Reactor Safety and the Research Budget

As light water reactors begin showing signs of old age, Washington reduces funds for research

The people at the Nuclear Regulatory Commission (NRC) whose job is to prevent nuclear accidents work in a schizophrenic environment. As demands for protecting public safety grow more numerous and more complex, the federal support for dealing with them grows weaker.

Ever since the accident at Three Mile Island, the NRC has tried to broaden its outlook on safety issues. It has focused less intently on the possibility of spectacular but unlikely events, such as large pipe breaks, which seemed so important 10 years ago. Now it has begun to look closely at potential consequences of mundane mishaps. Three Mile Island showed that the small and far more likely slipups may be just as disastrous as the big ones. Thus, the NRC has opened up a whole new category of worry. In the process, it has produced an enormous list of safety problems that must be investigated and remedied quickly.

At the same time, the NRC has been told to cut its proposed 1982 budget by 12 percent, just like other federal agencies. The cuts will fall heavily on the safety technology staff and on research. Indeed, NRC officials estimate that research will absorb about 75 percent of the mandated reduction. On top of this, the Administration has asked the NRC to accelerate the licensing of light water plants and to prepare to license the breeder reactor. These new demands also strain resources.

The Administration is hoping to cool the NRC's regulatory ardor. It is quite possible, however, that cutting funds for research and safety technology will only increase the turmoil in nuclear plant oversight. One of the benefits of research, if it is well done, is that it helps anticipate problems and sort them according to significance. One of the NRC's greatest needs today is to decide which safety issues are the most important and which can be set aside for later. Consider the problem of reactor vessel cracking, known in the trade as the "thermal shock" issue, suddenly a hot topic at the NRC.

At the heart of the problem is the steel vessel which in pressurized water reactors, holds the radioactive fuel and the water that cools the fuel. This metal cylinder is very tough, but as time goes by it is weakened by neutron radiation from the reactor core. Gradually the steel loses resilience. The process is not well understood. But it is known that after a decade, the most heavily irradiated section of the vessel (the midline) becomes quite brittle. It becomes brittle even at relatively high temperatures, in the range of 220° to 290° F. Flaws in this section of the vessel may expand into cracks and, under certain circumstances, the cracks may burst, spilling the water which is needed to cool the fuel core.

This could happen, for example, if the hot (550°F), brittle area at the middle of the vessel were suddenly doused with cold (40°F) water at very high pressure (2200 pounds per square inch). The scenario is not implausible. It is precisely what could happen if there were a break in the main steam line outside the pressure vessel, followed by a deliberate attempt to cool the reactor while maintaining high pressure in the vessel. The heat shock and the pressure would put tremendous stress on the fragile section of steel. A crack might develop, burst, dump water on the floor faster than emergency cooling systems could make up the loss, and lead to an accident at least as severe as the one at Three Mile Island.

"Asking me whether this is the most important safety problem for reactors is like asking someone who's in the middle of the Battle of the Bulge what's going on in the war," says NRC's Richard Johnson. He is a licensing official directly involved in deciding what should be done about thermal shock. He is not a commander in this safety improvement campaign, but a metallurgist and task manager for the thermal shock program. This is just one of three safety issues which he is working on, all of them judged by NRC standards to be of the highest priority.

Johnson says that the NRC staff who were most interested in thermal shock and cracking had tried to get the NRC to pay attention for at least 10 years. Then in the summer of 1981, the upper-level managers finally took notice. The chief of Nuclear Reactor Regulation, Harold Denton, gathered his staff together and asked them to select out a handful of the worst from a score of badly threatened reactors, including at least one from each of the manufacturers: Westinghouse, Combustion Engineering, and Babcock & Wilcox. The NRC sent letters to eight reactor owners in August, asking them to supply data and to come up with ideas for remedial action. Most of this information will be collected this year, and the NRC hopes to be ready to propose remedies by next spring.

Several things prompted the NRC's concern about thermal shock. One was an old analysis of brittle steel based on worst-case assumptions showing, as Johnson says, that "we should have had a broken pressure vessel a few years ago." Another prod came from an analysis of a routine "transient" (unplanned shutdown) which occurred at the Rancho Seco reactor near Sacramento, California, in 1978. The study found that if the reactor had been 10 years old (rather than 3), the transient could have cracked and burst the walls of the pressure vessel. Last, and perhaps most important, NRC staffer Demetrios Basdekas took this information to Representative Morris Udall (D–Ariz.), chairman of the

An old analysis of brittle steel based on worst-case assumptions showed that "we should have had a broken pressure vessel a few years ago."

0036-8075/81/1113-0766$01.00/0

House subcommittee on energy and the environment. Udall became interested and urged the NRC to investigate.

Quite apart from the politics involved, the NRC's sense of urgency derives from "damn good data" developed over the last 5 years, Johnson says. The NRC's chief of safety technology, Thomas Murley, confirmed the worst expectations in February 1981 when he carefully reexamined the data from Rancho Seco and found that all the elements of a thermal shock scenario had been present—except for a brittle vessel.

In May 1981, the NRC asked the Oak Ridge National Laboratory to gather together all the available information on thermal shock and to help estimate the amount of risk involved. The laboratory produced a draft report on 9 October, concluding that "pressurized thermal shock must be regarded as a serious potential threat and merits a great deal more study using refined techniques." The final draft is due later this fall; it will say essentially the same thing.

One of the authors, R. D. Cheverton, says that the scenario for a thermal shock accident is quite plausible and that the consequences could be severe. But he points out there are huge uncertainties in the data used to calculate what happens at each step in such an accident.

To grasp the degree of uncertainty, consider the difference obtained simply by using different computer models to simulate a thermal shock. The Oak Ridge staff used two techniques, known as the IRT code and the TRAC code, both of which were developed for studying the behavior of an overheated fuel core. One difference is that IRT assumes incorrect, and TRAC assumes correct, operator action. They were adapted, not entirely successfully, for estimating what would happen to an overstressed pressure vessel. The Oak Ridge group found that in simulating a break in the main steam line, the IRT said that a reactor vessel would be vulnerable to rupturing after only 3 or 4 years of use. With the same assumptions, the TRAC code showed that the pressure vessel would not rupture during its entire lifetime.

Many years of research on steel cylinders have produced nothing more definite than this. The engineers have concluded that America's aging pressurized reactors may already pose a serious threat to public safety. And they have added a footnote saying that much of the data leading to this conclusion may be wrong.

This safety problem is different from others that bedevil the NRC in a couple of respects. Unlike corrosion problems, thermal shock could occur suddenly and without warning. It is larger than most other issues. Perhaps as many as 20 pressurized water reactors may be affected. The remedies are awkward and terribly expensive. One solution sometimes mentioned would be to close the affected plants and ask the owners to try to anneal the weakened steel by heating it to a very high temperature for a couple of days. A plant might have to be put out of commission for 2 years to do this. Even this might not be adequate, for metallurgists have not had enough experience with irradiated steel to guarantee that annealing would remove all the flaws from a weakened pressure vessel.

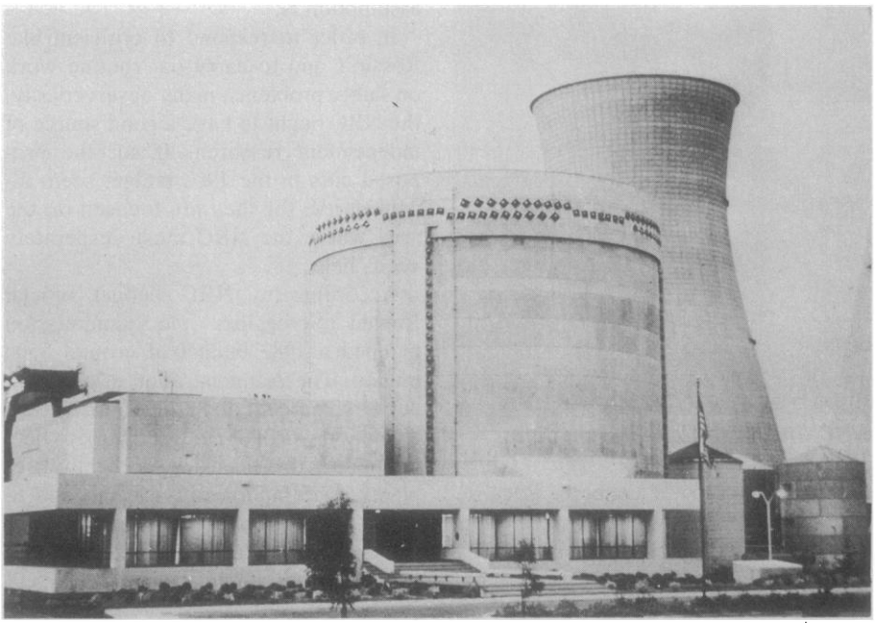
NRC Chairman Nunzio Palladino met with the members of the independent Advisory Committee on Reactor Safeguards (ACRS) on 16 October to discuss plans for coping with thermal shock. The ACRS told Palladino that this was an urgent matter, but not one requiring immediate plant closings. Palladino, however, could not give the ACRS a firm schedule for his own plans to clarify the risks involved. By common consent, it seems to have been decided that the NRC will have a grace period of 1 year in which to come up with better information that will confirm or dispel the threat.

Herbert Kouts, a member of the ACRS, is a physicist at the Brookhaven National Laboratory who has carried out research on reactor vessel problems for more than 20 years. In his opinion, the NRC has not attacked the problem with the coordinated and vigorous program that will be required if it wants to have good risk estimates within a year.

Jack Roe, technical assistant to NRC Chairman Palladino, says that without formally deciding to do so, the NRC is giving special attention to the problem of thermal shock. Roe declines to rank it in relation to other safety issues since, he says, that would be like trying to decide which of his children he likes the best. NRC officials do not want to appear neglectful of any of the problems that have been winnowed out and placed on the list of unresolved safety issues (USI). All of these are given an "A" ranking in priority (thermal shock is listed under A-11, "reactor vessel materials toughness") and are worked on together.

In the past, the NRC was criticized for shunting aside the biggest problems, labeling them "generic issues," and studying them to death. The USI list is a managerial gimmick designed to overcome that tendency. Once a problem has been ranked as a USI, it acquires special significance. A task manager is assigned. Milestones and deadlines for solving the problem are set. Quarterly reports to Congress describe the progress of work.

The August report listed 16 active USI's, running from A-1, "water hammer," to A-48, "hydrogen control measures and effects of hydrogen burns on safety equipment." Although few seem as threatening as thermal shock, many



Atomic Industrial Forum

Rancho Seco 1, Clay Station, California

During an emergency shutdown in March 1978, the operators at this plant unwittingly simulated all the elements of a thermal shock incident. Fortunately, the reactor vessel was too young (3 years old) to crack, as an older vessel might have done.

could have severe consequences for public safety and for the economic health of the industry. The combined item A-3, -4, and -5 deals with the corrosion of heat transfer tubes in the steam generators of pressurized water reactors. Although the problem first appeared in 1976, it has

NRC Chairman Nunzio Palladino

now become a major concern. Because the tubes carrying hot, pressurized water from the reactor vessel are disintegrating more rapidly than expected, it has become necessary to impose a strict regimen of chemical treatment. This is expensive and difficult to sustain. Tubes must be plugged to prevent leakage of the radioactive coolant. In some cases, the efficiency of the reactor is lowered. Many owners will have to follow the steps taken by the Virginia Electric Power Company last year at its Surry 1 and 2 reactors. Both steam generators were replaced for a total cost of $112 million.

Safety items are removed from the USI list after a "technical resolution" has been found. The August USI report mentions 10 problems—independent of the 16 active ones—which have been shifted to the resolved status. This means that the NRC has assessed the scope of the problem, recommended action, and begun to negotiate with owners about what should be done. It does not mean that the owners agree or readily comply with the NRC's assessment.

The industry tends to view these matters in the most optimistic light, while the NRC staff tries to be conservative about risks. For example, the NRC's research suggests that some reactors are already vulnerable to a thermal shock accident. David Rossin, the new director of the industry-backed Nuclear Safety Analysis Center in Palo Alto, California, does not agree. Rossin says the work done at Oak Ridge and the NRC includes many conservative assumptions that should be discarded. For example, he mentions that the Oak Ridge scientists assumed that cold water entering the hot pressure vessel would not mix with the hot water and steam already present; thus they avoided the question of whether or not the mixing would lessen the thermal shock. Rossin's center, which now has a budget of $6.5 million, is preparing to show just how unlikely the assumption is.

In order to respond to criticism like Rossin's and to carry out routine work on safety problems, many observers say, the NRC ought to have a good source of independent research. If so, the proposed cuts in the 1982 budget seem ill-considered, for they are focused on the area where the NRC most desperately needs help.

According to NRC budget official Ronald Scroggins, the Commission planned a 1982 budget of around $500 million. The Administration asked for a cut of 12 percent and added new duties: $7 million worth of contract work to help accelerate the licensing of light water plants, $7.5 million for research and licensing work for the breeder reactor at Clinch River, Tennessee, and $1.5 million for work on miscellaneous safety issues related to Three Mile Island.

The cutback, together with the new duties, will reduce funds for activities proposed for 1982 by about $45 million. About $39 million of that will be taken from the planned research budget, reducing it by $15 million from the 1981 amount.

The spending decisions have not been set out in detail, but NRC officials say that the cuts will affect research on high-level waste disposal sites and probably end research grants to universities. For several years, the ACRS has recommended that the NRC phase out the large and expensive loss of fluid test (LOFT) facility in Idaho, which is used to simulate large pipe-break accidents. It has served its purpose, the ACRS believes, and should now be abandoned. The money could be made available for research on other safety problems. Some NRC staff members would like to cancel LOFT and save an estimated $14 million in 1982, but it is not yet clear whether Idaho politicians will permit that to happen.

It is clear, however, that the NRC will have to make do with a shrinking research budget for the next few years. The constraints are being imposed at a time when the NRC is trying to examine new technical issues as well as reorganize its methods of conducting research. It will be especially difficult for the NRC to focus on the category of small-scale mishaps that the accident at Three Mile Island indicated are important precursors of an accident. In times of retrenchment, federal agencies tend to protect old and familiar ideas. They do not set out on new explorations.

A review of the NRC's research effort, conducted by a panel of experienced outsiders,* concluded in September that new explorations are precisely what should be supported. The review, undertaken for the (now defunct) President's Nuclear Safety Oversight Committee, urged that the NRC close down LOFT and get started on eight new problem areas that "urgently need research . . . [and] on which no significant research is being done." For example, the reviewers found it "somewhat surprising that no research to improve the reliability [of electric power at nuclear plants] is included in any of the programs the review group has considered." The report listed 11 other areas in which work needs to be improved. It concluded that the NRC's long-range research plan should be rewritten to "infuse it with a more up-to-date and logical structure" to avoid "the tendency to support more of what has already been done."

The review group concluded in September that the NRC should rewrite its research plan to avoid "the tendency to support more of what has already been done."

It would be reassuring to learn that this advice was being taken to heart and that the NRC was being encouraged to anticipate potential safety problems. However, the Administration believes this reassurance may not be affordable.—ELIOT MARSHALL

*"Report of the Reactor Safety Research Review Group" to the President's Nuclear Safety Oversight Committee, September 1981, chaired by Norman C. Rasmussen of MIT.