In the Wake of Tokaimura, Japan Rethinks Its Nuclear Future

The Japanese government remains committed to nuclear power, but safety concerns linger.

A fresh concrete wall now hides from view the building where Japan's worst nuclear accident occurred, on 30 September, at a uranium processing plant in Tokaimura (see story on page 52). At press time, a government-appointed task force was still assessing what had happened. Meanwhile, local police were conducting a criminal investigation, plant operator JCO Co was stripped of its business license, and several civil suits had been filed by companies who claimed their profits had suffered due to the accident. Antinuclear activists seized on the accident to condemn the government's commitment to nuclear energy. In a statement issued a day after the accident, the Citizens' Nuclear Information Center demanded that the government "openly lay out the dangers and problems of nuclear energy utilization and . . . scrutinize the propriety of current nuclear energy policies."

Indeed, the events of 30 September have placed Japan's entire nuclear enterprise under scrutiny. Whereas past accidents, such as a 1995 fire at a fast-breeder reactor, aroused suspicions, they were not generally perceived as immediate threats to public safety. The criticality accident at Tokaimura, which sent dozens of emergency workers and nearby residents to the hospital and forced hundreds of thousands of others to remain indoors for 24 hours, was clearly different. Although the Japanese government initially portrayed the accident as an anomaly resulting from JCO's negligence, it has since taken steps to address more systemic safety problems. A Labor Ministry inspection prompted by the accident found health and safety violations at 15 of the 17 nuclear facilities visited; at several sites, workers were not being routinely checked for radiation exposure. On 22 October, the government announced that it would be submitting two bills to the Diet, one to create a new law aimed at improving the response to serious nuclear accidents, the other to require nuclear fuel processing facilities to undergo the same kind of regular inspections now done at nuclear power plants and also to train employees on nuclear safety.

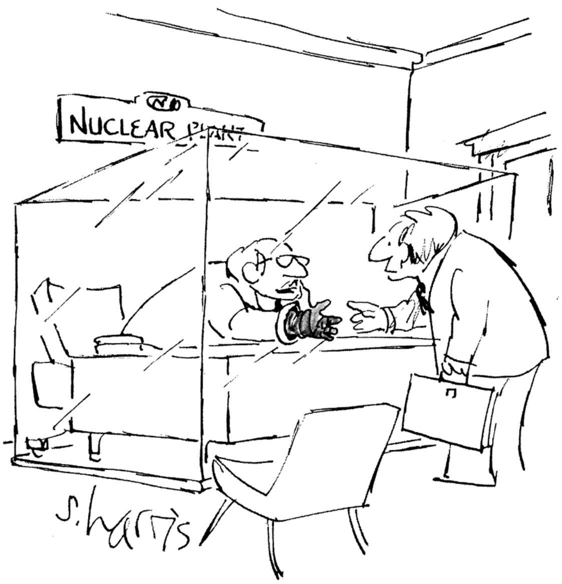
Committed to nuclear

Despite the gross mistakes that appear to have led to the criticality accident, official support for nuclear energy in Japan seems to be unshaken, at least for now. Since the oil crises of the early 1970s, the goal of Japan's energy policy has been to decrease the country's reliance on foreign fuel imports. With few natural resources of its own, Japan has embraced nuclear energy. It currently derives about one-third of its electricity from nuclear power, and it invests heavily in nuclear energy–related R&D and new reactors. According to *International Energy Outlook 1999*, a report issued by the US Department of Energy's Energy Information Administration, Japan, in contrast to nearly every other industrialized country, is projected to boost its nuclear capacity, by 22% in the next 20 years. "Even through their recent economic troubles and some previous accidents [at nuclear facilities], they've continued to construct new reactors," notes John Moens, a nuclear industry expert at the EIA. "That shows a commitment. Whether or not they're pursuing it with a happy heart, it's hard to say." However, Moens adds, even the Japanese utilities are now less optimistic in their outlook for nuclear, and their plan to build 16 to 20 new reactors by the end of the year 2010 seems unrealistic.

As part of its goal of energy self-sufficiency, Japan has maintained a policy of reprocessing its spent nuclear fuel, rather than treating it as waste, as the US does. Though the Japanese government once hoped to reprocess all of its nuclear fuel domestically, such a plan is unlikely to happen any time soon. Construction of a ¥2.14 trillion ($19 billion) reprocessing plant in the northern village of Rokkasho has experienced significant delays and cost overruns. Japan is now looking into setting up an interim storage site for nuclear waste in Russia.

Even before the accident on 30 September, international concern had been mounting over Japan's shipments of radioactive waste and fuel from overseas reprocessors (see PHYSICS TODAY, January 1997, page 56). The bulk of the plutonium being extracted from the spent fuel is to be used for mixed oxide (MOX) fuel in commercial light-water reactors, a move that has also proved controversial. Licensing plants to burn MOX fuel had been going "incredibly slowly" before Tokaimura, says David Albright, head of the Washington, DC–based Institute for Science and International Security (ISIS), and can be expected to slow down even more.

Some of the recovered plutonium has also been earmarked for Japan's fast-breeder reactor program, but that has been



"I'M FINE. THERE'S JUST A CHANCE I WAS EXPOSED TO SOMETHING."

largely dormant since 1995, when a massive leak of sodium coolant caught fire at Monju, a prototype breeder reactor. In a report issued exactly two years before the Tokaimura accident, Japan's Atomic Energy Commission noted that "it is premature to make a decision about when Japan can put the fast-breeder reactor into practical use." The report blamed Monju's operators, the state-owned Power Reactor and Nuclear Fuel Development Corp (PNC) for causing "a loss of public faith," through its mismanagement of the accident and its attempts to cover up the incident with doctored videos and incomplete reports. PNC was also criticized for its mishandling of a 1997 fire at its reprocessing plant in Tokaimura; the reopening of that facility has been put on indefinite hold. (Last year, PNC was reorganized and reborn as JNC, the Japan Nuclear Cycle Development Institute. It was a fuel order for JNC's Joyo experimental breeder reactor that the workers at Tokaimura were rushing to complete when the criticality accident occurred.)

And so, with no immediate demand for reprocessed fuel, Japan is quickly amassing a plutonium surplus. According to ISIS estimates, at the end of 1998, Japan had 29 tons of separated plutonium, of which 24.4 tons were still stockpiled in Europe awaiting return shipment. "To Japan's credit, they have said they want to reduce the amount of separated plutonium to zero," Albright notes. "So they at least agree that separated plutonium is not desirable. And I would say it's dangerous."

No more like Tokaimura

Clearly, Japan can ill afford to have another accident on the scale of Tokaimura. During the last decade, growing antinuclear sentiment has significantly slowed down the expansion of the country's nuclear power industry. A *Mainichi Daily News* poll conducted just days after the accident showed that 70% of the Japanese public opposed nuclear power. Responding to such fears, the Ministry of International Trade and Industry recently began holding seminars around the country, to try to shore up support for nuclear power. "We need to increase public understanding of nuclear energy, as it is the government's firm position to continue using nuclear power as a principal source of energy," a MITI official told reporters in announcing the promotion campaign.

Public opinion will likely play an increasing role in determining Japan's nuclear future. Already, in the last few years, nuclear critics have had some success in democratizing the planning process. Prefectural governments are now putting nuclear energy questions to voters in local referendums. In one such vote, held in 1996 in the town of Maki, 61% voted against selling public land for a new nuclear reactor; construction has since been suspended. In June, Japan's Atomic Energy Commission began a review of the nation's "long-term program for research, development, and utilization of nuclear energy," something it does every five years or so. The 32-member committee appointed to carry out the review includes, for the first time, two people critical of nuclear development. Their report is expected by the end of next year.

JEAN KUMAGAI

What Happened at Tokaimura?

Analysts are trying to figure out how workers ended up putting enough uranium in one tank to initiate a chain reaction.

On 30 September, as workers at a Japanese nuclear fuel processing plant in Tokaimura were adding enriched uranium to a precipitation tank, they saw a blue flash—signaling the onset of a nuclear chain reaction. Exactly how did this accident occur? It will be some time before we get an official report and learn about the accident's impact on Japan's nuclear power program. (See previous story.) However, as PHYSICS TODAY goes to press, independent analysts have already gleaned enough information from preliminary accounts such as those posted on the Web by Japan's Science and Technology Agency (STA), which licenses nuclear facilities,[1] to piece together a picture of how a solution containing enriched uranium became critical, what power levels were reached, and what releases of radiation ensued.

Cautions not heeded

The plant where the accident occurred is operated by JCO Co Ltd. Its main function is to convert uranium hexafluoride into uranium dioxide fuel for some of Japan's commercial nuclear power plants. This uranium has been enriched to contain up to 5% of the fissile isotope, U-235. In addition, the JCO plant occasionally purifies uranium to be made into fuel for an experimental breeder reactor known as Joyo, which requires fuel enriched to 18.8% ^{235}U. For these higher levels of enrichment, one has to be far more careful because of the higher probability of accumulating a critical mass—that is, amassing so much ^{235}U that at least one neutron from each fission, on average, stimulates another fission.

STA regulations place a mass limit of 2.4 kg on the amount of 18.8% enriched uranium that can be processed at one time at the JCO plant. Nevertheless, the workers there added a total of about 16 kg to the tank, causing a self-sustaining chain reaction.

The purification procedure licensed by STA for the Joyo fuel is shown by the blue lines in the figure on page 53. The workers feed uranium oxide (U_3O_8) in powder form into a dissolving tank, where it is mixed with nitric acid to produce uranyl nitrate, or $UO_2(NO_3)_2$, which is then transferred to a buffer tank. From there, it is sent into the precipitation tank, where ammonia is added to form a solid product (with contaminants remaining in solution). Uranium oxide is extracted from that solid, and the process is repeated until the oxide becomes sufficiently pure. At that point, the uranyl nitrate in the buffer tank gets shipped to another facility, where uranium dioxide is prepared and made into Joyo fuel.

On the day of the criticality accident, workers were running fuel through the last steps of this process, according to Thomas McLaughlin of Los Alamos National Laboratory, one of three nuclear experts sent by the US Department of Energy to learn about the accident. The JCO plant only needed to mix some high-purity enriched uranium oxide (U_3O_8) with nitric acid to form uranyl nitrate for shipping. During this operation, the workers deviated from the licensed procedure in three basic ways. First, to speed up the process, they mixed the oxide and nitric acid in 10-liter buckets rather than in the dissolving tank (in doing so, they followed the practice that JCO had written into its manual—without STA approval). Second, for convenience, they added the bucket contents to the precipitation tank rather than to the buffer tank.