Chapter Eighteen

The Shaw Effect...

It appears also that [long-term changes at the NRTS] will be influenced by technology trends, national policy, and other factors largely outside the control or option of the immediate community or the State itself.

—William Ginkel, 1967—

The ATR start-up group was having a bad day, and it wasn't the first one. It was preparing to bring the reactor critical for the first time. As the operators rotated the control cylinders, they saw that the count-rate recorders were not behaving according to prediction. It could mean a delay like an earlier one when the stainless-steel coolant pipe had been accidentally over-pressurized. Some of the pipe, thirty-six inches in diameter, had bulged and deformed. The pipe was ruined. Replacing it had cost millions of dollars and a year of time.[1]

In the face of this new trouble, the team shut down the reactor, opened the pressure vessel, removed the fuel, and inspected. They soon discovered that the drive mechanisms for the sixteen control cylinders would not rotate on command. Each of the drive units had been installed backwards. The problem took less time and money to fix than the earlier problem, and in an earlier day, might have been considered just one of the routine bugs that accompany any complex new project.

This time, the ATR start-up problems and parts failures came under the close scrutiny of Milton Shaw, since late 1964 the director of AEC-Headquarters' Division of Reactor Development and Technology. He sent investigators to discover the management failures that must have caused the mishap, an intense process that further postponed the start-up.[2]

As a former aide to Admiral Rickover, Shaw had been exposed to the safety philosophy of the Nuclear Navy. As wholeheartedly as Rickover, he believed in accident prevention *via* excellence, quality control, and redundancy. He once said of himself, "My wife jokes that when I build a dog house, it'll withstand a seismic event." Although such features had not been absent from NRTS safety philosophy, the principles of Site remoteness and geographical separation of reactors had been major guarantors of public safety. It was likely that if Shaw chose to assert his convictions, the shift in emphasis would change the comfortable old way of doing things at the NRTS.[3]

INEEL 68-3496

Aerial view of TRA looking south. The large ATR building is at right of photo. Its associated cooling towers are below it and farther to the right.

Loss of Fluid Test Facility tunnel entrance

INEEL 79-5542

Above. Logo for Aerojet Nuclear Corporation. Middle. Logo for Idaho Nuclear Corporation. Below. Logo for Allied Chemical.

A forceful and skillful manager, Shaw also practiced his mentor's "abrasive interface" style of dealing with people, making no virtue of tact even on ceremonial occasions. The president of an IDO contractor, Chuck Rice, recalled one such occasion:

After I had been elected president of Nuclear [Aerojet Nuclear], we had a big dinner for key managers in the company at the Stardust Motel. Milton Shaw was there, Bill Ginkel, many from Aerojet, all the way down to branch managers. Shaw got up and did his Rickover-type tirade on all that these people in the room had done wrong. They were lousy managers, had poor control, and so on.

When it was my turn to speak, I got up and listed the outstanding accomplishments of the group and complimented them on the work they had done so well.

As I walked out after dinner,
de Boisblanc came up and said,
"I really appreciated the comments.
You'll be fired, but it was nice to hear it."

The next day there was a meeting on whether to fire Rice or not. Shaw said, "Find out the reason for his speech. Then we'll decide." Someone called me and I said, "Shaw works at Headquarters, I work here. If we are to do well, I've got to invite the people who work here to join my party." I kept my job.[4]

Later, Rice and Shaw developed a warmer relationship. But Shaw's observation of the ATR troubles reinforced his view that a quality assurance approach to reactor operations—even test reactors like the ATR—was the only correct approach. Parts and systems must meet standards, and management must assure the standards be observed. The ATR problems had made a strong impression on him. Years later, he still referred to them when discussing the quality issue with the JCAE.[5]

As Shaw considered the state of the AEC's national reactor program, he felt there was duplication of effort and poor coordination among the labs. Key members of the AEC commission and the JCAE supported him in this view. Shaw felt that the situation justified reform, redirection, and tight control. His introduction to the ATR gave him no reason to exempt the NRTS or its contractors from this overall appraisal. Shaw's new broom began the sweep, and the dust-up generated discord and anxiety, program changes, and personnel dislocations. Some misunderstandings lasted for years.[6]

Phillips' five-year operating contract, which the AEC had renewed regularly since Phillips began at the Site in 1951, was scheduled to conclude in 1966. In March of 1965 the AEC announced a new approach to selecting the next contractor. The AEC wanted contractors that intended to invest in the nuclear industry. While Phillips had a laudable record—and in fact would continue to manage reactor safety research—Phillips' only involvement in the industry, aside from uranium mining, had been at the NRTS. The company was inclined more to research, not engineering. It had no other nuclear involvement.[7]

By June 1965, thirty companies said they were interested in the $29 million contract. The Idaho Falls newspaper kept track of the “titan firms” visiting the Site. Ginkel and his staff rented the Elks Club for briefings and conducted Site tours for the visitors. Up for new management were all three materials testing reactors (MTR, ETR, ATR), their supporting engineering groups and zero-power reactors, the Chem Plant, the Hot Shop and other TAN facilities, most of the site-wide craft and other services—and 1,800 people ranging from bus drivers to scientists. The deal, as usual, would be cost plus fixed fee.[8]

The AEC liked the Aerojet General Corporation. The company, which had been founded in 1942 to design and build rocket engines, had managed a project for the AEC and NASA in Nevada called NERVA, a joint effort to develop a nuclear-powered rocket. The AEC liked Aerojet’s “disciplined approach to engineering and quality, which Aerojet...had developed in its Space Program operations.” Aerojet also had the right kind of ambitions. It wanted to become a major nuclear player and had entered the field of commercial gas-cooled reactors. Managing the NRTS would give its people the experience and competencies necessary to make the grade. Aerojet’s proposal was managed by Allan C. Johnson, who, after his post-SL-1 departure from the NRTS, had landed on his feet at Aerojet. As assistant to Aerojet’s chairman, he and J. Bion Philipson, an NRTS pioneer then also with Aerojet, led the company to the winner’s box.[9]

There was a catch. Aerojet had little experience in chemistry, an unacceptable weakness considering the importance of the Chem Plant. The AEC suggested a shot-gun marriage between Aerojet and one of the other bidders, Allied Chemical. The two companies adjusted their bids and created Idaho Nuclear Corporation (INC), with an understanding that Allied expertise would manage the Chem Plant. Allied held a minority interest in the company (Phillips continued to manage the STEP program as an independent contractor). Dr. Charles H. Trent from Aerojet became president and Bion Philipson his deputy. The new regime began on July 1, 1966.[10]

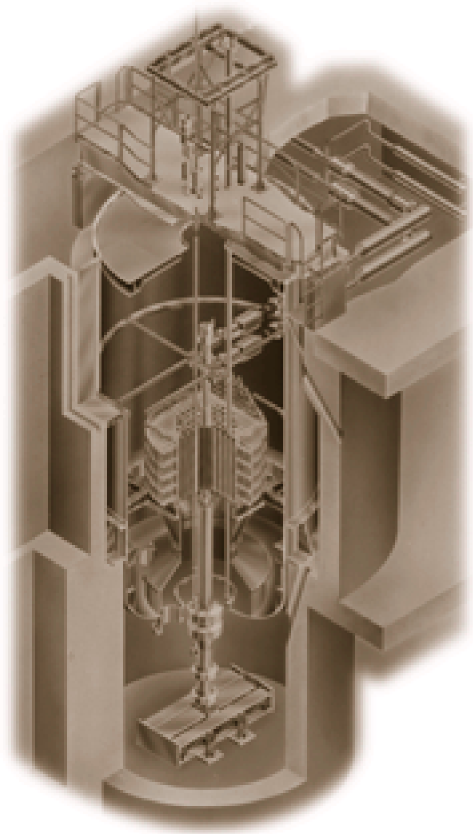
The change jolted Phillips employees, some of whom had been part of the Phillips family for most of their careers. “Suddenly, we were like an arm grafted onto a new body,” observed one of them. Gradually, they adapted, although Aerojet never re-created the Phillips’ style of benign paternalism. The Frank Phillips Men’s Club and the Jane Phillips Sorority disappeared.[11]

Shaw soon felt compelled by the rapid onset of the commercial power industry to reorganize the safety test program (STEP) for water-moderated reactors. The STEP program had progressed far beyond the NASA tests studying the impact of ocean crashes on reactors launched into space. The program now involved two main branches. One was to continue exploring reactor excursions. The SPERT IV facility would be supplanted by a much larger and more sophisticated reactor called the Power Burst Facility (PBF). It would subject test fuel to transient bursts of energy far surpassing the capability of any previous reactors.

The second branch opened up research on an altogether new realm of possible accidents. In 1963 the New Jersey Central Power and Light Company said it would build a 515-megawatt nuclear power plant because this was cheaper than all the other options, including coal. General Electric would build the plant for a fixed price and hand it over to the utility to operate. This “turnkey” contract—and others that followed—signaled that GE and its chief competitor, Westinghouse, were ready to go commercial. The two companies scaled up the power plants to higher and higher power levels, each aiming to become market leader. Within another two years, they were designing

INEEL 72-2662

Loading fuel into PBF reactor, 1972.



Cutaway illustration of the PBF reactor.

1,000-megawatt reactors, far exceeding any previous AEC demonstration projects. The fierce competitive struggle led the two companies to sell reactors as loss-leader products. The true profitability or economic superiority of nuclear over fossil fuel plants was—at least at that time—debatable.[12]

The huge plants presented new safety problems. The AEC's Division of Nuclear Safety, which performed licensing and safety reviews of proposed plants, had thus far dealt with plants of much lower power. Even so, the AEC had not permitted them to locate near highly populated areas. Additionally, the reactor buildings had to be built so that if an accident occurred, the fission products—should they escape the cladding and the reactor pressure vessel—would not pass beyond a third barrier called a containment vessel. Typically, containment vessels were dome-shaped and constructed to withstand the pressures that might result from a steam explosion.

In the new plants, the reactor core contained tons of fuel. Analysts imagined the consequences if the coolant somehow failed to carry away the heat of fissioning. Suppose a pipe leaked or broke? The SPERT tests had proven that such a situation would easily put a stop to the chain reaction: the loss of pressure would allow the water to turn to steam; the lower density of steam would fail to moderate the neutrons; and the nuclear reaction would stop. But the radioactive decay of the fission products inside the fuel elements would continue to produce heat and continue to need cooling. Even though the decay heat was a small percent of the heat of a fissioning reactor, it was enough to melt the fuel and clad metal, leading to potentially violent interactions with water or air.

Clearly, more was at stake in a large commercial reactor. If something happened to the coolant flow, an emergency back-up system had to send water to the core and carry heat away. It was chiefly a matter of engineering, not physics.

Scientists at Brookhaven National Laboratory attempted to define what might be at stake. They imagined the worst case loss-of-coolant accident (LOCA) in a reactor located very near a large city. They elaborated it with the worst possible weather conditions. Then they calculated the consequences if the fuel melted. They speculated that it would drop to the bottom of the pressure vessel, melt through it, fall to the concrete floor and basements beneath the power plant, burn through the concrete, and proceed through the earth "to China," or at least in the direction of China, until the fuel cooled naturally. Worse, steam pressure might rupture the containment vessel and send fission products into the atmosphere whichever way the wind was blowing. Having breached their triple containment, the fission products would be an immediate hazard in the air and could eventually contaminate soil and water supplies.[13]

New Jersey Central and other license applicants were proposing a variety of back-up cooling systems that would prevent fuel from ever getting hot enough to head for China. The trouble was that these had not been proven to work. None of the safety testing at the NRTS—or anywhere else—had tested a large-reactor LOCA, the China Syndrome, or how the many variables in large-scale reactor systems would interact. Consequently, AEC regulators had a host of new technical questions. The Phillips engineers had anticipated many of the questions and were ready with a plan. In 1963 Phillips began a $19.4 million program to build a special reactor to explore LOCAs. The main idea was to load up the reactor and the containment building with instrumentation, operate the reactor, and then withhold the coolant to "see what happens."[14]

The Loss-of-Fluid Test (LOFT) reactor was to be a 50-megawatt reactor with fuel elements clad in stainless steel and surrounded by a containment vessel. Phillips placed the domed structure next to the old hangar building at TAN, finding the old four-track railroad and other ANP facilities very adaptable to a new mission. The shielded control building next to the hangar became the LOFT control room. Phillips hauled out the old shielded locomotive, intending to move the reactor from the containment building to the Hot Shop for detailed examination after the experiment. Kaiser Engineers broke ground for the project on October 14, 1964, a happy ceremony that brought the vice-chairman of the JCAE, Chet Holifield, to Idaho to make the featured speech.[15]

The LOFT experiment was fairly simple. It would be a small version of a large reactor, the containment vessel an integral part of the test. The cooling-system components would come "off the shelf" from the commercial vendors who sold to General Electric and Westinghouse, not from the fabrication shops at the NRTS where parts were so often given individual attention, not mass produced. In a series of non-nuclear experiments, the operators would first test the performance of the components—the emergency sprays, pressure suppression devices, and other emergency equipment that would supposedly come into play if the regular coolant pipe broke. They would also find out how much pressure the containment vessel could endure.[16]

After those tests, the grand finale would be the NRTS specialty—a test to destruction. Operators would "break" an 18-inch coolant pipe, delay the insertion of the control rods, cut off the cooling water, and decline to spray water onto the core. They could study the melting fuel, perhaps learn something useful about the dynamics of the process. The instrumentation would keep track of the fission products, measuring what fraction of the total might reach the atmosphere. They expected to learn enough about LOCAs to define more precisely the sequence of events and the exact nature of the hazards. The data would be extrapolated to larger-scale reactors. The test was expected to take place in the winter of 1968.[17]

The LOFT project hit a snag immediately. The new commercial reactors proposed to use zircaloy cladding instead of stainless steel. In 1965, therefore, Phillips changed the LOFT reactor design for zircaloy-clad fuel. This affected the parameters for the safe operation of the LOFT reactor, so the safety studies had to be redone. These changes delayed the project. Back in Washington, the regulators were trying to cope with license applications. They wondered whether the proposed tests, being performed on a small reactor, would actually tell them anything relevant about large reactors. Some of the AEC staff doubted that the methods for analyzing the core melt or the water interaction with melting zircaloy were sophisticated enough to produce meaningful data. Nor were they sure that the containment vessel would withstand the gas pressures generated during the meltdown.[18]

Milton Shaw wondered if the LOFT project would fall prey to the same kinds of problems as the ATR. He saw the possibility that unreliable parts or equipment might interfere with good

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Governor Don Samuelson (center) visits LOFT site in 1967. Bill Ginkel on left, Joe P. Lyon of INC on right.

test results. What was the point of an experiment if it used the wrong parts, the wrong materials, and met the wrong specifications? Results could never be duplicated. The project was about ten percent complete, and the reactor's eighty-ton pressure vessel had been fabricated. Nevertheless, Shaw stopped the work to "regroup and do the job right." Quality assurance hit the LOFT project. The experiment was going to become much more complex.[19]

But not immediately. Forward motion on LOFT stalled while contending forces within AEC Headquarters settled their differences—sometimes at a leisurely pace. The issue of power plant siting had divided the regulatory and development arms of the AEC. With their low confidence in the utilities' proposals for untested backup safety systems, the regulators were reluctant to allow power plants close to cities, the load centers. On the development side, Shaw, the commissioners, and the JCAE resisted imposing excessive or unnecessary costs on utility companies. The grip of nuclear power on economic viability was too tenuous, and they didn't want the fledgling industry to falter because of unnecessary costs.

Related to the siting issue, a difference of opinion emerged on how to—or whether to—research the China Syndrome. One view was that the AEC should confront it directly: test it, understand it, characterize it, and learn how to make it inherently impossible. This had been one purpose of the original test plan for the LOFT experiment. The other view was that this was costly and unnecessary. The China Syndrome should simply be prevented. Emergency core cooling system (ECCS) engineering should be so foolproof that nuclear fuel would never have a chance to melt. If anything was to be researched, it should be these engineering preventatives.[20]

Shaw felt that standards and criteria, combined with experience and good engineering judgment would protect public safety. He sided with those who felt it was possible to prevent accidents by building reliable back-up systems—defense-in-depth. Understanding the moment-by-moment progress of an accident that would never happen was a waste of money.

As the 1960s wore on, the debate continued. The regulatory staff had no independent control of a research budget, so their needs for research results on LOCAs went unmet. Staff committees formed, talked, and dissolved. At the same time, applications kept coming in for review; the regulators needed the results of LOFT-type experiments and they didn't have them.

For LOFT the upshot of all the talk was a loss of support for the original experiments. Those advocating research on the mechanism of the China Syndrome ultimately were disappointed. Aside from Shaw's determination to make LOFT a showcase for new quality assurance procedures, the project drifted. People were laid off. Work stopped, started, stopped. Funds were held back or stinted, even though they had been appropriated.

The AEC desired to see improved accountability in management, so in 1969 Phillips joined Aerojet and Allied as a minority partner in the operating contract. As Bill Ginkel said at the time, the AEC was looking for "upgraded engineering, standards, codes and guides, documentation, plant reliability, and quality level of performance." Absorbing Phillips into the corporation was intended to strengthen overall management of NRTS programs. Aerojet continued as the majority partner.[21]

Personnel layoffs soon followed and continued into 1971. Idaho scientists wrote angry letters to the Idaho congressional delegation, blaming LOFT problems on poor policy direction and bungled management from Washington. Some people thought Shaw was robbing LOFT funds to support his greater interest in breeder reactor development. Aerojet hired new people for the LOFT project at the same time it was letting go of Idaho people. "The deteriorating situation at the NRTS...continues to worsen," wrote one employee to Senator Len Jordan. In a departure from previous custom, the new LOFT work center—174 employees—was moved from the Site to the Rogers Hotel in Idaho Falls, which contributed further to resentment and misunderstanding.[22]

A belief arose that the Shaw/Aerojet managers were autocratic and vindictive, eliminating people who dissented from the official point of view. The *Post-Register* called for the congressional delegation to rescue the NRTS from the poor AEC management that was causing both the layoffs and "scientific disillusionment" at the Site. Governor Cecil Andrus made a similar appeal. "We can ill afford the loss," he wrote of the layoffs.[23]

INEEL 69-6280

Aerojet president Chuck Rice tried to explain the general upheaval in morale and the impact of Shaw's new procedures to Idaho congressman Orval Hansen:

In the past, reactor and environmental safety was derived from experienced experts working together as a loosely knit team, each member of which expected the remaining members to perform the appropriate functions at the appropriate time without clear cut lines of responsibility and delegated authorities. In response to AEC desires and directives, this informal system has, in a period of less than one year, been replaced by a highly formalized system that places primary reliance on unswerving adherence to a set of interlocking procedures and responsibilities that have been subjected to multiple reviews by boards of specialists. The writing of procurement specifications has become a job for the skilled engineer rather than the purchasing agent. Carefully documented engineering studies have replaced the quick fix by the maintenance man.[24]

Meanwhile, the STEP program operators had managed to carry out useful work in spite of difficulties. They developed computer models predicting the behavior of coolant in a LOCA. Among other experimental devices, they built a simulated reactor called Semiscale to help understand how coolant water would behave as it depressurized after a pipe broke. This process was called a "blowdown." Blowdown tests and computer analysis of the simulated accidents led to computer programs, called codes, capable of predicting the performance of backup cooling systems during a blowdown. The codes originated at the NRTS with the help of the INEL Supercomputing Center (ISC), which was built in 1968.[25]

INEEL 68-3179

Above. Semiscale was a simulated reactor. Instrumentation leads leave head of the core. Left. Semiscale blowdown test, 1968, simulated a break in a coolant pipe.

The Semiscale heat source was electrical but created the same high temperatures as a reactor. Between November 1970 and March 1971, a series of tests demonstrated—unexpectedly—that after certain accidents, steam pressure in the coolant pipes prevented any emergency water at all from gaining access to the core. If this was a picture of what might happen in a large reactor, the problem was serious indeed. The margins of safety that had previously been assumed for commercial emergency core cooling systems would have to be revised downward.[26]

The findings provoked the AEC to hold hearings on the matter. Semiscale scientists from Idaho traveled to Washington to explain their findings before people who were reluctant to believe that the Semiscale results could be extrapolated to large reactors. Nevertheless, Idaho research was solid and persuasive. The AEC adopted a set of requirements more conservative than had been the case before. They were "Interim" Acceptance Criteria, a set of safety requirements that a utility company had to meet in order to obtain a license from the AEC. The Criteria went into effect immediately, without the customary time elapsing for further comment. NRTS work thus had an impact on safety requirements for commercial reactors.[27]

Milton Shaw finally decided how he wanted to redirect the LOFT program. The AEC regulators needed to examine plans for emergency cooling systems, predict their performance in an accident, and then decide whether or not to approve the plans. With such complex systems as a nuclear reactor, they were using computer models. Therefore, the testing program at the LOFT reactor in Idaho should verify the accuracy of the codes. With reliable codes, the regulators could confidently evaluate proposed power plant design proposals.[28]

For the LOFT team, it was like starting over. Reorienting the project took time and required more money. The reactor needed more elaborate piping and instrumentation—all quality assured. The project slipped its schedule repeatedly. The completion date moved out to 1971, then 1972, 1973, and beyond. Phillips, and then Aerojet, could not get fabricators to supply the major primary pump and heat exchangers on schedule. The standards were set so high that vendors refused to bid on the secondary coolant pump. Code specifications for piping and steam generators changed, and this caused more delays. Construction halted completely from May 1968 to October 1970.[29]

For all of the delays, Shaw had blamed Phillips. Idaho scientists resented this unfairness. Shaw himself had authored the delay. The quality-oriented delays were particularly irritating. Why should standards that would protect the crew of a submarine apply to short-term experiments in a remote, isolated desert? But the conditions of work at the NRTS had changed. Scientists began to realize that the early traditions were giving way. The outcome of the LOFT struggles showed that they were losing their early freedom to define their own research problems.[30]

In 1971 when it was time for the IDO to negotiate a new operating contract, Aerojet took over completely, subcontracting with Allied to run the Chem Plant and assuming the STEP program from Phillips. The name changed from

An artist's view of LOFT circa 1964 shows reactor inside domed containment building.

INEEL 64-6461

INC to ANC—Aerojet Nuclear Corporation. Phillips, co-inventor of the world's only reactor testing station, was, with little ceremony, gone for good. Its earlier ambitions regarding nuclear energy had abated; changes in the NRTS programs and the environment in which it now operated gave it little further stake in testing nuclear reactors.[31]

In 1972, *Science* magazine charted the LOFT-centered erosion of affection between the NRTS and AEC Headquarters. The author, Robert Gillette, described with dismay how NRTS scientists met him secretly one night on a back street in Idaho Falls and then drove to one of their homes. "That men nationally recognized in their profession felt they had to do this shows how far relations between the AEC and Idaho have deteriorated," he wrote. But the new Aerojet manager, Charles Leeper, supported Shaw. "The highly creative days and the permissive times are behind us," he said, "and the demands now are for a hard bitten reduction to economical practices.[32]

Although work protocols, management philosophy, and the burden of paperwork had changed, it was still possible to do good work at the NRTS. Better days were ahead for LOFT.

After the troubled start-up of the ATR, the reactor went on to perform superbly, like a theatrical play after a poor dress rehearsal. In August 1969, the operators ran it for the first time at its full power level of 250 megawatts. The designers originally expected to run the ATR twenty-one days before having to shut down and reload new fuel. In practice, they ran in thirty-four day cycles and longer. In the next ten years, the ATR regularly set new performance records, running at 98.2 percent operating efficiency and on-line eighty percent of the year. This was a superior accomplishment because the ATR was so complex a machine that any of four hundred different reactor and experimental systems could fail and shut down the reactor. Breaking performance records meant that a team was sharp, diligent, and skillful.[33]

The Shaw effect was not limited to the total reorientation of the LOFT program and the imposition of a new style of management and procurement. It also played out in the theater of operations at Argonne-West. Shaw had a strong commitment to the future of the breeder reactor. But it turned out that he did not have a strong commitment to Argonne-West. When this became apparent to the eastern Idaho supporters of the NRTS, a boost machine went into high gear.

INEEL 67-5184

ATR technicians check the fit of a dummy fuel element in the reactor core (before ATR became operational). The curved pipes are for instrument leads and reactor coolant. The vertical pipes provide paths for experiments into the core area.