CHAPTER 15

# Challenging the Atomic Energy Commission on Nuclear Reactor Safety: The Union of Concerned Scientists

*We had at the beginning of our work no inkling whatsoever that there was anyone within the depths of the nuclear community who shared anything like the positions we were developing.*

*As we continued to work and meet at Oak Ridge [National Laboratory] and [the National Reactor Testing Station], we were quite surprised to find the reactions of men there so close to ours. We found it personally astonishing once the hearing gained its momentum to see the number of people who were so clearly accepting a position quite divergent from the official position of the Atomic Energy Commission.*

*I think that this has been both personally to us and I think to the public at large one of the most revelatory aspects of this public proceeding.*[1]

—Daniel F. Ford testifying at the AEC hearings on reactor safety, Bethesda, Maryland, August 22, 1972





*Dan Ford*

Dan Ford seems an unlikely person to trouble the powerful Atomic Energy Commission (AEC), much less the giant electric utility industry. Although still in his twenties, Ford, who has the deceptive appearance of an overgrown schoolboy, has become one of the key leaders in a movement to force a reconsideration of the country's rapidly increasing commitment to nuclear power for generating electricity.

Ford is not a scientist. He studied economics as an undergraduate at Harvard, obtaining his bachelor's degree in 1970. The environmental movement came into its own that year, and when Ford was offered the position of coordinator of environmental research for the Harvard Economic Research Project, where he had worked as an undergraduate, he jumped at the opportunity. The appointment offered a welcome pause before the academic routine of graduate school.

In his new job Ford was responsible for a pilot study on the costs and benefits of various methods of generating electrical power. The majority of electric power plants then being built in the United States were (and still are) nuclear, and there was considerable public controversy over the dangers of cancer and genetic defects from the small amounts of radioactivity which are released into the environment during the normal operation of these new plants—and also some concern about the possibility of a much larger release of radioactivity as a result of a serious accident at a nuclear power plant. It was natural, therefore, that Dan should look into these questions.

One day in the spring of 1971, while Ford was educating himself on nuclear reactors, he discovered that the AEC had published a notice in the *Federal Register* giving any interested public group thirty days in which to petition for a public hearing on the application of the Boston Edison Company for a license to operate its big new Pilgrim nuclear power station, located in Plymouth, Massachusetts.[2] The notice had received no press attention, and it seemed unlikely to Ford that there would be any response. He therefore decided to see to it that a hearing would be held so that the public could be informed and take action in its own interest.

Ford began by writing to Boston newspapers asking them to inform their readers about the AEC deadline. The only response was a brief article in the *Boston Globe*—but to Ford's exasperation, it failed even to mention the deadline. After several phone calls, Ford finally managed to convince the editor of the *Globe* to publish his letter just days before the deadline.[3]

## *The Union of Concerned Scientists*

Meanwhile, however, Ford had received a response from another direction. A helpful reporter had put him in touch with Dr. James MacKenzie, a short, bushy-haired, energetic young physicist who had recently left MIT to work full

time on environmental issues for the Audubon Society and who was also chairman of the MIT-based Union of Concerned Scientists (UCS).

The UCS had been organized in 1969 in response to the "March 4 movement" by student activists at MIT that challenged scientists to take public positions on the misuse of technology—particularly in Vietnam and the strategic weapons race.[4] Long after student activism had died down, the committed core of the UCS continued to work hard on issues they considered timely. Their initial focus was on preparing popular expositions of the technical arguments against new strategic weapons systems such as ABM and MIRV and against the Army's continued commitment to chemical and biological warfare. But a number of the UCS members became interested in the new political issues being raised by the environmental movement. When Ford contacted MacKenzie, the UCS was finishing a major study of the Boston air-pollution problem.

A meeting of the UCS was hastily called, and Dan Ford presented his case. He pointed out the disturbing fact that the AEC's Advisory Committee on Reactor Safeguards had expressed the opinion that the expected release into the air of radioactive fission products from the Pilgrim reactor would be excessive. There was also the question of the wisdom of placing the giant reactor so close to the Boston metropolitan area. Many experts—including AEC officials and the ACRS—had expressed the opinion that the barrier of distance is the most important protection for the general population in case of accidental release of some of the enormous store of radioactivity contained in a modern nuclear reactor. But the AEC had allowed the utilities to site reactors ever closer to metropolitan areas in order to reduce expenditures on power transmission lines.[5]

The UCS agreed that these were issues well worth exploring, and a small group decided to petition for a public hearing on the Pilgrim reactor. This was a significant commitment because, as a price for such an "intervention" in the licensing process, the AEC insists that any "intervenor" participate fully as a party in proceedings which sometimes drag on for many months. It testifies to the impression that Ford had made on the scientists of the UCS that they invited this young economist to join them and organize their participation in the Pilgrim reactor hearings. The petition was filed just hours before the AEC deadline.

## *The Battle over Nuclear Power*

The UCS intervention was not an isolated action. The Pilgrim reactor was one of dozens which were being built around the country as the electrical utilities anticipated a rapidly growing national demand for electrical power. And the new nuclear plants, as the vanguard of a conspicuous new technology with a frightening potential for radioactive pollution, had become natural targets for environmental groups across the country.

The citizen groups that opposed the new power plants had been unable to find a respectable technical basis for their concern that the plants might blow up and spew lethal amounts of radioactivity over surrounding areas, so they were forced in licensing hearings to argue about more mundane problems. One of these was concern about increased cancer and genetic risks from the relatively low levels of radioactivity released from reactors during their normal operations. Two widely recognized experts, John Gofman and Arthur Tamplin of the AEC's Lawrence Livermore Laboratory in California, had articulated these concerns in a most forceful manner in articles, books, and testimony at reactor licensing hearings since 1969.[6] In 1971 the AEC retreated and proposed more stringent radioactive-release standards for nuclear reactors.[7]



A second major issue that had been raised by environmentalists is that of "thermal pollution" of lakes, rivers, and coastal waters. The amount of cooling water used by large modern power plants is enormous, with nuclear power plants requiring about 50 percent more than fossil fuel power plants of the same capacity because of their lower thermal efficiency and the fact that the fossil fuel power plants reject some waste heat through their smokestacks.[8] Starting in 1971, the utilities began installing cooling ponds and cooling towers costing millions of dollars.[9]

## *Emergency Cooling*

Environmental groups had attacked nuclear power plants both on the basis of their everyday releases of small amounts of radioactivity and because of their thermal pollution—and had been substantially appeased. But just as the Union of Concerned Scientists was entering the fray, the unspoken issue—the danger of catastrophic releases of large amounts of radioactivity—finally surfaced.

Early in their preparation for the Pilgrim reactor hearings, the UCS contacted citizens' groups engaged in similar interventions in connection with other reactors. From the Businessmen for the Public Interest, a Chicago group which was supporting interventions into the licensing of a number of nuclear reactors around Lake Michigan, they learned of the failure, in semi-scale-model tests, of a crucial reactor safety apparatus known as the "emergency core-cooling system."[10] The tests had been performed at the AEC's National Reactor Testing Station in Idaho in November and December 1970.[11] Dan Ford, Jim MacKenzie, and two other UCS scientists—Ian Forbes and Henry Kendall—decided to educate themselves on the purpose of the emergency core-cooling system (ECCS) and the consequences if it failed to work as designed.

A typical reactor of the sort now being licensed for operation generates about a billion watts of electricity—enough electrical power to supply the needs of nearly a million Americans. This power originates in the heat generated by the splitting ("fissioning") of uranium nuclei in the reactor "core." The core, typically about twelve feet long and fourteen feet in diameter, contains about a

hundred tons of uranium formed into ceramic pellets of uranium oxide held inside tens of thousands of long, thin "fuel rods." At full power the energetic fission fragments heat up the centers of the uranium oxide pellets to about 4,000° F ("degrees Fahrenheit"). The heat flows out through the zirconium alloy "cladding" of the fuel rods to heat up the high-pressure water circulated between the fuel rods. In carrying away the heat to power turbines that generate the electricity, the circulating water keeps the fuel rod cladding at the relatively low temperature of about 600° F. If the water were to be lost—through a broken pipe, for example—the cladding would heat up and rupture unless the emergency core-cooling system (ECCS) could reflood the core with water within a minute or so. This would occur even though the "chain reaction" stops as a result of the loss of the neutron-slowing action of the water which has been operating for some time the fission products build up to the point where their radioactivity alone generates enough heat to melt the core.

If the ECCS in such a reactor for any reason failed to do its job adequately when called upon, the ensuing events would be dramatic.[12] Within minutes the core, with its hundred tons of uranium, would begin to melt from the heat of its intense radioactivity and slump to the bottom of the reactor vessel. By this time the situation is already beyond control. Any attempt to cool the molten mass would only exacerbate the problem: the water would react with the hot metal chemically, liberating still more heat and explosive hydrogen gas. Within an hour the molten core would melt through the six-inch thick steel reactor vessel, releasing an immense amount of radioactivity, equivalent to the fallout from a large number of Hiroshima-sized nuclear bombs, into the reactor containment chamber—the domed concrete shell within which the reactor vessel and its primary cooling system are housed. Despite its name, the containment chamber would also be unable to keep the seething core from reaching the human environment. About a tenth of the core's total radioactivity is in the form of radioactive gases. Chemical explosions might occur, causing the containment shell to crack open and releasing these gases into the atmosphere. Even if the dome remained intact, the core would melt through the concrete floor of the containment chamber within about a day and would continue to melt its way down through the earth and rock below—probably for hundreds of feet. Because of the path that the core takes in this scenario, it is half-jokingly called the "China syndrome."

A location hundreds of feet underground might at first sight seem to be an ideal final resting place for the intensely radioactive core. Unfortunately, there is no guarantee that much of the radioactivity would still not escape to the surface. The hot radioactive gases could seep up into the air (if they had not already done so), and the remainder of the core would be available to contaminate the ground and surface water. Because of the enormous thirst of nuclear reactors for cooling water,[13] they are generally built on riverbanks, lakeshores, or seashores. The contamination of these waters could be on a very large scale. There is sufficient long-lived radioactive strontium-90 in a large reactor core to contaminate thousands of cubic miles of water—many times the volume of Lake Michigan—to a level greater than that which the AEC considers safe.



The UCS scientists extrapolated a 1957 AEC analysis[14] of the possible consequences of a hypothetical reactor accident in which a large fraction of the core's radioactive gases were released into the atmosphere to apply to the much larger reactors then coming into operation. Their conclusions beggar the imagination:

> If . . . the radioactive materials are released under a temperature inversion, by no means an uncommon nocturnal condition, with a 6.5 mph wind, . . . lethal effects can extend 75 miles downwind in a strip of maximum width up to 2 miles. Injuries would be likely at up to one or two hundred miles, the presence of moderate rain yielding the lower figure. . . .
>
> . . .The cloud would be increasingly difficult to see after it had moved away from the accident site, and would be invisible long before it had lost its lethality.[15]

Nearby cities would have to be evacuated as rapidly as possible. Long-term restrictions on normal use of the contaminated area would be inevitable. According to the UCS scientists, such restrictions would extend a minimum of fifteen miles from the reactor site and could reach distances of hundreds of miles.

Summarizing the implications, the UCS authors concluded:

> It is abundantly clear from our study that a major nuclear reactor accident has the potential to generate a catastrophe of very great proportions, surely greater than any peace-time disaster this nation has ever known. The full scale and consequences of such a catastrophe cannot fully be recorded, yet it is against such an ill-understood but awesome event that the scale of, and confidence in, the reactor safeguards must be weighed.[16]

Despite its tremendous importance, the emergency core-cooling system was designed almost entirely on the basis of greatly simplified computer calculations. The purpose of the semi-scale tests at the National Reactor Testing Station in Idaho was to verify that these computer programs in fact correctly simulated the behavior of the ECCS. But when the tests were actually conducted, the results were not as expected. The model did not behave as the computer programs had predicted. Instead of cooling off the model reactor core, the emergency cooling water was swept away by the escaping steam out the same pipe break through which the original cooling water escaped. Since the model was not realistic the failure of the tests reflected most directly on the computer programs, but the predicted effectiveness of the emergency cooling systems of actual reactors is based on such programs. The AEC has scheduled a much more elaborate series of "loss-of-fluid tests" in Idaho starting in 1974. In the meantime, the AEC and the reactor companies have been working at improving the computer programs.

Perhaps the most puzzling thing about the Idaho tests was their timing. The nation's utilities were investing tens of billions of dollars in nuclear reactors, but

the AEC had given its safety program such a low priority that it had hardly begun testing the effectiveness of the emergency cooling systems of these reactors by the time they were being frozen in steel and concrete. The AEC's "watchdog" Advisory Committee on Reactor Safeguards (ACRS) had urged for years that these safety systems receive realistic tests, but the Idaho "teakettle-sized" tests represented only the first, extremely unsophisticated steps in the testing program.[17] Although the significance of the Idaho tests remains debatable, the AEC's irresponsible neglect of its reactor safety program could hardly be disputed.

The UCS issued its report[18] on the possible implications of the failure of the Idaho tests at a press conference in July 1971. This was the first such discussion intelligible to the layman, and it caused a sensation. That same evening both the NBC (Huntley-Brinkley) and CBS (Cronkite) network news programs reported the story on nationwide television. A new national controversy had been born.

## *To License or Not to License?*

The AEC faced a real dilemma in the area of reactor licensing: How could it issue operating licenses for nuclear power plants when the Idaho tests had raised a serious question as to their safety? At the beginning of May 1971 AEC Chairman Glen Seaborg wrote the chairman of the Congressional Joint Committee on Atomic Energy, Senator John O. Pastore (D.-R.I.), telling him that the AEC expected delays in reactor licensing while a "senior task force" reviewed emergency cooling system effectiveness.[19] Then on May 13, 1971, AEC officials appeared before the Joint Committee requesting additional funds for reactor safety research. AEC Assistant General Manager for Reactors George Kavanaugh acknowledged that the test results were causing concern: "If [the situation] were better, we might not have been allowed to come up here asking for money."[20]

Meanwhile, every month's delay in starting up their new reactors would cost the electrical utilities millions. They would not sit patiently by awaiting the results of a long, drawn-out review—especially since it was generally agreed that the probability was remote that any particular reactor would suffer an accident serious enough to strain the capabilities of its emergency cooling system. It was out of the question to wait on the results of a comprehensive testing program. That would take years. A few weeks after its formation, therefore, in mid-June 1971, an AEC task force came up with proposed new "Interim Acceptance Criteria" for reactor emergency cooling systems. Although the recommendations lacked supporting documentation, the collective leadership of the Atomic Energy Commission, the five AEC Commissioners, quickly accepted them and promulgated them formally on June 29, 1971.[21]



In fact, the Interim Criteria were remarkably convenient for the nuclear industry. All reactors already operating or up for licensing could satisfy them. If the criteria had been much more stringent, the reactors might well have been required to operate at much lower and correspondingly less economical power levels or to undergo major modifications. Either course of action would have been a disastrous blow to the prestige of the AEC—possibly even to the future prospects of nuclear power.

As far as the AEC was concerned, the matter was settled and reactor licensing could proceed. The UCS group was not so sure—but what more could they do? No great expertise had been required on their part to draw the public's attention to the failure of the Idaho tests or to cite the 1957 AEC report on the possibilities for catastrophe should a major release of radioactivity occur in an actual reactor accident. But to oppose the Interim Criteria would be to challenge directly the technical judgment of the Atomic Energy Commission. The AEC had accumulated an enormous reservoir of expertise during the quarter-century of research and development which had gone into the design of the latest generation of commercial nuclear reactors, and the UCS scientists were quite unfamiliar with reactor engineering. In fact, Henry Kendall, who was to become the chief technical expert of the UCS in this area, later admitted that, at the time of the original UCS report on the emergency cooling problem, he was uncertain about even the most basic design differences between the two major types of commercial water-cooled reactors.

On the other hand, the AEC's case for the adequacy of its ECCS Interim Criteria could be no stronger than its weakest link. The challengers would not have to match the full range of expertise available to the AEC in order to challenge the AEC's conclusions. Furthermore, while the engineering details of nuclear reactors might be unfamiliar to the UCS scientists, the physics was not. They were confident in their abilities to understand quickly the calculations on which the Interim Criteria were based. So, minus their one nuclear engineer (Ian Forbes, who had to return to full-time teaching at the Lowell Technological Institute in Massachusetts), Kendall, Ford, and MacKenzie started to study the AEC analysis.

They soon found that, in the absence of actual experimental information on how an emergency core-cooling system might work, the AEC task force had again relied on highly simplified mathematical descriptions of the reactor and core-cooling system, with the ECCS performance being predicted using computer simulations. But the "garbage in-garbage out" axiom of computer experts seemed to the UCS scientists to be highly relevant here. Not only were the computer models necessarily oversimplified in the face of the complexity of the phenomena occurring in a nuclear reactor which had just lost its cooling water, but also, the UCS scientists found, crucial assumptions had been made that were demonstrably false.

One of these assumptions—that the geometry of the reactor core would remain unchanged during a loss-of-coolant accident—was directly contradicted by the results of experimental tests on fuel rods at the AEC's Oak Ridge National

Laboratory in Tennessee. In these tests the fuel rods began to swell, buckle, and rupture at temperatures hundreds of degrees lower than the peak temperatures that the AEC's Interim Criteria specified as allowable in the interval during which the core would be uncovered by water.[22] The AEC canceled its funding for these crucial Oak Ridge experiments in June 1971 (soon after the troublesome results began to appear), eliciting the following protest from Oak Ridge's director of nuclear safety research, William B. Cottrell: "We are astounded at your decision to discontinue this experimental work.... No one really knows what will happen in a reactor core in the event of a loss-of-coolant accident."[23]

The UCS group issued a report detailing its criticisms of the AEC's Interim Criteria in October 1971.[24]

## *The Licensing Hearings*

The UCS attempt to challenge the adequacy of the emergency cooling system of the Pilgrim nuclear reactor at Plymouth, Massachusetts, in 1971-1972, was opposed by Boston Edison, owner of the reactor, on the grounds that the installation conformed to the AEC's Interim Criteria.

The emergency cooling issue had meanwhile been injected into licensing hearings on several reactors in other states. In November 1971 Dan Ford participated as a technical interrogator on this issue in the hearings on the Indian Point 2 reactor, located on the Hudson River above New York City. After much deliberation, the Indian Point 2 hearing board was at least partially persuaded by the UCS case, and in December 1971 it informed the AEC that it had serious questions about both the technical and the legal validity of the Interim Criteria.

In order to avoid further challenges on emergency core cooling in hearings on individual reactors, the AEC decided to hold comprehensive national hearings on this subject. The AEC initially proposed that these hearings be merely "advisory." But after negotiations with lawyers representing the Consolidated National Intervenors—a newly formed coalition of environmental groups which had been involved in individual reactor licensing hearings—the AEC agreed to rule on the emergency cooling issue on the basis of the record established in these "rule-making" hearings. Information possessed by the AEC, the reactor manufacturers, the electric power companies, and the Intervenors would be placed in the hearing record and subjected to cross-examination. Nevertheless, the AEC steadfastly refused to allow the Intervenors to subpoena documents or individuals, a right which had always been accorded to all participants in local nuclear reactor interventions.



## *The AEC's Experts*

In order to get additional information, Dan Ford, Henry Kendall, and Jim MacKenzie had decided in November 1971 to pay a visit to the AEC's reactor safety experts at Oak Ridge National Laboratory. The UCS group was surprised to find that the Oak Ridge scientists were generally in agreement with their own misgivings about the AEC's new regulations on reactor safety systems. They returned to Cambridge laden with useful AEC documents. After the visit, the laboratory's Associate Director, Donald Trauger, reported to Milton Shaw, director of AEC's Division of Reactor Development and Technology:

> We felt that the technical publication of this group, as well as their professional integrity, justified our meeting with them. However, inasmuch as the Union of Concerned Scientists has intervened in the hearing on the... Pilgrim reactor, we also felt that you should be aware of the nature of our discussions....
>
> ... H. W. Kendall ... showed us how he has used our data ... to demonstrate that approximately 85 percent of the fuel rods are "candidates" for producing ... coolant channel blockage in the range 70 to 100%. Kendall had reached this conclusion independently, and wanted to know if he was using our data properly—which he was, within the limits of its accuracy....
>
> The three members of the Union of Concerned Scientists who visited here appeared to be well educated and dedicated people.... They have become intimately familiar with the relevant published literature.... They have become aware of various deficiencies in the case for ECCS performance.[25]

The UCS group had already begun to acquire an extensive library of AEC documents on reactor safety. Their first major acquisitions were documents picked up, at Dan Ford's request, by an MIT physicist visiting Oak Ridge in June 1971. These were supplemented by documents obtained by Ford on a trip to AEC headquarters in Germantown, Maryland, as a special consultant on environmental economics in July 1971. (The AEC documents in question were not widely distributed, but they were not secret. The entire U.S. civilian reactor program has been unclassified for many years.) With their trip to Oak Ridge, however, the UCS had for the first time acquired access to an even more valuable source of information: they had won the confidence of some of the people who *wrote* the AEC reports. Ford and Kendall followed up their visit to Oak Ridge with trips to the Battelle Memorial Institute in Columbus, Ohio, an AEC reactor safety contractor, and to the AEC's National Reactor Testing Station in Idaho, where the scale-model cooling tests had been done. Although the officials at these institutions were less cooperative than those at Oak Ridge, Ford and Kendall found the scientists there not reluctant to discuss their own work.

## *The Hearings Begin*

They have opened up a Pandora's Box of scientific doubts and bureaucratic heavy-handedness.[26]

*—Nucleonics Week*

The AEC's hearings on reactor emergency safety systems began in January 1972 with several days of legal wrangling between Myron Cherry, one of the lawyers representing the Consolidated National Intervenors, and the hearing board. At issue were objections to Dan Ford's participation in the hearings as a "technical interrogator" for the Intervenors and the Intervenors' demands that a number of AEC internal documents be put into the record and that representatives of the AEC's Advisory Committee on Reactor Safeguards be available at the hearings for questioning.

Ford's participation was objected to both by the board and by lawyers representing the reactor manufacturers and the electric utility companies on the grounds that he was not technically qualified. Ford admitted that he had never studied physics in college but maintained that he nevertheless could "ask the right questions" in the hearing as a result of his work with the UCS scientists. Although one of the hearing board members criticized him as an "instant expert," the board eventually decided to let him participate on a provisional basis "since Ford is the best the National Intervenors say they can produce."[27] (Teaching and research responsibilities prevented the scientific members of the UCS reactor safety team, Professor Kendall in particular, from participating regularly in the hearings.)

The AEC ruled that its Advisory Committee on Reactor Safeguards would not be represented at the hearing, and it refused to divulge that committee's formal review of the Interim Criteria on emergency cooling. Threatened with a lawsuit under the Freedom of Information Act, however, the commission decided to overule the hearing board and released most of the other documents demanded by Cherry. Most of these were AEC staff memos concerning the emergency core-cooling system. This decision was an important windfall for the Intervenors, for these documents revealed the existence among the AEC staff of a great deal of uncertainty about the effectiveness of the reactor safety systems and the adequacy of the Interim Criteria.

The hearings had opened with considerable fanfare in a plush auditorium at AEC headquarters. But as the Intervenors began to hammer away at the AEC's case, the proceedings were moved to a rented office building in Bethesda, Maryland. Armed with the just-released internal memoranda, Cherry and Ford began to undermine the confident façade presented by official AEC witnesses.[28]

In a memorandum of June 1, 1971, less than a month before the Interim Criteria had been issued, the Chief of the Systems Performance Branch of the AEC's Division of Reactor Standards, Dr. Morris Rosen, and his deputy, Robert J. Colmar, had sent their final detailed criticisms of the developing Interim Criteria to the AEC task force charged with preparing them. Rosen and Colmar



disagreed not just with small details of the proposed criteria but with the entire logic behind them:

> The [AEC Division of Regulation] task force has undertaken to resolve the current regulatory difficulties . . . by attempting to formulate a "prescription" to be applied to each reactor vendor's codes and to be used as a basis for licensing reactors on a plant-by-plant basis.
>
> This approach is predicated on the notion that the codes in their present state of development are definitive. . . .
>
> We take exception to this current approach. We have consistently pointed out that this approach is too limited for the task at hand. . . . We believe that the consummate message in the accumulated code outputs is that the system performance cannot be defined with sufficient assurance to provide a clear basis for licensing.[29]

(In the AEC argot, "vendor," though it may conjure up images of Coke machines, actually means Westinghouse, General Electric, or one of the other reactor manufacturers; and a "code" is nothing more exciting than a computer program used to calculate phenomena such as the temperature of the reactor fuel rods during an accident.)

When Rosen and Colmar eventually were allowed to testify at the hearings, they expressed their misgivings about the AEC's reactor safety-system standards in even stronger terms. Rosen presented an eighty-page critique of the Interim Criteria. He said that he was disturbed and discouraged

> to continue to see the advice of what I believe can be considered a significant portion of, more likely, a majority of the knowledgeable people available to the Regulatory staff, still being basically disregarded. . . .[30]
>
> Margins of safety once thought to exist do not, and yet reactor power levels continue to increase resulting in an even more tenuous situation.[31]

Colmar explained in his testimony how he had become aware of the deficiencies in emergency cooling systems as early as February 1970—nearly a year before the Idaho scale-model tests—in the process of correcting Westinghouse's misinterpretation of its own computer programs. He stated flatly that in his opinion some form of reduction in reactor operating power was desirable until more experimental information on the effectiveness of reactor safety systems became available and characterized the Interim Criteria as "a triumph of hope over reason."[32]

Early in January 1972, Rosen was removed from his job and given an advisory position, and Colmar requested a transfer. Rosen was philosophical about the switch, saying that he had to "consider it as a promotion. . . . Of course, I am off ECCS—except in an overlook position."[33] He was also quoted as saying that "it's the sort of thing that, if it happened very often in an organization, you'd have to wonder."[34] Later he left the AEC.

G. Norman Lauben, one of the members of the AEC task force, had served in Dr. Rosen's department. When the Intervenor's lawyer, Myron Cherry, inquired during the hearings whether any of the task force members present could not

personally support the official testimony, Lauben reluctantly raised his hand. He explained that if a certain variable in the computer programs used to evaluate the cooling system's effectiveness were decreased by as little as 20 percent—an amount that others testified was within the uncertainty of measurement—then reactor emergency cooling systems deemed acceptable under the Interim Criteria might actually be unable to prevent catastrophic core meltdown. In Lauben's opinion, insufficient experimental information was available to justify this lack of conservatism on the part of the AEC. When the chairman of the AEC task force, Dr. Stephen Hanauer, disagreed and claimed that the Interim Criteria were adequately conservative, Cherry asked:

CHERRY: Dr. Hanauer, in the area in which [Lauben] stated that he thought that the codes ought to be more conservative, can you state, sir, whether you believe that in that area you or Mr. Lauben possesses a greater understanding of the problem, in your judgment.
HANAUER: I think Mr. Lauben does.
CHERRY: Thank you, Dr. Hanauer.[35]

Hanauer later also admitted under cross-examination that three of the members of the AEC Advisory Committee on Reactor Safeguards who were most knowledgeable in the area of emergency core cooling had expressed concerns about the adequacy of the Interim Criteria.[36]

The reluctance of AEC witnesses to express open criticism of their superiors is understandable. But throughout the hearing the Consolidated National Intervenors continued to receive many letters, reports, and memos in addition to those officially released by the AEC. "The AEC leaks like a sieve," remarked Cherry cheerfully in explaining that many of the documents arrived in the mail in unmarked envelopes.[37] One of the most revealing of these documents, labeled "Hints At Being a Witness," was obtained in another way, however: it was accidentally given to Dan Ford by one of the AEC legal staff. Hint number 10: "Never disagree with established policy."[38]

Having finished the cross-examination of the AEC task force, the Intervenors next questioned the scientists from Oak Ridge National Laboratory whom the UCS team had met on their visit several months earlier. One of these witnesses was the scientist whose important work on fuel rod failure had been terminated abruptly by the AEC in June 1971, Oak Ridge metallurgist P. L. Rittenhouse. His written testimony was bland enough to satisfy the AEC bureaucracy, but when Rittenhouse actually appeared at the hearings to defend his testimony, he was sharply critical of the Interim Criteria. Under questioning by Cherry, Rittenhouse jolted the proceedings by asserting that a great many of his colleagues in AEC laboratories and the AEC headquarters staff shared his concerns. When asked to back up this assertion, he pulled out a list of twenty-eight names which he proceeded to read into the record. He described these individuals as persons "whom I have worked or at least talked with personally more than once.... These people have too many reservations



... shared too generally for me to pass off."[39] One of those whose name was mentioned by Rittenhouse was William B. Cottrell, Director of the Nuclear Safety Program at Oak Ridge. The Intervenors introduced into the hearing record a long letter, replete with supporting documents, from Cottrell to AEC headquarters:

To summarize what follows herein, we are not certain that the Interim Criteria for ECCS adopted by the AEC will, as stated in the Federal Register, "provide reasonable assurance that such systems will be effective in the unlikely event of a loss-of-coolant accident."[40]

Shortly after Cottrell had sent this letter, in December 1971, one of his superiors at Oak Ridge had called AEC headquarters asking that the letter be returned, claiming that it was only a "draft." Subsequent testimony by Cottrell established that the letter did in fact represent the views of a number of Oak Ridge reactor safety experts and that it was not a draft.[41]

In the first months of the reactor safety hearings, the Intervenors thus disclosed a deep rift between the AEC's reactor experts—particularly those in the AEC's laboratories who studied reactor safety problems—and the AEC bureaucracy, who channeled funds for the research and had to act on the results. The extent of the resulting tension will perhaps be indicated by the following remarkable letter from Alvin Weinberg, director of Oak Ridge National Laboratory, to James Schlesinger, Chairman of the Atomic Energy Commission:

Dear Jim:

When you called me in Florida you asked me to make clear to our [Oak Ridge] people that, when they testify at the ECCS hearings, they are to present their views fully and without reservation. I have conveyed this message to Messrs. Rittenhouse, Trauger, Cottrell, [and others]. That some of the testimony may prove to be in conflict with the interim criteria will not prevent them from presenting their data and conclusions as honestly and fairly as they can.

With respect to the criteria themselves, I have only one point to make. As an old-timer who grew up in this business before the computing machine dominated it so completely, I have a basic distrust of very elaborate calculations of complex situations, especially where the calculations have not been checked by full-scale experiments.... This is expensive, but there is precedent for such experimentation—for example, in the full-scale tests ... on nuclear weapons.

I have one other point. I believe [Oak Ridge] and the other National Laboratories should have been as intimately involved in the preparation of the interim criteria as we have since been in the preparation of AEC testimony for the hearings. That we were not so involved reflects a deficiency in the relation between Laboratory and Commission that troubles me.... [The AEC's National Laboratories] must be called upon fully by the Commission even when this may uncover differences of opinion between the Laboratories and the staff of the Commission.... I can guarantee that our opinion, if solicited, will be both honest and responsible.[42]

## *National Intervenors vs. Milton Shaw*

Barely concealed behind the diplomacy of Weinberg's letter was a history of steadily worsening relations between the National Laboratories and the AEC Division of Reactor Development and Technology, headed by Milton Shaw. During his eight years as the AEC's reactor czar, Shaw had won a reputation as a hard-boiled engineer and an autocratic administrator. His empire included not only all AEC design and development of conventional and "breeder" reactors (reactors which would convert enough non-fissionable materials to fissionable fuel to more than replenish the fissionable fuel which they "burned"), but also all reactor safety research. Shaw's office was thus in a position to curtail crucial research on the safety systems of commercial nuclear reactors; to censor unwelcome reports–even to impede the communication between the safety experts and the AEC Regulatory staff which is responsible for certifying the safety of the designs of commercial reactors; and to intimidate or transfer dissenting AEC employees. There is evidence that Shaw's office actually did each of these things.

In a series of articles, *Science* magazine reporter Robert Gillette documented the continued neglect by the AEC of crucial safety research. Indeed, Gillette indicated that Shaw's office had even gone so far as to spend money authorized for safety studies of conventional reactors on the development of the breeder reactor instead. Gillette reported that from 1965 through 1968, $12 million, or 8.5 percent of the funds appropriated by Congress for reactor safety research, were diverted to other purposes or simply not spent. And of the money actually spent for reactor safety, development of safety systems for future breeder reactors cut sharply into expenditures for safety research for ordinary reactors.[43]

The fate of a detailed report on emergency core cooling research needs prepared by the staff of the National Reactor Testing Station (NRTS) in Idaho (part of Shaw's command) illustrates the blockage of the AEC's internal communication channels. On April 4, 1972, the Intervenors had the opportunity to cross-examine J. Curtis Haire, manager of the nuclear safety program of Aerojet Nuclear, the AEC's primary contractor for light water reactor safety research at the NRTS. Haire admitted that his laboratory's reports on nuclear safety were sent to Shaw's office for review prior to publication and that, in its reports on the failure of the semiscale-model emergency cooling tests, Aerojet had been forced virtually to eliminate discussions of the relevance of these tests to the effectiveness of emergency cooling systems. The next day Shaw himself happened to be on the witness stand, and Cherry asked him if it was not a fact that the Idaho reports were being censored and edited. Shaw replied:

> Censoring? If you want to use that terminology in the sense I think you are using it, yes. . . . I think it is a basic requirement that reports that are issued by people who are working for us have in them factual information, they are not speculative in the sense of not referring to things they should not.[44]

Haire was then questioned again the following day.



CHERRY: Now is it a fact, Mr. Haire, that the censoring which is going [on] . . . is not a disagreement with . . . technical judgement, but, rather, results in an inhibition of a free and open discussion of [the NRTS] views on safety?

HAIRE: Yes, it is rather an inhibition of free and open discussion rather than a matter of taking issue with technical matters. . . . I believe that RDT [Shaw's Division of Reactor Development and Technology] is trying to avoid the problem or burden, if you will, of having to spend a lot of time answering public inquiries that are addressed to them.

CHERRY: On nuclear safety?

HAIRE: On general questions of nuclear safety, yes.

CHERRY: Now, sir, this belief, is it based on any conversations with persons at RDT?

HAIRE: Yes.

CHERRY: Who?

HAIRE: Mr. Pressesky [Andrew Pressesky, Shaw's deputy for reactor safety].

CHERRY: He told you that?

HAIRE: In substance, yes.[45]

Curtis Haire was subsequently removed from his job and given a position in charge of "program development." It was of course denied that this action was taken in reprisal for his testimony.[46] But Haire's boss, the president of Aerojet Nuclear Corporation, had warned that if any employee's comments

> sour his relationship with the customer [the AEC], we cannot guarantee that after some time has elapsed he will still be in his same position. We would, however, make every effort to find him a suitable opening.[47]

A similar rule was put into effect at Oak Ridge National Laboratory at the insistence of Shaw, and so Oak Ridge director Weinberg was able to protect the jobs of employees in ill favor with the reactor czar only by transferring them to a part of the laboratory not within Shaw's jurisdiction.[48]

Shaw's handling of the nuclear reactor safety program became one of the key points of contention on the "hidden agenda" of the reactor safety hearings. There was therefore great interest when he finally took the stand himself. Dan Ford was the technical interrogator.

In the course of his testimony and Cherry's preliminary cross-examination, Shaw consistently maintained that the Interim Criteria were adequate. He professed to be entirely unshaken in this conviction by the adverse testimony presented at the hearings, and he even asserted that no important experimental data were lacking in support of the criteria. Shaw also maintained that he had prepared his written testimony entirely by himself and took full personal responsibility for the judgments expressed therein.[49] Since these judgments were at such variance with those offered by the experts from Oak Ridge and Idaho, Ford pressed Shaw to back them up:

FORD: Mr. Shaw, I would like to ask you some questions about page 22 of your testimony and your opinion that one of the major areas of conservatism is related to the area of blowdown heat transfer. Now with respect to

blowdown heat transfer, the interim criteria [use the] Groeneweld correlation. Can you tell me, Mr. Shaw, is the Groeneweld correlation a steady-state or a transient heat transfer correlation?

SHAW: I would prefer to cover this as I indicated before. [Shaw had earlier asked for an opportunity to consult sources before replying to questions.] . . .

FORD: Did you ever know whether it was a steady-state or a transient heat transfer correlation?

SHAW: I cannot recall whether I ever addressed this question in those terms.

FORD: Have you ever read the [AEC report] referenced in the interim policy statement as the source of the Groeneweld correlation?

SHAW: I cannot recall whether I ever read that document. . . .[50]

FORD: What are the documents you consulted?

SHAW: Mr. Ford, I have been in this business twenty-some-odd years. All right? The information relating to this goes back through these years. My job depends upon this information over these twenty-odd years. I cannot recall every bit of information that I used in this regard nor do I see any good reason to try to do it.

FORD: What documents did you consult?

SHAW: I do not recall.

FORD: Do you not recall any?

SHAW: I do not recall the documents. I am sure I depended a great deal upon my background.[51]

Ford emphasized to the hearing board that his queries were not "curve-ball or esoteric questions . . . thought up just to test the witness." They were questions on the basic literature, on subjects and references that played an important part in the Interim Criteria. The questioning continued:

FORD: Well, what is the basic experimental source of information on reflooding heat transfer, Mr. Shaw?

SHAW: Again, I believe that is detail, if you don't mind. . . .

FORD: Have you ever heard of the FLECHT program?

SHAW: Oh, absolutely. In fact, I think I initiated it, didn't I?

FORD: But you did not seem to recall that the FLECHT program was the basic source of experimental data on heat transfer in the reflooding period. How in the world do you explain that?

ENGELHARDT [AEC chief counsel]: I object to that, Mr. Chairman. It is argumentative.

CHAIRMAN GOODRICH: I will sustain the objection, much as I would like to hear the answer.

(*Laughter*)[52]

The nuclear industry press was uniform in its opinion of the outcome of the day's hearing. *Nucleonics Week*, a McGraw-Hill trade paper, stated its impressions as follows:

Milton Shaw, director of the AEC Div. of Reactor Development and Technology and thus head of the government's civilian nuclear power program, was verbally floored by the National Intervenors last week at the rulemaking



hearing on emergency core cooling. In a theatrical day of questioning, Shaw simply was unable to answer direct questions about his own written testimony, although he maintained over and over again that he was indeed the author of that testimony.[53]

Shaw's disastrous performance at the ECCS hearings may have been more a reflection of his basic lack of interest in the safety problems of conventional reactors than of any lack of ability. It was widely believed in the AEC's National Laboratories that Shaw had one overriding ambition: to be known as "the father of the breeder reactor." This ambition is in accord with the tradition of the AEC. As one critic of the agency has said:

In any technical adventure, there are exciting parts and there are dull parts. An analysis of every AEC blunder to date indicates clearly that the AEC has accomplished the exciting aspects of every job with competence, expertise and dispatch. But as with individuals, organizational competence isn't defined as doing exclusively just what pleases and satisfies. There's also the dull but inescapable part of any job which must get done, too, like cleaning up the mess after a job is over.[54]

## *Ford and Kendall Cross-Examined*

Although at the opening of the hearings the nuclear industry dismissed the dissent within the AEC over the Interim Criteria as "healthy,"[55] Shaw's humiliation and the accumulating weight of expert testimony against the Interim Criteria soon forced a reassessment. "ECCS Situation Growing Steadily More Ominous for AEC, Industry," headlined *Nucleonics Week* on April 20, 1972. The accompanying article reported that, in a meeting of the AEC Commissioners with top staff officials, including Shaw, there had been

"hard questions" on how AEC had gotten into its present position. . . . AEC chairman James Schlesinger was upset to find that the scientific basis for and conservatism of the interim ECCS criteria are how in doubt after he had been assured by AEC staff of their validity.[56]

Testimony by the reactor manufacturers during the summer produced no significant new evidence in support of the AEC reactor safety regulations. It thus developed that the industry's last chance to demolish the Intervenors' case against it would occur when Henry Kendall and Dan Ford took the stand in August 1972 to defend their 300-page written testimony.[57]

This portion of the hearing again opened with several days of legal dispute over Ford's qualifications to participate. This time the hearing board ruled that Ford could testify only on those portions of the UCS testimony that he had actually written. The Intervenors' attorney, Myron Cherry, argued that this worked an unnecessary hardship on Kendall, since Ford had attended the entire

hearing so far while Kendall had not been able to do so; but Cherry was overruled. In any case, it was true that, although Ford had been responsibile for the gathering and preliminary evaluation of references, Kendall had done the actual technical analysis. Kendall was the physicist, and it was he who would have to defend his technical critique.

Henry Kendall, in his forties, is tall and rangy, obviously an outdoorsman. His manner is intense and his chiseled face, penetrating eyes, and sweptback dark blond hair give him a striking presence. Now a full professor of physics at MIT, Kendall has built a solid career as an experimental physicist while leading a remarkably active life. Inherited wealth has allowed him to follow his adventurous instincts. He has a considerable reputation as a mountain climber and mountain photographer, with a number of first ascents of 20,000-foot peaks in the Andes to his credit. He is also a skindiver and a private pilot. And finally, Kendall had been for a number of years a member of the elite "Jason" advisory group of Defense Department consultants, with which he had worked on both military and civilian problems.

During the legal maneuvering before Kendall took the stand, an industry lawyer gloated over what he claimed was the Intervenors' "gross lack of confidence in their testimony."[58] An AEC staff member even went so far as to invite a *New York Times* newsman to be present to report Kendall's expected demise. The jubilation in the reactor proponent ranks was premature, however, When the cross-examination actually began, Kendall fared rather well. Indeed, the cross-examination gave Kendall the opportunity to argue that his analyses were, if anything, overcautious: reactors might well be even *less* safe than his prepared testimony asserted. Finally, after surviving nearly two weeks of cross-examination with no serious setbacks (except for losing fifteen pounds!), Kendall faced his last challenger: Westinghouse.

Westinghouse is the largest American manufacturer of nuclear reactors, and its pressurized-water reactors have perhaps come under the heaviest attack for safety deficiencies. The Westinghouse team fared little better at beating Kendall down than its predecessors, however. Before long the Westinghouse lawyer, Barton Z. Cowan, was reduced to minor quibbling about the accuracy of quotations in the UCS testimony. Later Cowan announced that he would publicly discredit Kendall by quizzing him on his expertise with a list of questions from twenty-four technical disciplines, but Cowan never got beyond disciplines number 1 (hydraulics and fluid mechanics) and 2 (thermodynamics). Finally, Cowan asked Kendall and Ford rather sarcastically if it was not possible that the AEC staff was in a better position to evaluate reactor safety than the UCS. Ford responded by using the opportunity to express his misgivings about the conduct of the AEC staff in the ECCS controversy. He reminded the hearing board that the AEC task force that had devised the Interim Criteria had utilized data and analyses provided by the reactor manufacturers, while they had ignored (or never saw) independent analyses leading to different conclusions prepared at the AEC's own laboratories. In Ford's view, the staff's independence was further



compromised by previously promulgated AEC positions. Ford concluded:

> The final reason which would seem to inhibit the Regulatory Staff's ability to perform an objective, credible, scientific assessment of the safety implications of reactor systems and the acceptability of emergency core cooling systems has to do with the divided loyalties that seem to be built into the Atomic Energy Commission by the legislation that set it up.
>
> The Atomic Energy Commission seems to have accepted the responsibility to promote nuclear power rather than to be the guardians of the public interest in nuclear affairs. And I think this dedication on the part of the Atomic Energy Commission is reflected in the criteria that we have been reviewing in this hearing and is reflected in the Regulatory Staff's inability to do the job they ought.[59]

After this the Westinghouse lawyer became even more sarcastic, asking: "Is there any area in ECCS where anybody knows more than you two fellows?"[60] This question gave Ford and Kendall an opportunity to explain eloquently what they saw to be their role in the hearings. They could equally well have been presenting a general argument for the necessity of public interest science:

FORD: Mr. Cowan, in terms of general knowledge of the field of emergency core cooling . . . [we] would readily defer to the various people—thorough, competent, solid engineers—who have dedicated themselves to studying this field. . . .

> Now, I think that our function has been in part to assist these people in communicating with the Atomic Energy Commission by developing and cultivating this forum in which they can . . . break through the various bureaucratic manacles that have prohibited them for so long from expressing what is a widely shared, deeply felt view in the nuclear community itself, among those persons intimately concerned with this area. . . .

KENDALL: [The] question here is a question of communication and of freedom to communicate, and not being able to speak freely. . . .

> These are qualified people in that Laboratory [i.e., Oak Ridge], and we all hold them in considerable respect. The difficulty is not that they do not know enough, it is that they are not heard. And the contribution that we believe that we can make is that we are in a position to be heard better than they. . . . We can speak relatively freely of institutional pressures, and say things that would otherwise have to be extracted with great difficulty from reluctant mouths.
>
> There is no question, Mr. Cowan, but that many of the people who have taken the stand here are professionals who have spent a good portion of their professional lives in this field and have available to them from memory many more facts with respect to emergency core cooling systems and with respect to nuclear reactor operation than I do.
>
> There is no question but what that facility is not the critical and important facility for the kinds of things that are under discussion in this hearing, because what is called for here is a question of judgment, first, and second, a position from which one can speak freely.[61]

### *The Hearings Conclude*

The rebuttal phase of the AEC hearings on reactor emergency cooling systems was followed by a second round of testimony in late 1972 that produced few surprises, and then by the submission of closing statements by all parties in early 1973. In their closing statements, all of the reactor manufacturers except General Electric contended that the AEC's ECCS Interim Criteria were too conservative and should be weakened, while General Electric was willing to accept them as they stood but was quite certain that they should not be made any more stringent.[62] On the other side, Kendall and Ford argued that, in view of the inadequate experimental understanding of the actual behavior of emergency cooling systems—a deficiency that had been brought out by their own testimony and by that of AEC reactor safety experts—the Interim Criteria were without justification and the AEC had no basis for licensing water-cooled reactors.

The AEC regulatory staff, as participants in the hearing, also submitted a closing statement. The recommendation which it contained displeased both the reactor manufacturers and the Intervenors. The regulatory staff proposed new reactor licensing criteria that were slightly more conservative and filled in some of the gaps which had been exposed in the Interim Criteria. The regulatory staff speculated that some reactors might even be "derated"—forced to operate below their full power levels—by as much as 20 percent until their emergency cooling systems could be upgraded to meet the new criteria. Others doubted that any such derating would actually result.[63] Kendall termed the changes largely "cosmetic" and emphasized once again that the fundamental problem lay, not with the details of the criteria themselves, but instead with the lack of the basic knowledge required to assure that, in the event of a loss-of-coolant accident in a major nuclear reactor, its emergency cooling system would be able to prevent a catastrophic release of radioactivity into the environment.[64]

The final decision on whether and how much to modify the ECCS Interim Criteria was issued by the AEC Commissioners themselves more than a year later on December 28, 1973. The Commissioners essentially adopted the criteria proposed by the regulatory staff.[65]

### *AEC Licenses Reactors Anyway*

The national hearings on the ECCS Interim Criteria were orginally convened because the AEC had failed, in December 1971, to convince the local hearing board on the Indian Point 2 reactor of the adequacy of the Interim Criteria. The issue had first been publicly articulated in reports by the Union of Concerned Scientists, and it had been forcefully presented in the Indian Point 2 hearings in



the course of Dan Ford's appearance there as a technical interrogator. The Indian Point 2 board's action automatically set a precedent for all other reactor licensing hearings, raising the possibility that the entire licensing program might grind to a halt, leaving billions of dollars' worth of completed nuclear power plants idle. It therefore seemed reasonable for the AEC to propose national hearings on the issue so that the same ground would not have to be worked over in each local hearing, and the local intervenors agreed to cooperate.

But then, in autumn 1972, with the national hearings still in midstream, the AEC suddenly instructed its local hearing boards to disregard the emergency core-cooling issue and proceed with the licensing of seventeen new nuclear power plants. The AEC contended that these plants were badly needed and that they were safe enough. The Consolidated National Intervenors felt betrayed. For a year and a half they had worked within the AEC's administrative procedures. And now, before the final judgment was in, they saw the AEC committing itself to the design standards of current nuclear power plants. Henry Kendall concluded that the outcome of the national hearings was a foregone conclusion, and that the hearings had been used by the AEC mainly as a device to remove the troublesome safety question from the licensing hearings on individual nuclear power plants during the crucial period when nuclear power was finally coming "on line" on a large scale. Shaw's sabotage of the AEC's own safety program during this period provided additional basis for this cynical view.

Time was indeed running out for the Intervenors. While the local hearings on reactor operating licenses and the national hearings on the reactor ECCS Interim Criteria ground on, the hard-pressed electric utility companies continued to order new nuclear power plants. In 1972 the capacity of the nuclear reactors already operating, under construction, or on order in the United States amounted to some 127 million kilowatts, about 40 percent of the total electric power generating capacity in existence in 1970.[66] By 1976 or so, when many more of these nuclear plants will be in operation, shutting them down would be so disruptive that even a major catastrophe might not bring that about.

The AEC doubtless should have followed the advice of its own Advisory Committee on Reactor Safeguards in 1966, when construction began on the present generation of billion watt reactors, and should have pressed a serious program of research on reactor safety. It may still not be too late for a crash program of reactor safety research. The emergency core cooling problem is basically an engineering problem, difficult but probably not insoluble if the reactor industry and the AEC give it sufficiently high priority. It is encouraging that the reactor manufacturers have been redesigning reactor cores for operation at lower power density, for greater controllability in the event of an accident. Westinghouse is reportedly also designing a new improved emergency core cooling system.[67]

### *Beyond the Hearings*

Despite the frustrations of the ECCS hearings, they gave the Union of Concerned Scientists an opportunity to get the facts out into the open, including the AEC's own reactor experts' data and opinions. On the basis of that record, Ford and Kendall decided in autumn 1972 to build a fire of public concern under the AEC and Congress's Joint Committee on Atomic Energy. Their efforts were greatly aided by a series of in-depth articles in *Science* magazine by reporter Robert Gillette,[68] which were followed by regular coverage of the subject in the *New York Times* and other leading papers. And on May 31, 1973, ABC television screened an hour-long documentary on nuclear reactor safety featuring interviews with Ford and Kendall as well as with Milton Shaw and several AEC Commissioners. Ralph Nader had become interested in reactor safety in late 1971, but hesitated to associate himself with the Consolidated National Intervenors until he had studied the issue in detail. By January 1973, on the basis of the ECCS hearings record and the personal presentations of Kendall and Ford, Nader decided to join forces with them. Thereafter he repeatedly endorsed UCS positions and attacked the AEC in press conferences, speeches, and television appearances.[69] The UCS also involved itself in a major debate over nuclear power which has developed in California, where Ford and Kendall have testified on reactor safety before the state's Public Utilities Commission and the state legislature.

### *AEC Reorganization*

In 1973, partly as a consequence of changing leadership and partly in response to the political and legal pressures generated by the Intervenors and their allies, the AEC made some moves to reorganize its efforts on reactor safety. In May 1972 Senator Howard Baker (R.-Tenn.), in whose home state Oak Ridge National Laboratory is located, had tried unsuccessfully to convince his colleagues on the Joint Committee on Atomic Energy that reactor safety research should be separated from Milton Shaw's AEC Division of Reactor Development and Technology.[70] Both then and on several later occasions, AEC Chairman James Schlesinger joined with senior members of the Joint Committee in staunch support of Shaw. But in January 1973, Schlesinger was moved by President Nixon to the directorship of the Central Intelligence Agency, and he was succeeded in the AEC chairmanship by Dixy Lee Ray, a marine biologist from Seattle.

Dr. Ray is a somewhat unusual woman who lives with two dogs in a mobile home in suburban Maryland. At first she was not taken very seriously either within or outside the AEC. But after biding her time for a few months, in mid-May 1973 she acted swiftly and decisively to force through a substantial



AEC reorganization along the lines that had been proposed a year earlier by Senator Baker. With the help of the new members on the Joint Committee on Atomic Energy, she was also able to secure the Joint Committee's approval. Although Dr. Ray insisted that the reorganization was not meant as a personal attack on Shaw, his office was stripped of all responsibility for conventional reactor safety research and left to concentrate on developing the breeder reactor. Shaw himself was said to be "absolutely furious" and threatened to quit the AEC, according to the nuclear industry trade press, while AEC safety researchers were reported to be "dancing in the streets" at the National Reactor Testing Station in Idaho. Dr. Ray demanded and received Shaw's resignation a few weeks later.[71]

In announcing the AEC reorganization, Dr. Ray said that it would provide for

> greater emphasis and effectiveness in our safety research programs . . . [and give] new directions and a renewed dedication to safety research which will help speed resolution of the still unanswered questions.[72]

Asked whether she expected substantive changes under the new director of reactor safety research, Dr. Herbert Kouts, a former chairman of the Advisory Committee on Research Safeguards, her response was "Good heavens, I would hope so."[73]

### *Conclusions*

The reactor safety issue is still far from settled. If reactors which the electric utility companies are building all over the country prove to be unsafe, the nation may have to learn to live with periodic radiological disasters in addition to the usual fare of hurricanes, earthquakes, floods, and the steady toll of automobile accidents. Or perhaps serious reactor accidents will be exceedingly infrequent—perhaps not even one by the end of this century. One hopes that the latter eventuality is more likely, but one would like to be in a position to say so with greater assurance.

No matter how the reactor safety issue is finally resolved, three lasting conclusions can already be drawn. First, with respect to the AEC: even if the conflict-of-interest issue had never been raised before, the present reactor safety controversy illustrates convincingly the unacceptable situation created by lodging responsibility for promoting and regulating nuclear power in one and the same agency. Since the subversion of the AEC's regulatory function has been encouraged or condoned at the level of the AEC Commissioners and the Congressional Joint Committee on Atomic Energy, the recent reorganization at a lower level has not dealt with this central problem. It is furthermore intolerable that the hearings on reactor safety had to be conducted before an AEC-appointed board, with official AEC witnesses defending an AEC-approved

position and unofficial AEC witnesses subjected to threats of losing their jobs, with AEC documents and advisors not subject to subpoena, and with the final decision in the hands of the AEC Commissioners. In any fair and impartial hearing, the government agency charged with regulating reactors and protecting the public interest would have itself prepared the testimony that the Consolidated National Intervenors were forced to draw "from reluctant mouths," to use Kendall's phrase. Indeed, if an independent agency were charged with nuclear safety, it seems probable that the problems of emergency core cooling would have been dealt with much earlier and in a more adequate manner.

A second conclusion is that one does not have to be the world's greatest expert to challenge even so mighty and technically esoteric an agency as the AEC. Great effort and dedication are required; most important of all is good judgment, self-confidence, and independence of mind. The true reactor safety experts at the AEC laboratories responded to the dedication and competence of Kendall and Ford and undertook to educate them and cooperate with them.

Finally, it is difficult to avoid being struck by the multiple failures of our scientific institutions that this reactor safety controversy has revealed. The supposedly independent AEC Advisory Committee on Reactor Safeguards had been quietly warning the Commission of serious deficiencies in reactor safety research ever since 1966. But these warnings fell on deaf ears, and the urgency of the need for additional information and safer reactor designs did not become apparent even to the larger nuclear science community until the ECCS hearings began. And even these hearings did not result from a demand by nuclear reactor engineers for an airing of all the relevant information. They came about because of the willingness of one economist and a few physicists to look into important issues far from their normal areas of expertise and to interject these issues into a reactor licensing controversy initiated by environmentalists. The costs of preparing and presenting the technical arguments have been borne by environmental groups like the Sierra Club and the Audubon Society; Kendall and Ford themselves have personally raised a substantial fraction of the $200,000 which they have spent thus far. Their professional colleagues and scientific organizations have not been among the major contributors.

Kendall and Ford are among the pioneers in public interest science. Their achievements will hopefully inspire others.

## NOTES

1. U.S., Atomic Energy Commission, *In the Matter of Acceptance Criteria for Emergency Core Cooling Systems for Light Water Nuclear Power Reactors,* Docket No. R.M. 50-1 (Hereafter referred to as *ECCS Rule-Making Hearing.*) transcript, p. 19299.
2. *Federal Register,* April 23, 1971, p. 7696.
3. *Boston Globe,* April 1971.



4. The March 4 lectures are reprinted along with a brief history of the March 4 movement in Jonathan Allen, ed., *March 4* (Cambridge: MIT Press, 1970). See also Dorothy Nelkin, *The University and Military Research: Moral Politics at M.I.T.* (Ithaca, N.Y.: Cornell University Press, 1972).
5. See, e.g., Ralph E. Lapp, "The Nuclear Power Controversy: Safety", *New Republic,* January 23, 1971, p. 18.
6. For a pungent popular presentation of the views of these authors, see their joint efforts *"Population Control" Through Nuclear Pollution* (Chicago: Nelson Hall, 1970) and *Poisoned Power* (Emmaus, Penn.: Rodale Press, 1971). Although these books have a slightly hysterical tone, their facts appear to be basically correct. (See *The Effects on Populations of Exposures to Low Levels of Ionizing Radiation* [Washington D.C.: National Academy of Sciences, November 1972].) The books also give an almost unique inside view of some of the problems which have arisen from the AEC's dual role of promoter and regulator of atomic energy.
7. *New York Times,* June 8, 1971, p.1.
8. See, e.g., Ralph Lapp, "The Nuclear Power Controversy: Power and Hot Water", *New Republic,* January 6, 1971, p. 20.
9. *New York Times,* March 17, 1971, p. 29.
10. The tests applied most directly to "pressurized-water reactors," which are built by Westinghouse, Babcock and Wilcox and Combustion Engineering. The other common variety of modern power reactor is General Electric's "boiling-water reactor," which also requires an elaborate emergency cooling system. A third, less common design is the Gulf General Atomic "high-temperature gas-cooled reactor."
11. The AEC supports a number of major laboratories. The experts on the safety problems of conventional power reactors were in 1970 located mostly at the Oak Ridge National Laboratory in Tennessee and the National Reactor Testing Station (NRTS) in Idaho. Both have staffs of several thousand employees, but Oak Ridge is one of the AEC's "multi-purpose laboratories" with programs in many areas of physical and biological research and engineering while the NRTS is more "mission oriented." Oak Ridge is operated for the AEC by Union Carbide and the NRTS by Aerojet-General. The Lawrence Livermore Laboratory, mentioned previously, is operated for the AEC by the University of California and has as its primary mission the refinement of nuclear weapons.
12. For an illustrated description see Tom Alexander, "The Big Blowup Over Nuclear Blowdowns," *Fortune,* May 1973, p. 216. The illustrations include color photos of fuel rods swollen and contorted in tests at Oak Ridge simulating conditions in an overheated reactor core.
13. This "once through" cooling water is not run through the reactor core. Instead, it is used to recondense the steam which has delivered the energy of the reactor to the turbines which drive the electric generators. The "primary cooling water" which passes through the reactor inevitably becomes contaminated with radioactivity and must be recycled.
14. U.S. Atomic Energy Commission, "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants," AEC Report No. WASH-740 (Washington, D.C.: AEC, 1957).
15. Ian A. Forbes, Daniel F. Ford, Henry W. Kendall, and James J. MacKenzie, *Nuclear Reactor Safety: An Evaluation of New Evidence* (Cambridge, Mass.: UCS, July 1971). (The address of the UCS is P.O. Box 289, MIT Branch Station, Cambridge, Mass. 02139.) The report is reprinted in U.S. Congress, Senate, Committee on Interior and Insular Affairs, *Calvert Cliffs Court Decision,* 92nd Congress, 1st Session, November 3, 1971, Part 2, pp. 295-305; the passages quoted appear on p. 299. This UCS report is also reprinted in part in *Nuclear News,* September 1971, p. 32. (*Nuclear News* is the monthly organ of the American Nuclear Society.)
16. *Ibid.* (*Calvert Cliffs Decision*), p. 300.
17. The delays in the AEC's nuclear safety program and the resulting controversy within the AEC establishment are discussed in a series of articles by Robert Gillette titled "Nuclear

Safety" and subtitled "The Roots of Dissent," *Science* 177 (1972): 771; "The Years of Delay," p. 867; "Critics Charge Conflicts of Interest," p. 970; and "Barriers to Communication," p. 1030.

18. Forbes et al., *Nuclear Reactor Safety*, note 15.

19. The text of the Seaborg letter is reprinted in *Nucleonics Week*, May 13, 1971, p. 6. (*Nucleonics Week* is a McGraw-Hill trade newsletter.)

20. Quoted in Robert Gillette, "Nuclear Reactor Safety: A Skeleton at the Feast?" *Science* 172 (1971):918. Gillette notes that the Joint Committee had already received a secret AEC briefing on the emergency cooling system issue on May 3, 1971.

21. "Criteria for ECCS for Light Water Reactors," *Federal Register* June 29, 1971, p. 125.

22. R. Lorenz, D. Hobson, and G. Parker, *Final Report on the First Fuel Rod Failure Transient Test of a Zircaloy-Clad Fuel Rod Cluster in TREAT*, Report No. ORNL-4635 (Oak Ridge, Tenn: Oak Ridge National Laboratory, March 1971).

23. Quoted in Robert Gillette, "Nuclear Safety: Critics Charge Conflict of Interest", *Science*, 177 (1972):970.

24. Daniel F. Ford, Henry W. Kendall, and James J. MacKenzie, *A Critique of the New A.E.C. Design Criteria for Reactor Safety Systems* (Cambridge, Mass: UCS, October 1971). Reprinted in *Calvert Cliffs Court Decision* pp. 306-319. (Also reprinted in part in *Nuclear News*, January 1972, p. 28.) The contents of this and the UCS July report (Forbes et al., *Nuclear Reactor Safety*) are summarized in Ian A. Forbes, Daniel F. Ford, Henry W. Kendall, and James J. MacKenzie, "Cooling Water," *Environment*, January-February 1972, p. 40.

25. Letter from Donald B. Trauger, Associate Director, Oak Ridge National Laboratory, to Milton Shaw, Director, Division of Reactor Development and Technology, AEC, November 24, 1971. Entered as exhibit F, testimony of Intervenors' counsel, Myron Cherry, *ECCS Rule-Making Hearing*, March 17, 1972. The letter is reprinted in part in *Congressional Record* 118 (1972):10450.

26. *Nucleonics Week*, April 20, 1972, p. 1.

27. Quoted in *Nuclear Industry*, February 1972, pp. 11-20. (*Nuclear Industry* is published by the Atomic Industrial Forum, a nuclear industry association.)

28. Richard D. Lyons, "Nuclear Experts Share Doubts on Power Plant Safety," *New York Times*, March 12, 1972.

29. Morris Rosen and Robert J. Colmar, "Comments and Recommendations to the REG ECCS Task Force," memorandum of June 1, 1971. Exhibit No. 715 of the ECCS Hearing record; reprinted in the *Congressional Record* 118 (1972):9303, 9304.

30. Prepared testimony of Dr. Morris Rosen, Technical Advisor to the Director, Division of Reactor Licensing, *ECCS Rule-Making Hearing*, Exhibit 1043, p. 34.

31. *Ibid.*, p. 40.

32. Quoted in Robert Gillette, "Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," *Science* 176 (1972):498.

33. Quoted in *Nucleonics Week*, March 2, 1972, p. 11.

34. Quoted in Gillette, "Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," p. 498.

35. Quoted in *Nucleonics Week*, March 2, 1972, p. 1.

36. *ECCS Rule-Making Hearing*, transcript, pp. 2114-2120.

37. Quoted in Robert Gillette, "Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," *Science*, 176 (1972):496.

38. Quoted in Daniel F. Ford and Henry W. Kendall, "Nuclear Safety", *Environment*, September 1972, p. 48, footnote 6.

39. Quoted in *Nucleonics Week*, March 16, 1972, p. 2.

40. Letter from William B. Cottrell et al. to L. Manning Muntzing, Director of AEC Division of Regulation, December 6, 1971. Submitted as Exhibit No. 1020 at the *ECCS Rule-Making Hearing*; reprinted in part in the *Congressional Record* 118 (1972):10449.



41. Gillette, "Nuclear Reactor Safety: At the AEC the Way of the Dissenter is Hard," p. 498.

42. Letter from Dr. Alvin A. Weinberg to Dr. James R. Schlesinger, February 9, 1972. Exhibit No. 1027 at the *ECCS Rule-Making Hearing*; reprinted in part in the *Congressional Record* 118 (1972):10449.

43. Gillette, "Nuclear Safety: Critics Charge Conflicts of Interest," p. 972.

44. *ECCS Rule-Making Hearing*, transcript, p. 7289.

45. *Ibid.*, pp. 7592-7593.

46. *Nucleonics Week*, September 7, 1972, p. 8.

47. Gillette, "Nuclear Safety: The Roots of Dissent," p. 773.

48. Member of Weinberg's staff, December 1971, personal communication.

49. See e.g. *ECCS Rule-Making Hearings*, transcript, p. 724. See also *Nuclear Industry*, April 1972, p. 9.

50. *ECCS Rule-Making Hearings*, transcript, pp. 7382-7383.

51. *Ibid.*, p. 7387.

52. *Ibid.*, pp. 7434-7435.

53. *Nucleonics Week*, April 13, 1972, pp. 4-5.

53. *Ibid.*

54. H. Peter Metzger, *The Atomic Establishment* (New York: Simon and Schuster, 1972), p. 244. Metzger's book is a hard-hitting presentation of the history and consequences of the insulation from outside criticism of the AEC and the Joint Committee on Atomic Energy.

55. Quoted in *Nucleonics Week*, February 17, 1972, p. 1.

56. *Nucleonics Week*, April 20, 1972, p. 1.

57. Kendall and Ford were assisted in preparing this testimony by two Union of Concerned Scientist Colleagues, Professors James A. Dawson of the Harvard School of Public Health and James V. Fay of the MIT department of mechanical engineering. Fay wrote one of the chapters.

58. Quoted in *Nucleonics Week*, August 3, 1972, p. 3.

59. *ECCS Rule-Making Hearing*, transcript, pp. 19266-19267.

60. *Ibid.*, p. 19267.

61. *Ibid.*, pp. 19267-19278.

62. *Nuclear Industry*, March 1973, p. 40.

63. Robert Gillette, "Reactor Safety: AEC Concedes Some Points to Its Critics," *Science* 178 (1972):482.

64. *Not Man Apart*, December 1972, p. 1. (*Not Man Apart* is the monthly magazine of Friends of the Earth.) Kendall and Ford, private communication.

65. U.S. Atomic Energy Commission, *Acceptance Criteria for Emergency Core Cooling Systems, Light-Water-Cooled Nuclear Power Reactors, Opinion of the Commission*, Docket No. R.M. 50-1.

66. *Nuclear News*, 1972 International Conference Program, p. 107.

67. See, e.g., *Nuclear Industry*, July 1972, p. 27; *ibid.*, October 1972, p. 48; *Nucleonics Week*, October 26, 1972, p. 2. The Electric Power Research Institute, which is funded by the electric utility industry, has also undertaken the funding of its own program of research on nuclear reactor safety. See, e.g., John Walsh, "Electric Power Research Institute: A New Formula for Industrial R & D," *Science* 182 (1973):263.

68. Gillette, "Reactor Safety," note 17.

69. See, e.g., *New York Times*, January 4, 1973, p. 18.

70. *Nucleonics Week*, May 4, 1972, p. 4. Senator Baker is an old friend of Alvin Weinberg, then director of the Oak Ridge National Laboratory. Baker admitted consulting with people at Oak Ridge before making his proposal, but he denied that it was Weinberg's idea.

71. *Nucleonics Week*, issues of May 17, 24, 31, 1973. See also *Science* 180 (1973):935.

72. *New York Times*, May 22, 1973, p. 17.

73. *Nucleonics Week*, May 31, 1973, p. 3.