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MEDICAL ISOTOPE PRODUCTION

Conversion from HEU to LEU based production and alternative methods

Since 1992 the US restricted its high-enriched uranium (HEU) exports to encourage other countries to convert civilian facilities to low-enriched uranium (LEU), which can't be used directly to make nuclear weapons. Instead in mid 2005 Congress passed the Energy Policy Act of 2005, which includes provisions relaxing restrictions on HEU exports for medical isotope production. The primary beneficiaries of the new law are producers of medical radioisotopes.

Last January the US Committee on Medical Isotope Production without Highly Enriched Uranium published a study that was motivated by this conflict between the non-proliferation objectives and the assurance of the supply of medical isotopes. The report is the product of a congressionally mandated study to examine the feasibility of eliminating the use of HEU in reactor fuel, reactor targets, and medical isotope production facilities. The report focuses on the use of HEU for the production of the medical isotope molybdenum-99 (Mo-99), whose decay product, technetium-99m (Tc-99m), is used in the majority of medical diagnostic imaging procedures, and on the use of HEU for research and test reactor fuel. Unfortunately the committee doesn't seriously discuss the use of techniques without the use of reactors and HEU or LEU targets for the production of medical isotopes. Interestingly, Canada - the world largest producer of Mo-99 - is considering this option.

Research and Test Reactors

Increasing concerns about the proliferation of HEU prompted the formation of the Reduced Enrichment for Research and Test Reactors (RERTR) program by the Department of Energy (DOE) in 1978. Over the 26-year initial period of the RERTR Program, only 38 U.S.-designed research and test reactors were converted from HEU fuel to LEU fuel, and not a single Russian-designed reactor was converted. During the same period, more than 200 research reactors, the majority fueled with HEU, permanently shut down because of obsolescence, problems with aging materials and facilities. Of the new reactors commissioned during this period only one of significant power, FRM II in Munich, Germany, as well as a few Chinese Miniature Neutron Source Reactors were started up with HEU.

Presently, DOE's HEU elimination efforts are being carried out under the Global Threat Reduction Initiative (GTRI). This initiative is focused on the minimization of HEU in civilian research and test reactor fuels and targets. Research and test reactors that have defense-related missions and naval reactors used to power surface vessels and submarines are out of the scope of this program. The committee reports that DOE National Nuclear Security Administration (DOE-NNSA), in collaboration with several other organizations, has made substantial progress in converting reactor fuels and targets to LEU through GTRI. It recommends that the GTRI Program be continued until research and test reactors worldwide have converted their fuel and targets to LEU or have been permanently shut down and their HEU fuel has been returned to the country from which it originated.

Nuclear research and test reactors have been in operation for more than 60 years. They underpin the development of power and propulsion reactors and are used for research in amongst others the fields of nuclear physics and engineering, nuclear chemistry, materials science, and biology.

Currently they have been widely considered as indispensable for the production of medical isotopes to supply a rapidly increasing demand for diagnostic and therapeutic procedures based on nuclear medicine techniques. According to the committee more than 700 research reactors are known to have been commissioned worldwide, and 240 of these are currently in operation in 55 countries. Another 9 reactors are in various stages of construction and several more are planned. Since 1975 significantly more research and test reactors have shut down each year than have started up. Of the 240 operating research reactors, 203 are or were fuelled with HEU, almost all of them supplied with HEU originated from the US or Russia. GTRI has a strategic plan to convert 125 of these reactors - still planned to be operating by 2018 - and thereby minimize the commerce in HEU for research reactors.

As of December 2008, the status of the conversion program is as follows: 58 reactors have been fully or partially converted and four reactors were shut down before conversion. Between 1978 and 2004 38 of these conversions took place and 20 conversions (including those of two Chinese reactors) took place between 2004 and present, representing an acceleration over the pre-GTRI conversion rates. 40 reactors are estimated to be able to convert using existing qualified LEU fuels; and 27 reactors are planned for conversion with advanced LEU fuels that still need to be developed and qualified. A new high-density fuel is under development that would allow the conversion of at least 19 of these reactors.

IPPNW campaign to convert Radiopharmaceutical Production to LEU

As part of their International Campaign To Abolish Nuclear Weapons (ICAN) the International Physicians for the Prevention of Nuclear War (IPPNW) is campaigning to convert Radiopharmaceutical Production from HEU to LEU. Together with mayors, civil society groups, NGOs, churches and citizens, ICAN demand an end to nuclear weapons through a Nuclear Weapons Convention (NWC) which will make nuclear weapons illegal, banning their development, possession, use and threat of use. ICAN's priorities are the elimination of nuclear weapons in the same way comparable treaties have banned landmines and chemical and biological weapons; the immediate stop of upgrading, modernizing, and testing of new nuclear weapons; and to reduce the likelihood of nuclear weapons use.

"While it may seem like a small matter compared with the task of eliminating some 25,000 nuclear weapons from the world's arsenals," IPPNW states "the medical profession has a proliferation problem in its own backyard." As health care professionals they exert themselves to hasten the phase-out of medical commerce in HEU and so terminate one of the most vulnerable pathways to the much-feared "terrorist bomb", since there are no obstacles to convert to LEU sources for these radiopharmaceuticals. Among other things IPPNW urge the governments of Belgium, Canada, France, the Netherlands and South Africa, and Euratom, to require isotope production reactors within their jurisdiction, utilising HEU fuel or targets, to promptly be converted to LEU fuel and targets. They urge the governments that supply HEU to institute compelling incentives - preferably coordinated - for radiopharmaceutical producers to convert to LEU in the near future.

More information on the IPPNW-campaign at:
http://www.ippnw.org/Programs/ICAN/HEU.htm

Molybdenum-99 production

Most of the world's production of Mo-99 is carried out by irradiating HEU targets in research and test reactors that are fueled with LEU. With one exception, the US is currently the world's primary supplier of HEU for Mo-99 production, either directly through DOE or indirectly through the Euratom Supply Agency (ESA). The US origin HEU that is used for Mo-99 production has an enrichment of about 93% U-235 and

was originally produced for use in nuclear weapons. The exception is South Africa, which uses its own HEU (45% U-235) to produce Mo-99 in a reactor that is also fueled with HEU but is in the process of being converted to LEU. ESA does not publicly disclose the sources of HEU used for the manufacture of targets for medical isotope production. Most of this HEU is probably of US origin, but some may also be of UK origin.

Almost all of the Mo-99 used worldwide is produced by just four companies, all using HEU targets: MDS-Nordion (Ottawa, Canada), Mallinckrodt (Petten, The Netherlands), IRE (Fleurus, Belgium) and NTP Radioisotopes (Pelindaba, South Africa).
With the exception of the Belgian (BR2 in Mol) and the South African (SAFARI-1 in Pelindaba) reactors all of these producers use LEU-fueled reactors. According to the compilers of the report approximately 40-50 kg of US HEU are used annually for medical isotope production, including annual US exports of about 15.5 kg of HEU to Canada. The major part of this amount is used by the large scale producers named above (except NTP in South Africa). Supposing the worldwide Mo-99 production market shares of MDS Nordion (40%), Mallinckrodt (25%) and IRE (20%) are directly related to the consumption of HEU the annual US exports of HEU to the Netherlands and Belgium amount to minimally 8.9 and 7.8 kg respectively. Moreover the committee mentions that approximately 97% of the uranium originally present in the targets ends up in the process waste. Consequently, the accumulating waste from Mo-99 production contains substantial quantities of HEU. Worldwide, tens of kilograms of this HEU waste are accumulating annually from Mo-99 production. The Ottawa Citizen mentions an amount of 100 kg HEU in Chalk River (Ontario, Canada). Meaning sufficient HEU in Canada, the Nederlands and Belgium to make one or more nuclear bombs.

Probably the most important findings of the committee are: “There are no technical barriers to conversion of Mo-99 production from HEU targets to LEU targets.” [...] Production using LEU targets is technically feasible and in fact is being carried out by CNEA in Argentina and will be shortly by the Australian National Nuclear Science and Technology Organisation (ANSTO) using CNEA technology. The committee sees no technical barriers to scaling up production for large-scale production.” [...] “To the committee’s knowledge, none of the major producers are doing much actual development work on LEU targets and process [..]”. [...] Based on the information presented to it by producers, the committee did not see
any evidence that such R&D was being carried out.” Last but not least: “The committee judges that conversion within existing facilities could be carried out in as little as little as a few months to two years.”

Alternative techniques without use of a reactor
Though it has been a little step forward to use LEU instead of HEU, the committee didn’t seriously discuss the safest, cheapest and most reliable methods for the production of Mo-99. Recently a research scientist at Canada’s national particle and nuclear physics laboratory is calling on the federal government to look into ways of delivering radioactive medical isotopes without the need for nuclear reactors. According to Thomas Ruth the current system of delivering medical isotopes does not meet the demands of hospitals. Reactor closures at the isotope production facilities in Canada and the Netherlands led and leads to shortages in the worldwide supply of medical isotopes, drawing public attention to the fragile nature of the industry. “There are no near-term or even long-term solutions being implemented that could provide a reliable and adequate supply for Europe and North America,” he writes in *Nature*. He proposes two alternative methods the Canadian government should consider. The first method is the use of particle accelerator technology, in which an accelerator shoots photons at the relatively stable uranium-238 isotope. Scientists have concluded that such accelerators could be built. Ruth says that research has to verify those conclusions before such accelerators could become a reality. The second method is a move away from scans reliant on reactor-made isotopes and toward positron emission tomography (PET) scans.

Though PET scans use isotopes with a shorter half-life than reactor-produced isotopes, these isotopes can be created in hospital-run cyclotrons. Because less than 15% of nuclear medicine installations in the US are equipped with PET scanners, Ruth expects that PET scanners and cyclotrons would have to come down in cost for this to be an attractive option. Both proposals were first made in a report produced after a task force met in Vancouver in the fall of 2008 to discuss time lines and costs. The construction of an accelerator would take three to four years and, depending on the technology used, would cost between C$50 and C$125 million to build. In a recent budget the Canadian government called for C$351 million in funding to Atomic Energy of Canada Ltd. for its operations, including the development of the Advanced Candu Reactor, while there was no mention of any budget toward alternative means of producing medical isotopes. Just two days before Ruth's announcement the Chalk River facility was again in the news as opposition members of parliament grilled the government about two separate leaks at the AECL reactor. The Nuclear Safety Commission issued a statement saying that "at no time was the public or the environment at risk" and that no radioactive material leaked into the Ottawa River. But, recently AECL (Atomic Energy of Canada Ltd) announced plans to dump radioactive water in the Ottawa River. So, after assuring the Canadian House of Commons and the public that "no radioactivity has been *leaked* into the Ottawa River", the nuclear establishment is planning to *dump* the radioactive heavy water (containing radioactive tritium) into the Ottawa River *deliberately*.

Sources: "*Medical Isotope Production Without Highly Enriched Uranium*" (Prepublication Copy). Committee on Medical Isotope Production without Highly Enriched Uranium; Nuclear and Radiation Studies Board, Division on Earth and Life Studies; National Research Council of the National Academies. The National Academies Press, Washington, D.C., 2009. ISBN: 0-309-13040-9, 240 pages. http://www.nap.edu/catalog/12569.html / Ottawa Citizen, 28 January 2009: *"Canada needs to find a safer, reliable supply of isotopes"* / Sierra Club Canada News Release, 6 February 2009: "*Stop Dumping Radioactive Water in the Ottawa River*" / Ruth, Thomas; "*Accelerating production of medical isotopes*", Nature 457, 29 January 2009 / "*Making Medical Isotopes*", Report of the Task Force on Alternatives for Medical-Isotope Production, TRIUMF, University of British Columbia, Advanced Applied Physics Solutions, Inc., 2008 available at: http://admin.triumf.ca/facility/5yp/comm/Report-vPREPUB.pdf

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