The NNSA Global Threat Reduction Initiative's Efforts to Minimize the Use of Highly Enriched Uranium for Medical Isotope Production

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ABSTRACT: *The mission of the National Nuclear Security Administration's (NNSA) Office of Global Threat Reduction (GTRI) is to reduce and protect vulnerable nuclear and radiological materials located at civilian sites worldwide. GTRI is a key organization for supporting domestic and global efforts to minimize and, to the extent possible, eliminate the use of highly enriched uranium (HEU) in civilian nuclear applications.*

GTRI implements the following activities in order to achieve its threat reduction and HEU minimization objectives:

- *Converting domestic and international civilian research reactors and isotope production facilities from the use of HEU to low enriched uranium (LEU);*
- *Demonstrating the viability of medical isotope production technologies that do not use HEU;*
- *Removing or disposing excess nuclear and radiological materials from civilian sites worldwide; and*
- *Protecting high-priority nuclear and radiological materials worldwide from theft and sabotage.*

This paper provides a brief overview on the recent developments and priorities for GTRI program activities in 2010, with a particular focus on GTRI's efforts to demonstrate the viability of non-HEU based medical isotope production technologies.

1. Introduction

On April 5, 2009, U.S. President Barack Obama announced a new international effort to secure all vulnerable nuclear material around the world within four years.[1] Over the ensuing months, President Obama further outlined his comprehensive strategy for nuclear security to reduce the danger of nuclear terrorism, prevent the spread of nuclear weapons capabilities, and strengthen the nuclear nonproliferation regime. The U.S. National Nuclear Security Administration's Global Threat Reduction Initiative (GTRI) is a key organization for implementing this strategy due to its mission to reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide.

On September 24, 2009, President Obama chaired an historic meeting of the United Nations Security Council (UNSC), during which the UNSC unanimously cosponsored and adopted a resolution committing to work toward a world without nuclear weapons and endorsing a broad framework of actions to reduce the threat of nuclear terrorism. Specifically, UNSC Resolution 1887 "calls upon all States to manage responsibly and minimize to the greatest extent that is technically and economically feasible the use of highly enriched uranium for civilian purposes, including by working to convert research reactors and radioisotope production processes to the use of low enriched uranium fuels

[1] Remarks by President Barack Obama," White House website, http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered April 5, 2009.

and targets."[2] GTRI is responsible for supporting these efforts to minimize and, to the extent, possible, eliminate the use of highly enriched uranium (HEU) in civilian nuclear applications.

GTRI has three elements – Convert, Protect, and Remove – that provide a comprehensive approach to achieving President Obama's objective to secure and protect all vulnerable nuclear material within four years. This paper discusses the status of these activities, with a particular focus on GTRI's efforts in reducing the use of HEU in medical isotope production.

2. GTRI Program Overview

Implementation of GTRI's Convert, Remove, and Protect subprograms are critical elements to achieving the objective to reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide. Following is the status of GTRI's Convert, Remove, and Protect activities.

2.1 Convert

GTRI's Convert Program, also known as the Reduced Enrichment for Research and Test Reactors (RERTR), supports the conversion of domestic and international civilian research reactors and isotope production facilities from HEU to LEU. These efforts result in permanent threat reduction by minimizing, or to the extent possible, eliminating the use of HEU in civilian applications. Each reactor converted or shutdown eliminates a source of bomb material. Once the need is eliminated, any remaining HEU fresh and spent fuel can be permanently disposed of by GTRI's Remove Program.

The goal of the Convert Program is to convert or verify shutdown prior to conversion of 200 HEU reactors by 2020. To date, GTRI has converted or verified the shutdown of 67 reactors. Since October 2004, acceleration of the program has resulted in 28 HEU research reactors being converted or shutdown prior to conversion, including 19 international and 9 domestic conversions. In 2009, GTRI completed the conversion of all U.S. research reactors that could convert using existing fuels two years ahead of schedule. GTRI is also collaborating with four international facilities that will convert or shutdown their research reactors to LEU fuel before October 2010.

The Convert Program is also developing and qualifying new high-density U-Mo LEU fuel to enable the conversion of high-performance research reactors. In conjunction with the fuel development effort, GTRI established the fuel fabrication capability (FFC) project to work with industry, the U.S. Nuclear Regulatory Commission (NRC), the U.S. national laboratories and other entities to accelerate efforts to create a sustainable commercial-scale capability to fabricate and supply new ultra-high density U-Mo LEU fuel.

[2] UN Security Council, Resolution 1887, S/RES/1887, September 24, 2009, www.un.org/Docs/sc/unsc_resolutions09.htm

GTRI recently down selected the fuel design to a monolithic Uranium-Molybdenum fuel foil with a thin Zirconium sheath serving as a diffusion barrier. Key fuel performance and safety basis experiments will be conducted in 2010. This new capability will allow the U.S. to meet its international commitment to HEU minimization, and it is hoped that this model will encourage other countries to meet their commitments to minimizing the use of HEU in civilian applications.

2.2 Remove

GTRI's Remove Program supports the removal and disposal of excess nuclear and radiological material from civilian sites. These efforts result in permanent threat reduction by eliminating nuclear and radiological materials that terrorists could potentially acquire. The materials include U.S.-origin, Russian-origin, and "gap" material that are not covered under U.S. or Russian programs. Excellent cooperation with partner countries has enabled the removal of 55% of targeted vulnerable material, or 2,531.6 kilograms of 4,603.9 kilograms, to date.

All HEU material has been removed from 17 countries, including: Brazil, Bulgaria, Colombia, Denmark, Greece, Latvia, Libya, Philippines, Portugal, Romania, Slovenia, South Korea, Spain, Sweden, Taiwan, Thailand, and Turkey. GTRI completed the clean-out of all HEU from Romania, Taiwan, and Libya in 2009, and Turkey in early 2010. Upcoming shipments in 2010 will remove all HEU from Serbia and Chile.

Removal of abandoned radiological materials in other countries include radioisotopic thermoelectiric generators (known as RTGs), with emphasis on recovery within Russia. GTRI has established the ambitious goal of removal or disposal of 860 Russian RTGs by 2013. The close cooperation with Russian partners has resulted in the successful removal of 59% to date. The GTRI domestic radiological material removal program is working in cooperation with Federal, state, and local agencies, and private industry to recover and permanently dispose of excess radiological sources in the United States. Over 23,022 domestic sources have been recovered to date.

To secure all vulnerable nuclear materials, GTRI has identified the material for inclusion in its Remove Program scope. In order to secure these materials within four years, these materials are protected until a permanent threat reduction solution (conversion and removal) can be implemented.

2.3 Protect

GTRI's Protect Program protects high priority nuclear and radiological materials from theft and sabotage. These efforts result in threat reduction by improving the physical security of bomb material remaining at civilian sites until a permanent threat reduction solution can be implemented. GTRI's Protect Program involves both international and domestic material protection. Work is conducted to ensure material security building by building. Many of the buildings holding nuclear and radiological materials require a different approach since they are accessible to the public, such as hospitals and university facilities. A systematic and comprehensive methodology is applied to evaluate and implement security measures.

Working with Federal, state and local agencies, GTRI is targeting about 2,500 high priority buildings containing risk-significant quantities of nuclear and radiological materials in the U.S. This work has recently begun, and 106 have already been completed to date. GTRI has identified 1,756 international buildings with nuclear and radiological material that require security installations and/or protection upgrades. To date, 37% have been completed.

3. Minimizing the Use of HEU in Medical Isotope Production

GTRI is working to demonstrate a sustainable means of producing the medical isotope molybdenum-99 (Mo-99) without the use of HEU.

Mo-99 is a crucial radioisotope that is used in approximately 80 percent of all nuclear medicine diagnostic procedures, and in roughly 50,000 diagnostic and therapeutic nuclear medicine procedures performed everyday in the United States. Its primary uses include diagnosing heart disease, treating cancer, and studying organ structure and function. The isotope's short half-life and excellent binding properties make it uniquely suited for medical procedures, however due to its short half-life it must be produced continuously to meet the medical community's requirements.

The United States does not currently have a domestic production capability for Mo-99 and imports all of its supply from ageing reactors that use HEU in their production processes. As part of its nuclear nonproliferation mission, GTRI's mandate is to assist in the conversion of global isotope production facilities to use LEU, and to accelerate the commercialization of a reliable Mo-99 supply network in the United States that does not use HEU.

3.1 Development of LEU-Based Technologies to Enable Conversion of Global Medical Isotope Producers

As part of its nuclear nonproliferation mission, GTRI makes technical expertise available, on a non-proprietary basis, to all global isotope producers to assist with converting their Mo-99 production processes to use LEU.

GTRI provides technical support in a number of areas, including foil rolling, target fabrication, target irradiation, target disassembly, target dissolution, product recovery and purification, and waste treatment. GTRI also develops alternative LEU-based processes that increase the Mo-99 extraction efficiency and reduce the waste volumes generated, in order to facilitate the replacement of current HEU-based technologies. GTRI has long-standing relationships with current and potential Mo-99 producers through its development of LEU-based Mo-99 technology and cooperation with research reactor facilities converting to LEU fuel.

GTRI's efforts to develop LEU technology for isotope production were validated by a January 2009 National Academy of Sciences report, entitled *Medical Isotope Production*

Without the Use of Highly Enriched Uranium.[3] Released on January 14, 2009, the study provides confirmation of the viability of the technical progress made by GTRI and found the production of Mo-99 using non-HEU-based methods to be economically feasible. Specifically, the National Academies concluded that "LEU targets that could be used for large-scale production of Mo-99 have been developed and demonstrated," and that "the anticipated average cost increase to convert to the production of medical isotopes without the use of HEU would likely be less than 10 percent."

To further support non-HEU-based medical isotope production, GTRI participates in related efforts of the International Atomic Energy Agency (IAEA), such as the IAEA Coordinated Research Project on "Current and Novel, Non-HEU based Isotope Production and Supply Technologies for Mo-99 and Tc-99m Suitable for Medical Procedures."

3.2 Accelerating the Establishment of Domestic Commercial Sources of Mo-99

Over the past two years, technical difficulties and shutdowns at the major Mo-99 production facilities have caused serious Mo-99 supply shortages. The current supply shortage highlights the need for a reliable supply network in the United States, comprised of alternative production options (e.g. new non-HEU-based technologies and facilities) that will meet the demand of the medical community.

GTRI is working to develop a reliable and diversified Mo-99 commercial production capability in the U.S. that does not use HEU, an effort that requires strong cooperation between government and industry. It is imperative to ensure that this critical medical isotope is readily available for the medical community because of the current and projected isotope supply shortages. The goal is to develop a reliable Mo-99 commercial supply network in the United States to meet daily patient needs that is consistent with HEU minimization policy and avoids a single point-of-failure.

To further this critical effort, GTRI is supporting the U.S. private sector to accelerate the establishment of a reliable commercial Mo-99 production capability without the use of HEU. GTRI is demonstrating four non-HEU based technologies, in cooperation with commercial partners and the U.S. national laboratories. These technologies include LEU target technology, LEU solution reactor technology, accelerator technology, and neutron capture technology. The projects utilize resources and the wide-ranging expertise from the U.S. national laboratories and U.S. commercial entities.

Two Cooperative Agreements were awarded to commercial partners on September 30, 2009 to accelerate the production of Mo-99 in the U.S. without the use of HEU. These commercial partners are Babcock and Wilcox (B&W) for solution reactor technology and General Electric Hitachi for neutron capture technology. Cooperative Agreements are cost-share arrangements that require the private company to provide no less than 50-percent of total project funding.

[3] Committee on Medical Isotope Production Without Highly Enriched Uranium, National Research Council, Medical Isotope Production Without the Use of Highly Enriched Uranium, January 2009, <http://www.nap.edu/catalog.php?record_id=12569#description>.

3.3 The American Medical Isotope Production Act (H.R. 3276)

On July 21, 2009, U.S. Representative Edward J. Markey, Chairman of the House Energy and Commerce Committee Subcommittee on Energy and the Environment, and Representative Fred Upton, the Ranking Member of the Subcommittee, introduced The American Medical Isotope Production Act of 2009 (H.R. 3276).

The pending legislation would direct the U.S. Department of Energy (DOE) to establish a technology-neutral program to evaluate and support projects for the production of significant quantities of Mo-99 in the United States without the use of highly enriched uranium to be carried out in cooperation with non-Federal entities. In addition, H.R. 3276 directs DOE to establish a program to make LEU available, through lease contracts, to domestic commercial entities for Mo-99 production and to retain responsibility for the final disposition of waste created by the irradiation, processing, or purification of leased uranium. The legislation would also phase out the export of HEU for medical isotope production in 7 to 13 years.

On September 9, 2009, GTRI testified at the hearing of the House Subcommittee on Energy and the Environment on the legislation, and again on December 3, 2009 before the Senate Energy and Natural Resources Committee. NNSA supports H.R. 3276 because it recognizes the urgency of two important national priorities: nuclear nonproliferation and stability of the supply of medical isotopes.

3. Conclusion

Through GTRI's efforts to convert research reactors and isotope production facilities to use LEU, remove vulnerable nuclear and radiological materials, and protect thousands of facilities from the threat of sabotage and theft until a permanent threat reduction alternative can be implemented, GTRI is a critical element to meeting the international effort to secure all vulnerable nuclear material around the world within four years. GTRI's efforts to demonstrate and develop non-HEU based technologies for civilian nuclear applications, including in the production of medical radioisotopes, will achieve the important nonproliferation objective to phase-out the use of HEU in the civilian sector.