Nuclear Safety: Damaged Fuel Ignites a New Debate in AEC

For the past 2 months, the Atomic Energy Commission (AEC) has been investigating some puzzling damage—a few analysts prefer the word "incredible"—sustained by hundreds of fuel rods in the core of a large nuclear power reactor near Rochester, New York. The damage consists of bowed, cracked, and partially crushed rods, some of which are said to look as if they had been "squeezed in a vise." There is firm evidence as well that similar fuel damage has occurred recently, during the course of normal operation, in at least four other reactors—three in the United States and one in Switzerland. The cause of the damage is by no means clear, but the AEC's handling of the problem, and its implications for public safety, are fast becoming matters of intense debate among the commission's regulatory staff.

The Swiss reactor is now running at half power with the "degraded" fuel inside, and the three U.S. nuclear plants continue to operate with an undetermined number of the rods still in their cores. As a safety precaution, the AEC has ordered the Robert E. Ginna reactor, owned by the Rochester Gas and Electric Company, to run its 2-year-old plant at no more than 83 percent of capacity and to avoid subjecting the reactor to sudden surges in power demand. As a further precaution, the utility has redoubled its surveillance for broken or leaking fuel rods.

"The choice was either to let the plant run or shut down the industry," one AEC source said. "We're playing the risk game. The probabilities of an accident are small, although the consequences of an accident under these conditions might be worse."

No one, not even those within the AEC who seem most worried about the defective fuel, suggest at this point that it poses an "imminent" hazard to the public. There are concerns, nonetheless, that the behavior of the weakened fuel rods might be nearly impossible to predict in the unlikely event of a major loss of cooling water from the reactor. As one respected engineer puts it, "We haven't the foggiest idea how this fuel would behave in a loss-of-coolant accident."

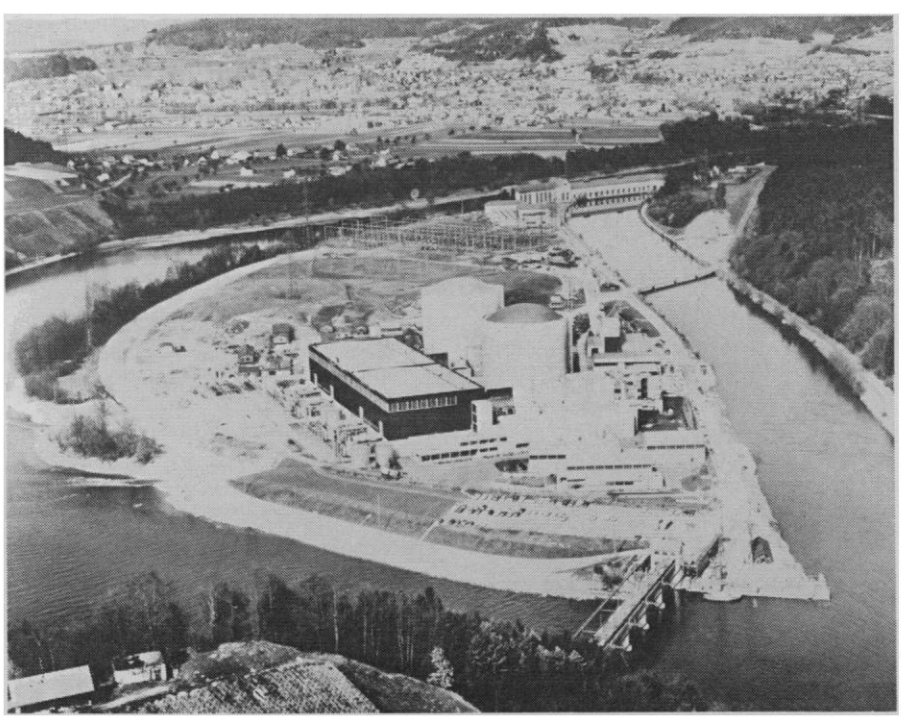
The first inkling of something amiss appeared over a year ago, when technicians at the Beznau 1 reactor near Baden, Switzerland, began a routine refueling operation. This involved replacing some of the 21,000 long, hollow zirconium alloy rods that make up the reactor's heat-generating core.

Each of the 12-foot rods is supposed to be filled with hard, brown pellets of enriched uranium oxide. To the dismay of the Westinghouse Corporation, which designed the Beznau reactor and furnished its fuel, a number of spent fuel rods were found to be empty near the top for a space of several inches. The huge internal pressures that prevail inside the reactor had collapsed some of the rods where the pellets were missing. And while this had no effect on the reactor's operation, it was still a matter of great concern, since fuel rods damaged in this way not only are structurally unsound but tend to develop "hot spots" that may lead to cracking and leakage of the intensely radioactive fission wastes contained inside.

The initial reaction of Westinghouse was to conclude that the problem must have been one of "quality assurance"—that someone back at the factory must have neglected to fill the fuel rods in the first place. To the few members of the AEC's regulatory staff who heard of the discovery at Beznau, this explanation seemed a reasonable one, mainly, as one man familiar with the affair says, "because any other explanation was just unthinkable."

Thinking the unthinkable, however, became an urgent necessity after refueling operations began in mid-April at the 420-megawatt Ginna reactor in Ontario, New York.

Like the Beznau plant, Ginna was designed and fueled by Westinghouse, and its core also contained about 21,000 of the same fuel rods. Earlier this year, neutron-monitoring instruments inside the core had picked up indications of "voids" or gaps of several inches between fuel pellets, so, when technicians removed 54 bundles of spent fuel rods (containing about 10,000 rods) they placed them in a deep pool of water to absorb heat and radiation and examined the bundles with a remote-control television camera. According to a report Westinghouse filed with the AEC on 30 June, the camera revealed that the upper 40 percent of dozens of rods were bent, dented, and partially crushed, and that a few showed cracks or holes. Only the outermost, or peripheral, fuel rods



Westinghouse photo shows twin 350-megawatt reactors of Beznau plant near Baden, Switzerland, where damaged fuel was first detected.

in the bundles were visible on the television screen. But of these, "10 percent . . . showed a series of abnormal conditions including failures, bowed rods, and collapsed cladding."

Donald Knuth, the assistant director for reactor safety in the AEC's regulatory branch, says it is reasonable to suppose that such defects are uniformly distributed through the fuel removed from the Ginna reactor. On this basis, as many as 2100 rods may have been damaged, of which more than 1000 may still be in the core.

Similarly affected fuel may also exist in two other power plants. At the Carolina Power and Light Company's H. B. Robinson 2 reactor, plant superintendent Ben Furr said that monitoring instruments "give some indication of the same problem but to a much less severe degree than at Ginna." He said there was no evidence of leaking fuel in the 700-megawatt Robinson plant at Hartsville, South Carolina, and that the utility had no plans to extract possibly damaged fuel assemblies until a scheduled refueling next year.

A spokesman for the Wisconsin Electric Power Company said they had similar instrument readings in their 497-megawatt Point Beach reactor at Two Creeks, Wisconsin, on Lake Michigan. "We've got some blips on our instruments, but we won't know what they mean until we look at the fuel this fall," he said. Like the Beznau, Ginna, and Robinson reactors, the Point Beach plant was designed and fueled by Westinghouse. A spokesman for Westinghouse said he would have "no comment on any aspect of nuclear fuels," and he declined even to say which other reactors contained their fuel. It was learned, however, that one other is currently of concern to the AEC. That is Consolidated Edison's 873-megawatt Indian Point 2 reactor, near New York City. The plant contains the same fuel as in the four other reactors and is currently awaiting an operating license before starting up. The prospect now arises that operation of Indian Point 2 —already delayed for months by construction problems, environmental protests, and a major fire last year—could now be delayed still longer, until questions about the integrity of its fuel are resolved.

The AEC's Knuth says the damage almost certainly originates from shrinkage or "densification" of the fuel pellets, which in turn is thought to result from a poorly understood combination of heat and radiation effects. By this line of analysis, the volume of the fuel pellets decreases as it becomes more dense, and the pellets settle down inside the fuel rods like breakfast cereal in the box. If the walls of the hollow rods are strong enough to resist pressures inside the reactor, the rod remains intact, and the pellets slip freely down, leaving a space at the top, as at Beznau. If pressure crimps the metal rods at random points, the downward motion of pellets is stopped and spaces open between them. These unsupported gaps are then vulnerable to crushing external forces.

By all indications, the AEC is a good deal closer to understanding how the damage occurs than to deciding whom, if anyone, to blame. On this point there are two conflicting lines of thought. One, favored by the nuclear industry, maintains that the problem begins and ends with faulty manufacturing and inspection by Westinghouse.

The other viewpoint carries serious implications for the health of the industry as a whole, for it argues that the damage probably manifests a "generic" flaw in fuel design that—sooner or later—will crop up in a number of large new reactors, regardless of who furnishes the fuel. Put another way, the scattered incidents now coming to light are interpreted by some as a "warning" that unexpectedly severe conditions may prevail inside the new generation of large-capacity power reactors, which have begun to come into operation only in the past 2 years. "It's a tough problem, and I'd hate to choose one answer or the other right now," the AEC's Knuth says. "But if it is generic," he adds, "we have a problem we haven't seen in our experiments before."

The three U.S. plants in question are only intermediate-sized forerunners of an even larger generation of reactors, of which dozens are now on order or under construction. Thus it would be more satisfying for everyone concerned, save perhaps Westinghouse, to find that the entire fuel problem originates with one company's shoddy workmanship and not with a design problem common to all brands of fuel.

Yet, as one knowledgeable authority who leans toward the latter view points out, "Nothing in a reactor is more thoroughly tested than fuel. After all, that *is* the reactor. What I think this problem says is that we're moving too fast in scaling up the size of reactors—that we're extrapolating too freely from small plants and small experiments. We have *got* to have operating experience factored into design, and we're just starting to get it with large plants."

Since the middle 1960's, conservative scientists and engineers both within the AEC and outside have been urging caution in the escalation of reactor size, but to little avail. In 1960, the largest nuclear plant on order by a utility had a generating capacity of 300 megawatts. Within 5 years, Westinghouse and others were receiving orders for plants four times that size.

The soaring size of nuclear reactors is largely a consequence of economic competition with fossil-fuel power plants. Larger generating stations produce more electricity for the investment dollar. And all through the 1960's the vendors of both nuclear and fossil-fuel plants fought for a competitive edge by capitalizing on economies of scale.

Critics of this race to gigantism, among them author-physicist Ralph Lapp, observe that boosting the capacity of a reactor is not simply a matter of making it physically larger. With increasing capacity there has been a concomitant rise in the "power density" of reactor cores, a term for the amount of heat produced by each linear foot of fuel rod. In less than a decade, power densities have more than doubled and Lapp, among others, argues that in the process of squeezing more energy from reactor cores the designers have narrowed the margins of safety by imposing ever higher expectations on such safety features as emergency core cooling systems (*Science*, 5 May).

For nearly 2 years, the AEC's regulatory staff has been embroiled in an internal, and more recently, public debate over the adequacy of emergency cooling systems. From this debate it has become evident that a sizable segment of the nuclear safety research community favors an indefinite moratorium on reactor power increases, until questions surrounding reactor safety systems are more nearly resolved. Within the AEC's regulatory staff, several respected engineers have advocated this position, including Morris Rosen, a technical adviser in the Directorate of Licensing. The new argument over the integrity of nuclear fuel will in all probability serve to intensify pressure for such a moratorium, much as that may temporarily hobble the nuclear industry in its race for supremacy over fossil fuels.—ROBERT GILLETTE