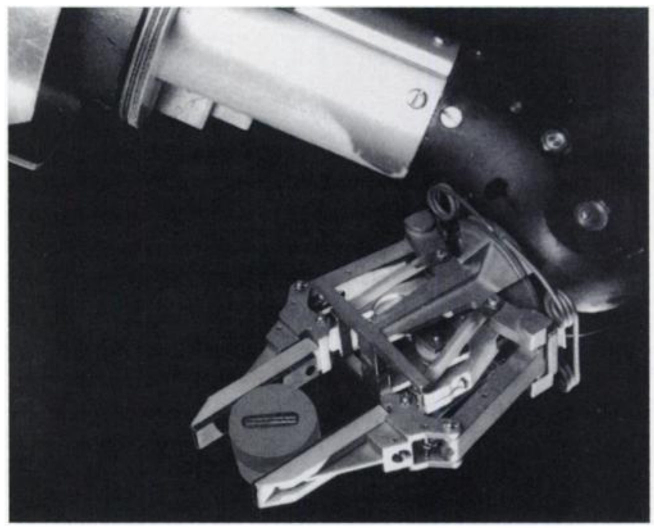
Ban on Enriched Uranium Exports Intended Against Bomb Builders also Affects Radiopharmaceutical Makers

Firms question whether the added burden to their industry is justified by the minuscule reduction in HEU already circulating. Preventing proliferation takes precedence over "small economic concerns," a congressional aide responds.



Researchers at Argonne National Laboratory are developing isotope production targets and fuels that don't require weapons-grade enriched uranium-235. The irradiated sample assembly shown here is mounted in plastic for examination under high magnification.
Photo: Argonne National Laboratory

ARMS CONTROL ADVOcates celebrated the passage of the Energy Policy Act of 1992 because it included a long-sought amendment intended to phase-out the industrial use of weapons-grade uranium. The law restricts the export of highly enriched ^{235}U, or HEU, for use as a target or fuel in a nuclear reactor and promotes the development of replacement fuels and targets that use enrichments of less than 20%.

The arms control measure carries a price that is troubling to producers of molybdenum-99 for nuclear medicine. The industry currently requires targets made of 90% enriched HEU available exclusively from the U.S. When irradiated in a reactor, the targets undergo fission to ^{99}Mo, xenon-133, and iodine-131, among other elements. While scientists say processes using low-enriched uranium, or LEU, are technically within their grasp, conversion would no doubt increase the cost of radioisotope production and ultimately the price of technetium-99m generators.

Just how much it would cost is a matter of heated debate. Radiopharmaceutical makers question whether the added burden to their industry is justified by the intended reduction in HEU circulating in world markets. Proponents of nonproliferation, such as Rep. Charles E. Schumer of New York who sponsored the HEU export restriction amendment, consider the costs negligible in comparison to the benefits to be gained in limiting the availability of HEU.

"Nonproliferation concerns take precedence over small economic concerns," says Alan Kuperman, legislative director for Rep. Schumer. "No one is interested in cutting off production [of molybdenum-99], but the U.S. is not going to continue to take the risk of terrorism." Arms control experts say that as little as 15-25 kg of HEU would be sufficient to build an implosion-type nuclear bomb.

Gulf War Fallout

Saddam Hussein and the shocking progress of the Iraqi atom bomb project cleared the way for the passage of the Schumer amendment. Proponents argued that an adequate stockpile of HEU is nearly all that stood in the way of an Iraqi bomb. Hundreds of reports and dozens of arrests of radioisotope smugglers from Eastern Europe have also heightened concerns about nuclear proliferation. Since many of the world's test reactors have plans to change over to LEU fuel, talk of converting targets for isotope production has become more earnest.

"We're assuming that conversion may be necessary if the U.S. says this is something we have to do, though the costs to our customers will be considerable," says Iain C. Trevena, PhD, vice-president of isotope production at Canada's Nordion Intl. "The question is, what is the benefit, given that there is a lot of HEU around anyway and the amounts of material we're talking about–grams of material [for isotope targets] versus kilograms for fuel–does it make sense? If the U.S. says yes then the industry is going to have to pick up the tab."

A large producer like Nordion may use over 20 kg of HEU per year, not counting fuel. Production facilities typically keep 5 kg or less of HEU on hand at any given time, thus avoiding the risk of a single theft of enough material to build a bomb.

Nordion, with its partner the government-owned Atomic Energy of Canada, Ltd., is the world's largest producer of ^{99}Mo and the sole source for North America. The company has already committed to begin using LEU fuel.

U.S. exports of HEU for the time being will continue to AECL/Nordion and other companies abroad. The Nuclear Regulatory Commission issued a three-year export license to AECL in 1992 for shipments of 93.35% enriched HEU for isotope production at Chalk River totaling 73.164 kg. The license allows up to 22.100 kg to be shipped in 1992, 24.321 kg in 1993, and 26.733 kg in 1993.

These and other HEU exports are allowed under the amendment, but only if LEU targets are not available. Congress also made exports contingent on continued U.S. government support for "actively developing" alternative LEU targets and fuel for reactors. Thus the measure restores funding to the Reduced Enrichment Research and Test Reactor (RERTR) Program at Argonne National Laboratory, which had languished under the Bush Administration.

RERTR Program

Efforts to eliminate HEU exports began during the Carter Administration. Fearing the diversion of HEU in reactor fuel to governments or terrorists seeking to join the nuclear club, President Carter launched the RERTR program in 1978. The mission of the $5 million a year program was to develop advanced LEU fuels to make weapons-grade material obsolete. The Nuclear Regulatory Commission mandated conversion of NRC-licensed reactors in 1986.

Work on LEU targets for isotope production began about the same time, but, being a secondary concern to reactor fuel, proceeded on limited funding until the money evaporated altogether in 1992. The Schumer amendment is expected to result in about $250,000 for targetry work. The appropriation for the entire RERTR program now totals $1.2 million.

Scientists in the RERTR program are convinced that workable LEU targets are possible. Their biggest challenge is to maximize product yields. Using 20% enriched targets rather than 90% enriched requires about a five or six-fold increase in total uranium content to achieve equivalent yields of ^{99}Mo. That means researchers have to figure out how to pack about six times more uranium into each LEU target to make up for the loss in enrichment.

Although designs vary, a typical HEU target is a hallow can coated inside with uranium oxide. Since increasing the density of such films is nearly impossible, researchers have experimented with different coatings like uranium metal foil and uranium silicide.

Processing the new targets presents another set of problems. After irradiation, HEU targets are washed with an acid solution that dissolves the uranium oxide coating and the fission products including ^{99}Mo, which is chemically separated out of the solution. Ideally, LEU targets should be made as compatible as possible with whatever process each producer is using for HEU targets.

These technical obstacles may have to be overcome more than once, since each of the producers of ^{99}Mo uses a unique process, says Armando Travelli, PhD, manager of the arms control and nonproliferation program at Argonne. He says the RERTR program is willing to work with the companies like IRE in Belgium, and AECL/Nordion in Canada to help them each develop targets that will work with their proprietary manufacturing methods. "Our goal is not to develop the details, but to allow the fabricators to tailor the research to retain their competitive advantage," Dr. Travelli says.

Increased waste production is another burden that comes with conversion. Processing more uranium for the same yield of ^{99}Mo means handling more radioactive by-products: three to six times the volume of dissolver solution, six times more fission product salts, and up to 30% more waste to dispose of at the end of all processing steps.

Getting the Food and Drug Administration to approve any alternative process will further add to the expense. Nordion's Dr. Trevena says that demonstrating the ability to meet FDA's product purity standards is a "nontrivial exercise." The plutonium content of an LEU target is about 26 times the amount in an HEU target, making purification more challenging.

"I don't know if there will ever be a suitable LEU target," says James McGovern of Cintichem Corp., a New York company that used to produce ^{99}Mo for Medi-Physics, Inc. While still in the business, Cintichem decided that if HEU became unavailable the company could no longer make a profit producing moly.

Is Conversion Feasible?

What conversion to LEU would ultimately cost remains unclear, since no one in the industry has released a complete and accurate analysis.

"We have been saying for many years that it is clearly feasible but not many people would agree," says Dr. Travelli. He dismisses as "a little like a charade" suggestions that the costs might be extreme.

"I don't believe the costs will be as large as companies have mentioned."

To back up his impression he recounts an episode at an international meeting where a group from Argentina expressed eagerness to start making ^{99}Mo. The big producers, he says, tried to explain to the newcomers that the business was just not profitable and that they were in it largely to fulfill an obligation to medical needs. "The Argentineans were not buying it at all," Dr. Travelli says. Argentina and other countries such as Peru and Indonesia remain extremely interested in ^{99}Mo production. Not to mention the U.S. Department of Energy, which has sunk most of the resources of its self-supporting isotope program into producing the material.

"The market numbers are very secret," Dr. Travelli says. "Profit margins I don't think are as narrow as [companies] say but it's true that it is a cut-throat business." According to the Internation-

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Uranium

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al Atomic Energy Association, a country with demand for 130 Ci or more per week could break even producing its own supply. As more ^{99m}Tc radiopharmaceuticals are developed, demand will only increase.

Advocates of Conversion

Meeting the medical needs of developing countries is one reason the IAEA has supported research on conversion to LEU targets. Nations with growing demand for radiopharmaceuticals but unlikely to secure shipments of HEU would still be able to produce ^{99}Mo domestically if investigators were to come up with alternative designs using LEU. But efforts to equip developing countries for production don't strictly depend on whether industrialized nations convert to LEU targets.

Arms control advocates insist that the threat of proliferation is reason enough to ban exports of HEU and say the sheer volume of the material around the world provides ample support for their cause. Over the years the U.S. has shipped about 24,000 kg of HEU to over 43 countries, primarily in fuel assemblies for research reactors. The 90% enriched fuel remains 40-60% enriched after burning. Most of this spent fuel remains in storage at reactor sites, awaiting shipment to the U.S. in exchange for credits with the Energy Department for more HEU. Only about 6,000 kg have been returned to the U.S. for reprocessing, according to Bas Bruyn, an arms control analyst and consultant to International Physicians for the Prevention of Nuclear War.

"HEU is a real proliferation concern," says Mr. Bruyn, who believes conversion to LEU targets is necessary "even if it costs a little bit more" to produce radiopharmaceuticals. "The costs of preventing proliferation of nuclear weapons grade materials are also very high," he says.

Slow Process Expected

Despite what appears to be mounting political pressure, the conversion to LEU targets may drag on for years. Prodding the major test reactors to switch to LEU fuels remains a much more pressing goal of the nonproliferation campaign. All eyes are on major facilities like the HFR Reactor at the Petten Establishment in the Netherlands that have yet to convert to LEU fuel, even though trial fuel assemblies are ready and waiting.

If and when viable target alternatives are available, the Schumer amendment allows production facilities to get around the export ban if they can show that conversion to LEU would bring a "large percentage increase" in the total cost of operating the reactor. That won't be an easy task for reactor operators, however, and "the burden of proof is on them," says Mr. Kuperman of Rep. Schumer's staff.

The situation is further complicated by the entry of the Energy Department into the ^{99}Mo market. The department's isotope production program is unlikely to use LEU targets since they recently bought the rights to HEU target designs used by Cintichem, Inc. a Medi-Physics subsidiary that used to produce isotopes. Furthermore, the Schumer amendment applies no pressure on the DOE to switch to LEU. "Internal use is not a problem, it's not the focus of the legislation," says Mr. Kuperman. Given this scenario, corporations outside the U.S. are likely to resist converting, citing the "bad" example of the Energy Department and its unfair competitive advantage.

Still, arms control officials believe that conversion to LEU targets and fuel is inevitable. "I think so," says Dr. Travelli of Argonne. The only real threat to that outcome he foresees is the expansion of another source of HEU, perhaps one of the cash-starved states of the former Soviet Union. The U.S. has an agreement with the Russian Federation to buy up weapons-grade uranium from the former Soviet Union and convert it into fuel for American nuclear power plants, but estimates of how much of the material the Soviet government had stockpiled and where it is now remain uncertain. China and France are also capable of enriching uranium (France and Russia even supplied 12.3 kg of 93% enriched ^{235}U and 10 kg of 80% enriched ^{235}U to Iraq before the Gulf War). For the Schumer amendment to work as intended, the U.S. would have to convince these foreign governments to clamp down on the distribution of HEU.

J. Rojas-Burke

Lines from the President

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needed "below regulatory concern" policy, or BRC, went down in flames when it encountered outraged and fearful environmental activists, consumer groups, and legislators illustrates the profound lack of understanding of risk magnitudes. Whether one is for or against nuclear power utilities, which stand to benefit substantially from BRC, medicine and research desperately need the logical definition of levels of radioactivity that are BRC. We in medicine should take advantage of the opportunity to assist the NRC as the "good guys" in trying to reduce the costs of health care and regulatory burdens in biomedical research.

Finding the appropriate regulatory balance between cost-effective, acceptable risk constraints and overburdensome, stifling restrictions is never easy or given to unanimous agreement. But the lack of a comprehensive and consistent program for all ionizing radiation satisfies no one, and is at the core of the NRC's and radiation medicine's current dilemma.

Paul H. Murphy, PhD
President