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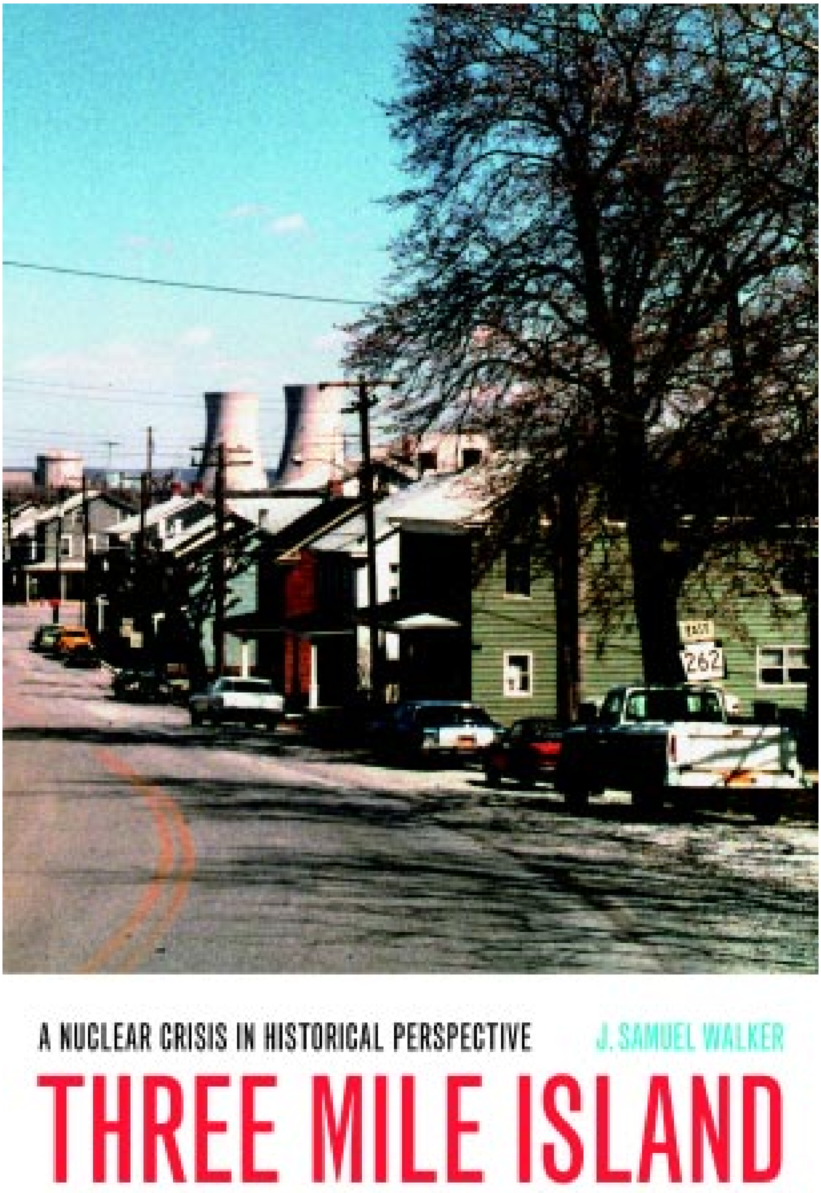

Chapter 4

Wednesday, March 28, 1979

"This Is the Biggie"

The first five hours of the graveyard shift that began at 11:00 P.M. on March 27, 1979, at the TMI-2 reactor were uneventful. The plant ran at 97 percent of full power while a staff of six employees monitored its operation and performed routine duties. The generator produced nearly nine hundred megawatts of electricity as clouds of steam billowed out of the plant's two cooling towers. TMI-1 was not operating because it had been shut down for routine refueling.

Like all power reactors built by Babcock and Wilcox and about two-thirds of the nuclear plants in operation in early 1979, both units at Three Mile Island were pressurized water reactors (PWRs). Three nuclear plant manufacturers used the principles of PWR design: Westinghouse, Combustion Engineering, and Babcock and Wilcox. The fourth vendor, General Electric, employed a different design called a boiling water reactor. In PWRs, the water pumped through the pressure vessel (at a rate of some ninety thousand gallons per minute) is kept under high pressure. As the water passes through the core, it is heated to about six hundred degrees Fahrenheit under normal operating conditions, but the high pressure of about twenty-two hundred pounds per square inch (150 times greater than atmospheric pressure) prevents it from boiling. In the TMI-2 plant, the core contained about a hundred tons of uranium encased in 36,816 thin, twelve-foot-long fuel rods. The pressure vessel that housed the core was thirty-six feet high and had steel walls nine inches thick.

Water circulates through the core in a PWR in what is known as the primary loop. After the heated water exits the core, it proceeds to one or more large containers called steam generators; the two steam generators at the TMI-2 plant were each seventy-three feet high. In the steam generators, the heat from the water passing through the core is transferred to the secondary loop, a separate system for circulating water. The

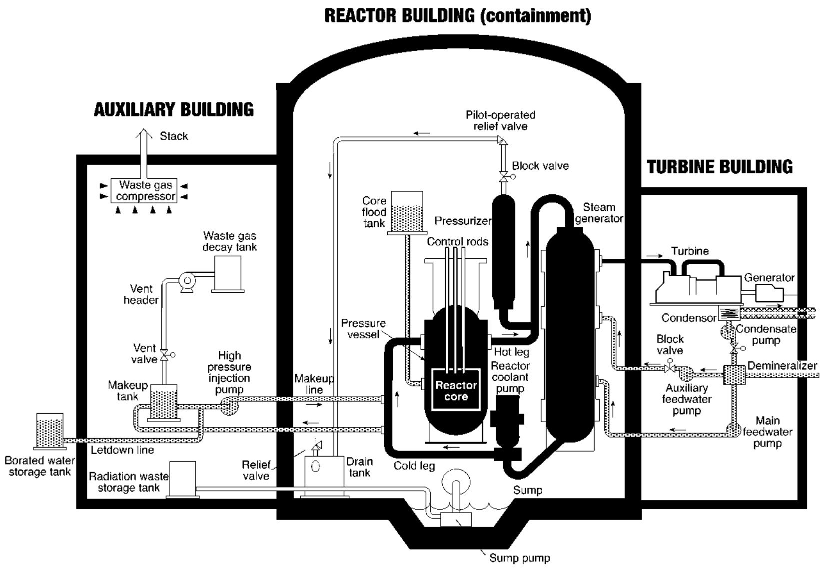

Figure 4. Schematic diagram of TMI-2. (Adapted from *IEEE Spectrum* 16 [November 1979]: 43–45. © 1979 by the Institute of Electrical and Electronics Engineers, Inc.)

water in the secondary loop is allowed to boil, creating the highly forceful steam that runs the turbine. The water from the primary loop becomes mildly radioactive from its contact with the core, but it is isolated from the water in the secondary loop. After transferring its heat in the steam generators, the water in the primary loop returns to the core. The steam in the secondary loop that drives the turbine is condensed back into liquid form and recirculated.[1]

THE CAUSES OF THE ACCIDENT

The chain of events that set off the severe accident at TMI-2 and melted a substantial portion of its core began innocently enough at 4:00 A.M. on March 28. The initial problem occurred when pumps in the condensate polishing system tripped. After steam that drives the turbine is condensed back to a liquid state, it passes through the condensate polishers, which remove impurities in the water. This process is a part of the secondary loop. Operators at TMI-2 had been working for several hours to clear a blockage in one of the eight polishers when the system's pumps unexpectedly shut down for reasons that have never been determined. A polisher bypass valve that would have allowed the water to continue flowing failed to open. One second after the pumps quit, the main feed-water pumps that sent water to the steam generators automatically tripped in response to the cutoff of water from the condensate polishers. Immediately, according to design, the turbine tripped, shutting down the plant. As soon as the turbine tripped, auxiliary feed-water pumps came on. But the flow of water from the auxiliary pumps to the steam generators was blocked by two valves that had inadvertently been left in a closed position. At this point the secondary system was unable to provide water to the steam generators.

The closing of the secondary system caused heat and pressure to rise rapidly in the primary system, largely because the steam generators could no longer remove heat from the water that had come from the core. As a result, eight seconds after the polisher pumps tripped, the reactor scrammed automatically. The control rods entered the core and terminated the production of heat from nuclear fission. But the problem of dealing with decay heat remained, and it was greatly complicated when a critical valve, called a pilot-operated relief valve (PORV), stuck open. This permitted large volumes of cooling water from the primary system to escape. The earlier events in the accident were serious but not unprecedented, irreparable, or particularly alarming. The failure of the relief valve was the principal mechanical cause of what soon became a grave crisis at Three Mile Island.

The PORV sat on top of a large container called the pressurizer, which at TMI-2 was forty-two feet high. The pressurizer performs a vital function in PWRs: using electric heaters and water sprays, it regulates the pressure in the primary system. Maintaining proper pressure is essential not only for operating efficiency but also for safety. A sudden increase can damage pipes and other equipment in the primary system, including the pressure vessel that holds the core (the pressurizer should not be confused with the reactor pressure vessel). If the pressure in a reactor rises so rapidly that the normal operation of the pressurizer cannot handle it, the PORV opens automatically to reduce system pressure. At TMI-2, the PORV opened three seconds after the condensate pumps tripped, exactly as designed. Unfortunately, ten seconds later, after the temperature and pressure in the primary system had diminished, it failed to close as designed. The open relief valve allowed growing quantities of reactor coolant to escape. This was not the first time that the PORV had stuck open at TMI-2, and it was a chronic problem at Babcock and Wilcox plants. The same sequence of events had occurred at Davis-Besse in 1977.

In that case, an operator recognized that the valve was open and immediately blocked it.[2]

The operators at TMI-2, however, did not realize what had happened and did not promptly shut off the PORV. Within a few seconds after the accident began, the plant's alarm systems, including a loud horn and more than a hundred flashing lights on the control panels, announced the loss of feed-water in the secondary loop, the turbine trip, the reactor trip, and other abnormal events. But they offered little guidance about the causes of those occurrences and did not differentiate between trivial and vital problems. One of the operators, Craig Faust, later commented, "I would have liked to have thrown away the alarm panel. It wasn't giving us any useful information." To make matters worse, there was no clear signal to show the position of the PORV. A signal light that had been installed during start-up testing a year earlier showed only that electrical current was sent to the valve to open it; by inference the valve was closed when the current (and the signal) were off. The operators checked the signal on the morning of the accident, saw that it was not lighted, and assumed, therefore, that the valve had closed properly. The operators might have determined that the valve was open by looking at a pressure indicator for the reactor-coolant drain tank, which was where the water that poured out of the open PORV wound up. But that signal was situated behind the seven-foot-high instrument panels that were the dominant feature of the control room. The operators had to walk around the tall panels to look at the drain-tank indicator, and did not do so as they attempted to cope with the flurry of confusing signals they were already receiving.[3]

The operators saw no definite signs that the plant was suffering a loss-of-coolant accident and was in danger of core "uncovery," in which the core is not fully covered with water. Their training programs had not prepared them for the conditions they confronted on the morning of March 28. The operators and supervisors on duty were well-qualified professionals, but they were baffled by the information they received. The two operators in the control room, Faust and Edward Frederick, were veterans of the navy's nuclear submarine program, had joined Met Ed in 1973, and had completed operator qualifying programs. The shift foreman, Fred Scheimann, who was in the turbine building trying to unclog a condensate polisher when the accident began, had also served in the nuclear navy. He had acquired fifteen years of nuclear experience and had worked at TMI for six years. Like his colleagues, the shift supervisor, William Zewe, had received his initial nuclear training in the navy.

Figure 5. The control room of TMI-2 as it appeared on April 3, 1979 (National Archives 220-TMI-DE9040061–13).

He had a total of thirteen years of nuclear experience and had been employed at TMI for seven years.

The navy provided the foremost talent pool for operators in the commercial nuclear industry, and it gave them solid training in the principles and procedures involved in running reactors. In addition, TMI-2 operators received training from Met Ed and from Babcock and Wilcox, which provided extensive experience on a reactor simulator. They were required to pass examinations administered by the NRC to qualify for operator licenses and to renew the licenses every two years. As a group, operators at TMI scored above the national average on NRC qualifying exams. Nevertheless, the experience and training of the operators on duty at TMI-2 when the accident occurred, and of the reinforcements that they soon called in, did not prepare them to cope with the deteriorating conditions in the plant. Their training courses and testing procedures placed much more emphasis on carrying out routine operating tasks, responding to minor malfunctions, and memorizing course materials than on developing the analytical skills needed to deal effectively with unanticipated problems. Operator training was not a high priority for the NRC or the nuclear industry, and the deficiencies in existing programs exacted a heavy price during the TMI-2 accident.[4]

The fundamental source of confusion for the operators on the morning of March 28 was that the water level in the pressurizer was high but the pressure in the primary system was low. This condition occurred because water was leaving the core and escaping out of the primary system through the open PORV. The water level in the pressurizer rose as coolant flowed through it. There was no instrument in the control room that acted like a gasoline gauge in an automobile to show the amount of coolant in the core. Operators judged the level of water in the core by the level in the pressurizer, and since that was high, they assumed that the core was covered with coolant. They were confused by the seemingly contradictory signals that the water level indicator for the pressurizer kept climbing while the pressure in the core was low.

The operators' primary concern was not the possibility that the plant was experiencing a loss-of-coolant accident but the possibility that the pressurizer was "going solid." Under normal conditions, the pressurizer contains both water and a steam cushion that are used to maintain proper pressure in the primary loop. If the pressurizer goes solid, it fills with water, which eliminates the steam and severely impairs the means of controlling pressure in the system. The operators at TMI-2 had been trained by both Babcock and Wilcox and Met Ed to avoid letting the pressurizer go solid, and they were keenly aware that filling it with water was undesirable and perhaps disastrous. Zewe, the shift supervisor, later explained that "if you go solid, you worry about an overpressure condition; you also worry about an underpressure condition, too, and the uncontrolled aspect of it."[5]

While the TMI-2 staff struggled to sort out conflicting signs and decide on appropriate actions, the plant's emergency core cooling system began to operate as designed. About two minutes into the accident, the high-pressure injection pumps, a part of the ECCS, automatically activated in response to the loss of coolant from the core. The two pumps fed water into the primary system at a rate of about a thousand gallons per minute, which was sufficient to make up for the coolant escaping through the open PORV. The high-pressure injection system, triggered by the low pressure and rising temperatures in the core, performed flawlessly. Despite the fact that the ECCS came on, the operators remained focused on their concern about the pressurizer going solid. In that context, the addition of a large volume of water to the primary loop was not a welcome development because it seemed to increase the chances that the pressurizer would fill with water. Therefore, about four and a half minutes into the accident, Scheimann, the shift foreman, ordered that one of the high-pressure injection pumps be shut down and the other sharply throttled back. He did so, he later recalled, because "pressurizer [water] level at that point was indicating that it was coming up at a rapid rate, and was rapidly approaching your solid indication." As a result, the plant lost much of a vital component of its defense against a loss-of-coolant accident.[6]

The effects of the ill-advised decision to scale back on the flow of water from the ECCS were compounded when the operators also shut off the four reactor coolant pumps. The pumps were huge pieces of equipment, described in one report as each the "size of a small truck." They were a part of the reactor's primary system; their function during normal operation of the plant was to force coolant through the core. A little more than an hour into the accident, the pumps began to shake so furiously that the operators could feel the vibrations in the control room. This was a result of the rising heat in the core and the growing presence of steam in the coolant. The operators still did not recognize that they were dealing with a loss-of-coolant accident, and in accordance with their training, at 5:14 A.M. they shut down two of the pumps to prevent damage to them. At 5:41 A.M. they turned off the other two.

As long as the reactor coolant pumps were operating, they circulated enough water and steam through the core to keep it covered. After the pumps were closed down, however, the steam in the pressure vessel (which provided some core cooling) separated from the water and rose to the top of the vessel, the level of cooling water fell even further, and the fuel assemblies in the core soon became uncovered. At that point the plant was suffering the kind of loss-of-coolant accident that reactor experts had long feared and tried to prevent. As a consequence of mechanical failures and operator errors, what began as a series of minor malfunctions escalated into a major crisis.[7]

In the first one hundred minutes or so of the accident, any one of a number of actions would have maintained adequate core cooling. If the operators had closed the PORV, allowed the ECCS to perform as designed, or kept the reactor coolant pumps running, the core would have remained covered and the emergency would have ended with minimal effects. As it was, water continued to pour out of the open PORV, the throttled high-pressure injection pumps could not provide more than a fraction of the coolant that was lost, and the shut-off reactor coolant pumps could not circulate coolant through the core. The plant operators failed to recognize indications of an increasingly serious loss-of-coolant accident. Although they did not panic, they grew progressively more troubled by the conflicting signals they received from the control panels. The plant's alarms contributed to a general atmosphere of confusion by continually reactivating. Finally, Brian Mehler, a shift supervisor who had just arrived at the plant to relieve Zewe, concluded from the pressure and temperature readings in the primary loop that the PORV was at least partially open. He was not certain of what was happening in the core, but he reasoned that no harm and perhaps some benefit could be achieved by shutting the offending relief valve. At 6:22 A.M., he ordered that a backup for the PORV, called a block valve, be closed. By that time, about thirty-two thousand gallons of coolant, more than one-third of the volume in the primary system, had flowed out of the stuck-open PORV. None of the staff in the control room took action to determine how long the PORV had been open or to replace the coolant that had escaped. Closing the block valve was a sound decision but insufficient in itself to prevent the severe damage to the core that leaving the PORV open for about two hours and twenty minutes had caused.

Within a short time after the reactor coolant pumps were shut down, the core began to slump. Without adequate cooling, the water that remained in the primary loop began turning to steam. As the fuel rods were exposed, the metal in the cladding reacted chemically with the steam, which not only ruptured the cladding but also released large amounts of hydrogen. The core suffered a severe loss of core geometry as its upper sections crumbled into a molten mass; researchers later discovered that about half the core had melted during the early stages of the accident. The uncovering of the core at TMI-2 produced a meltdown that was unprecedented and, at that point, undetected, although officials from Met Ed and the NRC gradually realized that they faced a serious challenge in finding a way to cool the heated core. Later investigations estimated that in some parts of the core, the temperature reached four thousand degrees Fahrenheit or more.[8]

GENERAL EMERGENCY

Around 6:30 A.M. on March 28, two and a half hours after the accident began, radiation alarms sounded in the control room. As the cladding on a growing number of fuel rods ruptured, levels of radiation far above normal were measured in the containment building and in the coolant in the primary loop. In addition, at about the same time, increasing levels of radiation were detected in the plant's auxiliary building. The auxiliary building was adjacent to the containment building and housed cooling and waste storage equipment. During the accident, the coolant that escaped through the PORV went to a drain tank in the containment building. As more and more coolant accumulated, the drain tank overflowed and spilled water onto the floor of the containment building. It was then pumped into waste storage tanks in the auxiliary building, which also eventually overflowed and caused radiation levels in the auxiliary building to rise. The major source of increasing radiation in the atmosphere of the auxiliary building and of releases to the environment was the flow of coolant between the core and the auxiliary building in the "letdown" and "makeup" systems. Those systems, which under normal conditions served to filter and remove impurities from the water that cooled the core, were not designed to prevent the escape of radiation from highly contaminated water. Leakage from the letdown and makeup systems produced high levels of radiation in the auxiliary building, some of which was released outside the plant through a ventilation stack.

The indications of higher-than-normal radiation in containment and in the auxiliary building made clear to the operators that they were dealing with an emergency. George Kunder, the TMI-2 superintendent for technical support, who had arrived at the plant at about 4:50 A.M. to assist the operators on duty, exclaimed after hearing the radiation readings, "Oh my God, we're failing fuel." Kunder and his colleagues did not know that the core was uncovered, but they realized that the situation was far more critical than they had previously believed. At 6:56 A.M., one of the plant supervisors—accounts vary on which one—declared a site emergency. The emergency plan for TMI-2 directed that this action be taken if radiation alarms sounded in more than one area. A site emergency meant that there was a possibility of an "uncontrolled release of radioactivity" within the plant's boundaries. It required evacuation of the affected buildings, closure of the gates leading to the plant, and notification of the NRC and the state of Pennsylvania. Less than half an hour later, Gary Miller, the Three Mile Island station manager, declared a general emergency. Miller, who had been talking with plant operators by telephone since early in the accident, arrived at the site at 7:05 and assumed authority as emergency director. New and alarmingly high radiation readings in the containment building persuaded him to announce a general emergency, which was defined as having the "potential for serious radiological consequences to the health and safety of the general public." Met Ed promptly began to measure radiation on and beyond the plant site. It found no detectable radiation directly across the river in Goldsboro and found levels on the island to be only slightly above normal.[9]

Once the site emergency and then the general emergency were declared, the response to the accident at Three Mile Island moved beyond the exclusive domain of Metropolitan Edison. It soon commanded an expanding mobilization of resources and expertise from local, state, and federal government agencies. Because of the uncertainty that prevailed at the plant, the information that the utility provided to government agencies on March 28 was usually fragmentary and sometimes contradictory or ambiguous. The reports it issued to the press and the public understated the severity of the accident. In turn, state government and NRC officials all too frequently circulated confusing or erroneous information about the accident.

THE STATE'S RESPONSE

At 7:02 A.M., six minutes after the Met Ed operating crew declared a site emergency, Zewe called the Pennsylvania Emergency Management Agency (PEMA). He told the duty officer, Clarence Deller, that the plant had been shut down and that there was a "high level of radiation" in the reactor building. Deller immediately notified emergency offices in Dauphin, Lancaster, and York Counties and also promptly contacted William E. Dornsife, who was a staff member of the Bureau of Radiation Protection, a part of the Department of Environmental Resources. Dornsife, the only nuclear engineer employed by the state, passed the information he received to superiors and colleagues in his agency and called the TMI-2 control room for further details. He learned that Met Ed thought the reactor had suffered a small loss-of-coolant accident, but that it had detected no radiation outside the plant. As Dornsife was talking with the control room, he heard in the background an announcement that plant employees should evacuate the fuel-handling building adjacent to containment. "It didn't hit me until I heard that," he later recalled. "And I said to myself, 'This is the biggie.'"

At 7:36 A.M., PEMA received word from TMI that the utility had declared a general emergency. It immediately advised several state and county agencies that an evacuation of the area surrounding the plant might be necessary. The director of PEMA, Oran K. Henderson, called Governor Richard L. Thornburgh at his home in Harrisburg to inform him that an accident had occurred at Three Mile Island. Thornburgh, who had been inaugurated just a few weeks earlier, was on his way to a budget meeting with state legislators. In their brief conversation, he told Henderson to keep him informed and to call the lieutenant gover-

Figure 6. Richard L. Thornburgh (left) and William W. Scranton III (The Historical Society of Dauphin County).

nor, William W. Scranton III, who was chairman of the state's emergency management council. Even at that point, Thornburgh was concerned about the possible consequences of the problem at Three Mile Island, in part because he instinctively felt that any accident at a nuclear facility could not be regarded as a trivial matter. "I really didn't want to frame any response of the State Government until I had more facts," he later commented, "but I think the question of evacuation crossed my mind immediately."[10]

Thornburgh assigned responsibility for collecting and reporting information about the accident to Scranton because of his confidence in the ability and integrity of the lieutenant governor. "We are compatible," he explained. "We don't have a situation which some other states have, where Lieutenant Governors do nasty things when the Governor is out of the state." After graduating from Yale University in 1969, Scranton had worked as publisher of three family-owned weekly newspapers in the area of Scranton, Pennsylvania, a city named for his ancestors. In that capacity he had criticized nuclear power, but had not taken a doctrinaire position. Scranton's father had served as a popular governor of

Pennsylvania during the 1960s and mounted a reluctant and belated challenge to Senator Barry Goldwater for the Republican presidential nomination in 1964. The younger Scranton's campaign in the Republican primary for lieutenant governor in 1978 was the first time he had entered elective politics. His views did not always conform with party orthodoxy. In 1972, he had editorially endorsed the Democratic candidate for president, George S. McGovern, because of his dismay with the "moral tone of the Nixon administration." He was an admirer of the Democratic governor of California, Jerry Brown, and, like Brown, practiced transcendental meditation.[11]

Scranton was informed about the accident at TMI by Henderson at 8:20 A.M. He had previously scheduled a press conference for 10:00 that morning to discuss energy problems. In the short time available, he sought to gather as much information as possible about the situation at the plant. Stories about the accident were already being reported by the news media, and Scranton knew he would be quizzed about it at the press conference. The media first received sketchy information about the accident when "Captain Dave," a traffic reporter for a Harrisburg Top 40 radio station, picked up a state police notice on his citizens band radio. He alerted the news director at his station, Mike Pintek, who promptly placed a call to the plant. An apparently frazzled switchboard operator mistakenly transferred him to the TMI-2 control room. The person who answered told him to call Met Ed headquarters in Reading because "I can't talk now, we've got a problem." Pintek contacted Met Ed and was told that the shutdown at the plant did not endanger the public. He aired a brief story on his station's 8:25 news program. About half an hour later, after receiving vague reports of a general emergency at TMI, the Associated Press issued a bulletin on its national wire announcing that an accident had occurred at Three Mile Island. It added that few details were available but that no radiation had been released from the plant.[12]

Meanwhile, Met Ed was scrambling to prepare a response to the increasing volume of inquiries it was receiving. Its public affairs staff members in Reading knew little about the situation at the plant and were unable to provide reliable or up-to-date information. Instead they offered bland affirmations about the safety of the plant that became increasingly less credible. The first statement from Met Ed declared that a malfunction had occurred at the plant and that it would be "out of service for about a week." The next statement, drafted at about 8:30 A.M., disclosed that TMI-2 had been "shut down due to a mechanical malfunction," but that "there have been no recordings of significant levels of radiation and none are expected outside the plant." The meaning of the phrase "significant levels of radiation" was ambiguous and, since extremely high levels had been detected in the containment building, misleading. An executive from Met Ed's parent company, GPU, complained the following day that Met Ed's press release "substantially" downplayed "the seriousness of the incident at that time." Later in the morning, GPU issued a press release that was more candid. It announced that a "low level release of radioactive gas beyond the site boundary" had occurred, but that it did "not believe that the level constitutes a danger to the health and safety of the public."[13]

By that time, reporters who attended Scranton's press conference had already been told about an off-site release of radiation. After gathering as much information as he could and receiving a briefing from Dornsife, Scranton prepared a statement on the TMI accident to present to reporters. Those activities made him almost an hour late in meeting with an increasingly impatient press corps. Scranton's opening statement was reassuring but confusing about the threat of radioactive releases. He declared that "everything is under control" and that "there is and was no danger to public health and safety." He went on say that, although "there was a small release of radiation to the environment, . . . no increase in normal radiation levels has been detected." Scranton did not make clear whether the "small release" had occurred within or beyond the plant boundaries or why it could not be detected. Reporters, after expressing resentment about having to wait so long for the lieutenant governor's appearance, raised questions about radiation hazards. As Scranton attempted to answer, Dornsife stepped in and announced that Met Ed had detected a small amount of radioactive iodine in Goldsboro. Dornsife had received this information just before the press conference began and had not had a chance to inform Scranton.

After Dornsife's statement, reporters addressed a series of pointed questions about radiation to him. They wanted to know what the measurements of radiation meant, how the radiation had escaped from the plant, and whether the state depended on Met Ed for information about the levels of radiation in the environment. The atmosphere of the press briefing was tense, and as a Pennsylvania official later commented, the exchange did not provide a "neat, orderly transfer of information." To make matters worse, Scranton learned shortly after the news conference that Met Ed in Reading was still claiming that no radiation had been detected off the Three Mile Island site, which contradicted what Dornsife had just told the press. It later turned out that Dornsife's report was incorrect; at that point, radiation had not been detected in Goldsboro. But the erroneous information that Dornsife received was made moot by radiation surveys that the state conducted in the late morning and early afternoon. Thomas Gerusky, the director of the Bureau of Radiation Protection, advised Scranton that slightly above-normal levels of radiation released from the plant had been detected as far away as Harrisburg. He attributed the radiation that showed up in the state's measurements to a steam venting that Met Ed had carried out without consulting state officials. An angry Scranton demanded that Met Ed immediately send a representative to brief him about the situation at the plant and the releases of radiation.[14]

RADIATION HAZARDS

The dearth of reliable and timely information was exacerbated by the difficulty that Scranton faced in evaluating the information he received. This remained a serious obstacle throughout the crisis for government officials, reporters, and members of the public who lacked a technical background; it was first graphically apparent when Dornsife tried, with limited success, during the lieutenant governor's press conference, to explain what measurements of radiation meant. The basic units for measuring radiation in 1979 were the *rad,* which indicated the amount of radiation delivered to human tissue, and the *rem,* which applied to chronic low-level exposures and indicated the effectiveness of different kinds of radiation in causing biological injury. For gamma radiation, which can penetrate far into the body from external sources, rads and rems are equivalent. The NRC and other regulatory agencies, drawing on the recommendations of leading scientists in the field, allowed those who worked in jobs where they were exposed to radiation a maximum of 5 rems per year "whole-body" exposure, which by definition included the most sensitive areas of the body. The permissible dose for individual members of the general population was one-tenth of the occupational level, or .5 rem per year. This was usually expressed as 500 millirems—a millirem is one one-thousandth of a rem. The average allowable exposure for large population groups, such as the population around TMI, was one-thirtieth of the occupational level, or 170 millirems per year. The NRC further required that nuclear plants restrict their emissions during normal operation so that a person who stood on the boundary of a plant twenty-four hours a day, 365 days a year would not be exposed to more than about 5 millirems per year.

Neither scientific experts nor regulatory bodies guaranteed that a person who received less than a permissible dose of radiation would remain free of injury; they did not claim that a threshold existed below which exposure was harmless. But they were confident that the limits offered an ample, if not absolute, margin of safety from radiation hazards. Radiation protection professionals urged that exposure for radiation workers and the general public be reduced to a minimum without discontinuing the use of radiation sources that provided valuable benefits. They agreed that exposures to radiation in amounts of 50 rads or more within a short period were progressively more likely to cause serious health effects, and that acute doses of 600 to 1,000 rads would be lethal to nearly everyone receiving them. Although there was strong evidence that exposure to radiation increased the risk of cancer, there was no conclusive information about the level of exposure likely to produce cancer or other illnesses.

The levels measured outside TMI-2 on March 28 were, by any standard, very small and unlikely to threaten public health—as long as they did not occur continuously over an extended period. Met Ed had twenty instruments for measuring environmental radioactivity in locations surrounding the site. Although one stack monitor that was calibrated to measure very low levels of radiation went off-scale early in the accident, readings from other instruments provided reasonably reliable information about releases from the plant. The highest reading was 7 millirems per hour; most measurements were in the range of 1 millirem per hour or less. Those values were far below the amount of radiation normally present in the environment. Natural background radiation, which comes from cosmic rays, radioactive elements in rocks and soil, and other natural sources, caused an average exposure to the population around TMI of about 100 millirems per year. The measurements of radiation released from the plant in the early hours of the accident, therefore, were not terribly alarming to experts. But neither were they insignificant. If, for example, continuous measurements of 1 millirem per hour were recorded off-site for seven days, they would reach the regulatory limit for population groups. The even more disturbing possibility was that higher and more dangerous amounts of radiation might escape if the reactor was not brought under control and if containment was breached as a result.

By the time Met Ed declared a general emergency, it was clear that radiation levels in the containment building of the plant were extraordinarily high, estimated at 800 rads per hour or more. As fuel cladding ruptured, releasing fission products from the fuel rods and pellets, the water and steam in the core became increasingly and intensely radioactive. By 9:00 A.M., radiation levels in containment had risen to about 6,000 rads per hour. Therefore, measuring the amount of radiation that leaked from the plant was a vital function for protecting public health and for deciding whether to order an evacuation from the area surrounding the plant. The Met Ed and state radiation teams who began to take measurements on the morning on March 28 were soon joined by experts from federal agencies. They included experienced and well-equipped emergency units from the U.S. Department of Energy, which performed essential functions while maintaining a low profile. The combined efforts of utility, state, and federal scientists provided wide-ranging surveys of radiation levels in the soil, water, and atmosphere surrounding the plant.[15]

MET ED AND THE STATE

In response to Scranton's urgent request for information, Jack Herbein, Met Ed's vice president for generation, accompanied by George Kunder and Gary Miller from the plant, went to Harrisburg to brief the lieutenant governor and other state officials. Herbein, the senior Met Ed official most familiar with the TMI plants, had arrived at the site by helicopter in late morning. He was a capable and dedicated engineer whose ability and performance had lifted him to the top ranks of Met Ed. His training and experience, however, had not prepared him to deal in a crisis situation with public officials or reporters whose knowledge of nuclear power was, at best, limited. When their questions tried his patience, he could be abrupt and dismissive. His role as a spokesman for Met Ed during the early stages of the accident was made more difficult by the many uncertainties about what was happening inside the plant. By the time he appeared at the site on March 28, about thirty reporters were waiting, many from outside of the Harrisburg area. Herbein told them that the problem seemed to be "some minor fuel failure" and suggested that "only a few" of the fuel rods had suffered serious damage.[16]

Herbein then departed from the site to meet with state officials in Harrisburg. The briefing did not go well; Scranton later commented that it "was not the most cheery get-together." The source of contention was the venting of steam that operators had carried out in an effort to stabilize the plant. Since the steam came from the secondary loop, it would be radioactive only if there were a leak in the steam generators. Gerusky, director of the Bureau of Radiation Protection, had told Scranton that dumping steam into the atmosphere was the cause of the radiation measured off-site. At the meeting, Herbein reported that he had ordered a halt to the release of steam begun that morning, but he also remarked that the process was "normal ventilation" that might be required periodically. Scranton complained bitterly that Met Ed had not informed the state before venting the steam.

In fact, it turned out that the information Gerusky gave Scranton was incorrect. The source of the off-site radiation was not the steam from the secondary loop but rather radioactive gases leaking from the auxiliary building. Herbein either did not know that the dumped steam was clean or did not explain it well. If Dornsife had been present, he might have been able to draw on his knowledge of reactor systems to sort out what those at the meeting perceived about the situation. But he had not been invited to attend. Scranton and the other state officials at the meeting believed that Herbein took an unduly optimistic view of conditions at the plant, and that he played down the threat that the accident posed to public health. They were also convinced that Herbein pledged not to vent steam again without informing the state, an impression that Herbein did not share. The meeting ended amid a clutter of confusion. But the main conclusion that state officials took from the conference was clear—that Med Ed could not be regarded as a source of reliable information. "Right from that moment on," commented Paul Critchlow, Thornburgh's press secretary, "we had virtually nothing to do with Met Ed."[17]

Shortly after the meeting with Herbein, Scranton held his second news conference of the day. He announced his disillusionment with Met Ed by stating that the situation at TMI was "more complex than the company first led us to believe." He told reporters that the utility "has given you and us conflicting information," and that "detectable amounts of radiation" from the plant had been released to the atmosphere. He added, "At this point, we believe there is still no danger to public health." Scranton's statements left no doubt that the state had written off the utility as a partner in responding to the accident. The state hoped that it would realize greater benefits in its efforts to guard public health by collaborating with the NRC. As Critchlow recalled, "I think we just almost instinctively preferred to deal with NRC people."[18]

THE NRC'S RESPONSE

The NRC, like the state, tried throughout the day to find out what had happened at the plant but had limited success. Immediately after declaring a site emergency, Met Ed placed a call to the agency's Region I office in King of Prussia, Pennsylvania, a suburb of Philadelphia. It was one of five NRC regional offices primarily responsible for, among other things, inspection of reactors under construction and in operation, investigation of plant problems and accidents, and verification of environmental monitoring procedures. When Region I's answering service received the first call from TMI, it was unable to reach the duty officer or other emergency contacts, who had left their homes and were on their way to work. It was not until 7:45 A.M., shortly after Met Ed declared a general emergency, that the NRC learned about the accident. Region I officials immediately called the TMI-2 control room and obtained the information then available about the situation at the plant, which was still very sketchy. It was clear, however, that the accident was serious enough to warrant prompt action. The director of the regional office, Boyce H. Grier, called NRC headquarters with news about the accident and quickly activated a regional incident response center that maintained constant communications with the TMI-2 control room. Grier also sent a team of five staff members to the site. They departed at 8:39 A.M. for the plant, a trip of about two hours, after informing the state police that they would be traveling in an NRC emergency vehicle on the Pennsylvania Turnpike.[19]

By the time Grier made his call to NRC headquarters, John G. Davis, the acting director of the Office of Inspection and Enforcement, had already heard about the accident from Joseph J. Fouchard, director of the NRC's Office of Public Affairs, who had been informed by the Region I public affairs officer. Davis immediately opened the headquarters incident response center, located in Bethesda, Maryland, a suburb of Washington, to respond to the developing emergency. He and others at the incident response center called senior staff officials and the commissioners to tell them about the accident. The chairman of the NRC, Joseph M. Hendrie, was out of his office for the entire day of March 28 to accompany his daughter to a local hospital for wisdom tooth surgery. He talked periodically with members of his personal staff about the accident from the hospital. He viewed the situation as serious but "reasonably well in hand," and he was confident that the acting chairman, Victor Gilinsky, would take appropriate action to deal with the problem.[20]

Gilinsky, one of the two original members still serving on the commission, had stirred considerable controversy during his tenure. He had first been appointed to the commission because of his expertise in the field of nuclear safeguards, which focused on the dangers of nuclear plant sabotage or theft of nuclear fuel. But he took a strong interest in other regulatory issues as well. He complained to his colleagues in December 1976, "Despite the fact that we all regard our principal responsibility as assuring the safety of nuclear power plants, . . . we spend astonishingly little time on the substance of reactor safety." Gilinsky, who had worked as a member of the regulatory staff of the AEC from 1971 to 1973, insisted that the NRC must be a stronger and more effective regulator than its predecessor. He believed that the AEC commissioners had deprived the regulatory staff of the resources it required and too often had dismissed the legitimate safety concerns it raised. "The safety experts at the Atomic Energy Commission were the low men on the AEC totem pole," he once declared. "The conditioning and attitudes that went with that status and—just as important—the consequent low regard of the nuclear industry for the regulators were inherited by the NRC in 1975."

Gilinsky was determined to improve the NRC's performance and enhance its reputation with the industry, nuclear critics, Congress, and the general public. He relentlessly raised difficult and inconvenient questions on a variety of issues with both the nuclear industry and the NRC staff, which annoyed staff members and convinced some industry officials that he was opposed to nuclear power. In fact, he subjected antinuclear arguments to the same kind of probing skepticism. Gilinsky's views won him bipartisan support among key members of congressional committees to which the NRC was responsible. Representative Morris K. Udall, chairman of the House Committee on Interior and Insular Affairs, told President Carter in 1978, "Commissioner Gilinsky . . . has shown his grasp of the full spectrum of knotty problems confronting the development of nuclear power, not the least of these being the critical need to instill public confidence in the NRC."[21]

Although Hendrie and Gilinsky frequently took opposing positions on regulatory issues, they reached similar conclusions about the severity of the Three Mile Island accident on the morning of March 28. Like Hendrie, Gilinsky regarded it as cause for concern but not alarm. He tried to keep his previously scheduled appointments to avoid the appearance of a crisis and, in his capacity as acting chairman, he spent much of the day responding to telephone queries from members of Congress and reporters.[22]

Less than half an hour after learning about the accident, Gilinsky placed a call to Jessica Tuchman Mathews, a member of the National Security Council staff at the White House. Mathews, who held a Ph.D. in biochemistry and biophysics from the California Institute of Technology, headed the council's office of Global Issues. She and Gilinsky knew and respected one another from their involvement in controversies over nuclear proliferation and the export of nuclear fuel to India. He decided to advise the White House about the situation at Three Mile Island, even if very little information was available, and he called Mathews because, as she recalled, "we had often informed each other of things that we felt the other one would be interested in." She, in turn, notified the White House Office of Science and Technology Policy, only to find to her annoyance that it was not inclined to act as the presidential staff's point of contact for the accident. By default, Mathews assumed that role. She immediately drafted a memorandum to her boss, national security adviser Zbigniew Brzezinski. She told him that the "reactor has been shut down and appears to be stable," but she added that a release of radiation to the environment was possible. Brzezinski promptly informed President Carter. Mathews continued to collect information about the accident as the day wore on.[23]

At about 10:00 A.M., Gilinsky and two of the other NRC commissioners, Richard Kennedy and Peter Bradford, met to receive a preliminary report about the accident from the incident response center. The other member of the commission, John Ahearne, had gone to the response center, which was located about ten miles from the commissioners' offices in downtown Washington. John Davis, the acting director of inspection and enforcement, told the commissioners that although radiation levels in the containment building were "very high," off-site measurements had "detected nothing." Edson G. Case, deputy director of the Office of Nuclear Reactor Regulation, reported that the emergency core cooling systems had been working for "up to several hours" and stated that "right now we have the situation under control." Fouchard, the director of public affairs, who had gone to the incident response center to consult with senior technical officials about the content of information provided to the public, requested and received the approval of the commissioners for a press release he had drafted. It declared that measurements for off-site radiation were "still being made," but that there had been "no indication of release off the site." At midmorning, therefore, the information available to NRC headquarters gave an incomplete and unduly favorable picture of conditions at the plant. The ECCS had been throttled back early in the accident, and the reactor was far from "under control." About the same time that the NRC issued its press release, off-site radiation was detected.[24]

The lack of clear information about the situation at Three Mile Island was paralleled by a lack of clearly defined roles and lines of authority within the NRC. By tradition, structure, and statutory mandate, the agency was ill prepared and ill equipped to deal with an emergency at a nuclear plant. It was not an operational agency that ran plants or carried out emergency procedures but a deliberative agency that made rules, considered license applications, and conducted inspections. It had no authority to tell the utility what it should do to stabilize the reactor, no capability for operating the plant, and no power to order an evacuation of the surrounding area. Its role was largely limited to collecting information and making recommendations. The NRC lacked a command structure for dealing with a major accident. Each component of the agency—commissioners, staff, and regional office—acted to fulfill its traditional functions. The commissioners weighed broad policy issues raised by the accident, including the delivery of accurate information to the public and the advisability of evacuating the area near the plant. The headquarters staff sought to grasp the technical details about the causes of the accident, figure out the condition of the reactor from the uncertain evidence available, and make appropriate recommendations to the commission and the utility. The regional office sent inspectors to observe and report on what was happening at the plant. No unit within the NRC and no single person was in charge of the situation. The absence of unambiguous lines of authority within the NRC became a source of confusion and embarrassment during the Three Mile Island emergency when the functions of the commission, the headquarters staff, and the region overlapped or, worse, left voids of responsibility.

From the outset, the regional office and the headquarters staffs acted with little guidance from or consultation with the commissioners. When Davis learned of the accident from Region I, he first informed the executive director for operations, Lee V. Gossick, who was the NRC's chief staff official. He then called other staff office directors, and only then tried to contact the commissioners. Operation of the incident response center in Bethesda was a staff function. Although two of the commissioners, Ahearne and Bradford, spent much of the day there, they were strictly observers who had gone to see how the agency performed during an emergency. What they witnessed about the NRC's ability to respond effectively to a major nuclear accident was edifying but not encouraging.

Ahearne, the newest member of the commission, had gone to Bethesda a short time after the staff had notified him that "an event" had occurred at Three Mile Island that required activating the incident response center. He had joined the NRC on July 31, 1978, the third member of the commission to be appointed by President Carter. Before his nomination, a series of tie votes among the four incumbent commissioners had produced, in the opinion of the White House science adviser, Frank Press, a "weak, divided NRC," and the president had sought a "highly qualified, balanced person" to break the stalemate. He selected Ahearne, who held a Ph.D. in physics from Princeton University and had served in a number of high-level posts in the Department of Defense during the 1970s. At the time of his appointment to the NRC, he was a deputy assistant secretary in the recently created Department of Energy. Although his background did not include direct experience in nuclear power safety, Ahearne had worked on energy policy as a member of the White House staff in 1977–1978. In that capacity, he had earned the admiration of Congressman John D. Dingell, who had lobbied the White House to make him an NRC commissioner. Widely regarded as moderate and nondoctrinaire in his approach to policy issues, Ahearne received support from partisans on both sides of the nuclear power debate and easily won approval from the Senate.[25]

Ahearne had arrived at the incident response center around 9:30 A.M. on the morning of the TMI-2 accident and stayed until after midnight. He realized that the staff was responsible for handling an emergency and "felt at times a little awkward being there because . . . the system was not structured to have Commissioners involved." Ahearne, who was familiar with the Defense Department's state-of-the-art emergency facilities, found the NRC's response center to be "very poorly equipped," even though it had been substantially upgraded after the Browns Ferry fire. Communications links were especially weak and ineffective. "The amount of information, the information flow . . . and the quality of the communication link [were] very poor," he later recalled. For example, the office had no speakerphone for group telephone calls. When a call came in from the plant or the Region I office, the receiver was placed on a chair and staff members gathered around to try to hear what was being reported. Regular telephone lines, which were frequently busy, had to be used because the response center had no dedicated lines from the plant or a data transmission system to speed the flow of information.[26]

EFFORTS TO STABILIZE THE PLANT

The technical problems of communicating with the plant were a source of frustration for NRC officials, but the fundamental difficulty in dealing with the accident remained the uncertainties and contradictions in the information they received. Although it was apparent that TMI-2 had experienced a serious accident, the proper means to cool the core, stabilize the plant, and prevent a major release of radiation were far from clear. One of the NRC regional inspectors, Charles O. Gallina, remembered that, when he and his colleagues reached the site around 10:30 A.M., they found the reactor in a state that "we never . . . had seen." By the time the NRC team arrived, radioactive gas had begun to leak into the control room of unit 2. This forced the twenty to thirty Met Ed employees in the control room to wear respirators and greatly complicated their ability to communicate with one another for the several hours that the masks were necessary.[27]

The plant operators and supervisors in the control room tried a series of procedures to gain control of the overheated and unstable reactor. Although some of the Met Ed staff believed that the core was uncovered, they did not convey their opinions to emergency director Gary Miller, who received conflicting signals about conditions in the core. Temperature measuring devices called thermocouples on many of the fuel assemblies, for example, gave some readings that were exceedingly high and others that were extremely low. This persuaded Miller and other Met Ed experts to disregard all the readings as unreliable, even though the high temperature readings turned out to be accurate. Whether or not the core was uncovered, it was clear that at least some of the fuel rods had been damaged and that finding a way to cool the core was essential. The fundamental problem was that much of the water in the core had turned to steam and therefore could not adequately cool the core. Around 9:00 A.M., Miller and his colleagues decided to repressurize the reactor in hopes that increasing the pressure would condense the steam back into water. They forced as much water as possible into the primary system from the makeup system and injection pumps, which had the salutary effect of covering the core. But it did not succeed in collapsing the steam, because the temperatures in the core were so high that the steam had reached a "superheated" state. As a result, the operators' efforts to restart the reactor coolant pumps that they had turned off hours earlier were futile.

When this attempt to reestablish adequate cooling by repressurizing the system failed, the Met Ed team decided to depressurize the system. In this way, they sought to activate a core flood tank, a part of the ECCS, that would dump water on the core if the pressure was low enough. The operators cut back on the flow of water to reduce pressure in the reactor, and the flood tank discharged a small volume into the core before shutting off automatically. The shutdown of the flood tank seemed to indicate that the core was covered, and the operators continued the process of depressurizing the reactor. In this way they hoped to reach a point where they could use a heat removal system that operated at low pressures. But the operators misinterpreted the signs of what was happening in the core. The flood tank had closed down because the water it sent to the core flashed to steam. As the operators continued to depressurize the system, the core was uncovered again.[28]

Throughout the day, NRC officials in the incident response center followed developments at Three Mile Island with increasing concern. In a conversation from the incident response center at about 1:45 P.M., Edson Case told Commissioners Gilinsky and Kennedy that depressurizing the reactor appeared to be working well. Asked how he felt about the "fate of the reactor," he replied, "I feel good. Now I get the impression that it's stabilized, or directly approaching a stabilized situation." Case, a veteran regulatory staff member, was highly regarded within the NRC for his technical knowledge and his plainspoken manner of expressing his views. His opinion carried a great deal of weight with the commissioners; Gilinsky insisted on talking to Case when he called the response center. Case based his judgment on the sparse information he had received from the NRC inspectors at the site, and within a short time, his evaluation was superseded by more ominous indications.

By the middle of the afternoon, NRC staff members, still forced to piece tidbits of information together to analyze the condition of the core, had become increasingly worried that at least a part of the core was uncovered. Their reading of the temperatures in reactor piping strongly suggested the presence of superheated steam in the pressure vessel, and the only logical explanation was that sections of the core had been exposed. At about 4:00 P.M., Victor Stello Jr., director of the division of operating reactors in the Office of Nuclear Reactor Regulation, grabbed a phone to inform plant operators of this conclusion and to impress upon them the need to "put more water in the core." Stello, one of the NRC's leading reactor experts, was a big man who spoke with a booming voice, and he stated his opinion with unmistakable clarity to the Met Ed staff member on the other end of the line. But even Stello's animated appeal did not convince the plant operators at that point that they must consider the implications of superheated steam. Stello told Gilinsky that he feared Met Ed failed to recognize that the core might not be covered. But he realized his information was so sketchy that he could not be certain of his judgment.[29]

Stello was not alone in his fears that the core of the reactor was uncovered. Babcock and Wilcox engineers, gathering information in their offices in Lynchburg, Virginia, reached the same conclusions and conveyed their analyses to Met Ed and GPU officials during the afternoon of March 28. Robert Arnold, vice president for generation of the GPU Service Corporation, also raised questions with plant operators about whether the core might be exposed. The Service Corporation was a GPU subsidiary that provided technical expertise to the three GPU operating companies, including Met Ed. Arnold talked with plant operators from his office in New Jersey around 2:00 P.M. and received assurances, based on the automatic shut-off of the core flood tank, that the core had not been uncovered. He remained uneasy, but like Stello in Bethesda and Babcock and Wilcox experts in Lynchburg, he deferred to those at the site who presumably had more complete information. Around 4:30 P.M., Arnold expressed his concerns to Jack Herbein, who had returned to the plant after his meeting with Scranton. Herbein agreed with Arnold's assessment and ordered the operators to stop depressurizing the reactor, which had not achieved its purposes, and to repressurize it again. This time, at about 7:50 P.M., the process of injecting more water into the core enabled the operators to start one of the reactor coolant pumps, which circulated water through the core and allowed the removal of heat by the steam generator. For the first time in hours, the plant made welcome progress toward a stable condition.[30]

THE NRC AND THE PRESS

While technical experts from Babcock and Wilcox, GPU, Met Ed, and the NRC tried to figure out the causes and consequences of the Three Mile Island accident, the NRC fielded a deluge of telephone calls from Congress, the news media, state officials, federal agencies, the Union of Concerned Scientists, and others. It sought to furnish accurate and up-to-date information that sorted out fact from rumor or speculation, but under the rapidly changing and highly uncertain circumstances, this was difficult. NRC staff members at the incident response center checked on and discredited some rumors about the accident, including a false report that the state of Virginia had ordered the evacuation of three of its counties. A more plausible, though equally erroneous, rumor was that Pennsylvania had decided to evacuate three counties. In other cases, the NRC was unable to provide current and reliable information or even to respond to the calls that poured in. Frank L. Ingram, Fouchard's deputy in the Office of Public Affairs, received so many queries that the message slips piled up to a point where "there was no way to sort through them."

He could not return most of the calls he received. Reporters who managed to get through to Ingram in his Bethesda office or officials at the incident response center in a separate building about a mile away were often exasperated. One newsman, Walter S. Mossberg of the *Wall Street Journal,* grew so frustrated by the problem of reaching technical staff members at the response center that he refused to get off the line when switchboard operators instructed him to call Ingram. He apparently never achieved his goal of talking with John Davis.[31]

During the afternoon of March 28, the NRC drafted a press release to provide the latest information it had about the accident. Gilinsky wanted the statement to be distributed in time to inform television news programs that would air at 6:00 P.M. Fouchard and the Region I public affairs officer, Karl Abraham, both former newspaper reporters, discussed the wording of the press release at length. They prepared a statement announcing that small amounts of radiation had been detected off-site from the plant, but they were uncertain of how best to explain the significance of the readings. Abraham said that he had been "very, very cagey" in talking to the news media because of the uncertainties about the accuracy of the measurements and about the source of the off-site radiation. Fouchard had been told by NRC experts at the incident response center that the off-site readings probably came from "direct radiation" that had penetrated the four-foot-thick concrete walls of the containment building. A very small amount of gamma radiation always escapes through the walls in an operating reactor, and the greatly elevated levels of radiation in the top of the containment structure at TMI-2 increased the likelihood that higher than usual amounts had reached the outside by that route. The press release that Fouchard and Abraham drafted did not mention the levels of radiation in containment or comment on the severity of the accident. Although it obviously qualified as a serious accident, its precise dimensions and the magnitude of the threat it posed to the public were still unclear.[32]

When Fouchard consulted with the commissioners about the draft press release, they raised several questions. Kennedy was concerned that the statement used the word *accident* twice to describe the situation at Three Mile Island. He feared that this would imply that the plant was in danger of the China syndrome and asked, "Is this an accident? What is an accident?" Fouchard replied, "I believe it's an accident, Mr. Kennedy." Eventually, the commissioners agreed to remove the second mention of the word *accident.* Although they had no policy or intention of understating the seriousness of the accident, they were careful to avoid over-

Figure 7. Victor Stello Jr. (left) and Joseph J. Fouchard (NRC).

stating it. Kennedy, who held a master's degree in business administration from Harvard University, worried that the press release would "scare everybody to death." Throughout his tenure on the commission, he had faulted the agency staff and his colleagues for bureaucratic delays and "interminable haggling" that impeded the licensing process and reflected poorly on the NRC's effectiveness. In his mind, it was the responsibility of Congress, not the NRC, to make "value judgments about the desirability of nuclear power." His job as commissioner, he once declared, was to make certain that the NRC did not cause "unwarranted delay" in the licensing process or "cast doubt upon the viability of the nuclear option." Kennedy's sensitivity to using the word *accident* was an extension of his outlook on the NRC's impact on the future of nuclear power.[33]

The press release that the NRC issued at about 5:00 P.M. announced that "low levels of radiation" had been detected off-site, and that the highest "confirmed" reading was about 3 millirems per hour at a point located one-third of a mile from the plant boundaries. This was presumably a ground-level measurement, though the statement was not clear on precisely where it was taken. The NRC reported that the off-site readings apparently were "principally direct radiation coming from radioactive material within the reactor containment building." In fact, the agency officials whom Fouchard consulted were mistaken; most of the off-site radiation came from releases from the auxiliary building.

The NRC's press release sought to outline clearly what the agency knew about the accident without indulging in speculation or unnecessarily alarming the public. But it fell short of its goals in important respects. It did not make clear that the NRC had reason to believe the accident was serious, and in that sense, it understated the severity of the crisis and the risk to public health. At the same time, by emphasizing that the radiation detected off-site probably had penetrated four feet of concrete, it made the radiation readings seem more ominous than the actual measurements suggested. Reporters were quick to interpret the releases through containment walls as a threat to public health. The *New York News,* for example, ran a headline in its March 29 editions that read, "Nuke Plant Spews Radiation in Pa., Goes thru 4-ft. Walls." NRC officials who talked with reporters were franker than the press release in assessing the accident. Fouchard told Stan Benjamin, a reporter for the Associated Press, in a widely quoted statement that, "they've got a hell of a lot of radioactivity in that containment building." Case was more specific; he told Benjamin that the radiation levels at the top of the containment dome were about 6,000 rads per hour.

In the absence of complete and unambiguous information, the NRC attempted to report accurately but also cautiously about conditions at the plant. Perhaps inevitably, the result was that in some ways it understated the severity of the accident and in other ways it provided the basis for disquieting stories about the hazards of off-site radiation releases.[34]

At the same time that the NRC deliberated over the release of information to the public, it conferred with Pennsylvania officials about the situation at the plant and the potential dangers to the public. After Herbein's meeting with Scranton, the state had lost confidence in Met Ed as a reliable source and looked to the NRC for expert advice. At about 6:00 P.M., following Scranton's second press conference, the lieutenant governor's executive assistant, Mark S. Knouse, called the plant and asked for a briefing from the NRC. In response, two members of the Region I contingent, James C. Higgins and Charles Gallina, traveled to Harrisburg; a third representative, Donald R. Neely, had planned to accompany them but had to stay behind because traces of radiation were detected on his trousers. Higgins, a reactor inspector, and Gallina, a Ph.D. and environmental radiation specialist, were well qualified to carry out their normal duties. Their training and experience did not extend to explaining reactor operations or radiation hazards to state government officials or the press, but they were forced into that role by default on the evening of March 28. There were no senior NRC officials at the site who could speak knowledgeably about conditions at the plant. In response to persistent questions from reporters and state leaders, Higgins and Gallina made statements on behalf of the NRC that soon turned out to have been ill advised.[35]

After arriving at the capitol, Higgins and Gallina met with Scranton and several other high state officials. They attempted to answer questions about the accident and radiation releases in terms that were accessible to nonexperts but had mixed success. Jay C. Waldman, Thornburgh's executive assistant, remembered asking them after listening for some time "to please explain in simple English terms what the hell happened here." The NRC representatives expressed confidence that the reactor was cooling and that radiation releases would soon be terminated. At 10:00 P.M., Scranton held his third press conference of the day. He provided a corrective to the NRC's earlier claim that the major source of emissions was direct radiation from containment. He declared more accurately that the radiation escaping from the plant came from ventilation of the auxiliary building. He added that measurements had not detected "any critical level" of radiation off-site. When reporters began to ask questions, Scranton turned the podium over to the NRC experts.

Higgins and Gallina provided a series of unsubstantiated assurances about the status of the plant that were not only speculative but also contradicted information coming out of NRC headquarters. They suggested that there was no "permanent damage" to the plant, that there had been "no significant core damage," and that the reactor would reach a "cold shutdown within a day." Although NRC experts at headquarters had told members of Congress and the press that they suspected operator error had contributed significantly to the accident, Gallina announced that he had seen no "indication of human error at this point." In Bethesda, one NRC staff member commented that if he learned the name of the "NRC spokesman in Harrisburg" who had claimed that the core of the plant had not been damaged, he would "strangle him."[36]

After the press conference, Higgins and Gallina went with Scranton and others to the governor's mansion to brief Thornburgh. While Mrs. Thornburgh offered sandwiches to a tired and hungry group of NRC, Department of Energy, and state officials, the governor sought to get a handle on "what the events of the day had been, and what the problem was, and what the prognosis was." Thornburgh was committed to collecting all the information he could before making decisions, an attribute that had served him well throughout his career. He had received a bachelor's degree in civil engineering from Yale University in 1954, but had decided that he was not a "very good engineering student" and turned to law instead. He attended law school in his hometown at the University of Pittsburgh and, after graduating in 1957, began practicing corporate law. When his first wife was killed in a car accident in 1960, however, he reassessed his career plans and decided to enter public service. He was appointed United States Attorney for western Pennsylvania and won wide recognition for his efforts to crack down on corruption and organized crime. He won a stunning victory as the Republican candidate in the Pennsylvania gubernatorial election of 1978 by overcoming a huge early lead held by his Democratic opponent. Thornburgh's training as an engineer, and especially his experience as a prosecutor, taught him the importance of gathering reliable information before taking action on any problem. "When you don't have the facts, you don't have much of anything," he declared.[37]

Thornburgh applied his prosecutor's skills to seeking information about the Three Mile Island accident. He pressed Higgins and Gallina to "lower their jargon level to something that we could understand." They provided the same answers about the condition of the plant and the small likelihood of public health effects that they had given earlier, and the governor was satisfied that "there certainly was no sense of urgency about steps that had to be taken." But after the briefing ended, he became increasingly troubled by the fact that nobody had talked about the possibility that a meltdown might occur. Thornburgh's knowledge of nuclear power was largely limited to a book he had read a couple of years before called *We Almost Lost Detroit,* written by John G. Fuller. It was a gripping narrative about an accident at a small nuclear plant in Michigan in 1966 that provided a vivid description of nuclear hazards. Despite inaccuracies and exaggerations, the book became an antinuclear totem in the public debate over the technology. Thornburgh realized that the subject of severe core damage and a meltdown had probably been raised during other discussions of the TMI-2 accident, but the issue bothered him "a great deal" and he found it difficult to sleep that night.[38]

Thornburgh's uneasiness about the condition of the plant and the threat it might pose was shared by other officials responsible for protecting public health and safety. Some indications from the plant were encouraging; coolant was circulating, heat was being removed, and the reactor appeared to be relatively stable. This led some observers to believe that the emergency had ended. But officials in Harrisburg and in Bethesda remained wary. Despite the promising signs from Three Mile Island, information was still fragmentary, the causes of the accident and the damage it produced were unknown, the containment building was brimming with intensely radioactive gases, the auxiliary building was heavily contaminated, the ability of crucial equipment to operate was questionable, and the condition of the core was uncertain. Although there was reason for hope, there was less reason to be confident that the crisis had passed.