Nuclear Safety (II): The Years of Delay

Although it could hardly have foreseen so at the time, the Atomic Energy Commission embarked in 1963 on a construction project that was to become one of the longest-running, most trouble-ridden ventures of its kind in the commission's 25-year history. That was the year the AEC set out to build a modest little nuclear reactor called LOFT at the National Reactor Testing Station in the Idaho desert. The reactor's name was an acronym for "Loss of Fluid Test," and it aptly indicated the $18 million facility's unusual mission.

According to plans at the time, LOFT would be completed in 1966. It would then be studded with instruments and sealed inside a massive concrete and steel "containment" dome at the desert proving ground. After a series of small-scale experiments, technicians would run the reactor up to its full power of 50 megawatts and abruptly drain it of its cooling water.

Inside the dome, LOFT would partially melt. But in destroying itself it would give safety researchers their first look at a reactor in the throes of what the AEC had formally declared to be the "maximum credible accident" that a nuclear power plant could reasonably be expected to suffer—a major loss of cooling water through a ruptured pipe.

The LOFT project was, therefore, of central importance to the commission's safety research program. In making this point, in its annual requests to Congress for money, the AEC was not stingy with superlatives. LOFT was the "largest and most vital" test facility in the safety program. It was the "focal point which provides a fundamental sense of direction to water reactor safety investigations." Among other things, LOFT would demonstrate a "live accident [that] makes investigators face reality."

Later on, the AEC promised that LOFT could make "extensive contributions" toward erasing nagging doubts about the adequacy of backup cooling systems in nuclear power plants—a subject the commission considered to be "perhaps the most urgent problem in water reactor safety," even before it became a public issue.

For all its stellar importance though, the only reality LOFT has yet made anyone face is that putting together an experimental reactor—even a small one—can be a very trying experience. Nine years later, the AEC is still struggling to finish building the LOFT facility, let alone run it. At last report construction was 80 percent completed, but work is now more than 6 years behind schedule. LOFT's crucial experiments have been expanded in scope but postponed until 1974 or 1975; by then, as many as 80 nuclear power plants that might have made use of the results in their design will already be running. What's more, now that construction costs have ballooned to $35 million, AEC officials in charge of the project have just about given up the idea of letting such an expensive piece of equipment seriously damage itself, much less melt. So in all probability the consummate experiment originally planned will not take place.

Nor is LOFT the only major safety test facility to have sustained long delays and soaring costs. A second reactor at the Idaho installation—the Power Burst Facility (PBF)—was completed last summer, 4 years late and $8 million or 100 percent over the original cost estimate. The PBF was designed to subject nuclear fuel assemblies to abnormally stressful conditions, in order to better understand the behavior of fuel rods before and during an accident. The commission has designated fuel-failure research as being of highest priority; thus between the two test reactors, some of the most urgent safety research planned by the AEC has been postponed.

What happened to LOFT and PBF? Interviews with AEC officials in Washington, and with scientists and engineers at the NRTS in Idaho, turn up a tangle of conflicting charges and countercharges that reflect strong disharmonies that have grown up between the two sides in recent years. An article last week outlined the nature of these problems and some of their history. This week's article attempts to unravel the reasons for delays in important safety research projects that appear to be both cause and victim of this enmity.

The basic causes of delay and overrun are clear enough in themselves; the controversy arises over whom, if anyone, to blame. For both reactors, the first major delays occurred just at the point when detailed designs had been completed and construction was about to begin. In the case of the PBF, the fuel-testing facility, AEC headquarters sent down an order in April 1965 to revise the blueprints and build a more "versatile" reactor, capable of running in a steady state as well as of producing bursts of power. It was a major design change, and one that the Government Accounting Office (GAO), the investigatory arm of Congress estimates cost $1.3 million and 10 months in progress. The GAO, in a brief report on LOFT and PBF last year, did not comment on the merits of this decision.

As for LOFT, by far the more troubled of the two projects, the AEC decided in May 1967 to radically alter the reactor's main purpose from one of proof-testing a containment shell of the type that surrounds nuclear power plants to one of testing out emergency core cooling systems. In this case, the GAO report made no comment on the merits or the consequences of this decision, although a reasonable guess might attribute half the delay and overrun to it.

More controversial is the matter of "quality assurance." Both sides agree that Washington made a vigorous effort, beginning about 1966, to apply strict new quality standards to the construction of the two reactor plants, and it is evident to all concerned that both projects became bogged down in the process. But whose fault was it?

Milton Shaw, the AEC's director of reactor development and technology (RDT), and the central figure in this dispute, is explicit: The responsibility, he has made amply clear in interviews and in testimony before the congressional Joint Committee on Atomic Energy, belongs to the Phillips Petroleum Company, whose nuclear division was hired by the AEC in 1950 to run the NRTS and to manage the Idaho site's safety research programs. At Shaw's behest, the AEC severed its remaining ties with Phillips last summer and turned over full responsibility for safety programs to the new operating contractor at NRTS, the Aerojet Nuclear Corporation (see box).

Shaw describes the years trying to complete the two projects—particularly LOFT—as one of the most frustrating experiences of his life. In the first place, he says, their objectives were "narrowly conceived" by Phillips. And second, for some reason, the company had endless problems getting pumps, valves, and other parts of "acceptable quality."

The Fall of Phillips Nuclear

The nuclear division of the Phillips Petroleum Company, it appears, was on its way out as operating contractor of the National Reactor Testing Station even before a fight erupted over its conduct of research projects. In May 1965 the Atomic Energy Commission announced that Phillips' contract would be terminated forthwith—except for its safety research responsibilities—and that the contract to run NRTS would be put up for open bid. An AEC news release at the time said this was not to be construed as a sign of dissatisfaction with the company, but was only "intended to give other companies a chance to compete for an AEC operating contract."

This decision marked the beginning of antagonism between scientists and engineers in the safety program, who were employed by Phillips, and the AEC's Division of Reactor Development and Technology. Although most of the 1800 Phillips employees not in the safety program were to be absorbed by the new contractor, the move understandably offended company loyalties. Moreover, it led to administrative complexities that safety research managers would just as soon have done without. "Suddenly we were an arm grafted onto a new body," said one. "New working relationships had to be established, and generally it was an unnecessary disruption."

The operating contract, worth $29 million in 1966, amounted to a rich subsidy for reactor manufacturers, and the AEC was not bashful about saying so. Special consideration, the commission said, would be given to bidders with a strong interest in commercial nuclear reactors "as evidenced by the firm's activity and investment in the field of atomic power."

Phillips had not involved itself in nuclear energy beyond its activities at the NRTS; consequently it was out of the running. The winner of the contract was the Aerojet-General Corporation, which at that time had made heavy investments in gas-cooled reactors and was facing a bleak outlook for sales. Together with the Allied Chemical Corporation, which had invested in nuclear fuel reprocessing, Aerojet formed the Idaho Nuclear Corporation in 1966 to run the NRTS.

The safety program remained in Phillips hands for 3 years more, but by 1969 the LOFT and PBF projects that it ostensibly supervised were in deep trouble. That June, under orders from the AEC, Phillips joined Idaho Nuclear as a third and minor partner with no top-management authority.

Last summer, yet another major reorganization removed both Phillips and Allied from the unequal triumvirate of operating contractors and left some research managers wondering about the legality of it all. Although no open bidding process took place, the AEC negotiated a new operating contract that led to the dissolution of Idaho Nuclear and to the creation of an entirely new corporate entity as the operator of the NRTS—the Aerojet Nuclear Corporation, a solely owned subsidiary of Aerojet General. Although AEC officials say that no contract procedures were violated in this shuffle, it does leave a residue of irony. Several years ago Aerojet dropped out of the reactor business, except for its duties at Idaho, for which the company now receives nearly $50 million a year.—R.G.

"For one reason or another," he told the Joint Committee in March 1970, "we were unable to get from Phillips the management talent necessary to get the LOFT and PBF projects done."

At Idaho, however, scientists and engineers in the safety program—some of them formerly employed by Phillips—tell a different story, the essence of which is that the AEC used Phillips as a scapegoat for much of its own ineptitude. To the extent that their story can be independently verified, there is evidence that Shaw shifted a significant portion of the blame for delays and overruns from the AEC to Phillips.

In interviews, the Idaho researchers conceded that the Phillips contingent at the NRTS did have some trouble hiring talented engineers and managers, partly because the site was so isolated.

At the same time, however, Shaw's explanations of the problems at Idaho appear to have omitted the fact that for virtually all the 15 years that Phillips ran the safety program it did not have full legal authority to administer design and construction contracts to the firms that actually built the dozens of test reactors at Idaho. Instead, that responsibility belonged to the AEC's own outpost at the proving ground, the Idaho Operations Office.

One senior engineer formerly with the PBF project explained the limits of Phillips authority this way:

> Our responsibility was limited to early, conceptual designs for projects like LOFT and PBF. The AEC operations office let the contracts to architect-engineers—the design firms—and to construction companies. Once detailed design began we merely had authority to review and comment on a project's safety and whether it was meeting its objective. These observations were passed on to the AEC.

As problems developed with LOFT and PBF, former Phillips officials at Idaho are said to have made a strong plea to Shaw in 1968 for full authority over the two floundering projects. The authority was granted in early 1969. Within 3 months, as problems continued and the Joint Committee wanted to know why, Shaw stripped Phillips of its management authority over the safety program on the grounds of its inability to hire sufficiently qualified staff. "The name of the game," said one man now employed by Aerojet, "is cover your number."

The GAO report on the two projects, issued in August 1971, confirmed but did not comment on, this train of events. Several researchers at Idaho, including two who had reviewed a draft version of the report, said that the final, public version omitted serious criticisms of the AEC's management of the LOFT and PBF projects. One of those who had read the draft said that, They attributed these deletions to pressure exerted by the commission, which customarily reviews GAO reports of AEC affairs before they are made public.

In an interview, Shaw was asked whether he thought it was fair to blame Phillips for delays in construction when they lacked full authority over contracts. "If they didn't have it, who did?" he said. The AEC, it was suggested. "Well, let's be fair. *Neither* Phillips nor the AEC out there had the necessary competence."

Perhaps the bitterest conflict of all at Idaho developed around Washington's efforts to institute stringent new quality standards in the construction of reactors—not only for commercial nuclear power plants, but for the AEC's own test reactors as well. These two parallel efforts—one internal, one aimed at the industry—commingled to a large extent, and, in the view of a number of safety program staff, with disastrous results. An administrator at Oak Ridge National Laboratory who watched the battle at Idaho from afar says:

> You have to give Shaw credit for pushing the industry to adopt tougher standards. They were urgently needed, and some elements of the industry—and I refer to Westinghouse and General Electric [the two leading reactor manufacturers]—fought it all the way. The question is whether these or similar standards are appropriate for research facilities. We think they are not.

The critics in Idaho charge that in late 1966 Shaw co-opted the LOFT project for use as a "showcase" for standards, to prove to a reluctant industry that they really were feasible. The problem, says an engineer involved in the affair, was that some of the standards, in their initial form, turned out not to be feasible:

> The whole philosophy became one of using LOFT to develop standards and check them out, rather than producing the safety information we desperately needed. And some of them were a bit extreme, requiring that metals be traceable back to the mine. . . . The overall effect was to drive up costs of some com-

FDA to Regulate All Blood Banks

Federal regulations will soon be extended to cover all blood-banking and plasma-collecting operations nationwide, regardless of whether they are engaged in interstate transactions, the Food and Drug Administration (FDA) announced on 26 August.

The new federal directive comes only a month after the Division of Biologics Standards (DBS), now known as the Bureau of Biologics (BOB), was transferred from the National Institutes of Health to the FDA.

The changes are scheduled to go into effect after a 60-day comment period. The FDA action is merely one step in what can be expected to be a series of federal initiatives relating to the nation's blood collection and distribution systems. The next move will probably come following the completion this fall of a massive NIH-sponsored blood study.

The BOB is already responsible for registration and inspection of some 530 large blood banks that collect about 85 percent of the nation's supply of blood for medical use. With its expanded purview, BOB will also oversee more than 3000 small community- and hospital-based facilities that collect the remaining 15 percent.

Plasmapheresis Centers Covered

The new regulations also apply to some 200 plasma-collecting and processing stations that hitherto have escaped federal regulation because they are engaged in collecting products declared in "short supply." These centers have only been required to conform to the requirements of their customers, the federally licensed manufacturers of plasma fraction products.

The legal justification for the new move is a provision Congress added in 1962 to the Food, Drug, and Cosmetic Act. The provision requires registration and inspection of all establishments that manufacture, prepare, or process drugs. All biologics (including blood) are regarded by the FDA as "drugs"—defined as "articles" used in the diagnosis, treatment, and cure of disease.

The new director of the BOB, Harry M. Meyer, offered no particular explanation as to why the regulations hadn't been changed long ago. It is known, though, that the previous leadership of the biologics bureau resisted making use of the food and drug law for fear the DBS would be ensnared by the FDA.

Some Blood Bankers Concerned

The American Association of Blood Banks (AABB), a voluntary organization to which most non–Red Cross banks belong, expressed some trepidation about the new ruling. President-elect Robert Langdell said that the AABB didn't want the government to be "superimposing" its authority on AABB banks, and that the regulations would result in a great deal of duplication of effort and costly paperwork. The duplication would only be partial. Government regulations are concerned with collection, storage, and distribution of blood, while AABB standards also cover the medical area, which includes processing, cross matching, handling, and infusion into the patient.

The Red Cross—which, together with the AABB, draws almost 90 percent of blood used by the nation's medical establishment—seemed happy with the FDA initiative. Medical director Tibor Greenwalt said he always welcomed outside inspection.

The recommended change in regulations will have little effect on a problem that has caused a good deal of public hue and cry of late: the high incidence of hepatitis in the blood of paid donors. Commercial blood banks are responsible for a large portion of hepatitis-contaminated blood (nonprofit banks also pay some donors), and most of these are already federally licensed.

—C.H.

ponents by a factor of 3 to 5 and to stretch out timetables by two and a half.

Months were consumed by haggling among Phillips, the AEC in Idaho, and teams of engineers under Shaw in Washington over the acceptability of particular pieces of plumbing. Voluminous documentation was required to verify that standards were being met and that tests and inspections were being carried out according to the new rules.

(Meanwhile the Power Burst Facility was having problems of its own. No one tried to use it as a showcase, but the new standards meant redesigning many parts. To speed things along, project engineers tried to meet the "intent" of new standards for pipes, pumps, valves, and other parts while liberally construing the "letter" of the standards. For their trouble, some were fired. "It was a hard learning experience," one man recalls, and one the GAO says accounted for most of the slippage in schedule.)

Amid all the bickering, construction on LOFT came to an almost complete halt between May 1968 and October 1970. One problem, it developed, was that no manufacturer in the country would bid on such essential items as coolant pumps and valves and control-rod mechanisms that Washington wanted made according to its new standards. This impasse was finally resolved by "cannibalizing" these parts from a number of old reactors, including one aboard the scrapyard-bound N.S. *Savannah,* the nation's first and only nuclear freighter. "So here we sit," says an engineer at Idaho, "building it out of scrap."

Roy Swanson, the AEC's project manager for LOFT at Idaho, confirms that such parts are being used in the reactor, but he says it's unfair to characterize them as "scrap," even if they are 10 or 12 years old and don't fully measure up to the new standards. He said that the pumps and valves are now being refurbished in shops at NRTS and they'll soon be good as new.

Did the use of LOFT to develop new standards cause major delays in the project? Swanson said:

> "Sure, it caused some delay, but the standards weren't *that* far out. They were based on experience in the Navy and elsewhere. And there were other problems, like building a 200-ton door for the containment [shell] so we could move the reactor in and out on a railroad car. . . ."

Was LOFT used to show industry that the new standards would work? Did this ploy work?

> "Yes, this did happen. You'd take a company by the hand and show them step by step how they could meet a standard, and you're starting to see companies advertise in trade journals that they meet RDT-Shaw standards. . . . It's true that some were a little too tough, and we couldn't get bidders on pumps and valves at first, but you go in and negotiate these things. And sometimes you have to compromise a little."

Isn't it understandable, Swanson was asked in a conversation, that safety researchers should be upset at having their project "expropriated" for this purpose? "Sure," he said. "But whenever you get into standards you take a beating on the head."

In Washington, Milton Shaw says that it's "ridiculous" to think that so important a research facility would be used principally as a showcase to sell new standards to the industry, although if it did so "that might have been a worthwhile spinoff."

Shaw says it was all part of a strenuous effort on his part to introduce a "disciplined engineering approach" to the conduct of reactor R & D by the AEC's national laboratories. For the laboratories' management, this entailed occasionally drastic reorganizations aimed at tying research more closely to specific goals—such as developing an economical breeder reactor—and it also meant establishing firm, clear lines of authority, modeled after the aerospace industry, leading back to Shaw's own teams of engineers in Washington. Moreover, laboratories were instructed to seek out and employ new program administrators who were familiar with the nuclear industry and sympathetic to the need for rigorous quality control in research.

This was necessary, Shaw says, to improve the reliability of expensive and potentially dangerous experimental facilities. "We were losing data because of breakdowns and defective equipment, and because some things were not being calibrated well enough to permit an experiment to be repeated."

The campaign for quality assurance at Idaho was prompted in part, he said, by the discovery in 1965 of "bum welds" in the Advanced Test Reactor while it was under construction. Repairs required virtually rebuilding the reactor, he said.

In the case of LOFT, Shaw conceded that he has had a hard time convincing experimenters at Idaho that their reactor should be built to higher standards than those applied to commercial nuclear power plants. This disparity is justified, he argues, because LOFT is meant to provide empirical verification of safety system designs, and it is not meant merely to "proof-test" a typical reactor. And he wants to prevent any mishaps, such as a ruptured pipe, that might accidentally damage the reactor. "We don't want the technology damned because of flaws in the equipment."

In important ways, during the past 8 years, Shaw has industrialized those segments of the national laboratories that come under his aegis as director of civilian reactor R & D. Major portions of the laboratories, he reported to the congressional Joint Committee this year, have been "converted from a research orientation to one stressing disciplined engineering application, proof-testing, and quality assurance, as well as soundly developed applied technology."

The laboratories have not taken kindly to this discipline, which they are inclined to view as excessive. (One of the first and sharpest protests came in 1967 from Albert V. Crewe, then director of Argonne National Laboratory, who remarked in a speech that Argonne's purpose was "not to build submarines but to produce knowledge.")

At Idaho, a senior physicist associated with the LOFT project made his complaint:

> Around 1968 money for basic physics, such as nuclear cross-section work, just dried up. The philosophy was that if something didn't solve a problem—particularly for the breeder—it wasn't going to be picked up in the budget. . . . We can't even do *applied* research now in some cases. Money budgeted for development work on instruments for LOFT essentially stopped in 1968. We'd like to make some improvements in them to extend the data we get from this reactor. But we're forced to use instruments already "on the shelf."

At Idaho and within the safety program at Oak Ridge National Laboratory equally strong feelings prevail that the new quality standards have driven up the cost of doing research without producing any visible improvement in the quality of the research itself.

Certainly test reactors at Idaho grew more expensive. At Oak Ridge, where a much smaller safety research program revolves to a lesser extent around great test facilities, estimates are that RDT standards have driven up the purchase cost of materials by 8 to 10 percent and doubled the cost of some equipment.

These added expenses—combined with the general inflation in the cost of doing research during the 1960's and on into the 70's—dealt a harsh blow to reactor safety research. As costs rose, the program's overall budget grew slowly in some years and remained static in others. At the same time, the Atomic Energy Commission, partly in response to prodding from the Joint Committee on Atomic Energy, found itself accelerating the breeder program, and dipping into money allocated to water reactor safety to do it. Something had to give, and what gave was research intended to resolve questions of the utmost urgency pertaining to dozens of commercial nuclear power plants then on the drawing boards and under construction.

—ROBERT GILLETTE

The Jackson Laboratory: "Mice Are Our Most Important Product"

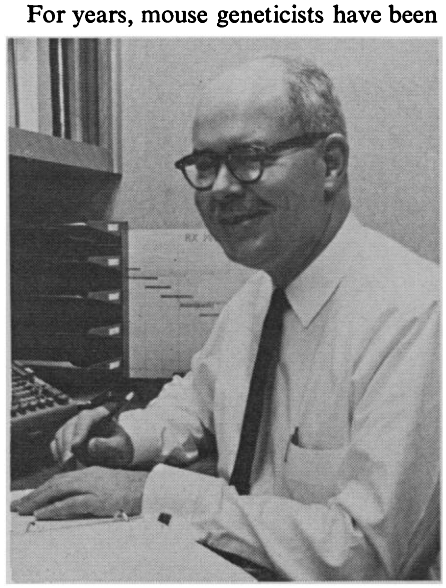
The Jackson Laboratory is a mouse house. Nine months of the year—especially in the icy dead of a Maine winter—the laboratory perks steadily along, in a remote, self-contained world in which a small band of only 34 scientists and their mice pursue the business of biological research. Investigators delve into questions ranging from reproductive physiology to aging, from cancer and transplantation immunology to behavior and environmental stress. It is a place where a person can work in an atmosphere of comparative calm, where people innately take the long view, where one can presume to stick with a single research problem for years, even decades, if need be.

With the coming of spring, the laboratory gets ready to assume its summer personality, and from June to September the isolation is broken by the arrival of visiting scientists and students, who come to take advantage of the three attractions that this institution alone can offer: (i) millions of mice, each carefully bred; (ii) ready access to the impressive expertise of those 34 researchers, who, collectively, probably know more about mice than anybody else; and (iii) the pleasures of a summer on the coast of Maine. During those months, which laboratory scientists quaintly refer to as "our busy time," the scientific population more than doubles.

Situated just 3 miles south of Bar Harbor on Mount Desert Island, the Jackson Laboratory has summer appeal that simply cannot be matched, especially if you have a taste for lobster or ocean sailing and happen to be a scientist with a fancy for genetics. Earl L. Green, who has been director of the laboratory for 16 years, says proudly, "It is the only private, nonprofit research institution devoted to mammalian genetics in the world." Then, as if to put that in perspective, he adds, "Of course, the world needs only one."

Assessing their public image, most staffers placidly concede that, as one of them put it, "Half the scientific world doesn't even know we exist"; yet they clearly thrive on the knowledge that the Jackson Laboratory is Mecca to anyone tuned in to mammalian genetics. And they take satisfaction in knowing that mammalian genetics is steadily gaining importance as a scientific discipline. "This is a golden time for mouse genetics," Elizabeth (Tibby) Russell, a laboratory geneticist since 1937, says fondly, with a measure of gratification that anyone might feel on watching the object of her life-long interest achieve new prominence.

For years, mouse geneticists have been a group unto themselves, a cadre of workers who each knows the other and shares his extraordinary enthusiasm at the discovery of a new gene mutation in a mouse. Many investigators in the larger, richer fields of science think of mouse geneticists as a pleasantly eccentric bunch. Some human geneticists have, at times, looked down their noses at the devotees of the mouse as being amateurs.



Earl Green

But now, mouse genetics is coming into its own. "The point to make about the Jackson Laboratory," says Park Gerald, a geneticist at Boston's Children's Hospital, "is that it is growing in importance. The lab is on the ascendant, becoming significant in its own right as a research center and not just as a supplier of mice, invaluable though that is." Gerald has been a frequent summer visitor to the laboratory.

During the last couple of years, in part to the credit of Jackson scientists, there has been remarkable progress in deciphering the genetic makeup of the mouse. New techniques in chromosome identification—chromosome banding techniques—have emerged that enable investigators to spot individual mouse chromosomes with a degree of precision that was previously impossible. Because mouse chromosomes look so much alike, standard karyotyping techniques that have been useful in looking at the gross structure of human chromosomes have not been terribly valuable to mammalian geneticists. Now, armed with banding techniques that distinguish finer points of structure, many gene linkage groups already have been assigned to specific locations on mouse chromosomes. "It will now be possible to extrapolate data from mice to man," says Gerald. The gap between mammalian and human geneticists is closing and people on both sides seem eager to get on with some collaboration.

The laboratory, as Earl Green sees it, exists to conduct research, train students, and grow mice. It is in its latter capacity that the laboratory is best