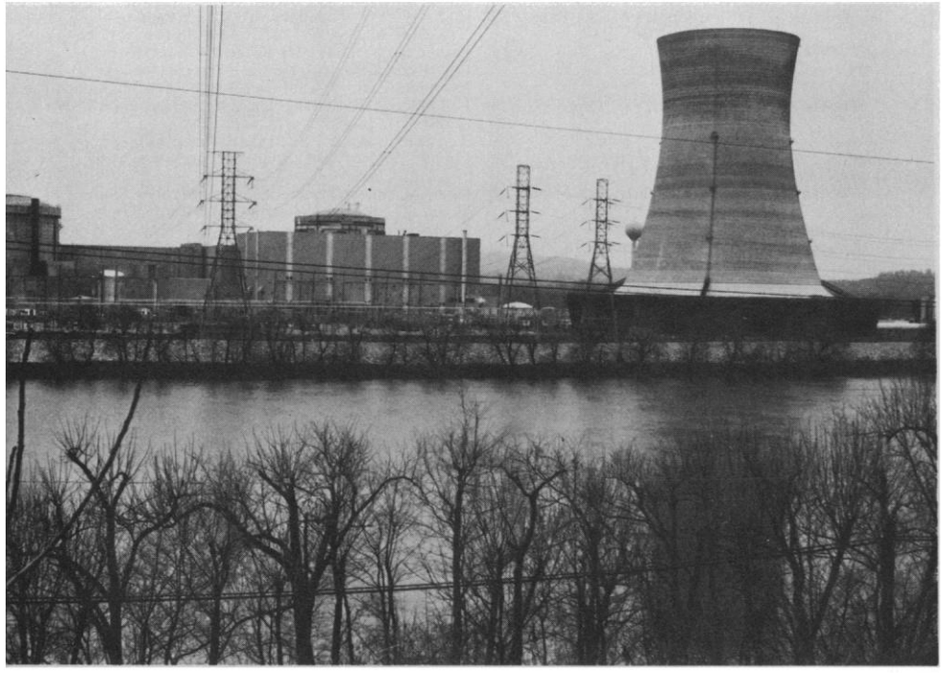
A Preliminary Report on Three Mile Island

The NRC learns of negligence, mechanical failure, and 48 hours of confusion in the control room

The accident at the Three Mile Island nuclear power plant was dangerously out of control for at least 48 hours, according to a preliminary staff report given to the Nuclear Regulatory Commission (NRC) on 4 April. That is how long it took the technicians to figure out with any certainty what had gone amiss. During the first $13\frac{1}{2}$ hours after the accident began, the reactor core overheated and then began to disintegrate. Technicians stopped this process by a fortuitous action whose significance they did not fully grasp until much later.



The guilty party, with cooling tower.

A mistaken move during this early period—such as a prolonged attempt to depressurize the reactor vessel, which is actually what the plant operators had in mind on the first day—would have caused serious damage to the control machinery and possibly produced a disaster in Pennsylvania. While this explosive and extremely hazardous situation developed, the people of Harrisburg were given bland assurances that the reactor was under control and that they had nothing to fear. It was not until the third day of the accident, after the full extent of the danger became known, that Governor Richard Thornburgh announced that it might be a good idea for women and children to leave the immediate area, if they were so inclined. Many were.

The NRC staff report of 4 April reveals that good luck had as much to do with averting a catastrophe as good engineering. For $13\frac{1}{2}$ hours, it appears, the reactor core was left partially exposed above the cooling water, while temperatures inside the reactor vessel climbed off the recording chart. Engineers in the control room realized that something inventive had to be done. As one NRC staffer said, "There was speculation . . . that there were voids or perhaps bubbles in the system." Fortunately for Harrisburg, in trying to collapse these imagined voids, the technicians repressurized the system and raised the water level to cover the reactor core. Had this decision not been made when it was, gas would have continued to fill the reactor vessel, ultimately reaching the pumps and threatening the only viable cooling mechanism. As it was, the damage was extensive, although not enough to trigger an irreversible meltdown.

Chance appears to have played an important part in ending the crisis; negligence was important in causing it. According to the NRC report, a key element in the cooling system—three auxiliary feedwater pumps—had been taken out of commission 2 weeks before the accident and left out. This was done in violation of federal regulations. NRC's director of nuclear reactor regulation, Harold Denton, said on 4 April: "The auxiliary feedwater pumps should have been operational. Had they been, we would have had a completely different outcome." Negligence joined with mechanical failure and sheer folly (a technician confusedly turned off the emergency cooling system at the peak of the crisis) to eliminate all the planned safety systems intended to keep the reactor from overheating. When the core overheated, it produced a new and unexpected problem, a 1000-cubic-foot bubble of hydrogen gas, an eventuality for which the local utility and the federal regulators were utterly unprepared.

It took 2 days to analyze this situation and another 3 days to get it under control. At this writing, the bubble has been dissolved and removed from the reactor core, but there is a possibility that a new bubble could form when the system is depressurized and cooled. For this reason, the plant is being cooled with exquisite care. According to Denton's projections, the job should be done by Easter, 15 April.

In its preliminary report to the commissioners, the NRC staff listed six major errors that contributed to the accident.

▶ The first was the failure to keep spare auxiliary feedwater pumps on-line as required by the NRC. Only one of four was operational on 28 March, leaving no margin of safety when the accident began at 4 a.m.

▶ Second, a relief valve in the primary coolant loop opened during the accident, as it should have, to let out overheated

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water. Then it failed to close. This caused a dangerous drop in pressure.

▶ Third, at least one water level indicator on the pressurizing system appears to have given a faulty reading, causing a technician to think the system was full of water when it was not. This made him think wrongly that the situation was under control.

▶ Fourth, when the emergency core cooling system came on automatically, which only happens when things are seriously amiss, another automatic system designed to contain radioactive leaks failed to come into play. The NRC rules say that this leak containment system should switch on simultaneously with the emergency cooling system.

▶ Fifth and sixth, technicians in the control room turned off the emergency and the primary cooling pumps. They should have been left on. No one knows why they were stopped.

The NRC staff described these and other technical blunders in considerable detail, but they did not explain why the public was not warned of the danger sooner. Commissioner Peter Bradford asked some searching questions on this score: For example, "What is there about what we have learned from this," he wanted to know, that in the future "would guarantee that we would not again go 48 hours with such a misconception of what the nature of the situation was?" Bradford brushed aside the technical answers and pointed out that "the Pennsylvania authorities should have been getting ready for asking people to move during those two days . . . and they weren't. They were going along . . . ." NRC staff member Edson Case cut in at this point: "I think the answer is, Commissioner Bradford, you learn from experience. We haven't had many of these experiences, if any."

Lacking practical experience, the NRC often relies on computer analyses for insight into what might happen in an accident. These are not a good substitute for the real thing, as the present case demonstrates. There were no guidelines for wrestling a 1000-cubic-foot bubble into submission. The NRC, as a result of its bout of practical experience in Pennsylvania, has set up a "bubble group" to think hard about the recent accident and come up with a computer program to deal with this anomaly should it recur.

Ignorance of bubble mechanics, however, does not seem a good excuse for the failure to alert the public of the dangers that were present on the morning of 28 March. Although the technicians did not know why, they did know that the reactor core had reached potentially catastrophic levels of pressure and temperature. The public learned of this several days later. The utility's failure to communicate this information quickly and the experts' confessed ignorance about the bubble do not augur well for the future of the nuclear program. Who can say with confidence now that the next accident will play itself out as docilely as this one has?—ELIOT MARSHALL

The Radiation Studies Begin

Although it is not yet possible to give a full inventory of the radioactive pollutants that escaped from the Three Mile Island nuclear plant, federal health officials recently put together some estimates of what has leaked out and of the probable effects on the health of Pennsylvanians in the vicinity. The picture is sketchy because no reliable system of monitoring radiation levels was in place until several days after the accident had begun, when federal officials fanned out across the countryside with their instruments.

By volume, the largest pollution hazard came in the form of the inert noble gases xenon and krypton. They do not combine with other chemicals or become fixed in the human ecosystem. The radioactive isotopes of these gases have brief half-lives, so that they decay within days. The nuclear plant began leaking radioactive gases on 28 March and continued to do so for at least 2 weeks afterward, steadily replenishing whatever had decayed. As a result, the 25,000 people who live within a 5-mile radius of the plant have been receiving radiation from the very beginning—in doses that ranged from about 1 to 2 millirems per hour during the first week, to around 0.1 millirem per hour now. At this writing, the Nuclear Regulatory Commission estimates that the maximum cumulative exposure for a person near the plant is approximately 100 millirems. This does not represent a significant dose in epidemiological terms. According to testimony given on 4 April by Joseph Califano, Secretary of Health, Education, and Welfare (HEW), a reasonable guess is that if 10,000 people are exposed to 1000 millirems of radiation, one additional fatal cancer will result.

While the plant's filters did not prevent xenon and krypton from leaking to the outside, they did prevent large leaks of highly toxic substances such as radioactive iodine and particulates. Iodine is chemically active and is quickly taken up by the human thyroid. Small amounts of iodine-131 and cesium-137 have been found in samples of milk and water taken near Three Mile Island. For iodine, the highest concentration found was about 41 picocuries per liter of milk, well below the emergency level of 12,000 picocuries per liter, the point at which the Food and Drug Administration (FDA) requires that cattle be put on uncontaminated feed. (China's most recent nuclear bomb test raised the iodine level in milk near Harrisburg to around 300 picocuries.) Cesium measurements also have been small.

At least one unmeasured and unauthorized release of radioactive water occurred early in the accident, when the plant operators flushed waste storage tanks into the Susquehanna River. There will be other uncontrolled spills of water, gas, and perhaps particulates as the plant is cooled and decontaminated. The biggest problem will be to dispose of 2 million cubic feet of radioactive gas and 270,000 gallons of radioactive water still in the building. This cleanup cannot begin for several months.

HEW has taken a few immediate steps to meet the crisis: Federal supplies of an iodine-blocking medicine have been rushed to Pennsylvania, 200 dosimeters placed around the plant to collect data on cumulative radiation levels, and a plethora of research projects set in motion. The FDA, at the urging of several concerned scientists, stockpiled enough potassium iodide last year to protect about 225,000 people in a major nuclear accident. (One of those who pressed the FDA to take this action, physicist Frank von Hippel, calculates that people as far as 200 miles downwind of a major iodine leak would need the protection.) Potassium iodide does its job by saturating the thyroid and blocking the path before the radioactive isotope can enter.

Meanwhile, the Center for Disease Control has begun to collect all known records on radioactive leaks from the plant and is developing a registry of all the workers for use in a prospective health study.—E.M.