EDITORIAL BY JAY BOUDREAU

THREE MILE ISLAND: *Aftermath and Impact*

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Los Alamos has been deeply involved in analyzing what happened at Three Mile Island and in developing the technical knowledge that will help prevent further accidents of this kind. But there are equally complex and challenging nontechnical questions about nuclear reactor accidents that our society must now resolve.

The United States has been using nuclear-generated electricity continuously since 1957 when the first commercial plant went on-line in Shippingport, Pennsylvania. Today 70 operational plants are producing 11 per cent of our electricity. Yet for all our familiarity with nuclear power, we cannot agree on what to do about the disabled Metropolitan Edison Company power plant on Three Mile Island.

For over two years the damaged reactor core of Unit 2, miles of radiation-contaminated wire and pipe, and 700,000 gallons of radioactive water have remained on the Susquehanna River island while Metropolitan Edison, citizen groups, courts, and state and federal agencies have argued about responsibilities and cleanup procedures. And right next door sits Unit 1, fully intact, but unable to operate because of a continuing dispute between Metropolitan Edison and the Nuclear Regulatory Commission.

How do we now recover from such an accident? And how do we reassure ourselves that nuclear energy, despite the accident and the general confusion surrounding it, is still a credible component of our energy supply system?

Before considering the serious economic and political impact of the Three Mile Island accident, we should look at the kind of physical damage done, at the amount of material involved, and at the cleanup technology required.

During the accident the core of the Unit 2 reactor was badly damaged, and 700,000 gallons of radioactive water were released into the containment building through a relief valve that was stuck open. The building's atmosphere was contaminated by 45,000 curies of krypton-85, a radioactive gas. It is likely that many of the control rods were melted, that the zirconium fuel-rod cladding was oxidized, embrittled, and shattered by thermal shocks, and that some of the ceramic fuel was also shattered into small fragments.

While the condition of the core will not be known until the reactor vessel head is removed, analysis indicates there will be a significant amount of fuel debris on grid spacers within the core; some of the fuel debris may even have been pumped into the steam generators. If there are large deposits of fuel debris on the steam generator tube sheets, the latter will have to be disassembled, increasing the radiation dose that cleanup workers will receive.

Because the condition of the control rods is not known and because fuel relocation and compaction could lead to increased generation of neutrons somewhere in the system, the concentration of boron (a neutron absorber) in the cooling water has been increased from its normal level of 1000 parts per million (ppm) to 3500 ppm to prevent criticality in the most reactive configurations possible. This concentration of boron will have to be maintained at all times, including during core removal.

Core removal will be the most challenging job from a technical standpoint and may take a whole year to complete. Because the vessel head penetration conduits have been damaged and because entanglement with core debris is likely, removing the head will require special care. The exact techniques that will be used are not yet decided, but the procedure will probably involve several steps: those conduits not damaged will be removed, optical devices will be inserted to view the underside of the head, and then special cutting tools will be devised to sever the entangled conduits.

Once the core head is removed, similar techniques will be used to take apart the core, which is now probably made up of particulate debris, resolidified material, and intact fuel-pin stubs. This mess will have to be cut apart and the core removed in sections. Although techniques developed in cleaning up other reactor accidents will be available, on-the-spot tool design will be required. Remote optical devices will be used to observe the character of the environment, mockups will be built, and the newly designed tools will be tested before attempts are made to section the core.

After the core is sectioned, its pieces and debris will be encased under water in transfer casks. These casks will then be moved through the spent-fuel transfer tubes and stored in the plant's spent-fuel pool until a decision is made about shipment off the site.

The health and safety of the public will not be in danger

during the cleanup operation, but the estimated 1000 cleanup workers will have to work in relatively high radiation fields for routinely long periods of time. Even so, these hazards can be dealt with through strict health physics and safety procedures. Thus both the technical and health problems appear tractable. The real problem lies elsewhere.

Cleaning up the reactor has severely taxed our regulatory, political, and industrial institutions. Neither industry nor the Nuclear Regulatory Commission was truly prepared for the accident or for its aftermath. In the early days of nuclear development, power reactors were owned by the government, and cleaning up accidents was the responsibility of the Atomic Energy Commission. Public involvement was minimal, and cleanups were usually quick and relatively inexpensive. In the mid-1960s the federal government gave the responsibility of reactor ownership and operation to private industry. Then in 1974 Congress established a new agency to license and regulate the nuclear power industry—the Nuclear Regulatory Commission. With licensing as its main concern and with no experience in commercial reactor cleanup, it is not surprising that the Nuclear Regulatory Commission dealt initially with the Three Mile Island cleanup in a series of ad hoc reactions.

There has been a long sequence of delays. The week after the accident Metropolitian Edison began design of a processing system (EPICOR-II) to treat contaminated water. It planned to discharge the processed water (which it claimed would meet state and federal radiation standards) into the Susquehanna River beginning in May 1979. The plan was never carried out. The city of Lancaster and the Susquehanna Valley Alliance both went to court to prevent discharge of the treated water. The Nuclear Regulatory Commission first responded by prohibiting any water processing without its permission. Later that year, after an environmental assessment, the Commission allowed the utility to begin processing the water but still prohibited its discharge.

Even these first steps opened the way for legal and political debates. The Nuclear Regulatory Commission was challenged as to whether it was acting legally in separating water decontamination from the rest of the cleanup operation and in basing its approval on an environmental assessment rather than on a fully developed environmental impact statement. Critics maintained that the environmental assessment process applied only to reactor licensing, not to an action as potentially significant as the Three Mile Island cleanup. It was argued that segmenting the cleanup was illegal, and in response to the protests, an environmental impact analysis was performed, including full public participation.

Failure to hold public hearings before venting krypton from the containment building resulted in the Sholly case. After a protracted environmental assessment and safety review, the Nuclear Regulatory Commission had concluded that venting would not involve any significant hazard to the public. The Commission's action was challenged. In 1980 the United States Court of Appeals in the District of Columbia found that the Commission had violated the law by allowing the krypton to be vented without first holding public hearings. Appeal of this case is now under consideration by the Supreme Court.

The Nuclear Regulatory Commission issued its Final Programmatic Environmental Impact statement for the overall cleanup of the Three Mile Island plant in March 1981, after an extended public comment period. The study presented alternatives ranging from full cleanup of the damaged reactor to no action other than continuing to maintain it in its present condition. The report concluded that full cleanup should proceed as quickly as possibly to reduce the potential for uncontrolled releases of radioactive material to the environment. The report also concluded that existing methods were adequate or could be suitably modified to perform virtually all of the necessary operations without exceeding accepted environmental limits. In April 1981, 24 months after the accident, the Commissioners issued a policy statement urging Metropolitan Edison to accelerate the pace of the cleanup.

The two-year delay from the time of the accident to the final report of the Nuclear Regulatory Commission is not the only problem Metropolitan Edison has in dealing with its damaged reactor. The company faces drastically inflated recovery costs and the need for about a thousand professionals and skilled laborers to perform the cleanup job. The utility has hired the Bechtel Corporation to prepare two comprehensive cleanup plans, but virtually none of the steps recommended in these plans can be implemented without Nuclear

Regulatory Commission approval and without rate relief. The rate-setting commissions, however, are reluctant to lay the full financial burden of cleanup on the rate payers, because cleanup costs have continued to escalate. Thus, Metropolitian Edison and its holding corporation, General Public Utilities, which together employ eleven thousand persons and serve four million customers, have been forecasting serious cash flow problems.

Metropolitan Edison has been losing about $1 million per month for the last two quarters, a condition without precedent in the electric utility industry. The market value of the holding company's stock fell from $18 per share before the accident to $4.50 per share in the spring of 1981, and no dividends had been paid on its common stock for the two previous quarters. The company has laid off 200 employees involved in customer service and 500 contractor employees, many of whom were engaged in routine maintenance. The cutback restricts the number of possible new residential hookups and increases the likelihood of protracted power outages (perhaps up to a week) after severe storms.

Metropolitan Edison continues to operate with a very limited margin between borrowing requirements and credit availability. If a majority of the banks decide that the company's revenues are not sufficient to assure its financial credit, or if the utility's future seems cloudy enough that the banks feel they may not be paid, the banks may call their loans. The company has no access to other lines of credit. Its revolving credit agreement with the banks is set for review in October 1981.

If Metropolitan Edison enters receivership, it is not clear what may happen to its remaining assets. In receivership the courts would decide how any available money would be spent, and there is no way to predict how much of the revenue would be awarded by the court to clean up Three Mile Island. Would cleanup costs be covered before bond credit was paid off? Would a bankruptcy trustee have the freedom unilaterally to change rates instead of having set by Public Utility Commissions? We do not know.

Meanwhile, Metropolitan Edison's Unit 1, which was down for refueling at the time of the accident, remains idle. To ensure a high level of safety and to increase public confidence, the Nuclear Regulatory Commission in July 1979 refused to allow Unit 1 to come back on-line. However, revenues from the operation of Unit 1 could go a long way toward improving Metropolitan Edison's standing in the financial community. This, in turn, might allow the utility to borrow some of the money to clean up Unit 2. (A further problem stems from the fact that Unit 1 was removed from the rate base in April 1980. This means, under current Public Utility Commission restrictions, that no income from Unit 1 can be used for the cleanup operation. Hence, the mechanism for eventual repayment of loans for the cleanup is uncertain.)

This last July the Governor of Pennsylvania submitted a proposal for financing the cleanup of Three Mile Island. The proposal calls for all involved parties to share the expense, and it includes the restart of Unit 1. While the proposal is viewed as an important first step, follow-up in securing agreements still remains. Before anything else can happen, the Nuclear Regulatory Commission must approve the restart of Unit 1. The Atomic Safety and Licensing Board has concluded its public hearings and, as predicted, reported favorably to the Commission in September. However, restart could be delayed until winter because the Nuclear Regulatory Commission has stated its intent to review the Board's decision before giving final approval.

Metropolitan Edison is not the only utility affected by the aftermath of Three Mile Island. Our failure to resolve the impasse has cast a shadow on the whole nuclear power industry. Soaring inflation, new and often contradictory federal and state regulations, and public intervention are all major factors in halting growth of nuclear power. No new plant orders have been placed since 1978, and more than 50 plants have been cancelled in the past five years. From 18 to 21 additional plant cancellations are expected in 1981.

A Department of Energy study (DOE/RG-0036, July 1980) reports on the national impact of protracted licensing delays of nuclear power plants. (Some of these delays were caused by safety adjustments made after the Three Mile Island accident.) The study recommends that

"...Every effort should be made to maintain the

current schedule for construction and licensing of these commercial units which are scheduled for operation by the end of 1985:

Diablo Canyon Units 1 and 2, California
San Onofre 2, California
La Salle County Units 1 and 2, Illinois
Farley 2, Alabama
McGuire 1, North Carolina
Summer 1, South Carolina
Sequoyah 2 and Watts Bar 1, Tennessee."

The study notes that failure to complete the nuclear units scheduled for operation by 1985 will result in the use of an additional 700 million barrels of oil. If no new nuclear units are added by 1985, then electric power reserve margins will be unsatisfactory throughout the entire midsection of the nation, from Michigan to Texas. Moreover, even if such plans are implemented, the northwest power pool will probably have an energy supply shortage by 1985.

The outlook for licensing is not good. Only three uncontested nuclear plants have been licensed by the Nuclear Regulatory Commission since the moratorium precipitated by Three Mile Island. This brings the total number of commercial operating nuclear reactors to 72. There are now 96 plants in some stage of licensing, but many of these may be delayed or cancelled.

The pending decision by the Supreme Court in the Sholly case will be important to the future of the nuclear power industry. Should the Court find that each and every amendment to an operating license must be subject to public review, the way would be open for thousands of hearings every year. The number of hearings would constitute a de facto shutdown of the nuclear industry.

As mentioned, increased complexity in the licensing process for nuclear plants is part of the aftermath of Three Mile Island. For example, after the President's Commission investigated the accident, the Carter Administration added two new partners to the licensing process—the state governors and the Federal Emergency Management Agency. Every nuclear plant must now have an emergency response plan approved by the governor of the state and also by the federal agency. These additional steps, desirable though they may be, are bound to delay licensing of nuclear plants.

Utilities are critical of such additional steps, and they are also critical of the uncertainty they face as a result of the proliferating, and largely uncoordinated, regulations. It is not surprising, therefore, that utilities are not placing orders for new nuclear plants. At a time when projected shortfalls of electricity are being well documented, the Nuclear Regulatory Commission predicts that only one construction permit application will be submitted between 1981 and 1986.

Moreover, such licensing problems are not restricted to nuclear plants; it is increasingly difficult to bring coal-fired generating plants into service. The difficulty stems from increasing government interest in and regulation of the problems associated with burning coal; for example, the build-up of carbon dioxide in the atmosphere, acid rain, land destruction, and transportation. Capital requirements for coal plants are already large (about 2/3 those for nuclear plants), and the expensive regulatory restrictions now added to the basic costs make utilities reluctant to commit themselves to build new coal plants.

Safety and environmental regulations are not the only factors restricting construction of new nuclear power plants. Inflation and tight money are also involved. As recently as 10 years ago, utilities routinely funded a large portion of a nuclear construction project internally. Today, with only about 20 per cent of such funds generated internally, the companies must compete in the open market for money to fund the remainder. Furthermore, it is becoming increasingly difficult for utilities to compete for capital in the open market. One reason is the high investment risk associated with costly plants that will not be producing electricity for 10 to 14 years. Another reason is the general wariness about a nuclear investment after the experience of Metropolitan Edison in recovering from the Three Mile Island accident. In addition, the reluctance of public utilities commissions to allow rate increases on the grounds that they fuel inflation makes it difficult for utilities to be sure of an adequate return on investments. This situation is

reflected in the market for utility bonds. In the past two years Standard and Poors has cut 37 bond ratings of electric utilities while raising only 6. And utility stocks now average only 3/4 of their book value. Yet despite their poor standing, the utilities will have to find some $600 billion in investment capital before the year 2000 just to keep up with the 2 to 3 per cent a year increase in demand estimated by the Department of Energy. This sum is four times more than the total capital invested by the utilities up to 1980.

As we have seen, the handling of the Three Mile Island accident weighs heavily on the nuclear power industry and on all electric power generation. Industry and government have still not resolved the key questions raised: Who pays for cleanup? How do we ensure safety and environmental protection without regulating the industry to death? The questions that we have so far resolved about the accident are technical ones. We know what happened and why it happened, and we know how to clean up the mess (though not what to do with the waste products). And we have some very good ideas about how to avoid similar accidents in the future.

Questions about the Three Mile Island accident are not the only elements in the electric power equation. Lack of investment capital, inflated construction costs, and uncertainties about the rate structure are also important. Yet none of these elements need be obstacles unless we want them to be.

The administration can streamline the procedure for licensing nuclear plants. It can reduce the number of steps and the number of agencies involved and can speed up the review process.

The Department of Energy can work more closely with state utility commissions and taxing authorities to find ways to encourage plant construction. For example, easing state taxes during plant construction would reduce construction costs and lower consumer rates.

At the same time, the industry should be given greater incentive to phase out and retire expensive, oil-fired plants. The current practice of simply passing increased oil costs to customers does not provide that incentive. The utility companies and the public utility commissions need to make a joint commitment to solve the problem.

Congress could establish an insurance pool to help companies like Metropolitan Edison recover from nuclear accidents. The industry's Edison Electric Institute has already pledged a contribution to the cleanup of Three Mile Island provided there are matching government and Public Utility Commission funds. Congressional action is all that is lacking.

Finally, the public as a whole and particularly citizen groups interested in clean air, resource conservation, and alternative energy sources must become involved in the solution. As a nation, we can no longer afford the luxury of opposing technological answers to social problems, especially the problem of energy. We must all accept the responsibility for weighing alternatives and arriving at practical conclusions. We must accept both the costs and the risks of our choices. We must, in fact, commit ourselves to the society we live in and to the technology that society has developed. This means both enjoying the benefits and paying for the mistakes.

What happened at Three Mile Island is at once vindication and indictment. Even when safety systems were overridden, the accident was largely contained. No one was hurt—that is the vindication of our engineering. But the mess is still there, and we cannot seem to clean it up—that is the indictment of our complex political and socioeconomic system. Unwillingness to assume responsibility is not a problem of the federal government or of the state government or of the nuclear industry or of the engineering profession or of any other group. It is a collective problem, and we must recognize it as such. Our state and federal governments have the authority and the resources to deal with Three Mile Island. The commitment and the will to use this capability must soon be brought to bear. The nation's best interests are not being served by continued delay. ■

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