Bomb-Free Nuclear Fuels for Research

Iraq's research reactor, like many others, was fueled with weapons-grade uranium; the search is on for something safer

Israel's recent destruction of an Iraqi nuclear research reactor, on the grounds that it allegedly was intended to generate material for an atomic bomb, underscores the efforts to devise a more proliferation-resistant fuel for such facilities.

The United States began exporting research reactors and nuclear fuel in the mid-1950's under the Eisenhower Administration's Atoms for Peace program. Today, the devices are also available from the Soviet Union, Germany, and France, the latter being the supplier of the Iraqi reactor. The great majority, including the Iraqi reactor, are of the swimming pool type, in which the core of nuclear fuel is immersed in an open tank of water. Most use the so-called MTR-type fuel, which has uranium arrayed in thin plates. None of them produce electricity; what researchers want are neutrons for scattering experiments, studies of the biological effects of radiation, and even the generation of mutants for new plant hybrids. Certain high-powered reactors, often called test reactors, are used to test new materials and fuel elements in a high-neutron environment and to train operators for power reactors.

Many research reactors use fuel with a uranium-235 content of less than 20 percent, the minimum concentration needed to make a nuclear weapon. (Power reactors in the United States use fuel with a concentration of 3 percent.) However, worldwide there are 153 research and test reactors that require more enriched uranium (152 after the Israeli raid). Most need fuel enriched to 93 percent. Such fuel would make excellent bombs.

Armando Travelli of Argonne National Laboratory is manager of a Department of Energy program to develop a less enriched fuel that would still allow high-performance reactors to achieve their research goals. The program was begun in 1977 as part of the Carter Administration's effort to curb the potential for nuclear proliferation. "The worry was not so much what the owner of the reactor might do with the fuel," says Travelli, "but what might happen to the fuel in shipment"—that is, theft of the fuel by terrorists or agents of another nation. "We've had excellent cooperation with all the countries we've approached about this," he adds.

The ideal, says Travelli, is a new fuel that looks just like the old: plates 1.27 millimeters thick and 8 by 60 centimeters in area, with about 20 plates stacked to form a single fuel element. The new plates would cost about as much as the old, would fit into the standard fuel assemblies, and could be placed in the reactors by normal procedures. And, using uranium at a much lower enrichment, they would produce as many neutrons as the highly enriched fuel. This would be accomplished by keeping the total number of uranium-235 atoms in the fuel element constant while packing in a great deal more uranium-238. Most current fuels contain 0.8 gram of uranium per cubic centimeter, says Travelli. The DOE's goal is to increase that to 7 grams per cubic centimeter. At that point, essentially every reactor would have the option of going to less than 20 percent enrichment. (A few very high-performance reactors in the United States and France might still need up to 45 percent.)

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With some financial help from DOE, General Atomic, the largest exporter of research reactors and fuel in the world and the only firm to export from the United States, has developed a new fuel for its TRIGA reactors that will convert most 70 percent and 93 percent enriched fuel to just shy of 20 percent.

General Atomic's new fuel does achieve 3.7 grams of uranium per cubic centimeter. However, Travelli points out that the fuel is in the form of pins—thin rods—rather than the standard plates. Using it means refitting the reactor. Moreover, the different geometry of the core alters the operating characteristics of the reactor, and many potential users are worried about that.

Travelli is confident, however, that new fuels with the conventional plate configuration will be available within the next few years. In current fuels, uranium is alloyed with aluminum to keep it from deforming in the neutron flux of the core and to help trap radioactive gases produced in fission. But the metallurgy of the alloy limits uranium concentration to about 0.8 gram per cubic centimeter.

The new approach, says Travelli, is to mix powdered aluminum with a powdered compound of uranium. With uranium aluminide as the compound, the DOE researchers have achieved 2.3 grams of uranium per cubic centimeter; with uranium oxide, 3.2 grams; and with uranium silicide, the magic 7 grams. Sample plates of all three types are scheduled to come out of the Oak Ridge reactor next month after 1 year of irradiation tests. Testing with full-sized fuel elements will be next.

A new French fuel, "Caramel," has been much in the news since the Israeli bombing. Iraq's refusal to accept the supposedly proliferation-resistant Caramel instead of highly enriched uranium has been held up as a damning indication of that nation's intentions.

With a high specific weight of uranium, 10.3 grams per cubic centimeter, Caramel needs enrichments of only 3 to 10 percent. The fuel is in the form of plates, with small squares of uranium dioxide arrayed like windowpanes. The squares are about the size of caramel candies, thus the name. Caramel comes close to Travelli's ideal; however, it requires quite a bit of manual effort to fabricate and thus is expensive. It has been tested in France's OSIRIS reactor, but has never been used elsewhere.

It must be said that these new fuels will address proliferation problems only at the front end of the fuel cycle, by eliminating the transport of highly enriched, weapons-grade uranium. By design, reactors using these new fuels will produce just as many neutrons as before; a nation wishing to develop nuclear weapons could still place a blanket of nonfissile uranium-238 around the core, where it would absorb those neutrons and become fissile plutonium-239. (Such activity would be very difficult to hide in a swimming pool reactor, however.) The key problem of proliferation continues to be not technical, but political: the creation of a reliable, trusted, and internationally accepted system of inspection and control.—M. MITCHELL WALDROP

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