alleged NRC employee impropriety in dealing with the licensee and its contractor at TMI-2. OIA concluded that the allegations were not substantiated.

Inspection of the Reactor Core

The first closed-circuit television inspections of the reactor core were performed on July 21, 1982. During this "Quick Look" inspection, a camera lowered into the core region revealed a rubble bed approximately five feet below the normal location of the top of the fuel assemblies. In an effort to verify and expand on data obtained during the Quick Look, the licensee received approval to conduct the Underhead Characterization Study, which is a datagathering effort preliminary to reactor vessel head removal. A first analysis of the Sonar Mapping Data indicates that the deep void found during the Quick Look inspection in 1982 extends across the entire cross section of the core and ranges from 5-to-6½ feet in depth. Gamma fields were measured in the range of 300-to-700 roentgens



Workers in protective clothing are inside the reactor containment building at TMI-2 drilling core samples from the concrete floor to determine how much radioactive contamination has been absorbed by the concrete.



CUTAWAY VIEW OF THE TMI-2 REACTOR VESSEL

per hour in the space formed by the underside of the reactor vessel head and the top of the plenum.

As a part of the Underhead Characterization Study, samples of core debris were taken from the surface of the rubble bed and at various depths in the core debris pile. The last step of the study will be the raising and parking of five control-rod-drive leadscrews from their fully inserted positions to determine the impact on general area dose rates in the vicinity of the reactor vessel head and service structure.

Radiation Dose Rate Reduction

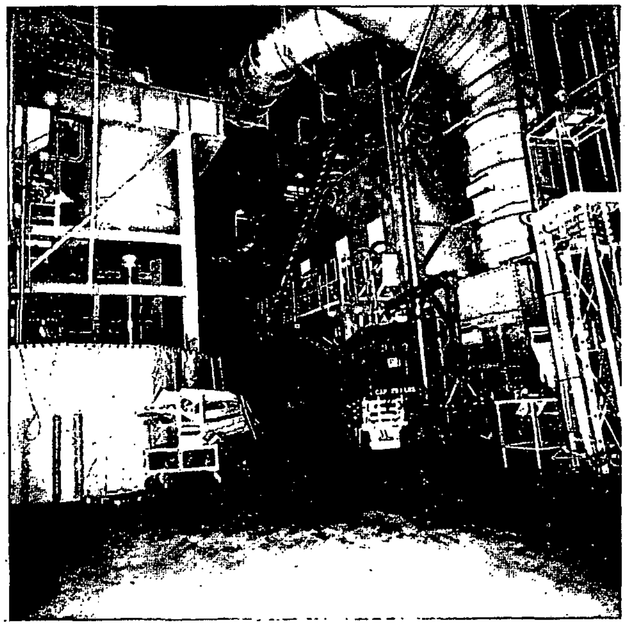
A dose rate reduction program was initiated in late 1982 to reduce the radiation levels inside the reactor building, so that occupational radiation exposure during cleanup activities would be kept as low as possible.

Dose reduction techniques applied during the first phases of this program included (1) shortening the transit time of workers in the reactor building by opening both personnel airlocks and modifying the ingress/egress paths; (2) decontamination by water flushing of such discrete radiation sources as the air coolers, elevator shaft, and enclosed stairwell; (3) elimination of other discrete radiation sources by removal of trash and contaminated equipment; and (4) placement of shielding at the 305-foot elevation, e.g., lead curtains around the core flood tank, lead sheets on the covered floor hatch, and water columns and bladder shields around the open stairwell, elevator, and enclosed stairwell.

Noticeable decreases in the general-area radiation dose rates have been realized since the initiation of the program. For example, in July 1983, the average occupational dose rates, as recorded by personnel dosimeters, were 140 millirems (mrem)-per-hour at the 305-foot level, 106 mrem-per-hour at the 347-foot level and 73 mrem-per-hour at the reactor vessel head and service structure. The comparable dose rates at those areas prior to the dose reduction program in the fall of 1982 were 350 mrem-per-hour at the 305-foot level, and 140 mrem-per-hour at the 347-foot level and at the reactor vessel head and service structure.

The dose reduction program is an ongoing effort, along with future cleanup actions in the reactor building, such as reactor vessel head lift and plenum removal. It is expected that significant further reductions will become increasingly difficult. As discrete radiation sources are identified and removed or shielded, the remaining sources are either more dispersed or of a kind that is not readily susceptible to decontamination by water flushing.

The photograph shows the upper part of the nuclear core of the TMI-2 reactor, with portions of fuel elements (the white strips) lying on the rubble bed and, in one case, protruding from it.



The plastic-covered lead blanket at the left is a shield against radiation from contaminated equipment inside the reactor containment of TMI-2.

Substantial contamination remains in the elevator pit, floor drains and sumps, ductwork and other inner surfaces of the air coolers, cable surfaces inside cable trays, and in concrete surfaces and paints. Some of the more complex activities under consideration are decontamination of selected surfaces with chemicals, removal of concrete and paint, and decontamination or replacement of cable trays.

Advisory Panel on TMI Cleanup

An Advisory Panel for the Decontamination of Three Mile Island Unit 2 was formed by the NRC in October 1980 in order to gain input and reaction from the residents of the Three Mile Island area and to provide the Commission with advice on major cleanup activities. The 12 members of the Panel include local citizens, local and state government officials and scientists (see Appendix 2 for a list of members). During fiscal year 1983, the Panel had six public meetings in Harrisburg, Pa., and two before the NRC Commissioners in Washington, D.C. During the year, the Panel discussed a variety of issues pertaining to the cleanup including funding and repair of the polar crane.

NRC

U.S. NUCLEAR REGULATORY COMMISSION

1984 Annual Report

Cleanup at Three Mile Island Unit 2

CHAPTER 3

Fiscal year 1984 was marked by significant progress in the cleanup of the accident damaged Unit 2 reactor at the Three Mile Island Nuclear Power Station (TMI) near Harrisburg, Pa. Numerous technical accomplishments were highlighted by the successful removal and storage of the reactor vessel head in July 1984. Prospective funding for future recovery activities was enhanced through additional commitments. Through increased efforts, General Public Utilities Nuclear Corporation (GPU) was able to complete activities previously delayed by funding limitations and allegations regarding polar crane safety. As a result, GPU is currently projecting the initiation of fuel removal activities in July 1985 with completion of the cleanup scheduled for mid-1988.

During fiscal year 1984, the reactor building polar crane was load tested and later used for the removal of the reactor vessel head, the placement of the head on its storage stand, and the placement of the internals indexing fixture (IIF) on the reactor vessel. Sonar and video inspection data were collected to assess core conditions in preparation for future plenum assembly removal and defueling of the reactor. The processing and shipment of radioactive wastes continued in support of cleanup activities as did dose reduction efforts aimed at keeping worker radiation exposures as low as reasonably achievable.

Cleanup Funding

Progress was also made in securing additional funding for future cleanup activities. The Edison Electric Institute, representing the utility industry, pledged funds totalling $25 million per year for six years, beginning in January 1985. A group of Japanese utility companies pledged a contribution of $18 million ($3 million for six years) to the cleanup, making the total level of funding for cleanup activities during 1984 approximately $95 million. The additional commitment of funds will help to eliminate some of the funding constraints to an expeditious cleanup of TMI Unit 2, which is one of the NRC's highest safety priorities. The TMI Program Office continues to monitor cleanup activities from the site and will continue to provide the oversight necessary to ensure the prompt decontamination of the facility and safe removal of radioactive materials from the site.

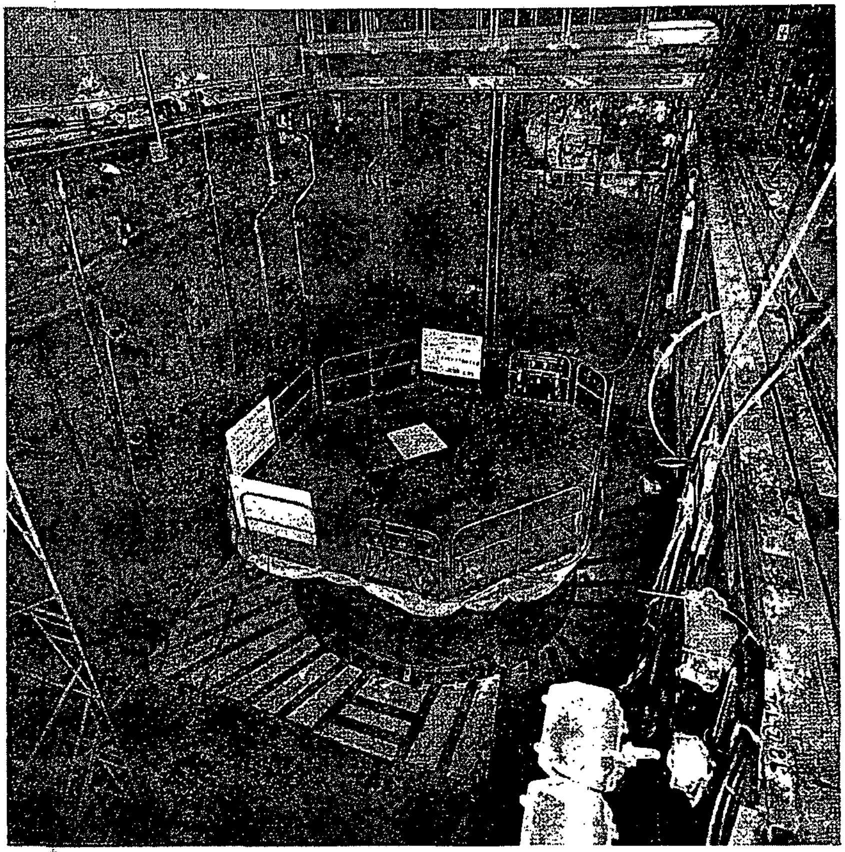
Reactor Building Activities

Workers entered the TMI-2 reactor building 167 times during fiscal year 1984 in the performance of numerous cleanup activities. Entries during the first quarter of the fiscal year were limited to one per week due to funding constraints and focused primarily on collection of reactor coolant samples. In early 1984, more frequent entries were made to prepare for and conduct the load test of the polar crane, to take additional core debris samples, to partially detension the reactor vessel head studs, and to perform video mapping of the reactor vessel internals. Reactor building entries during the third quarter of fiscal year 1984 were conducted to perform activities in preparation for reactor vessel head lift. These activities included depressurization and draindown of the reactor coolant system, refueling canal seal plate installation, control rod drive lead screw parking, auxiliary fuel handling bridge modifications and modification of the IIF. Shielding, radiation monitors and television cameras were installed to support head lift. During the last quarter of the fiscal year, reactor building activities included scabbling of the floor at the 347-foot elevation to reduce dose rates, the removal and storage of the reactor vessel head and the operation of the IIF water processing system to reduce radionuclide concentrations in the reactor coolant. Dose reduction efforts continued in preparation for plenum assembly inspection and pre-removal activities.

Reactor Building Polar Crane

At the end of fiscal year 1983, the Office of Investigations (OI) issued its report on the allegations regarding the safety of the polar crane and other cleanup-related issues. The staff reviewed the OI findings and concluded that the specific deficiencies cited did not result in a significant increase in risk to the public health and safety. The staff also recommended the implementation of a detailed action plan to correct the identified administrative and procedural deficiencies. An Enforcement Action resulting from polar crane refurbishment activities was issued on February 3, 1984.

On November 18, 1983, the staff approved the licensee's safety evaluation for the refurbishment and use of the Reactor Building Polar Crane. The crane was successfully load tested on February 29, 1984, when a test assembly weighing 214 tons was lifted and moved along predetermined test paths.



A major milestone in the cleanup of the Three Mile Island Unit 2 accident was the removal of the reactor pressure vessel head in July 1984. The photo shows a post-removal overhead view of the water-filled Internal Indexing Fixture (IIF), which is covering the open reactor vessel, and a shielded work platform lowered onto the IIF. The IIF was filled with five feet of water for radiation shielding.

Reactor Vessel Head Lift

A major cleanup milestone was achieved in late July 1984 when the reactor pressure vessel head was removed and placed in shielded storage. The polar crane was used to lift the head, place the head on the storage stand, install the cylindrical IIF over the open reactor vessel and lower the shielded work platform onto the IIF. Prior to work platform installation, the IIF was filled with five feet of water to provide radiation shielding over the exposed plenum.

Inspection of Reactor Core

A scale model of the damaged core was constructed in late 1983 based on sonic measurements obtained from inside the reactor vessel. This topographic model provided the most accurate indication of the extent of core damage to date. The volume of the cavity in the damaged area of the core was measured at 330 cubic feet or 26 percent of the original core volume. The bottom of the cavity ranges from 5-to-6 feet below the top of the core and the cavity extends to the core, forming wall in several areas. Forty-two of the original 177 fuel assemblies appear to contain some full-length fuel rods, but 23 of those 42 have less than 50 percent of the rods intact. The sonic mapping also revealed several partial fuel assemblies hanging from the underside of the plenum and indicated some distortion of the core forming wall. In early 1984, a comprehensive video mapping of the core was made and additional core debris samples were taken. The accurate characterization of core conditions provided by these activities has facilitated the planning of subsequent cleanup operations such as plenum removal preparatory activities, including the separation of unsupported partial fuel assemblies, which are scheduled to begin in October of 1984.

Waste Management

During fiscal year 1984, the Submerged Demineralizer System (SDS) and the EPICOR-II system continued to be used to process radioactive water in support of cleanup activities. The SDS was used primarily to process reactor coolant, reactor building sump water, and water generated during the decontamination of the "A" spent fuel pool. The EPICOR-II system typically was used to polish the effluent from the SDS. The SDS and EPICOR-II system processed approximately 532,000 and 272,000 gallons of water, respectively, during the year. Regarding the disposition of solid radioactive wastes generated by SDS and EPICOR-II operations, three SDS liners and 32 EPICOR-II liners were shipped to Hanford, Wash., during the year.

Occupational Exposure

GPU continued efforts to keep worker exposures as low as reasonably achievable during fiscal year 1984. These efforts consisted of extensive pretask planning and mock up training for each task, the use of radiation shielding, and the application of decontamination and dose reduction techniques. The effectiveness of the decontamination and dose reduction methods was demonstrated during the last quarter of the fiscal year. In July, workers entered the reactor building without respiratory protection for the first time since the accident, and subsequent entries were made without respirators, in accordance with ALARA principles. The head lift operation resulted in a cumulative worker exposure of 15 person-rem, compared to the staff's prediction of between 60 and 220 person-rem. Dose rates in the reactor building were restored to pre-lift levels following head lift and subsequent IIF installation and waterfilling. Since the completion of head lift, scabbling (the mechanical removal of a thin layer) of the concrete reactor building floor has resulted in a measured 50 percent reduction in local dose rates.

In January 1984, the TMIPO issued a draft supplement to the Final Programmatic Environmental Impact Statement (NUREG-0683), which revised the staff's earlier estimates of occupational radiation exposure resulting from the cleanup. The total radiation dose to cleanup workers is currently estimated to range between 13,000 and 46,000 person-rem as opposed to earlier estimates of 2,000 to 8,000 person-rem. The higher estimates resulted from a more accurate characterization of radiation fields in the reactor building based on numerous worker entries. Delays in the cleanup complicated decontamination efforts because radiation sources became more deeply entrained in building surfaces; as a result, early dose reduction efforts were less successful than anticipated. Although the staff's revised dose estimates are significantly higher than the previous estimates, the staff still concludes that the environmental impact is insignificant and the cleanup should proceed as expeditiously as possible, to reduce the potential for radiation release to the environment and to assure that TMI-2 does not become a long term waste disposal site.

Advisory Panel on TMI Cleanup

The Advisory Panel for the Decontamination of Three Mile Island Unit 2, comprised of citizens, scientists and local and state government officials, was formed by the NRC in 1980 in order to gain input from area residents regarding major TMI cleanup activities. (See Appendix 2 for a list of members). On November 29, 1983, NRC Chairman Nunzio J. Palladino appointed Arthur E. Morris, Mayor of Lancaster, Pa., as chairman of the Advisory Panel, upon the resignation of the previous chairman, John Minnich. During fiscal year 1984, the panel held eight public meetings in Harrisburg, Pa., and met twice with the NRC Commissioners in Washington, D.C. The principal topics addressed by the panel during the year included cleanup funding, occupational radiation exposure, polar crane repairs and reactor vessel head lift.

NRC

U.S. NUCLEAR
REGULATORY
COMMISSION

1985
Annual Report

Cleanup at Three Mile Island

CHAPTER 3

Substantial progress continued during fiscal year 1985 in all phases of the cleanup of the damaged Unit 2 reactor at the Three Mile Island Nuclear Power Station (TMI) near Harrisburg, Pa.

The safe removal and storage of the reactor vessel plenum assembly (PA) in May 1985 provided the access to the damaged reactor core necessary for the installation and operation of specially designed defueling equipment. Although delays in fabrication and delivery of this unique defueling equipment delayed the scheduled commencement of fuel removal activities from July until November of 1985, General Public Utilities Nuclear Corporation (GPU) still projects completion of the cleanup by mid-1988.

During fiscal year 1985, the highly radioactive reactor building basement was inspected through the use of a robotic vehicle. The PA was raised on jacks and all remaining attached fuel assemblies were dislodged prior to eventual PA removal and storage. Video inspections of the reactor vessel lower head revealed the distribution of core debris in that region and provided useful information for defueling planning and for revising previous theories regarding the accident. Decontamination and dose reduction activities continued in support of extensive defueling preparations. The processing and shipping of radioactive wastes also continued.

The cleanup funding situation continued to improve in fiscal year 1985, as GPU received payments from all sources that had pledged to contribute to the cleanup. By October 1985, the Edison Electric Institute, with support from six utilities in Pennsylvania and New Jersey, had paid GPU nearly $24 million of the $25 million pledged for calendar year 1985. The restart of TMI Unit 1 in October 1985 could result in an additional $15 million annual contribution to the cleanup from existing customer revenues. The financial aspects of the cleanup are addressed in more detail in Chapter 9.

Reactor Building Activities

A total of 238 entries were made into the TMI-2 reactor building during fiscal year 1985. First quarter activities included the inspection and jacking of the reactor vessel plenum, inspection of the polar crane, robotic inspection of the reactor building basement, and scabbling to reduce dose rates in work areas.

Based on indications that the plenum assembly had experienced deformation as a result of the accident, GPU elected to initially raise the PA on jacks to clear any potential interferences, in preparation for final lift. In December 1984, four hydraulic jacks were used to raise the 55-ton plenum assembly 71/2 inches. Long-handled tools were then used to detach remaining fuel assemblies and end fittings that adhered to the underside of the PA. Subsequent inspections indicated that all suspended debris had been dislodged and had fallen into the rubble pile in the core region.

During the fourth quarter of fiscal year 1984, GPU reported that one of the redundant brake systems on the reactor building polar crane had been found inoperable, because of a maladjustment of a manual brake release mechanism. The crane was initially removed from service and later its use was restricted to lifts of up to five tons. In January 1985, the polar crane was approved for full use, following an NRC inspection to verify the effectiveness of corrective actions taken by GPU. The polar crane was successfully used to lift and transfer the PA in May 1985.

Reactor building activities during the second quarter of fiscal year 1985 consisted of video inspections of the lower reactor vessel head, preparations for plenum assembly removal, and preparations for defueling, including partial installation of the Defueling Water Cleanup System (DWCS). Scabbling and water flushing activities were performed to further reduce reactor building radiation levels.

During the third quarter of fiscal year 1985, reactor building activities involved continued preparation for both plenum assembly transfer and for early defueling, including the installation of a dam in the fuel transfer canal, installation of additional DWCS components, assembly of fuel transfer equipment and installation of the defueling support structure. The 25-ton polar crane auxiliary hoist was load-tested and given its annual preventive maintenance. The PA was successfully transferred and stored during this period, as discussed below. Problems in the vendor's quality assurance program have resulted in delays in the delivery and acceptance of defueling canisters, canister storage racks and fuel transfer shields.

Reactor building activities during the fourth quarter of the fiscal year centered on early defueling preparations. The rotating defueling work platform with its cable management system was installed above the internals indexing fixture, directly over the open reactor vessel. Other defueling components installed included the service work platform, jib cranes, canister handling bridge, canister positioning system, defueling tool racks, and the fuel transfer mechanism. Installation of the vacuum defueling system began and the reactor building sump recirculation system was tested and declared operable. Additional inspections of the reactor vessel lower head were conducted as discussed below. Problems in the vendor's quality assurance program have resulted in delays in the delivery and acceptance of defueling canisters, canister storage racks and fuel transfer shields.

Plenum Assembly Transfer

The last major structural obstacle to defueling was removed in May 1985 when the plenum assembly was lifted from its jacked position in the reactor vessel, raised through the water-filled internals and transferred to its storage stand in the deep end of the fuel transfer canal. Prior to plenum transfer, a six-foot-high dam was constructed, allowing the deep end of the canal to be flooded to a level sufficient to provide adequate shielding for the stored plenum. The highest exposure rate during the transfer was 80 rems-per-hour at a point 3 feel below the plenum; the highest recorded exposure rate in the lead-shielded cubicle where workers were stationed was 30 millirems-per-hour.

The actual total occupational exposure for the PA transfer and storage operation was three person-rems, approximately 10 percent of the amount estimated in advance for this activity.

Reactor Vessel Lower Head Inspection

In February 1985, the first video inspection of the reactor vessel lower head region revealed the accumulation of a substantial quantity—estimated at 10-20 tons—of accident-generated debris. The debris bed had the appearance of a gravel pile composed of pieces nominally three-to-four inches long and half as wide. Similar material was observed by sighting up through the lower diffuser plate of the core support assembly. Although the composition of the debris could not be determined from the video inspections, it is evident that some molten material was generated during the accident, and that it resolidified and collected in the lower head area. Additional inspections conducted in July 1985, focusing on other quadrants in the lower head, disclosed that the debris bed was more shallow and individual pieces smaller in those areas, in contrast to the earlier determinations. In a separate effort, EG&G Idaho, Inc., under contract to the Department of Energy, ascertained that some areas of the core had reached temperatures of at least 5,100F (the melting point of uranium dioxide fuel) during the 1979 accident. This information, along with the lower head inspection data, will be used to revise certain theories of the TMI-2 accident sequence.

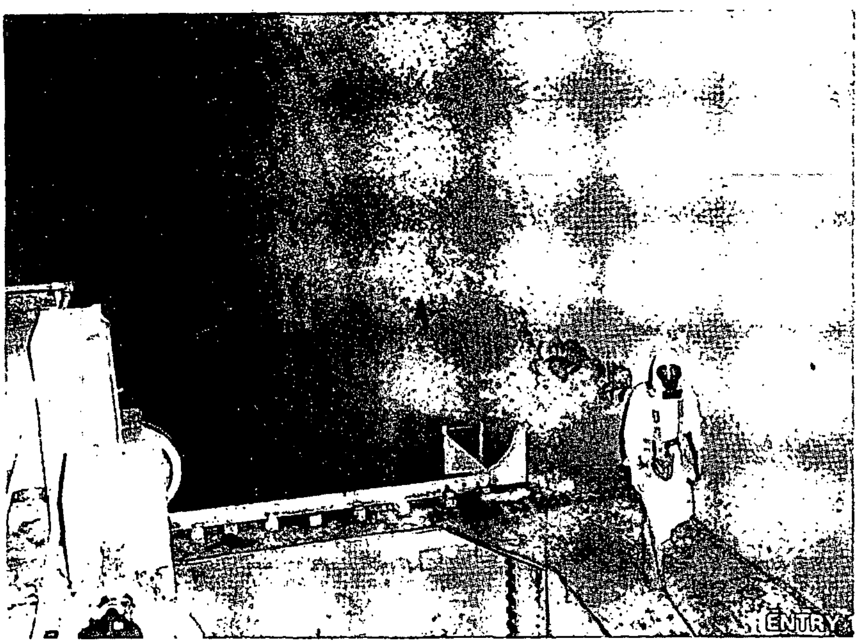
Waste Management

During the report period, the Submerged Demineralizer System (SDS) and the EPICOR-II system continued to be used to process radioactive water. The SDS was used to process reactor coolant, contaminated water generated from the makeup and purification demineralizer elution activities, reactor building sump water, and other water needing decontamination. The EPICOR-II system was also used to process miscellaneous waste water and to cleanse the effluent from the SDS. The SDS and EPICOR-II systems processed about 465,000 and 509,000 gallons of water, respectively, during the fiscal year. Two SDS liners and four EPICOR-II liners were shipped to the burial site at Richland, Wash.

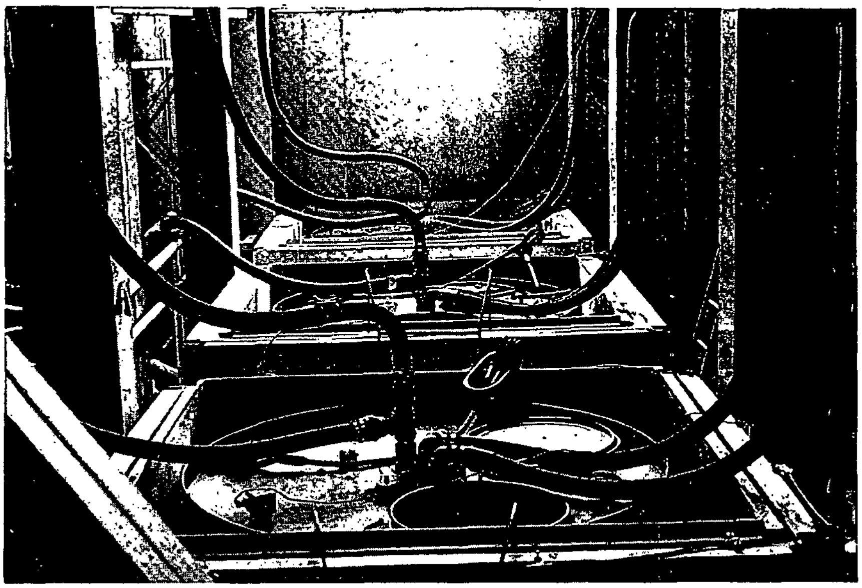
GPU Nuclear's burial privileges at the U.S. Ecology burial site in Richland were temporarily suspended in August 1985 when three barrels, out of a shipment of 104, were erroneously classified, labeled and certified by GPU as Class A radioactive waste. The privileges were restored after Washington State officials approved corrective measures taken by GPU to prevent future shipping and classification violations.

Decontamination and Dose Reduction Activities

Throughout fiscal year 1985, GPU continued decontamination and dose reduction activities aimed at maintaining



Some 238 separate entries into the reactor building at Three Mile Island Unit 2 occurred in 1985. Shown here is one of the early inspections of the plant's polar crane.



The Epicor II system to process radioactive water at TMI-2 continued in use during 1985 as part of the cleanup activity which has been going on since the accident in March 1979. The process vessels shown here are part of the Epicor system. They contain ion-exchange resins and are fitted with "quick-disconnect" hoses for liquid waste influent and processed waste effluent, with a vent line and overflow hose. Vented air from the vessels passes through special filter and charcoal adsorbers.

exposures to workers as low as reasonably achievable. Scabbling, a mechanical technique for removing the upper layer of concrete from a surface, was successfully employed in the reactor building and auxiliary and fuel handling building.

Upon completion of the bulk of reactor building scabbling activities in 1985, exposure rates on the entry level (305 feet elevation) and refueling floor (347 feet elevation) were reduced to 67 millirems-per-hour and 35 millirems-per-hour, respectively, a decrease of 30-70 percent. Shielding of the reactor building air coolers in conjunction with decontamination efforts and extensive pre-task training contributed to the lower-than-anticipated occupational exposure incurred during plenum assembly removal and transfer.

In the auxiliary and fuel handling building, scabbling and water flushes were used in the decontamination of the primary coolant makeup and letdown valve alleys, reactor coolant bleed tank rooms, the auxiliary building elevator, and various cubicles. A water flush of the seal return water system resulted in a 97 percent reduction in local exposure rates.

Chemical elution of the cesium from the highly radioactive makeup and purification demineralizer resins was completed in 1985. Approximately 4,200 curies of cesium-137 were removed from the resins, which were then placed in we layup in reactor coolant system quality water.

In November 1984, a robotic vehicle was used to inspect the highly radioactive building basement (282 feet elevation). General area radiation levels measured from 10 to 70 rems-per-hour, with hot spots as high as 1,100 rems-per-hour, confirming predictions that the basement is basically inaccessible to humans.

Advisory Panel on TMI Cleanup

The Advisory Panel for the Decontamination of Three Mile Island Unit 2, made up of citizens, scientists and local and State government officials, was formed by the NRC in 1980 to gain input from area residents regarding major cleanup activities. (See Appendix 2 for current membership.) In August 1985, the Commission approved a revision to the panel's charter to allow the panel to provide advice on the public's reactions to plans and results of certain health effects studies related to the TMI-2 accident. During the report period, the panel held eight public meeting in Harrisburg and Lancaster, Pa., and in Annapolis, Md., and met three times with the NRC Commissioners in Washington, D.C. Topics discussed by the panel during the year included TMI-2 health-effects studies, cleanup funding, flow of information to the panel, radiation protection issues, and NRC investigation and enforcement actions. The panel also received technical presentations on plenum assembly removal, Kr-85 monitoring during head lift, reactor vessel defueling, fuel shipping, and disposition of accident-generated water.

NRC

U.S. NUCLEAR
REGULATORY
COMMISSION

1986
Annual Report

Cleanup at Three Mile Island

CHAPTER 3

Fiscal year 1986 was marked by the most significant progress yet in the cleanup of the damaged Unit 2 reactor at the Three Mile Island nuclear power plant (TMI-2) near Harrisburg, Pa., since the accident in late March 1979. Removal of damaged fuel and structural debris from the reactor vessel finally got under way in late October 1985, six and one-half years after the event.

Special defueling equipment was used to transfer core debris from the reactor vessel to safe temporary storage locations in the Unit 2 spent fuel pool. Shipment of the damaged fuel from the TMI site to the Idaho National Engineering Laboratory (INEL) also began during the fiscal year. A special drilling rig was used to take full-length core samples, which will be analyzed at INEL to provide data for future defueling planning and to develop a better understanding of the TMI-2 accident sequence and its applications.

NRC on-site staff continued to monitor the day-to-day cleanup operations conducted by the licensee, General Public Utilities Nuclear Corporation (GPUNC). The on-site staff performed numerous reviews and issued necessary approvals of the licensee's detailed defueling procedures, and conducted periodic inspections of plant cleanup systems and equipment. In conjunction with headquarters staff, the NRC TMI site staff performed safety and technical reviews of licensee proposals for major cleanup activities to continue to assure the safe, expeditious cleanup of Unit 2.

During fiscal year 1986, GPUNC performed additional video inspections in previously inaccessible regions of the reactor vessel. Decontamination and dose reduction activities were performed in parallel with defueling operations. Surveys and sampling activities were conducted in the reactor building basement, the pressurizer, and the steam generators to measure radiation fields and quantify the radioactive debris in those areas. Seven of eight reactor vessel internal vent valves were removed to provide improved access to the lower vessel head. The processing and shipment of radioactive wastes also continued, primarily in support of defueling operations.

Although considerable progress was made during the fiscal year in defueling the TMI-2 reactor vessel, some operational difficulties were encountered. GPUNC employed numerous techniques, with varying degrees of success, to combat the growth of microorganisms in the reactor coolant, which at times seriously restricted visibility in the vessel. Also, certain defueling tools could not be used to perform the intended functions, particularly those designed to break up the hard mass of fused core debris. The licensee has been able to develop new tools and techniques to resolve the difficulties encountered to date and to allow defueling to continue. Because of the delays incurred as a result of these problems, and in light of a more accurate assessment of the nature and extent of the remaining defueling tasks, the licensee has slightly revised the schedule with regard to attainment of certain cleanup milestones. Defueling activities are projected for completion in the fourth quarter of calendar year 1987, representing a three-month adjustment to the schedule projected one year ago. The completion of the current phase of the cleanup is still estimated to occur by the third quarter of calendar year 1988.

The cleanup funding situation remained stable during fiscal year 1986, with committed sources in place to fund the estimated total cost of $965 million. Through the end of the fiscal year, approximately 700 million dollars had been spent on the cleanup, leaving a total of 265 million dollars for remaining cleanup expenses. (See discussion of the financial aspects of the cleanup at the end of Chapter 9).

TMI-2 Defueling Scheme

The licensee has designed and installed unique equipment and systems to accomplish the primary goal of the TMI-2 cleanup: the removal of the damaged fuel and structural debris from the reactor vessel. During defueling activities, the reactor coolant system (RCS) is vented to the reactor building atmosphere, with RCS cooling by natural heat loss. The internals indexing fixture (IIF), installed over the open reactor vessel and filled with water to an elevation of five feet over the vessel flange, provides additional radiation shielding for defueling workers. The RCS is borated to a concentration of approximately 5000-parts-per-million to prevent recriticality of the damaged fuel in any configuration. The Defueling Water Cleanup System (DWCS) is used to process reactor vessel water to reduce activity levels and to provide the visibility necessary to conduct the remote defueling operations.

Workers perform defueling operations from a shielded defueling work platform (DWP), which is located at a height of nine feet above the reactor vessel flange, over the IIF. The platform has a rotatable 17-foot diameter surface with six-inch steel shield plates and is designed to provide access for defueling tools and equipment into the reactor vessel. The DWP supports defueling operators, especially designed long-handled tools, remote viewing equipment, and two jib cranes used to manipulate the tools. Numerous manual and hydraulically powered long-handled tools are used to perform a variety of functions, such as pulling, grappling, cutting, scooping and breaking up the core debris. These tools are used to load debris into defueling canisters positioned under water in the reactor vessel. The canisters are then sealed and transported using shielded canister transfer equipment to submerged storage racks in spent fuel pool "A" of the Auxiliary and Fuel Handling Building (AFHB). The canisters are designed and stored to prevent an inadvertent criticality event. Following dewatering to control the buildup of combustible gases, the canisters are loaded into a specially designed shipping cask and transported to a Department of Energy facility in Idaho for interim storage.

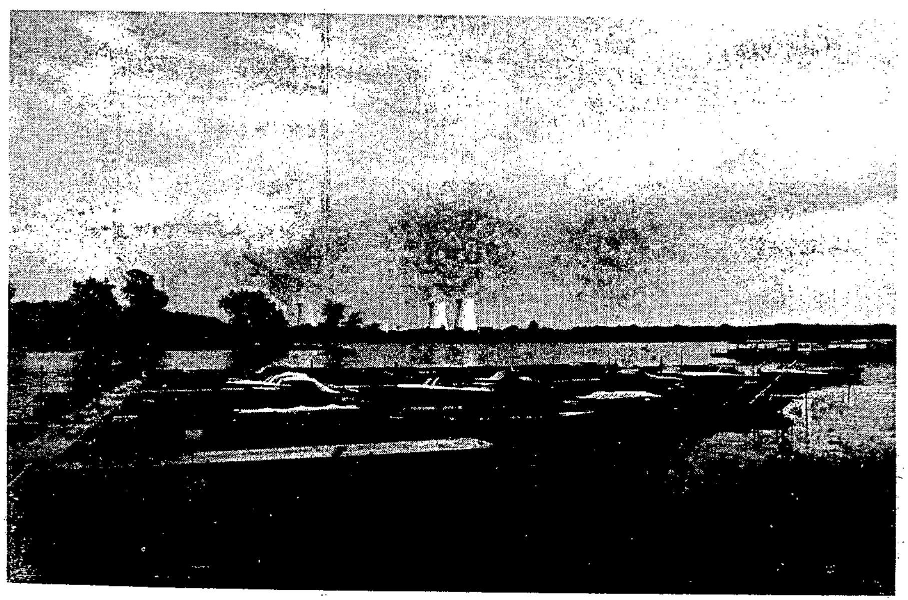
Reactor Vessel Defueling Activities

A total of 345 entries were made into the TMI-2 reactor building during fiscal year 1986, bringing the total number of entries made since the March 1979 accident to 1,047. Entries made during the fiscal year were primarily for installation and operation of defueling tools and equipment and defueling support activities.

During the first quarter of fiscal year 1986, GPUNC completed preparations for defueling and commenced preliminary defueling operations. Initial in-vessel activities involved the relocation of structural debris to allow the installation of the canister positioning system—a submerged, rotating carousel device capable of holding five defueling canisters. In December 1985, several defueling canisters were filled with debris consisting of fuel assembly end fittings, control rod spiders, and small pieces of fuel assemblies. In early January 1986, the first group of defueling canisters was sealed, dewatered, and transferred to storage racks in spent fuel pool "A" in the AFHB.

Dose rates to personnel during the initial phase of defueling were low and remained low throughout the year, averaging less than 10 mrem/hr on the DWP and less than 40 mrem/hr near the shielded canisters during transfer. The licensee discontinued the use of respirators during defueling activities, based on air sample data collected during the first month.

"Pick and place" defueling of the loose TMI-2 core debris continued through April 1986. Nearly 16 percent of the estimated total of 308,000 pounds of debris was removed from the reactor vessel before poor visibility temporarily halted defueling operations. A large population of microorganisms had rapidly developed in the RCS, clogging the DWCS filters and hindering the operators' ability to view remotely the defueling activities in the vessel. These growths, consisting of algae, fungi, bacteria, and aerobic and anaerobic organisms, proved difficult to kill in several tests. In April and May, GPUNC conducted a multi-phase program to restore reactor vessel water clarity. The program consisted of high pressure hydro-lancing to remove growths adhering to reactor vessel surfaces, the addition of hydrogen peroxide as a biocide, and the use of a high pressure positive displacement pump to kill the microorganisms. A diatomaceous earth (swimming pool-type) filter was then operated in conjunction with the letdown and makeup of batches of reactor coolant, to remove the organic material and improve the clarity of the RCS water. These techniques proved successful in restoring visibility in the vessel and were repeated as necessary to maintain water clarity throughout defueling activities for fiscal year 1986. Pick and place defueling was resumed in May, following the completion of the water treatment program.



This scene of the Goldsboro Marina on the bank of York Haven Pond shows one of the primary access points for fishermen working the Susquehanna River. The marina is just west of the Three Mile Island nuclear power plant, shown in the background.

In July 1986, the licensee conducted a core stratification sample acquisition program. Most of the loose core debris had been removed from the reactor vessel, and more data were needed to plan the defueling of the material under the hard crust layer of the damaged core. A special drilling rig was assembled on top of the DWP, and 10 full-length sampling penetrations were made from the surface of the debris bed to inches above the lower head of the reactor vessel. These samples of the reactor core (approximately 2.5 inches in diameter and eight feet long) will be analyzed at INEL, along with earlier samples of debris collected from the lower vessel head, in order to provide data on the material properties of the core debris. Video inspections of the core below the debris bed were performed through several of the bore holes created by the drilling operations. Initial inspections indicated that peripheral fuel assemblies are essentially intact below the rubble bed (or "hard crust" layer), but that the central core region consists largely of a fused mass of material.

The core drilling apparatus was modified in late July when solid face drill bits were used to perforate the hard crust layer of the core in 48 locations. These perforations, ranging in depth from a few inches to 48 inches, were made to improve the effectiveness of heavy duty defueling tools in breaking up the solidified core debris. The heavy duty tools were only marginally successful, and so the drilling rig was reinstalled at the end of fiscal year 1986, to be used as the primary tool for breaking up the hard mass of core debris. Remaining fuel assembly end fittings were removed from the top of the debris bed to clear the area for further drilling operations.

By the end of the fiscal year, approximately 57,000 pounds of core debris had been removed from the TMI-2 reactor vessel, representing nearly 19 per cent of the estimated total of 308,000 pounds in the vessel.

Waste Management

During fiscal year 1986, the Submerged Demineralizer System (SDS) and the EPICOR-II system continued to be used to process radioactive water in support of cleanup activities. The SDS was primarily used to process reactor coolant and water from the deep end of the fuel transfer canal. The EPICOR-II system was used mainly to polish effluent from the SDS and to process water from the chemical cleaning building sump. The SDS and EPICOR-II systems processed approximately 1,252,000 and 490,000 gallons of water, respectively, during the fiscal year. Twenty EPICOR-II dewatered liners were shipped to Richland, Wash., for burial during the same period.

Late in 1985, water in the fuel transfer canal, spent fuel pool "A", and miscellaneous processing tanks was treated with hydrogen peroxide to kill algae growths in those volumes. These growths were unrelated to the microorganisms later found in the RCS.

In July 1986, the licensee began operation of the newly constructed Waste Handling and Packaging Facility. The facility is used to process the increased volumes of low-level solid waste generated as a result of defueling operations. Activities conducted in the facility include sectioning, disassembly, and other size reduction operations; mechanical decontamination of equipment and tools; and packaging of solid wastes in 55 gallon drums and low specific activity boxes.

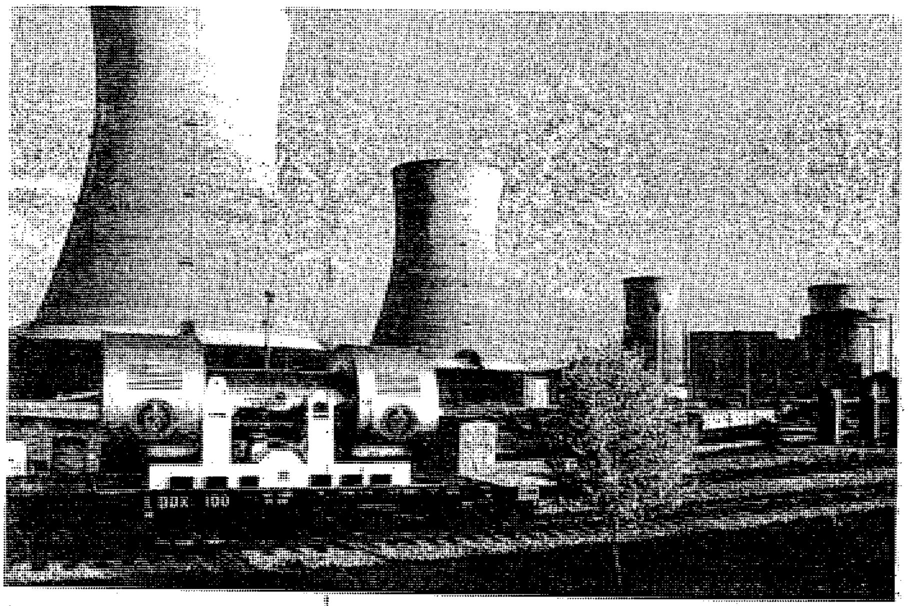
Also in July, GPUNC submitted a proposal for disposing of approximately 2.1 million gallons of slightly radioactive water, contaminated during the accident and used in subsequent cleanup operations. Of the proposed alternatives, the licensee requested approval of a method involving the forced evaporation of the water at the TMI site over a two and one-half year period. The residue from this operation, containing small amounts of the radioactive isotopes cesium-137 and strontium-90, and large volumes of boric acid and sodium hydroxide, would require solidification and disposal as low-level waste.

The licensee has petitioned the Secretary of Energy for the additional burial ground waste volume allocation necessary to implement this plan. The NRC staff was reviewing the licensee's proposal at the close of the report period and will make a recommendation to the Commission, whose approval is required prior to the initiation of any disposal option.

The first off-site shipment of fuel and debris removed from the damaged TMI-2 core took place in July of 1986. Under a previous agreement with the NRC, the Department of Energy (DOE) will take possession of the high-level waste at the TMI site boundary and is responsible for transport of the material and interim storage at the Idaho National Engineering Laboratory. In April 1986, the NRC issued certificates of compliance for the two Nuclear Packaging shipping casks to be used for shipment of the fuel debris by rail. Each cask is designed to hold seven defueling canisters; therefore, an estimated 35 to 40 trips will be necessary to ship all the TMI-2 core debris to INEL. Two additional casks were later shipped from the TMI site, so that by the end of the fiscal year, approximately 4 percent (12,000 lbs.) of the total estimated core debris had been transferred to INEL.

Decontamination and Dose Reduction

Throughout the fiscal year, GPUNC continued to perform decontamination and dose reduction activities aimed at maintaining worker radiation exposures as low as reasonably achievable (ALARA). Scabbling (the mechanical removal of a layer of concrete), water flushing, vacuuming, painting, and hands-on techniques such as wiping and scrubbing were the primary methods used to decontaminate areas in the reactor building and the AFHB. Decontamination efforts during the year helped to maintain low average



A U.S. Department of Energy (DOE) shipping cask awaits loading at the Three Mile Island nuclear power plant. The cask, licensed by the NRC, is used to transport debris from the damaged TMI reactor core for interim storage at DOE's Idaho National Engineering Laboratory, near Pocatello, Idaho.

dose rates at the 305-foot and 347-foot elevations in the reactor building (67 mrem/hr and 40 mrem/hr, respectively), and resulted in freeing over 90 percent of the area at the 281-foot elevation in the AFHB from contamination controls.

In conjunction with ongoing decontamination activities, sampling and surveys were performed in areas of the reactor building and the AFHB. Video inspections and thermoluminescent dosimeter surveys conducted in the pressurizer indicated that little fuel was deposited there as a result of the accident. Small quantities of particulate material were discovered in the steam generator upper head spaces. A robot vehicle was used to collect concrete samples of the highly radioactive reactor building basement, where dose rates typically remain in excess of 100 rem/hr, for the purpose of planning decontamination of basement surfaces. A robot device was also used to measure the high dose rates in the AFHB Seal Injection Valve Room. The measured dose rates due to gamma radiation in the room ranged from 30-75 R/hr in general areas to 300 R/hr in hot spots. The defueling work platform continued to be the lowest dose rate area in the reactor building because of special dose reduction efforts and shielding. Dose rates on the DWP averaged 8 mrem/hr for most of the fiscal year.

Advisory Panel on TMI Cleanup

The Advisory Panel for the Decontamination of Three Mile Island Unit 2—composed of citizens, scientists, and state and local officials—was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues (see Appendix 2 for a list of current members). During fiscal year 1986, the panel held five public meetings in Harrisburg and Lancaster, Pa., and met twice with the NRC Commissioners in Washington, D.C. Topics addressed by the panel during the year included: TMI-2 health effects studies presented by the Pennsylvania Department of Health and local citizens, status of the ongoing defueling operations, Department of Energy plans for off-site shipment and storage of fuel, the licensee's proposal for disposal of the accident-generated water, and ongoing NRC enforcement actions.

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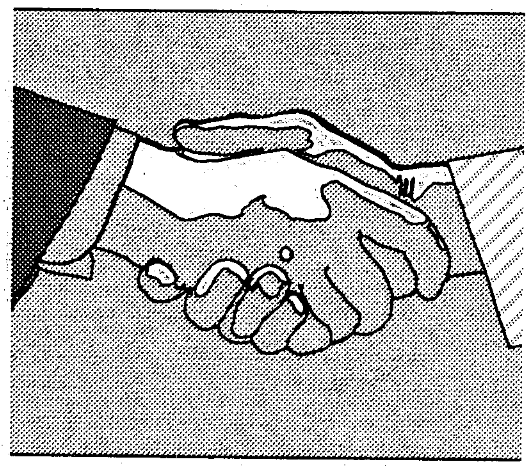

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REGULATORY
COMMISSION

1987
Annual Report

Cleanup At Three Mile Island

Chapter 3

During fiscal year 1987, significant progress was made with the cleanup of the damaged reactor at Unit 2 of the Three Mile Island nuclear power plant (TMI-2) near Harrisburg, Pa. Decontamination and dose-reduction activities continued in parallel with defueling operations, as did the processing and shipment of radioactive wastes.

Workers using long-handled tools performed defueling operations at Unit 2 from a shielded platform located nine feet above the reactor vessel flange. This deployment allowed for the removal of damaged fuel and structural debris in the reactor vessel at a greater rate than before. As of the end of September 1987, a total of 162,451 pounds of damaged fuel and debris had been removed from the reactor vessel. That volume represents more than 55 percent of the post-accident core inventory and includes the remnants of 132 of the total of 177 original fuel assemblies. Defueling of the original core region was expected to be completed by the end of 1987, with the removal of the remaining fuel assemblies. The next areas to be defueled are the lower internals and the lower head (below the normal core region). These areas contain a mixture of loose material and solidified, once molten, material. The areas between the baffle plates (outside the normal core region) and the core barrel will also have to be defueled. Other cleanup activities in fiscal year 1987 included defueling of the "A" steam generator, which yielded about 10 pounds of debris. The decay heat drop line was also found to contain a significant quantity of fuel and will be cleaned along with the remainder of the reactor coolant system piping. The completion of defueling is expected by the end of calendar year 1988.

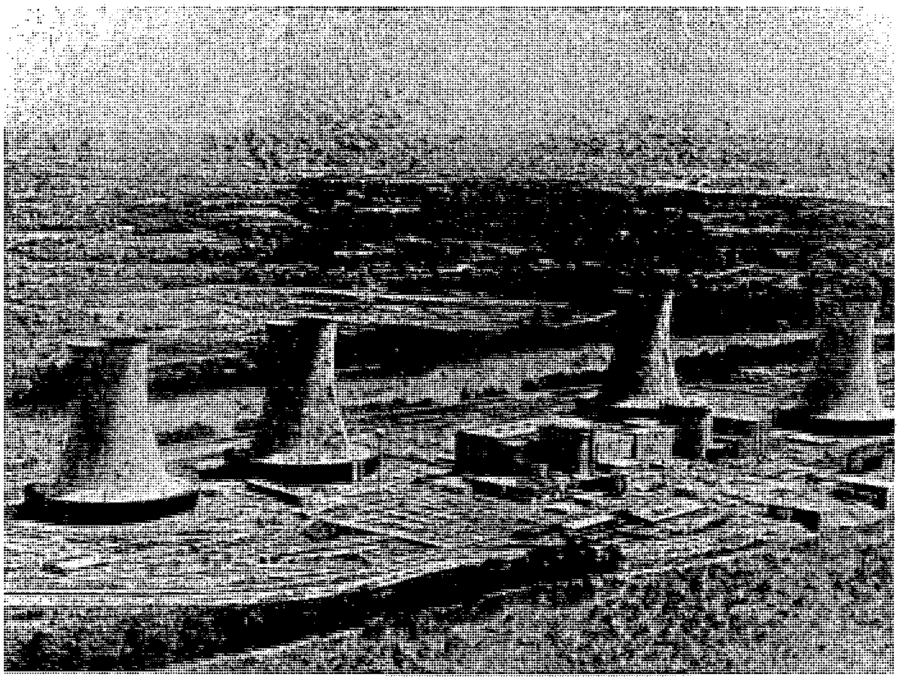
Dose rates to personnel during defueling were low and remained low throughout the report period. The rates averaged less than 10 mrem/hr on the shielded platform and less than 40 mrem/hr near the shielded core debris canisters during canister transfer. Projected cumulative worker dose for calendar year 1987 is 1,027 person-rem. This is below the licensee's goal of 1,175 person-rem and just 120 person-rem (13 percent) above the 907 person-rem total for calendar year 1986.

Shipment of damaged core material from the TMI site to the Idaho National Engineering Laboratory (INEL) continued throughout the period. A total of 16 shipments of debris have been made to INEL, 15 of them occurring in fiscal year 1987. These shipments comprise 112,348 pounds of debris, which is more than 37 percent of the total amount to be removed from the reactor vessel. General Public Utilities Nuclear Corporation (GPUNC) made arrangements to use a third shipping cask to help expedite shipments to INEL.

During the report period, the Submerged Demineralizer System (SDS) and the EPICOR-II system were used to process radioactive water. The two systems processed about 352,518 and 609,515 gallons of water, respectively. Currently, the EPICOR-II system handles all processing of contaminated water, with the SDS in a standby mode. Twenty-nine EPICOR-II dewatered liners were shipped to Richland, Wash., for burial during this same period.

In July 1986, GPUNC submitted a proposal for disposing of approximately 2.1 million gallons of slightly radioactive water. This water was contaminated either during the accident of April 1979 or during subsequent cleanup operations. The proposed method involves the forced evaporation of the water at the TMI site over a two and one-half year period. The residue from this operation—containing small amounts of the radioactive isotopes cesium-137 and strontium-90, and larger amounts of non-radioactive boric acid and sodium hydroxide—would require solidification and disposal as low-level waste. The staff evaluated the licensee's proposal together with eight alternative approaches, giving consideration to the risk of radiation exposure to workers and to the general public; the probability and consequences of potential accidents; the necessary commitment of resources, including costs; and regulatory constraints. The results of the staff evaluation were presented in the June 1987 Final Supplement No. 2 to the "Programmatic Environmental Impact Statement" (NUREG-0683), dealing with disposal of accident-generated water. The staff concluded that the licensee's proposal to dispose of the water by forced evaporation to the atmosphere, followed by on-site solidification of the remaining solids and disposal thereof at a low-level waste facility, was an acceptable plan. The staff also concluded that no alternative method of disposing of the contaminated water was clearly preferable to the GPUNC proposal. An opportunity for a prior hearing to consider removing the prohibition on the disposal of the contaminated water was offered, and the matter was pending before the Atomic Safety and Licensing Board at the end of fiscal year 1987.

Throughout 1987, GPUNC performed decontamination and dose-reduction activities aimed at maintaining worker radiation exposures at a level as low as reasonably achievable. Scabbling (the mechanical removal of a layer of concrete), water flushing, vacuuming, painting, and hands-on techniques such as wiping and scrubbing were the primary means for decontaminating areas in the reactor building and the auxiliary and fuel-handling buildings (AFHB). Sludge removal from the auxiliary building sump and the reactor building was completed, and a flushing of the reactor building begun in September 1987. Seventy-five percent of the



The Three Mile Island (TMI) nuclear power plant, located on an island in the Susquehanna River in Dauphin County, Pa., was the scene of the nation's most serious nuclear accident when, on March 28, 1979, a partial meltdown of the reactor core to TMI Unit 2 occurred. (Unit 2 is the cylindrical containment building to the right in the photo.) Although no one was killed or injured in the accident, it remains a major traumatic episode in the history of the technology. In the years since the event, many far-reaching changes in regulatory requirements and procedures have been introduced.

previously contaminated areas (462,708 square feet) of the AFHB has been decontaminated. Of 143 contaminated cubicles in the AFHB, 107 have been decontaminated. Twenty-three of the remaining 36 cubicles were expected to be cleaned up during the last quarter of calendar year 1987.

The NRC continued to monitor the day-to-day cleanup operations of the licensee. The staff at TMI performed numerous reviews and issued approvals of the licensee's detailed defueling procedures and conducted periodic inspections of systems and of equipment used in the cleanup. In conjunction with headquarters staff, the NRC staff at the TMI site performed safety and technical reviews of licensee proposals for major cleanup efforts, in order to assure that they would genuinely contribute to the safe and expeditious cleanup of the plant.

The Advisory Panel for the Decontamination of Three Mile Island Unit 2, which is composed of citizens, scientists, and State and local officials, was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. (See Appendix 2 for a list of current members of the panel.) During fiscal year 1987, the panel held seven public meetings, in Harrisburg and Lancaster, Pa., and met with the NRC Commissioners in Washington, D.C. Among the topics addressed by the panel during these meetings were: TMI-2 health effects studies presented by the Pennsylvania Department of Health and local citizens, the status of the ongoing defueling operations, the Department of Energy's plans for off-site shipment and storage of fuel, the licensee's proposal for the disposal of accident-generated water, and the NRC's continuing oversight and enforcement activity.

Financial Aspects of TMI-2 Cleanup

Funding by GPU. (For background, see the *1986 NRC Annual Report,* p. 150.) Revenues collected by General Public Utilities Corporation's three operating subsidiaries in Pennsylvania and New Jersey continued to be expended on cleanup during 1987. Customer funding of the cleanup amounted to about $48 million in 1987 and is estimated to total approximately $250 million over the course of the cleanup effort. GPU continues to provide cash advances from internal sources to alleviate any cash flow problem related to cleanup activities. The total 1987 advance is estimated at $37 million. The GPU projections provided to NRC indicate a continuing GPU commitment to provide such cash advances as needed. Continued improvement in GPU's financial condition and cash flow position gives greater assurance that such cash advances will be made.

Cost Sharing Plan. During 1987, GPU continued to receive cash payments from all suggested contributors in the TMI-2 cleanup cost sharing plan proposed by Pennsylvania Governor Richard Thornburgh in July 1981 (see *1986 NRC Annual Report,* p. 150). The Edison Electric Institute's (EEI) industry cost-sharing program paid its committed $26 million annual contribution in 1987, the third year of industry contributions through the EEI program. The NRC will continue to monitor the cleanup funding situation closely.

ANNUAL REPORT 1988

United States Nuclear Regulatory Commission

Cleanup at Three Mile Island

Chapter 3

During fiscal year 1988, progress continued on the cleanup of the damaged reactor at Unit 2 of the Three Mile Island nuclear power plant (TMI-2) near Harrisburg, Pa. Defueling, decontamination, and the processing and shipment of radioactive waste all continued in parallel. It is required by law that these activities be covered in a separate chapter of the NRC annual report.

Defueling operations in the reactor vessel were performed from a shielded work platform located nine feet above the vessel flange. Long-handled tools and remotely operated equipment were used in defueling operations. As of the end of September 1988, the entire original core region had been defueled, including all 177 damaged partial length assemblies. Defueling and dismantling of the lower core support assembly was in progress at the end of the report period. Approximately 204,000 pounds (68 percent) of fuel and core debris have been removed out of an estimated total of 300,000 pounds. The steam generators, pressurizer, and hot legs have also been defueled. Principal areas remaining to be defueled include the reactor vessel lower head, baffle plate area, core bypass flow holes, and the decay heat drop line. Full completion of defueling is expected by mid-to-late 1989.

Shipment of core debris from the TMI site to the Idaho National Engineering Laboratory (INEL) continued as before. A total of 31 casks have been shipped to INEL, 15 of them during fiscal year 1988. These shipments have 191,300 pounds of debris, which is 64 percent of the estimated total to be shipped.

The submerged demineralizer system, originally used to decontaminate the water in the reactor building basement, has been removed from service. During its service life, it processed 4,566,000 gallons of water. The Defueling Water Cleanup System (DWCS) is currently being used to process water from the reactor coolant system and the "A" spent fuel pool. The EPICOR-II system processes the remainder of the contaminated water at TMI-2 and, through fiscal year 1988, had processed a total volume of 4,500,000 gallons.

When the reactor building basement was flooded, radionuclides were adsorbed and absorbed on concrete surfaces. The structural poured-concrete walls held the deposit primarily in a surface layer, while the hollow concrete block walls by the elevator shaft were permeated. Scarification, the abrasive removal of thin layers of concrete using ultra-high pressure water sprays, was used to reduce radioactivity levels in accessible structural walls. Holes were drilled in the hollow walls and they were flushed from the inside to leach out absorbed radionuclides.

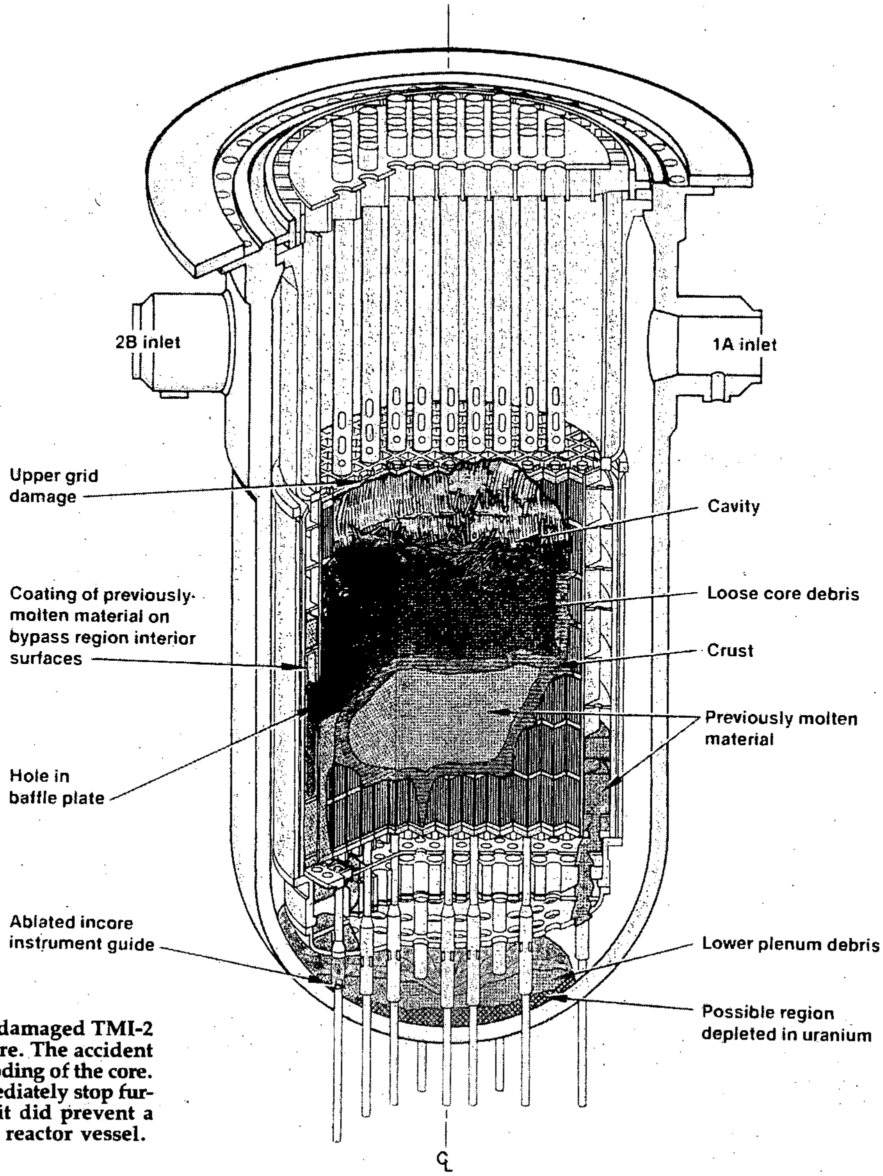
Scabbling (a mechanical abrasion and ablation process), steam vacuuming, and hands-on decontamination work continue in the auxiliary and fuel handling buildings. At the end of the fiscal year, 120 of 143 cubicles had been satisfactorily decontaminated. System flushes were in progress, with 61 of 76 identified system-flowpaths having been completed.

Dose rates to defueling crews remained low throughout the period. The exposure rates have averaged slightly less than 10 mrem/hour over the course of defueling thus far. Projected cumulative worker dose during calendar year 1988 was 960 person-rem. That was below the licensee's goal of 990 person-rem and less than the 1987 total of 975 person-rem.

The NRC continued on-site monitoring of the day-to-day cleanup operations at the TMI-2 site. The staff carried out reviews and inspections on the scene of licensee procedures, systems, equipment and operations. The on-site and Headquarters staff, in conjunction with the technical review branches, performed safety and technical reviews of license amendments, recovery operations plan changes, and licensee proposals for cleanup efforts to assure that the cleanup would proceed in a safe manner, in accordance with NRC regulations. In February 1988, the TMI-2 Project Directorate was terminated, and the inspection program for TMI-2 was assumed by the TMI resident inspection staff. Technical review and project management functions were assumed by a Headquarters project directorate.

In July 1986, GPU Nuclear Corporation (GPUN) submitted a proposal for disposing of approximately 2.3 million gallons of slightly radioactive water. The water was contaminated either during the March 1979 accident or during subsequent cleanup operations. The proposed method of disposal of the water is forced evaporation over a two-and-one-half year period. The residue from this operation—containing small amounts of the radioactive isotopes cesium-137 and strontium-90, and larger amounts of nonradioactive

TMI-2 Core End-State Configuration



The final state of the damaged TMI-2 reactor core is shown here. The accident was terminated by reflooding of the core. This action did not immediately stop further core melting, but it did prevent a melting through of the reactor vessel.

boric acid and sodium hydroxide—would require solidification and disposal as low-level waste. The staff evaluated the licensee's proposal together with eight alternative approaches, evaluating both the radiological and nonradiological consequences of implementing each alternative. The staff found that the licensee's proposal—to dispose of the water by forced evaporation to the atmosphere followed by on-site solidification of the remaining solids and disposal of the solids at a low-level waste facility—was an acceptable plan. The staff also concluded that none of the alternative methods of disposal was clearly preferable to the licensee's. The staff offered an opportunity for a hearing prior to taking final action on the licensee's proposal. The matter was pending before the Atomic Safety and Licensing Board at the end of fiscal year 1988.

In December 1986, the licensee proposed to place TMI-2 in an interim monitored storage condition for an unspecified period of time, after the completion of the current defueling effort. The licensee's term for this condition is "Post Defueling Monitored Storage." During this storage period, sampling and studies would be conducted to help decide on the best ultimate disposition of the facility. Should the decision be to no longer use the facility for any purpose, then it would remain in the storage condition until Three Mile Island Unit 1, on the same island site, was ready to be decommissioned. Both facilities would then be decommissioned together. The NRC staff has begun the environmental review of the licensee's proposal. In April 1988, the staff published Draft Supplement No. 3 to the "Programmatic Environmental Impact Statement" (NURGE-0683), dealing with "Post Defueling Monitored Storage and Subsequent Cleanup." The staff assessed the licensee's proposal and six alternatives. The licensee's proposal and one of the alternatives—continuing and completing the cleanup without a storage period—were evaluated in detail.

The NRC staff concluded that both the licensee's proposed plan and the NRC staff-identified alternative for completion of cleanup are within the applicable regulatory limits and each could be implemented without significant environmental impact. Neither alternative was found to be clearly preferable from an environmental impact perspective. The staff must complete a final version of the impact assessment and also conduct a safety evaluation prior to taking any action on the licensee's proposal.

The Advisory Panel for the Decontamination of the Three Mile Island Unit 2, which is composed of citizens, scientists, and State and local officials, was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. (See Appendix 2 for a list of current members of the panel.) During fiscal year 1988, the panel held five public meetings in Harrisburg and Lancaster, Pa. The principal topic discussed during the meetings was the licensee's proposal to place the facility in long term storage at the conclusion of the current cleanup effort.

Financial Aspects of TMI-2 Cleanup

Funding by GPUN. (For background, see the *1987 NRC Annual Report*, p.44.) Revenues collected by GPU Nuclear Corporation's three operating subsidiaries in Pennsylvania and New Jersey continued to be expended on cleanup during 1988. Customer funding of the cleanup amounted to about $34 million in 1988 and is estimated to total approximately $250 million over the course of the cleanup effort. GPUN continues to provide cash advances from internal sources to alleviate any cash flow problem related to cleanup activities. The total 1988 advance is estimated at $20 million. The GPUN projections provided to NRC indicate a continuing GPUN commitment to provide such cash advances as needed. Continued improvement in GPUN's financial condition and cash flow position gives greater assurance that such cash advances will be made.

Cost Sharing Plan. During 1988, GPUN continued to receive cash payments from all suggested contributors in the TMI-2 cleanup cost sharing plan proposed by then Pennsylvania Governor Richard Thornburgh in July 1981 (see *1987 NRC Annual Report*, p.44). The Edison Electric Institute's (EEI) industry cost-sharing program paid its committed $23 million annual contribution in 1988, the fourth year of industry contributions through the EEI program. The NRC will continue to monitor the cleanup funding situation closely.

ANNUAL REPORT 1989

United States Nuclear Regulatory Commission

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Operational Safety Assessment

The NRC headquarters staff participates with the regional staff in the review and follow-up of events at operating nuclear reactor facilities to identify items of generic significance and to determine if an ordered derating or shutdown of a plant is indicated. These reviews involve evaluating events against existing safety analyses, appraising plant and operator performance during events, reviewing licensee analyses, and assessing any need for corrective action.

In fiscal year 1989, the staff—as part of the formalized program for the assessment of major incidents—assigned augmented inspection teams to determine the facts regarding the following operating reactor events:

- Impaired shutdown cooling capability at Oyster Creek (N.J.) in October 1988.
- Electrical fire with loss of forced coolant flow at Oconee Unit 1 (S.C.) in January 1989.
- Backflow of reactor coolant through check valve in high-pressure injection line at Arkansas Unit 1 in January 1989.
- Unit 2 auxiliary transformer fault causes Unit 1 trip and equipment malfunction at LaSalle Units 1 and 2 (Ill.) in March 1989.
- Multiple equipment failures following load rejection at Palo Verde Unit 3 (Ariz.) in March 1989.
- Steam generator tube rupture at McGuire Unit 1 (N.C.) in March 1989.
- Unexpected opening of reactor core isolation cooling system valve at Pilgrim Unit 1 (Mass.) in April 1989.
- Inattentive licensee employees at Braidwood Units 1 and 2 (Ill.) in April 1989.
- Freeze plug failure in service water system at River Bend (La.) in April 1989.
- Hot water intrusion into auxiliary feedwater system at Comanche Peak Unit 1 (Tex.) in April 1989.
- Reactor operation outside bounds of test procedure at Seabrook Unit 1 (N.H.) in June 1989.
- Loss of safety system redundancy resulting in loss of control room instrumentation at Cook Unit 2 (Mich.) in August 1989.
- Inadequate net positive suction head of auxiliary feedwater pumps at Robinson Unit 2 (S.C.) in August 1989.
- Contamination of sub-basement by leaking drums at Nine Mile Point Unit 1 (N.Y.) in August 1989.
- Water spill from refueling water storage tank into auxiliary building at McGuire Unit 2 (N.C.) September 1989.

When generic problems are identified in the course of a staff review of reported events and problems, there are a number of actions that can be taken by the NRC. For one, Information Notices are issued to notify utilities of events or problems that could affect their plants. Utilities are expected to determine whether the problems described are applicable to their plants and to take appropriate corrective action. Bulletins have a similar function but further request specific actions to be taken by utilities and require written confirmation when actions have been completed. In fiscal year 1989, the staff issued 105 Information Notices and seven Bulletins, including supplements. Generic Letters may also be issued to address operational safety matters having broad applicability. In fiscal year 1989, the staff issued 13 Generic Letters of this type, including supplements.

CLEANUP AT THREE MILE ISLAND

During fiscal year 1989, progress continued on the defueling and cleanup of the damaged reactor at Unit 2 of the Three Mile Island nuclear power plant (TMI-2) near Harrisburg, Pa. Defueling is nearing completion, as radioactive waste and fuel debris shipments have continued in parallel. General Public Utilities Nuclear (GPUN) Corporation, the licensee, de-emphasized decontamination efforts in order to concentrate on defueling. The current level of effort in decontamination is geared toward maintaining plant access and operability of systems. When defueling is complete, the licensee intends to redirect its effort to decontamination.

During fiscal year 1989, the central portions of the five layers of the lower core support assembly (LCSA) were cut away and removed. This move provided an access path to the reactor vessel (RV) lower head. Loose core debris was vacuumed from the LCSA and the lower head and loaded into defueling canisters. A large (approximately six feet in diameter by 1.5-ft. thick), once molten, resolidified mass on the RV lower head was broken up and also placed in canisters. Several hundred pounds of fine loose debris were scraped and vacuumed from the hot legs. As of September 30, 1989, approximately 283,000 pounds (94 percent) of core debris has been removed out of a total of approximately 300,000 pounds. The remaining debris is principally located behind the core baffle plates, on the RV lower head, and in the outer periphery of the LCSA. The completion of defueling was expected by November 1989.

Shipment of core debris from the TMI site to the Idaho National Engineering Laboratory (INEL) continued. During fiscal year 1989, four shipments containing a total of 75,500 pounds of fuel debris were shipped. The total shipped to date is 266,800 pounds which is 89 percent of the estimated total to be shipped.

Exposure rates to defueling crews remained low, averaging approximately 10 millirems-per-hour over the course of defueling, to date. Projected cumulative worker exposure for calendar year 1989 was approximately 850 person-rem. This is below the 1988 total of 917 person-rem.

Public hearings on the GPUN proposal to evaporate 2.3 million gallons of accident-generated water (AGW) were held by an Atomic Safety and Licensing Board (ASLB). The hearings concluded on November 15, 1988. On February 3, 1989, the board issued a decision finding in favor of GPUN on all relevant issues. On April 13, 1989 the Commission affirmed the ASLB decision without prejudice to any appeals. GPUN began to construct the evaporator in August 1989. The licensee expected to complete testing and begin operation of the evaporator in late November 1989.

A July 1989 video inspection of the RV lower head disclosed several cracks which appeared to be associated with incore instrument penetration nozzles. Higher quality color videos and a mechanical probe were used in August to obtain better information on the cracks. The cracks appeared to be up to approximately 6 inches in length, 0.25 inch wide, and more than 0.19 inch deep, but not "throughwall" wide. An international research effort, funded in part by the NRC, will obtain samples from the RV lower head, including the area containing the cracks. That effort will take place after defueling has been completed.

The 11-member Advisory Panel for the Decontamination of Three Mile Island Unit 2, which is composed of citizens, scientists, and State and local officials, was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. (See Appendix 2 for a list of current members of the panel.) During fiscal year 1989, the panel held three public meetings in Harrisburg, Pa. Principal topics discussed by the panel during these meetings were the details of the licensee's AGW disposal system, off-site radiation monitoring programs around TMI-2, and the licensee's proposal to place the facility in long term storage at the conclusion of the current cleanup effort. In October 1988, the panel met with the NRC Commissioners to discuss a variety of concerns of local individuals and other issues.

Financial Aspects of TMI-2 Cleanup

Funding by GPUN. Revenues collected by the GPUN Corporation's three operating subsidiaries in Pennsylvania and New Jersey continued to be expended on cleanup during calendar year 1989. Customer funding of the cleanup amounted to about $7.7 million in 1989 and is estimated to total approximately $255.9 million over the course of the cleanup effort. GPUN continues to provide cash advances from internal sources to alleviate any cash-flow problem related to cleanup activities. The total 1989 advance is estimated at $6.5 million. The GPUN projections provided to the NRC indicate a continuing GPUN commitment to provide such cash advances as needed. Continued improvement in the GPUN's financial condition and cash-flow position gives greater assurance that such cash advances will be made.

Cost-Sharing Plan. During calendar year 1989, the GPUN continued to receive cash payments from all suggested contributors in the TMI-2 cleanup cost sharing plan proposed by Pennsylvania Governor Richard Thornburgh in July 1981. The Edison Electric Institute's (EEI's) industry cost-sharing program paid its committed $16.3 million annual contribution in 1989, the fifth year of industry contributions through the EEI program. The NRC continues to monitor the cleanup funding situation.

ANTITRUST ACTIVITIES

As required by law since December 1970, the staff has conducted pre-licensing antitrust reviews of all construction permit applications for nuclear power plants and certain commercial nuclear facilities. (See "Procedures for Meeting NRC Antitrust Responsibilities," NUREG-0970, May 1985.) In addition, applications to amend construction permits or operating licenses transferring ownership interest or operating responsibility in a nuclear facility are subject to antitrust review.

In fiscal year 1989, the staff completed antitrust operating license reviews associated with three power production facilities and one construction permit antitrust review of a uranium-enrichment facility. The staff also received one request to re-evaluate one of the reviews associated with a production facility. The staff ultimately concluded that there had been no significant activity on the part of the licensees that would create or maintain a situation inconsistent with the antitrust laws. Additionally, the staff initiated one operating license review of a power production facility and one construction permit review of a uranium enrichment facility.

ANNUAL REPORT 1991

United States Nuclear Regulatory Commission

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UNITED STATES NUCLEAR REGULATORY COMMISSION

When generic problems are identified in the course of a staff review of reported events and problems, there are a number of actions that can be taken by the NRC. If warranted, Information Notices are issued to notify utilities of events or problems that could affect their plants. Utilities are expected to determine whether the problems described are applicable to their plants and to take appropriate corrective action. Bulletins have a similar function but request specific actions to be taken by utilities and require written confirmation when actions have been completed. In fiscal year 1991, the staff issued 98 Information Notices, including 16 supplements, and two Bulletin supplements. Generic Letters may also be issued to address operational safety matters having broad applicability. In fiscal year 1991, the staff issued 19 Generic Letters, including three supplements.

Implementation Status of Safety Issues

The NRC publishes a document annually giving the status of the implementation of planned actions dealing with major safety issues. Volume 1 of this document—setting forth the status of implementation and verification of actions addressing the Three Mile Island (TMI) Action Plan Requirements— was published in March 1991. Volume 2—describing the status of implementation and verification of unresolved safety issues (USIs)—was published in May 1991. Volume 3—which addresses the status of implementation and verification of generic safety issues (GSIs)—was published in June 1991. These reports constitute the basis for a combined, updated annual report to the Commission, the first to be issued in November 1991.

As reported in volume 1 of the document, approximately 99 percent of the TMI Action Plan items have been implemented at the 112 licensed plants. Of the 13,527 applicable items, 13,404 have been completed or closed out, and only 123 remain open. About 50 percent of the remaining 123 open items are projected to be implemented by the end of calendar year 1992.

CLEANUP AT THREE MILE ISLAND

During fiscal year 1991, preparations continued for placing the damaged Unit 2 reactor at the Three Mile Island (Pa.) nuclear power plant (TMI–2) in post-defueling monitored storage (PDMS). (PDMS is a passive monitored state similar to the SAFSTOR option of decommissioning.) The NRC has offered the opportunity for a public hearing prior to issuance of the license change which would authorize implementation of the monitored storage. Final residual fuel measurements and calculations for special nuclear material accountability at the facility are nearing completion. The evaporator system, used to dispose of the 2.1 million gallons of accident-generated water, began operation and has decontaminated and vaporized approximately one-third of the water.

In August of 1988, General Public Utilities Nuclear (GPUN) Corporation, the licensee, submitted a Safety Analysis Report to document and support their proposal to amend the TMI–2 license to allow the facility to enter PDMS. Through the end of fiscal year 1991, the licensee had issued 13 amendments to the report. The NRC staff and contractor consultants from Battelle Memorial Institute's Pacific Northwest Laboratory (PNL) have evaluated the licensee's proposals and are preparing a Safety Evaluation regarding the license conditions and technical specifications necessary to implement PDMS. The evaluation is expected to be issued early in fiscal year 1992. On April 25, 1991, the staff published a notice of opportunity for a prior public hearing regarding the license change to implement PDMS.

During July and August of 1991, the reactor vessel was drained to make final measurements of the residual fuel remaining in the vessel. The reactor vessel fuel measurement program is the final step in the special nuclear materials accountability program at TMI–2. The measurement technique made use of an array of helium-filled detectors to measure fast neutrons produced by the residual fuel. Calibrations were made using americium-berylium and californium sources. Because of the very complex geometries involved, data reduction and calculations are not expected to be completed until early in calendar year 1992. The NRC staff and consultants from PNL have performed independent evaluations and made independent measurements of GPUN's earlier fuel measurements in the auxiliary and reactor buildings. The staff and PNL will continue to monitor and evaluate the licensee's reactor vessel fuel measurement program.

The evaporator system began vaporizing accident-generated water on January 24, 1991, after a prolonged period of system testing, modification, and repair. At the end of fiscal year 1991, a total of 738,800 gallons had been decontaminated and vaporized.

The 11-member Advisory Panel for the Decontamination of Three Mile Island Unit 2 is composed of citizens, scientists, and State and local officials. (See Appendix 2 for a listing of members.) The panel was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. During fiscal year 1991, the panel held two meetings in Harrisburg, Pa. Principal topics discussed at these meetings included decommissioning funding status and plans, results of cancer studies in the TMI area, status and progress of the cleanup at the TMI–2 facility, and the future of the Advisory Panel.

ANNUAL REPORT 1992

United States Nuclear Regulatory Commission

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UNITED STATES NUCLEAR REGULATORY COMMISSION

- Unusual event and manual scram resulting from power oscillations at Washington Nuclear Unit 2 (Wash.) in August 1992.

- Scram without feedwater trip and other equipment failures at LaSalle Unit 2 (Ill.) in August 1992.

When generic problems are identified in the course of a staff review of reported events and problems, there are a number of actions that can be taken by the NRC. If warranted, Information Notices are issued to notify utilities of events or problems that could affect their plants. Utilities are expected to determine whether the problems described are applicable to their plants and to take appropriate corrective action. Bulletins have a similar function, but they request that specific actions be taken by utilities, and they require written confirmation when actions have been completed. In fiscal year 1992, the staff issued 105 Information Notices, including nine supplements, and four Bulletins, including one supplement. Generic Letters may also be issued to address operational safety matters having broad applicability. In fiscal year 1992, the staff issued 14 Generic Letters, including one revision and four supplements.

Cleanup at Three Mile Island

During fiscal year 1992, preparations continued for placing the damaged Unit 2 reactor at the Three Mile Island (Pa.) nuclear power plant (TMI–2) in post-defueling monitored storage (PDMS). PDMS constitutes a passive, monitored state similar to the SAFSTOR option of decommissioning. The NRC staff estimates that the plant will be physically ready to enter PDMS by August of 1993. The licensee, GPU Nuclear (GPUN), plans to keep TMI–2 in the PDMS state until both TMI–1 and TMI–2 are decommissioned, expected in 2014.

In August of 1988, GPUN submitted a safety analysis report (SAR) to the NRC documenting its proposal to amend the TMI–2 license to allow the facility to enter PDMS. Throughout fiscal year 1992, GPUN submitted 15 amendments to this SAR. The NRC staff and contractor consultants from Battelle Memorial Institute's Pacific Northwest Laboratory (PNL) have evaluated the licensee proposals, and a Safety Evaluation (SE) addressing the license conditions and technical specifications necessary to implement PDMS was issued on February 20, 1992. As part of the evaluation, the staff published a technical evaluation report (TER) which appraised PDMS as an integrated process and assessed licensee commitments that were not in the technical specifications. The staff published a notice of opportunity for a prior public hearing regarding the license change to implement PDMS, on April 25, 1991. One individual petitioned to intervene. The petitioner, the licensee, and the NRC staff reached a settlement on September 25, 1992, and the request to intervene was withdrawn; on October 16, 1992, the Atomic Safety and Licensing Board dismissed the proceeding.

In early fiscal year 1992, final neutron measurements of the residual fuel remaining in the vessel were completed. The reactor vessel fuel measurement program is the final step in the special nuclear materials (SNM) accountability program at TMI–2. The SNM inventory is being taken in accord with agreements between GPUN, the Department of Energy (DOE), and the NRC regarding the core material accountability and fuel transfer to DOE. The NRC staff and consultants from PNL have performed independent evaluations and made independent measurements of GPUN's earlier fuel measurements in the auxiliary and reactor buildings. The staff and PNL will evaluate the final results of GPUN's reactor vessel fuel measurement program.

The evaporator used to decontaminate and dispose of the 2.3 million gallons of accident generated water (AGW) continued processing and vaporizing AGW during fiscal year 1992. During a large portion of fiscal year 1992, the evaporator system was used in a "decoupled" mode, i.e., the evaporators decontaminate incoming water, but no water is sent to the vaporizer. This mode is used to pre-process water for later reprocessing in the "coupled" mode, where it is vaporized. At the end of fiscal year 1992, a total of approximately 1,282,000 gallons of AGW had been decontaminated and vaporized.

The 11-member Advisory Panel for the Decontamination of Three Mile Island Unit 2, composed of citizens, scientists, and state and local officials, was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. (See Appendix 2 for membership.) During fiscal year 1992, the panel held two meetings in Harrisburg, Pa. Major topics discussed at these meetings included the NRC staff's SE and TER addressing PDMS, the status and progress of cleanup at the TMI–2 facility, and the decommissioning funding status and plans.

ANTITRUST ACTIVITIES

As required by law since December 1970, the staff has conducted pre-licensing antitrust reviews of all construction permit and operating license applications for nuclear power plants and certain commercial nuclear facilities. (See "Procedures for Meeting NRC Antitrust Responsibilities," NUREG–970, May 1985.) In addition, applications to amend construction permits or operating licenses resulting from a proposed transfer of ownership interest or operating responsibility in a nuclear facility are subject to antitrust review.

ANNUAL REPORT 1993

United States Nuclear Regulatory Commission

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- Loss of iridium-192 source and therapy misadministration at Indiana Regional Cancer Center (Ind.), in November 1992.
- Unauthorized forced entry into protected area at Three Mile Island Unit 1 (Pa.), in February 1993.

When generic problems are identified in the course of staff reviews of reported events and problems, a number of actions that may be taken by the NRC. If warranted, Information Notices are issued, notifying utilities of conditions or problems that could affect their plants. Utilities are expected to review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Bulletins and Generic Letters have a similar function but may request that specific actions be taken by utilities and require written confirmation when such actions have been completed. In fiscal year 1993, the NRC began issuing a new class of generic communication, called Administrative Letters, to transmit information to the utilities that is essentially administrative in nature. In fiscal year 1993, the staff issued 99 Information Notices, including one revision and six supplements; six bulletins, including two supplements; nine Generic Letters, including two supplements; and four Administrative Letters.

Cleanup at Three Mile Island

During fiscal year 1993, preparations continued for placing the damaged reactor at the Three Mile Island Unit 2 (TMI-2; Pa.) nuclear power plant in post-defueling monitored storage (PDMS), a passive, monitored state similar to the SAFSTOR option of decommissioning.

In August of 1988, the licensee, GPU Nuclear (GPUN), submitted a Safety Analysis Report (SAR) to document and support their proposal to amend the TMI-2 license to a "possession-only" license and to allow the facility to enter PDMS. The staff issued Final Supplement 3 to the Programmatic Environmental Impact Statement for the TMI-2 decontamination and cleanup, in August of 1989. In February 1992, the staff issued a safety evaluation regarding the PDMS license amendment and a technical evaluation report regarding PDMS. These three NRC staff documents form the basis for the staff position on the acceptability of PDMS. On April 25, 1991, the staff published a notice of opportunity for a prior hearing regarding the licensee's request to amend its license. A member of the public petitioned to intervene in the license amendment proceedings. The petitioner, the licensee, and the NRC staff reached a settlement agreement on September 25, 1992. The request to intervene was withdrawn and on October 16, 1992, the Atomic Safety and Licensing Board dismissed the proceeding.

The reactor building preparations for PDMS were completed in October 1992, and it is now in a pre-PDMS condition. The NRC staff issued a possession-only license on September 14, 1993; the expectation is that TMI-2 will enter PDMS late in the fourth quarter of calendar year 1993 or early 1994. GPUN plans to keep TMI-2 in the PDMS state until they simultaneously decommission TMI-1 and TMI-2 in 2014.

On February 1, 1993, GPUN notified the NRC staff that the current best estimate of the residual fuel in the reactor vessel was 2,040 pounds (925 kilograms), based on data from recently completed fast-neutron measurements. The measurement technique made use of an array of helium filled detectors to measure fast neutrons produced by the residual fuel. The estimate was derived from calculations made by on-site staff and an independent review by an off-site group headed by Dr. Norman Rasmussen of the Massachusetts Institute of Technology. The estimate was reviewed and endorsed by three other independent reviewers from national laboratories.

For the balance of the facility external to the reactor vessel, earlier licensee estimates based on measurements, sample analyses, and visual observations indicated that no more than 385 pounds (174.6 kilograms) of residual fuel remains. The NRC staff and consultants from Battelle Pacific Northwest Laboratories have performed independent evaluations and made independent measurements of these earlier fuel measurements in the auxiliary and reactor buildings. On July 6, 1993, the staff issued an analysis confirming earlier analyses done by the licensee which indicated that the fuel remaining in the TMI-2 reactor vessel will remain subcritical, with an adequate margin of safety, during PDMS.

Evaporation of the treated, accident-generated water began in January 1991, after a prolonged period of system testing, modification and repair. On August 12, 1993, the decontamination and evaporation of 2.23 million gallons of accident-generated water was completed.

The 10-member Advisory Panel for the Decontamination of Three Mile Island Unit 2, held its last meeting during fiscal year 1993. The Panel, composed of citizens, scientists, and State and local officials, was formed by the NRC in 1980 to provide input to the Commission on major cleanup issues. (See Appendix 2 for a listing of the members.) The principal topics discussed at these meetings included the NRC staff Safety Evaluation and technical evaluation report addressing PDMS, the status and progress of cleanup at the TMI-2 facility, and the decommissioning funding status and plans. Two meetings were held in fiscal year 1993: the first was held at NRC headquarters in Rockville, Md., while the last meeting (the 78th overall) was held in Harrisburg, Pa., on September 23, 1993. Commissioner Kenneth Rogers attended the final session to express the Commission's appreciation to the Advisory Panel for their dedication and service over the past 13 years.

Loss of Spent Fuel Pool Cooling Function

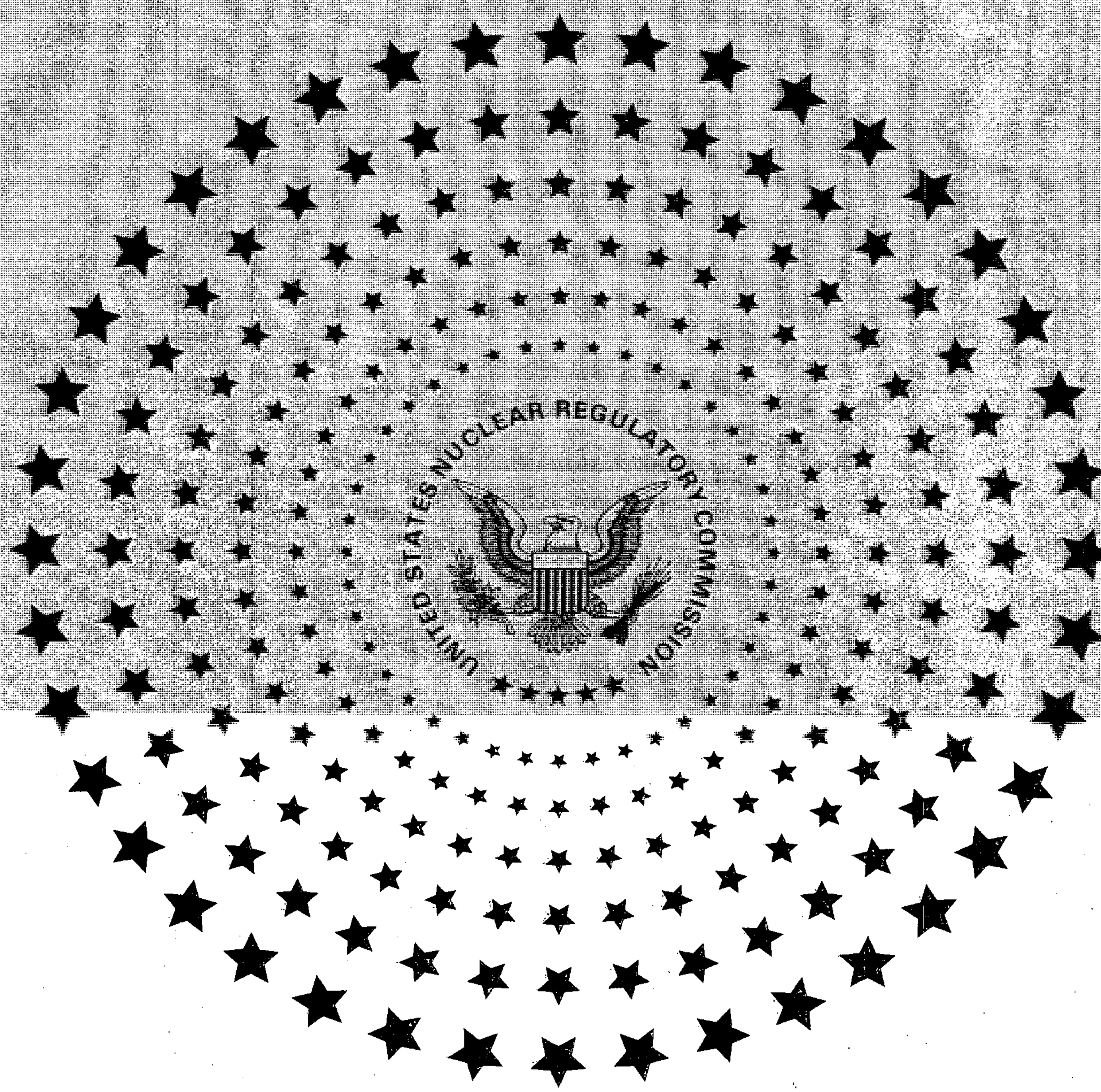
The staff is evaluating a 10 CFR Part 21 report filed on November 27, 1993, contending that the design of a certain reactor facility failed to meet numerous regulatory requirements with respect to a postulated loss of normal cooling function in the spent fuel pool. The report provided a series of detailed technical and regulatory arguments to support the assertion.

The Advisory Panel for the Decontamination of Three Mile Island Unit 2 held its last meeting during fiscal year 1993. The Advisory Panel had been formed by the NRC in 1980 to provide input to the Commission on major cleanup issues at the TMI site. The last meeting (the 78th overall) was held in Harrisburg, Pa., on September 23, 1993. Commissioner Kenneth Rogers attended the final session to express the Commission's appreciation to the Advisory Panel for their dedication and service over the past 13 years.

Panel members attending the final meeting are pictured above. They are, left-to-right, front row: Ann Trunk, Resident of Middletown, Pa.; Arthur E. Morris (Panel Chairman), Resident and former Mayor of Lancaster, Pa.; Joel Roth (Panel Vice Chairman), Resident of Harrisburg, Pa.; Elizabeth Marshall, Resident of York, Pa. In the back row, left-to-right, are: Kenneth L. Miller, Director of the Division of Health Physics and Professor of Radiology, Milton S. Hershey Medical Center, Hershey, Pa.; Thomas Smithgall, Resident of Lancaster, Pa.; Lee H. Thonus, Alternate Designated Federal Official, Non-Power Reactors and Decommissioning Projects Directorate, NRC Office of Nuclear Reactor Regulation (Region I); John Leutzelschwab, Professor of Physics, Dickinson, College, Carlisle, Pa.; Niel Wald, Professor, Department of Environmental and Occupational Health, University of Pittsburgh, Pittsburgh, Pa.; Michael T. Masnik, Designated Federal Official, Non-Power Reactors and Decommissioning Project Directorate, NRC Office of Nuclear Reactor Regulation; Frederick S. Rice, Resident of Harrisburg, Pa.; and Gordon Robinson, Associate Professor of Nuclear Engineering, Pennsylvania State University, University Park, Pa.

U.S. NUCLEAR REGULATORY COMMISSION

1995 ANNUAL REPORT



the factors contributing to the phenomenon, and to evaluate potential remedies. This effort led to the development of a draft bulletin entitled, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling Water Reactors," and a draft regulatory guide (RG) DG-1038 (proposed revision 2 to RG 1.82) entitled, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident." The draft bulletin and RG detail the staff's proposed resolution for this issue, and were issued on July 31, 1995, for a 60-day public comment period. The draft bulletin outlines three options for resolving this issue, although licensees are free to propose alternative means of resolution:

(1) Install large strainers of sufficient capacity to prevent the strainers from clogging.

(2) Install a self-cleaning strainer with the capability to remove debris from the strainer surface, thereby preventing clogging.

(3) Install a backflush system.

Each of these options would require additional supporting measures to ensure compliance with 10 CFR Part 50.46. For example, for backflush, an analysis would be required to demonstrate that operators have sufficient time and system capability to operate the backflush in a timely fashion and for as many times as might be needed during an accident. The current schedule for resolving this issue calls for issuance of a final bulletin by early 1996.

CLEANUP AT THREE MILE ISLAND

During 1994, the damaged reactor at Three Mile Island Nuclear Station (TMI) Unit 2 (Pennsylvania), was placed in post-defueling monitored storage (PDMS), a passive, monitored state similar to the SAFSTOR decommissioning alternative. GPU Nuclear, the TMI licensee, plans to maintain Unit 2 in PDMS until TMI Unit 1 permanently ceases operation. At that time, the licensee will decommission both units simultaneously. The NRC staff continues to monitor TMI Unit 2, and requires the licensee, to submit quarterly PDMS reports summarizing ongoing Unit 2 activities.

LOSS OF SPENT FUEL POOL COOLING FUNCTION

The staff has completed its site-specific evaluation of a 10 CFR Part 21 report, which was filed on November 27, 1992. That report contends that the design of the Susquehanna Steam Electric Station (SSES) (Pennsylvania) failed to meet numerous regulatory requirements with respect to a postulated sustained loss-of-cooling function in the spent fuel pool mechanistically resulting from a LOCA. The 1993 and 1994 NRC Annual Reports provide background regarding the postulated event sequence and early NRC review activities. In general, the staff concluded that suitable modifications had been made to SSES to address postulated seismically induced design-basis events within the facility's licensing basis. The staff further concluded that other postulated events leading to a sustained loss of spent fuel pool cooling were outside the licensing basis for SSES, and the potential for occurrence was remote. The staff presented its findings before the Advisory Committee for Reactor Safeguards (ACRS) on December 8, 1994, and documented its conclusions in a safety evaluation report for SSES, which was issued to the Pennsylvania Power and Light Company (the licensee) on June 19, 1995. The staff also issued NRC Information Notice (IN) 93-83, Supplement 1, on August 24, 1995, to summarize the conclusions for the nuclear industry and members of the public.

The staff is currently implementing a generic plan to address the concerns identified in the 10 CFR Part 21 report, as well as separate concerns related to spent fuel storage pools identified during a special inspection at a permanently shutdown reactor facility. The generic plan includes the following actions:

- search and analysis of information regarding spent fuel storage pool issues

- assessment of spent fuel storage pool operation and design at selected reactor facilities