Hazy Picture of Chernobyl Emerging

Details of the accident remain unclear, but Western experts are putting together a rough sketch of what happened; Soviet officials have promised to release data soon, AAAS meeting told

Philadelphia

More than a month after an explosion ripped apart a Soviet reactor and put the town of Chernobyl firmly on the world map, information about the accident remains at best sketchy. The problem is not just that Soviet officials have been sparing with the data they have released; American experts believe that the Soviets themselves do not yet have a clear picture of what happened.

However, Harold Denton, a top official of the U.S. Nuclear Regulatory Commission (NRC), told a packed session at the otherwise sparsely attended annual meeting of the AAAS here that the Soviet government has promised to provide a complete briefing to Western experts some time this summer. An internal Soviet investigation is scheduled to produce a report by early July, and a meeting between Soviet and Western experts is expected to take place at the International Atomic Energy Agency (IAEA) in Vienna after that. Until the Soviets release their findings, Denton said in an interview, "Whatever we say about the accident is speculation."

A hazy picture of the catastrophe is, however, beginning to emerge from official Soviet statements, accumulating knowledge of the design of the Chernobyl unit IV reactor, analysis of the radioactive fallout from the explosion and subsequent fire, and unofficial Soviet accounts provided at an IAEA meeting in late May.

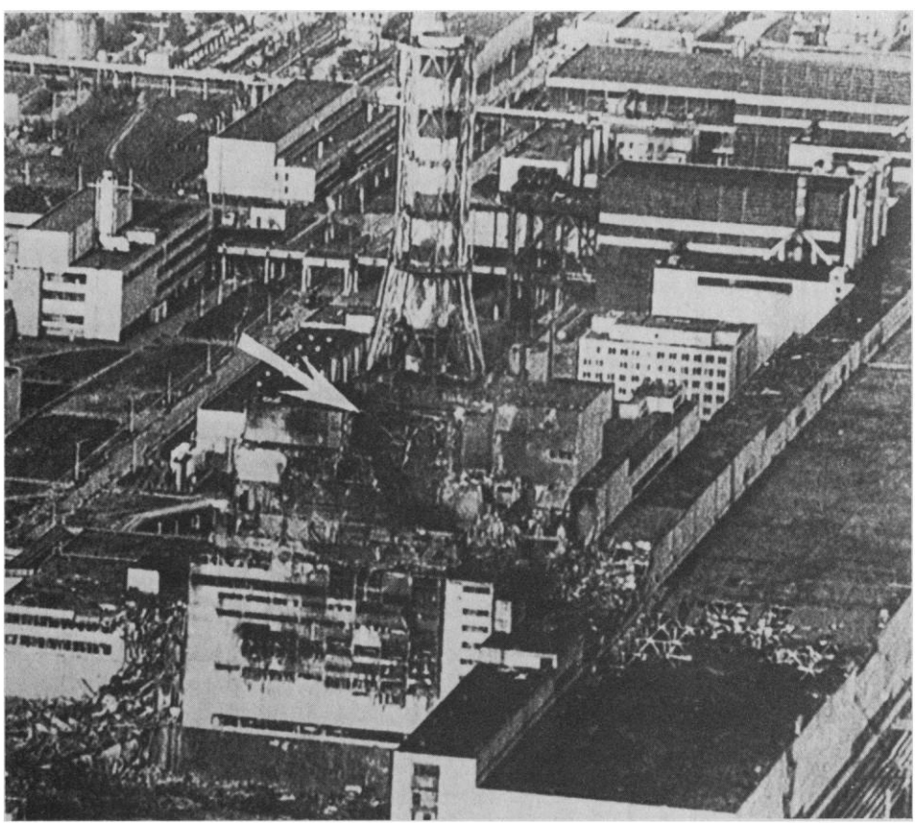
A consensus seems to be forming around the belief that the accident started in the reactor itself when it was running at low power and that a fast-moving sequence of events quickly overwhelmed the safety and containment systems at the plant. How much of the reactor's total inventory of radioactive material was released to the environment is uncertain, but some estimates suggest that half the iodine and cesium, two of the more volatile elements, were ejected. If so, some 40 million curies were released; in contrast, the Three Mile Island accident is believed to have released just 15 curies.

According to official Soviet statements, an explosion occurred at the unit IV reactor at Chernobyl at 1:23 a.m. on Saturday, 26 April, when the reactor was running at low power prior to a planned shutdown. In a televised statement on 14 May, Soviet leader Mikhail Gorbachev said the apparent cause was "an unexpected power surge" followed by a hydrogen explosion. Five days later, Ivan Yemelyanov, a top Soviet nuclear energy official, told Western reporters that the reactor's heat output surged from 6% of its capacity to 50% in 10 seconds.

What caused the power surge is unclear, but U.S. rector experts familiar with the design of the Chernobyl plant point out that it has a so-called positive reactivity coefficient, which means that, over a certain range, the nuclear reaction increases as the power output rises. One government scientist who asked not to be identified, says this could "seriously aggravate" a local problem in the core and can be difficult to control. Victor Gilinsky, a former NRC commissioner, noted at the AAAS symposium that Soviet reactors are highly automated, and suggested that the accident may have happened so fast that it "may have gotten away from the operators." (Reactor designs used in the West do not have a positive coefficient.)

The accident apparently ruptured some of the pressure tubes that pass through the massive graphite moderator and circulate water around the fuel rods. Without cooling water, the fuel elements rapidly heated up and began to melt. Experts theorize that a highly combustible mixture of gases was formed when steam came in contact with the hot graphite, generating hydrogen and carbon monoxide, and zirconium in the fuel rods reacted with superheated stem to produce more hydrogen.

Sufficient energy apparently was released, either when the pressure tubes ruptured or by the power surge itself, to breach the



Wide World

The remains of unit IV. *This photograph, released by Tass 13 days after the accident, shows the massive destruction of the building that housed the reactor.*

shielding above the reactor. The reactor is usually surrounded by an inert environment of helium and nitrogen, but when the shielding was breached, the gases mixed with air and a massive explosion occurred, followed by a fire as the 1700-ton graphite moderator ignited.

One theory, prominent among Western experts until recently, is that the explosion was preceded by a fire in the nearby turbine hall, but Denton says this theory is no longer fashionable. Soviet delegates at last month's IAEA meeting talked repeatedly of an overpressure of steam in the reactor, followed by the generation of hydrogen and an explosion and fire, he said.

The Soviet delegates also mentioned in conversations at the Vienna meeting that experiments were being conducted at the reactor at the time of the accident, Denton said. But they gave very little information about the nature of the experiments or their contribution to the accident. There has been some speculation in the West, based on no hard evidence, that the experiments might have involved plutonium production for military purposes. Gilinsky says he finds it suspicious that the Soviets have not provided any information about the experiments and suggested that if they had any military implications, "we may never know" the full details of what precipitated the accident.

Whatever started the sequence of events, the containment around the reactor core was evidently breached early in the catastrophe. This has already provoked an intense argument in the United States between the nuclear industry and its critics over the implications for U.S. reactor safety.

Shortly after the accident, spokesmen for the Atomic Industrial Forum, the nuclear industry trade association, stated that the Chernobyl plant, unlike U.S. reactors, had no containment system to isolate radioactive debris from the environment in the event of a major mishap. The clear implication is that such a catastrophic release of radioactivity would not happen here. When Soviet literature on the plant was analyzed, however, it became clear that it did have some containment features. This led the antinuclear Public Citizen, a group founded by Ralph Nader, to take out a full-page advertisement in the *New York Times* claiming that Chernobyl's containment "bears a striking resemblance" to the system used in most boiling-water reactors in the United States.

U.S. experts familiar with the reactor design say that the containment system at Chernobyl is better than nothing—which is what Soviet reactors had prior to about 1980—but it is unlikely to be as effective as U.S. systems. According to one government reactor expert, Soviet engineers added some containment features to the basic design but did not reconfigure the plant itself. "It is a very rudimentary attempt to have some containment functions," he says.

According to an analysis by NRC staff members, the reactor itself is surrounded on the sides by concrete capable of withstanding pressures of 27 pounds per square inch, and the major high-pressure pipes are surrounded by a 57 pounds-per-square inch containment. Both regions are designed to vent through valves into so-called pressure-suppression pools that have been added beneath the reactor. The pools, which are similar to a system used in U.S. boiling-water reactors, are supposed to condense steam, thereby relieving pressure that may build up during an accident. The general consensus among U.S. experts is that the containment system is designed to handle a large pipe break and to keep superheated steam away from the reactor core.

U.S. experts believe that the containment is weakened by the fact that it is penetrated by hundreds of pipes. It is also not clear what the containment is like over the top of the reactor's massive core. A unique feature of the Chernobyl-type reactors is that they can be refueled while the reactor is operating, and the shielding over the reactor has hundreds of plugs that can be removed to take out and insert fuel rods. Robert Bernero, a top safety official at the NRC believes the top of the reactor is the weakest point. "It is very difficult for us to figure out even where the pressure boundary is," he says.

In any case, it seems that the top of the reactor blew apart early in the accident and the subsequent explosion and fire spewed radioactivity into the atmosphere. Just how much was released is a matter of some dispute, in part because the calculations are based on radioactive fallout in European countries hundreds of miles from the reactor. Until the Soviets release data from the region surrounding Chernobyl, the full dimensions of the catastrophe will not be known.

According to calculations by a group at the Lawrence Livermore National Laboratory, perhaps 40% of the reactor's total inventory of radioactive fission products was ejected in the initial explosion and fire, and a further 10% was vented over the following few days. If correct, some 40 million curies of radioiodine and 3 million curies of radioactive cesium were spewed into the environment.

The initial explosion and fire were believed to have been so energetic that a large fraction of the debris was carried very high into the atmosphere. If so, fallout close to the plant in the first day or so may not have been as serious as might be expected from an accident of this magnitude.

George Greenley of the Livermore team says it was "like solving a mystery putting it all together." The group used a computer program originally developed for modeling thunderstorms, which has more recently been used for analysis of the "nuclear win-

Soviets Buy Robots

Under the cover of darkness two Soviet cargo planes slipped into Karlsruhe, West Germany, on Saturday, 10 May. They stayed at the airport only for a few hours—long enough to pick up three specialized robots needed to probe the gutted Chernobyl nuclear power plant. Normally, the sale of such equipment could require a clearance under Coordinating Committee regulations governing the transfer of high technology to Eastern Bloc countries. State Department officials, however, say it appears that this sale was approved on an expedited basis because of the 26 April Chernobyl disaster.

Negotiated over a week's time, the sale is said to be worth more than $10 million to Kerntechnische Helssdienst, GmbH, a nuclear equipment manufacturer located near Karlsruhe. The largest device supplied to the Soviets is a 30-ton camera-equipped shovel loader. Capable of lifting 2.5 tons, the radio-controlled machine has a range of 1 kilometer. A smaller camera-guided and radio-controlled machine with 200-kilogram lifting capacity also was supplied. The third machine also has camera vision, but is cable controlled. About 2 meters long, it has a maximum lifting capacity of 80 kilograms.

The Soviets sought to avoid publicity on the purchase, according to German industrialists and a knowledgeable American scientist. The supplier received little notice prior to the cargo planes' arrival, sources say. The Soviets also declined to receive detailed lessons on the operation of the machines in West Germany. Instead, they reportedly asked the company to send technicians to Moscow to provide training. ■ MARK CRAWFORD

ter" phenomenon, to estimate the release. The estimate was derived by back calculations from fallout monitored in Sweden.

Greenley admits that the analysis of the Chernobyl fallout patterns pushed the program to its limits and that there are many uncertainties in the conclusions. NRC researchers accept the general thesis that about 50% of the reactor's radioactive compounds were ejected. "We are saying that is a best starting guess," says Denton. Themis Speis, who has been heading a team at NRC that has been monitoring the Chernobyl data, says estimates of the fraction of volatile radionuclides that escaped from the plant range from 20% to 60%.

Not everybody agrees, however. Richard Wilson, a physicist at Harvard who headed a study of severe nuclear accidents for the American Physical Society, argues that less than 10% of the radioiodine was emitted. He bases this on the fact that the ratio of iodine to some other radioisotopes in Sweden was surprisingly low. The mechanism by which iodine would be selectively retained in the plant is unclear, however, and Wilson's low estimate is not widely supported.

What is clear is that it will be many months before the accident is understood. And how complete the understanding will eventually be will depend critically on how much information the Soviets are prepared to release in Vienna later this summer. ■

COLIN NORMAN

AAAS Meeting Briefings:

Researchers Found Reluctant to Test Theories

Despite the emphasis placed by philosophers of science on the importance of "falsification"—the idea that one of a scientist's main concerns should be to try to find evidence that disproves rather than supports a particular hypothesis—experiments reported at the AAAS annual meeting suggest that research workers are in practice reluctant to put their pet theories to such a test.

In a paper on self-deception in science, Michael J. Mahoney of the University of California at Santa Barbara described the results of a field trial in which a group of 30 Ph.D. scientists were given 10 minutes to find the rule used to construct a sequence of three numbers, 2,4,6, by making up new sequences, inquiring whether they obeyed the same rule, and then announcing (or "publishing") what they concluded the rule to be when they felt sufficiently confident.

The results obtained by the scientists were compared to those achieved by a control group of 15 Protestant ministers. Analysis showed that the ministers conducted two to three times more experiments for every hypothesis that they put forward, were more than three times slower in "publishing" their first hypothesis, and were only about half as likely as the scientists to return to a hypothesis that had already been disconfirmed.

Mahoney added, however, that both groups rarely generated experiments that were deliberately intended to try to falsify rather than to confirm their hypotheses (the correct answer had been the rule: list any three integers in ascending order).

"In the everyday practice of science, of course, corroboration and disconfirmation are often combined," he told the AAAS meeting. "But it is somewhat disconcerting that the logically more powerful and informative process of falsification remains relatively less appreciated and practised by many scientists."

In another experiment designed to study how the conclusions of a scientific paper affected the way that the paper was evaluated by journal referees, five different versions of an article reporting results of an experiment involving the psychological behavior of children were submitted to 75 referees.

Analysis of the referees' reports showed that those versions of the paper in which the results were written up in a way that appeared to confirm traditional views in orthodox behaviorism received a considerably more positive reaction from referees than those which appeared to undercut these views.

"With identical experimental procedures, for example, a manuscript reporting positive results was rated as methodologically superior to one reporting negative results," said Mahoney. These manuscripts were also significantly more likely to receive a recommendation that they should be published

He admitted that his investigations of the factors influencing referees decisions had not been unanimously welcomed. Almost one quarter of those who had been used in the study—without being informed of the fact—subsequently expressed disapproval of the way they had been deceived into participating, and three tried to have him fired or reprimanded by the American Psychological Association.

In a subsequent experiment, in which referees were this time informed of the nature of the study, a variation in the institutional affiliation listed for authors did not appear to affect the evaluation of the scientific content of a paper. However, Mahoney said that the greater the number of self-citations—for example, to other papers listed as being "in press"—the greater the chance that the paper would be recommended for publication.

Such experimental data, said Mahoney, suggested that the content and quality of scientific knowledge was consistently constrained by cognitive, emotional, and behavioral processes. ■ DAVID DICKSON

MIT President Attacks Federal Research Priorities

The relationship between research universities and the government is once again cooling, according to Paul Gray, president of the Massachusetts Institute of Technology. After a brief recovery from the turbulent and divisive period of the late 1960's and early 1970's, he told the AAAS meeting in a plenary lecture, "there are signs all around that we—the universities and the federal government—may be in danger of drifting further apart."

One reason, he said, is a "sea change" or sharp reduction "in the number of federally-supported fellowships, traineeships, and research assistantships for graduate students in the sciences since 1969." Another is an imbalance in the proportion of the federal budget devoted to military, rather than civilian, research, which now approaches 75%. This is "cause for concern," Gray said, because it "may draw talented people, including students and faculty, away from other promising lines of inquiry." Federal policymakers need "to keep in mind that many of the benefits of university research have arisen from the opportunity for faculty to address a wide variety of fundamental questions in science and technology," he added.

Calvin Campbell

Paul Gray. *The universities and the federal government may be drifting apart.*

University-government relations have also suffered because of a sharp decline in "real" or inflation-adjusted funds for university research facilities since the mid-1960's,