January 9, 2014

The Honorable Barbara Boxer
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, DC 20510

Dear Madam Chairman:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am pleased to submit the "Report to Congress on the Current Disposition of Highly Enriched Uranium Exports Used as Fuel or Targets in Nuclear Research or Test Reactors." The National Defense Authorization Act for Fiscal Year 2013 (Public Law 112-239), which was signed into law by the President on January 2, 2013, requires the NRC to submit this report. In particular, Section 3175 of the Act, which was included in Subtitle F of Title XXXI (which may be referred to as the American Medical Isotopes Production Act of 2012), requires submission of this report.

The NRC is providing the information requested in a public report (Enclosure 1) that includes narrative, figures, and tables. Additionally, we are providing a non-public annex to the report (Enclosure 2) that contains additional country-specific information. This non-public annex is designated "Confidential/Foreign Government Information – Modified Handling Authorized."

The enclosed report and the annex provide information requested based on records dating back to 1950. The report and the annex focus on the current disposition of the highly enriched uranium (HEU) exported from the United States for use as fuel or targets in research and test reactors. Information on HEU exported for other purposes is not included, based on the direction in Section 3175 of the Act.

Enclosure 2 transmitted herewith contains Confidential/Foreign Government Information – Modified Handling Authorized. When separated from Enclosure 2, this transmittal document is decontrolled.

This report and the annex build on the January 1993 report that the NRC submitted to Congress on the disposition of HEU exports, as required by Section 903(b) of the Energy Policy Act of 1992. The NRC consulted with other relevant agencies in the development of the enclosed report and the annex.

Please do not hesitate to contact me if you need additional information.

Sincerely,

/RA/

Allison M. Macfarlane

Enclosures:
1. Publically Available Report
2. Non-Public Annex

cc: Senator David Vitter

Identical letter sent to:

The Honorable Barbara Boxer
Chairman, Committee on Environment
and Public Works
United States Senate
Washington, DC 20510
cc: Senator David Vitter

The Honorable John Boehner
Speaker of the House of Representatives
Washington, DC 20515

The Honorable Joseph R. Biden, Jr.
President of the Senate
Washington, DC 20510

The Honorable Thomas R. Carper
Chairman, Subcommittee on Clean Air
and Nuclear Safety
Committee on Environment and Public Works
United States Senate
Washington, DC 20510
cc: Senator Jeff Sessions

The Honorable Fred Upton
Chairman, Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515
cc: Representative Henry A. Waxman

The Honorable Edward Whitfield
Chairman, Subcommittee on Energy and Power
Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515
cc: Representative Bobby L. Rush

The Honorable John Shimkus
Chairman, Subcommittee on Environment
and the Economy
Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515
cc: Representative Paul Tonko

The Honorable Mike Simpson
Chairman, Subcommittee on Energy
and Water Development
Committee on Appropriations
United States House of Representatives
Washington, DC 20515
cc: Representative Marcy Kaptur

The Honorable Dianne Feinstein
Chairman, Subcommittee on Energy
and Water Development
Committee on Appropriations
United States Senate
Washington, DC 20510
cc: Senator Lamar Alexander

The Honorable Carl Levin
Chairman, Committee on Armed Services
United States Senate
Washington, DC 20510
cc: Senator James Inhofe

The Honorable Buck McKeon
Chairman, Committee on Armed Services
United States House of Representatives
Washington, DC 20515
cc: Representative Adam Smith

United States Nuclear Regulatory Commission
Report to Congress on
the Current Disposition of Highly Enriched Uranium Exports Used as Fuel or Targets in Nuclear Research or Test Reactors

INTRODUCTION

This report has been prepared in response to the National Defense Authorization Act for Fiscal Year 2013 (Public Law 112-239) (NDAA 2013), which was signed into law by President Obama on January 2, 2013. Specifically, Title XXXI, Subtitle F of the NDAA 2013 contains the American Medical Isotopes Production Act of 2012, which, in Section 3175, "Report on Disposition of Exports," requires the following:

> Not later than 1 year after the date of the enactment of this Act, the Chairman of the Nuclear Regulatory Commission, after consulting with other relevant agencies, shall submit to the Congress a report detailing the current disposition of previous United States exports of highly enriched uranium used as fuel or targets in a nuclear research or test reactor, including—
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> (1) their location;
> (2) whether they are irradiated;
> (3) whether they have been used for the purpose stated in their export license;
> (4) whether they have been used for an alternative purpose and, if so, whether such alternative purpose has been explicitly approved by the Commission;
> (5) the year of export, and reimportation, if applicable;
> (6) their current physical and chemical forms; and
> (7) whether they are being stored in a manner which adequately protects against theft and unauthorized access.

This Nuclear Regulatory Commission (NRC) report provides the information requested based on available records from various sources dating back to 1950. It also includes background information describing key features of the legal and institutional framework governing United States (U.S.) exports of highly enriched uranium (HEU) and indicates how some of the features have changed over the years.[1] The report focuses on the current disposition of the HEU exported from the United States for use as fuel or targets in research and test reactors (RTRs). Information on HEU exported for purposes other than use as fuel or targets in RTRs is not included in this report based on the direction in Section 3175 of the NDAA 2013.

The NRC staff compiled the information in this report by analyzing data from various sources including the U.S. national database for tracking movements of nuclear materials from and to facilities within the United States known as the Nuclear Materials Management and Safeguards System (NMMSS) database, export license records, reports by and technical discussions with staff from the National Nuclear Security Administration's (NNSA) Global Threat Reduction

[1] HEU is defined as uranium enriched to 20 percent or more in the isotope uranium-235. Low Enriched Uranium (LEU) is defined as uranium enriched to less than 20 percent in the isotope uranium-235.

Initiative (NNSA/GTRI), U.S. interagency bilateral physical protection visit reports, and other public and non-public sources. This report builds on the NRC's January 1993 report to Congress on the disposition of previous HEU exports.[2] The NRC staff also consulted with the Department of Energy (DOE), the Department of State (DOS), and other relevant agencies on the content of this report.

The report provides information about U.S. HEU exports and imports, as it is recorded in the NMMSS database, through December 31, 2012.[3] Depending on the dates of the other sources with which the NMMSS data was compared and analyzed, certain information about HEU locations, material forms, and adequacy of physical protection measures can be either more or less current than December 31, 2012. In all cases, the staff used the best available information.

SUMMARY OF FINDINGS

Since 1957, records indicate that the United States has exported a total of approximately 22,600 kilograms (kg) of HEU for use as fuel or targets in RTRs to a total of 35 countries either directly (to 32 countries) or indirectly (to an additional three countries) as a result of re-transfers between those countries (see Table 1). The records indicate that approximately 6,100 kg of that U.S.-supplied HEU presently remains in 20 countries, with 95 percent of that material located in five of those countries. Many of the 20 countries have converted their RTRs from HEU to low enriched uranium (LEU) fuel or have committed to doing so in the future.

The remaining 15 countries of the 35 countries that received U.S. exports of HEU for use as fuel or targets in RTRs no longer possess any U.S.-supplied HEU for these purposes and have either converted facilities to LEU or have shut down the facilities that required HEU. The records also indicate that since 1957, approximately 7,700 kg of HEU has been returned to the United States primarily as irradiated fuel. Additional information on individual countries and the current disposition of HEU is designated Confidential/Foreign Government Information – Modified Handling Authorized and is presented in a separate, non-public Annex to this report.

Available information indicates that more than 4,300 kg of the U.S. HEU has been eliminated by down-blending to LEU; approximately 500 kg of HEU has been eliminated in highly-dilute processing waste; and at least 2,400 kg of HEU has been destroyed (burned up) through irradiation in RTRs. As of the issuance of this report, the NRC staff was not able to definitively reconcile records for approximately 1,600 kg of HEU that was exported by the United States. As discussed in the HEU data uncertainty section of this report, the reconciliation effort is challenging due to a variety of different factors, including the lack of historical records from all of

[2] The NRC submitted the 1993 report in response to Section 903(b) of the Energy Policy Act of 1992. That report addressed only the first four items listed in Section 3175 of the NDAA 2013. In addition, the 1993 report covered all HEU exports, not only HEU exports used as fuel or targets in RTRs.

[3] The NRC staff chose the cut-off date for NMMSS data to coincide with the date of enactment of the NDAA 2013 and with the close of a quarterly regulatory reporting period that would be completely reviewed and reconciled in time for the staff to include in this report.

the foreign countries, as well as the inherent accounting and other uncertainties associated with the overall HEU RTR fuel cycle and medical isotope processing operations.

The reconciliation challenge is considerably less severe for more recent HEU exports. Starting in the 1980s, based on the guidance provided in the NRC's 1982 HEU policy statement, license applicants started obtaining and including more detailed information in export license applications.[4] Over the years, the information provided has become increasingly more detailed and important to the licensing process. Currently, non-public checklists, which are reviewed and confirmed by U.S. Government technical experts, contain highly detailed information about application HEU inventories, production requirements and schedules, and waste and scrap streams and other information. This information greatly increases the transparency of the disposition of contemporary U.S. HEU exports.

The U.S. Government, led by the National Security Staff, DOE, and DOS, has intensified efforts and achieved significant successes over the last several years to further enhance global commitments to minimize the use of HEU for fuel or targets in RTRs. In this context and consistent with the other provisions of the NDAA 2013 concerning medical isotopes production, the U.S. Government continues to engage with other foreign governments to convert existing facilities to LEU fuel and targets, prioritize returns of HEU to the United States, and reconcile historical record-keeping discrepancies to the extent possible. The NRC strongly supports and appreciates the sensitive nature of these ongoing efforts with foreign counterparts. The NRC staff has neither any evidence to suggest nor any reason to believe that any U.S.-exported HEU has been stolen from a foreign facility or diverted to non-peaceful uses.

BRIEF OVERVIEW OF LEGAL AND INSTITUTIONAL FRAMEWORK GOVERNING U.S. EXPORTS OF HEU

Following President Dwight D. Eisenhower's "Atoms for Peace" speech to the United Nations General Assembly on December 8, 1953, the Congress amended the Atomic Energy Act of 1946 by replacing it with the Atomic Energy Act of 1954 (AEA) to establish the legal framework for developing the U.S. civilian nuclear industry and promoting cooperation with other countries in the peaceful uses of nuclear energy under appropriate controls to protect public health, safety, and U.S. common defense and security.

The U.S. Government recognized from the outset of Atoms for Peace that in a world with increasing numbers of nuclear suppliers and recipients, the only acceptable and credible long-term approach to protect global security interests required the establishment of an effective, independent safeguards verification system administered by an international organization of broad membership and strong collective purpose. The U.S. Government strongly promoted the development and implementation of the International Atomic Energy Agency (IAEA) safeguards verification system to, among other things, avoid reliance on a series

[4] "Statement of Policy on the Use of HEU in Research Reactors" (47 Fed. Reg. 37,007, published August 24, 1982, U.S. NRC)

of overlapping, duplicative bilateral safeguards applied by competing individual suppliers. Sovereign national authorities would establish requirements for and oversee facility operator compliance in protecting public health, safety, and security within their territories and the IAEA would independently monitor and inspect facilities and materials to verify peaceful use commitments. Supplier countries agreed to respect the sovereignty of their trading partners to manage and control the nuclear facilities and materials in their legal jurisdictions.

Agreements for Peaceful Nuclear Cooperation

Peaceful nuclear cooperation agreements, also known as "123" agreements, named for §123 of the AEA, are a cornerstone and a precondition of exports of U.S. nuclear materials. Presently, the United States has bilateral 123 agreements with 20 individual countries, with the European Atomic Energy Community (EURATOM)[5], the IAEA[6], and Taiwan[7]. The scope and content of bilateral peaceful nuclear cooperation agreements have evolved quite significantly since the 1950s, especially as the key instruments of the nuclear nonproliferation regime – IAEA safeguards and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) – took shape. They have also evolved as a result of technological progress in the nuclear field, as well as changes to U.S. statutory requirements, including in particular enactment of the Nuclear Non-Proliferation Act of 1978 (NNPA).

Certain fundamental precepts in U.S. peaceful nuclear cooperation agreements have not changed and have withstood the tests of time. The United States obtained and continues to obtain guarantees by the governing bodies of the cooperating nations and organizations stipulating that safeguards (verifications) will be maintained, that no material or equipment supplied by the United States under the agreements will be used for nuclear weapons or for research on or development of nuclear weapons or for any other military purpose, that the appropriate physical protection measures will be maintained, and that the United States will have certain prior consent rights if, for example, the material or equipment supplied under an agreement needs to be transferred to a third party that had not been provided for in the agreement.

Up until the 1970's, most bilateral agreements with the countries interested in building and operating RTRs provided for the lease of HEU with explicit provisions for the return of the spent

[5] EURATOM was created by the Treaty of Rome signed in March 1957 by Belgium, the Netherlands, Luxembourg, France, Italy, and the Federal Republic of Germany. The EURATOM Treaty entered into force in January 1958, and following U.S. enactment of the EURATOM Cooperation Act of 1958, a U.S.-EURATOM Agreement on a "Joint Program" in nuclear power development applications was concluded in November 1958 and was valid until 1985. An "Additional Agreement" was concluded in June 1960 to cover additional nuclear power applications and was valid until December 31, 1995. In 1973, Denmark, Ireland and the United Kingdom became members of EURATOM and, since that time, several additional countries have become members, with the current total number of countries reaching 28 today. The U.S. concluded another Agreement for Cooperation with EURATOM in 1995, which entered into force in March 1996, and meets the requirements of the AEA, as amended including by the Nuclear Non-Proliferation Act of 1978.

[6] The U.S.-IAEA Agreement for Cooperation entered into force in August 1959, and was amended in 1974 to permit the U.S. to supply power reactor fuel through the Agency to Member States under long-term contracts. As amended, the agreement remains in force through August 6, 2014.

[7] The agreement with Taiwan is administered on a non-government basis by the American Institute in Taiwan.

nuclear fuel to the United States. Following ratification of the NPT, the United States began relying on the IAEA to implement safeguards, and the United States stopped applying bilateral safeguards. The United States also began to operate under a policy known as the "Off-Site Fuels Policy," and no longer required returns of spent fuel but continued to accept, store and process it for certain countries and in certain cases. The Off-Site Fuels Policy and associated programs have evolved into the current NNSA/GTRI-managed Foreign Research Reactor Spent Nuclear Fuel Acceptance Program.

Export Licensing Requirements

The requirements and process of granting export license approvals for HEU exports have also evolved since the 1950's. Initially, the bilateral cooperation agreements and all other aspects of the U.S. reactor research, development, and demonstration programs were promoted, executed, and administered by the U.S. Atomic Energy Commission (AEC). In 1975, the responsibility for nuclear material export licensing was transferred to the NRC, which was established by the Energy Reorganization Act of 1974. The NRC licenses exports of nuclear material and equipment pursuant to the criteria set forth in the 1954 AEA, as amended. NRC regulations in Title 10 of the Code of Federal Regulations, Part 110, set forth the criteria for licensing exports of nuclear materials and equipment as prescribed by the AEA.[8]

The licensing criteria address the issues of nuclear non-proliferation, physical protection, and HEU minimization. Overall, it must be determined on a case-by-case basis that approval of proposed exports of nuclear material or equipment will not be inimical to the common defense and security of the United States. In conducting nuclear material export licensing reviews, the NRC must seek the judgment of interested U.S. Government executive branch agencies (i.e., the Departments of Commerce, Energy, and Defense, as coordinated by DOS) as to whether approving a proposed export would be consistent with U.S. statutory and foreign policy requirements. The NRC cannot issue an export license if the Executive Branch recommends denying the license; however, if the Executive Branch recommends approval and the NRC disagrees, the license application must be referred to the President of the United States for action, which is subject to Congressional review.

It should be noted that every HEU export license issued by the AEC and the NRC has satisfied applicable requirements. These requirements include domestic law, internal AEC/NRC export licensing regulations, Agreements for Peaceful Nuclear Cooperation, Project and Supply Agreements, the NPT as applicable, and IAEA agreements and protocols.

The bulk of the U.S. HEU exports and imports (approximately 95 and 80 percent respectively) occurred prior to 1990 (see Figures 1 and 2). U.S. HEU exports peaked in the late 1960s and have since declined dramatically due to the shutdown of many foreign HEU-fueled RTR facilities and programs, additional export controls imposed under the NNPA in 1978, and the establishment of DOE's Reduced Enrichment for Research and Test Reactors (RERTR) program to convert such facilities to LEU. In addition, in August 1982, the NRC issued a

[8] DOE has authority under Section 54d. and 111b of the AEA to export up to 500 grams of HEU.

"Statement of Policy on the Use of HEU in Research Reactors" (47 Fed. Reg. 37,007) expressing support for the RERTR program to convert facilities to LEU. The NRC also indicated that it would perform more rigorous reviews of the need for and inventories of U.S.-supplied materials in foreign RTRs with the intent of eliminating inventories of U.S.-supplied HEU to the maximum degree possible.

The AEA was also amended in 1992 to add the following more stringent criteria to Section 134 for licensing exports of HEU to be used as fuel or targets in RTRs:

- There is no alternative nuclear reactor fuel or target enriched in the isotope U-235 to a lesser percent than the proposed export, that can be used in that reactor;
- The proposed recipient of the uranium has provided assurances that, whenever an alternative nuclear reactor fuel or target can be used in that reactor, it will use that alternative fuel or target in lieu of HEU; and
- The U.S. Government is actively developing an alternative nuclear reactor fuel or target that can be used in that reactor.

The following additional criteria were added to Section 134 of the AEA in 2005 for licensing exports to certain countries of HEU to be used solely for medical isotope production:[9]

- The recipient country supplies an assurance letter to the U.S. Government indicating that any intermediate consignees and the ultimate consignee specified in the export license application are required to use the HEU solely to produce medical isotopes; and
- The HEU for medical isotope production will be irradiated only in a reactor in a recipient country that:
    - Uses an alternative nuclear reactor fuel; or
    - Is the subject of an agreement with the U.S. Government to convert to an alternative nuclear reactor fuel when alternative nuclear reactor fuel can be used in the reactor.

In addition, under the provisions added to Section 134 in 2005, the NRC is required to review the adequacy of physical protection requirements that are applicable to the transportation and storage of the HEU for medical isotope production or control of residual material after irradiation and extraction of medical isotopes. If the NRC determines that additional physical protection requirements are necessary (including a limit on the quantity of HEU that may be contained in a single shipment), the NRC shall impose such requirements as licensing conditions or through other appropriate means. Presently, the United States continues to export HEU for use as RTR fuel or targets to a limited number of facilities in Canada and Europe.[10] The primary purpose of these HEU exports is to support medical isotope production.

[9] Those countries include Belgium, Canada, France, Germany, and the Netherlands.
[10] In 2013, the appropriate HEU export licenses were amended to add RTRs in Poland and the Czech Republic as temporary intermediate consignees to receive and irradiate medical isotope targets. These reactors may receive

Significant Recent Policy Developments

In April 2010, President Obama hosted the first Nuclear Security Summit in Washington, D.C. and met with 47 heads of state to discuss actions to increase security for nuclear materials and prevent acts of nuclear terrorism and trafficking. The summit reinforced the principle that all states are responsible for ensuring the best security of their materials, for seeking assistance if necessary, and for providing assistance if asked. It promoted the international treaties that address nuclear security and nuclear terrorism and led countries to commit to specific national actions to advance global security. One of the key items included in the Joint Communique issued by the Summit is that world leaders "[r]ecognize that highly enriched uranium and separated plutonium require special precautions and agree to promote measures to secure, account for, and consolidate these materials, as appropriate; and encourage the conversion of reactors from highly enriched to low enriched uranium fuel and minimization of use of highly enriched uranium, where technically and economically feasible."[11]

At the 2012 Seoul Nuclear Security Summit, Belgium, France, the Netherlands, and the United States issued a "Joint Statement on Minimization of HEU and the Reliable Supply of Medical Radioisotopes." That statement reaffirmed commitments on the part of those four countries to support conversion of European production industries to non-HEU based processes by 2015, subject to the regulatory approvals to reach a sustainable medical isotope production for the benefit of patients in need of vital medical isotope diagnostic treatments in Europe, the United States, and elsewhere. It was also agreed at the 2012 Summit that in the longer term, the use of HEU will be completely eliminated for production of medical isotopes.

CURRENT DISPOSITION OF U.S. EXPORTS OF HEU

Section 3175 of the NDAA 2013 directs the NRC to provide specific information about the current disposition of previous U.S. HEU exports used as fuel or targets in RTRs. Public information responsive to the specific questions in Section 3175 is provided in the following sections. Additional responsive information is contained in a separate, non-public Annex to this report.

The data in this report is derived from multiple sources. One data source was the records on more than 1,700 transactions involving export shipments of HEU from U.S. facilities and more than 1,400 transactions involving imports and receipts of HEU at U.S. facilities as captured in the NMMSS database, through December 31, 2012. The NRC staff also examined information available from other sources including nearly 800 export licenses and license amendments issued since the early 1970's, as well as information assembled by NNSA/GTRI and from

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HEU targets, containing gram-quantities of HEU each, for irradiation. Following irradiation the targets are promptly shipped away to isotope production facilities in other countries.

[11] "Communiqué of the Washington Nuclear Security Summit," (The White House, Office of the Press Secretary, Washington, DC, April 13, 2010).

bilateral physical protection visit reports, which in some cases were more recent than December 31, 2012. Depending on the dates of the associated sources, information about HEU locations, material forms, and adequacy of physical protection measures can be either more or less current than December 31, 2012. In all cases, the staff used the best available information.

As was the case in 1993, when the NRC last reported comprehensively to the Congress on HEU exports, there is no single, comprehensive source of data to easily respond to the requirements in Section 3175 of the NDAA 2013. The U.S. Government has not required foreign recipients of U.S.-supplied HEU or their governments to regularly report on their inventories of these materials beyond acknowledging initial receipt and, if applicable, submitting safeguards declarations to the IAEA. As indicated at the 2010 and 2012 Nuclear Security Summits, the U.S. Government accepts that foreign nations are responsible for the materials they import within their borders consistent with national law and international obligations. Although the U.S. Government continues to work with certain partners to reconcile inventory records, these reconciliations are not facility-specific, but at a State level. In addition, the information about foreign government-declared holdings of U.S.-exported material is not entered into NMMSS. Adding new inventory reconciliation or other requirements to U.S. 123 agreements or other international instruments would be a major change to the status quo and may not be in the national interests of other countries. Furthermore, any unilateral change in U.S. legal requirements along these lines would need to take into account reciprocity, and requirements for the United States to likewise share facility-specific sensitive information with dozens of other countries.

United States law has instead required the U.S. Government to obtain nonproliferation, peaceful use, and safeguards assurances from foreign government authorities on a case-by-case basis as a pre-condition for authorizing the export of any special nuclear materials, including HEU to foreign RTRs for use as fuel or targets. The U.S. Government has relied on these assurances among other factors in determining that the foreign recipient and the responsible government oversight authority will implement and maintain the controls to ensure that the nuclear materials are appropriately used, controlled and safeguarded. The U.S. Government and the global community have also relied on the IAEA to conduct independent safeguards audits and inspections to verify that the records for and physical inventories of nuclear materials, whether supplied by the United States or another country, are consistent and provide no evidence of diversion.

HEU Locations

As of the issuance of this report, the records indicate that approximately 6,100 kg of U.S. HEU, which was exported for use as fuel or targets in RTRs, remained in storage and/or in use at approximately 40 locations in 20 countries (see Table 1 and separate non-public Annex to the report).[12] Of these 20 countries, seven countries, including Canada, Japan, and five EURATOM countries, possessed inventories of greater than 25 kg of U.S.-exported HEU, and an additional

[12] These 20 countries do not include Poland and the Czech Republic, which were authorized by the NRC in 2013 as intermediate consignees to irradiate HEU targets for the production of medical isotopes.

eight countries possessed inventories of less than 25 kg but greater than 1 kg of U.S.-exported HEU.

Approximately 7,700 kg of U.S.-supplied HEU has been imported back to the United States. Most of the material returned has been irradiated HEU fuel, which was delivered to DOE facilities at the Savannah River Site near Aiken, South Carolina and the Idaho National Laboratory near Idaho Falls, Idaho. Unirradiated HEU has been delivered to DOE facilities as well as to commercial, NRC-licensed facilities for processing, storage, and/or potential re-use including as down-blended LEU.

HEU Irradiation Status and Current Physical and Chemical Forms

Approximately 60 percent of the U.S.-origin HEU remaining in foreign countries is irradiated and 40 percent is unirradiated. Most of the irradiated material is in the form of irradiated RTR fuel, targets, and medical isotope production residues. The unirradiated U.S. HEU at foreign facilities exists primarily in the form of fabricated RTR fuel and medical targets, but some of the unirradiated HEU is in the form of metal, compounds, scrap, and waste.

Uses Stated in Export License, Alternative Uses, NRC-Approved Alternative Uses

In most cases, U.S.-supplied HEU was used for its stated uses as described in relevant U.S. export licenses. For the most part, U.S. export licenses have anticipated the need for transfers among certain countries and typically identified approved intermediate facilities (fuel and/or target fabrication facilities) and ultimate foreign consignees (RTRs and target processing facilities). In a number of instances, and to the extent that some countries subsequently transferred and/or received U.S.-supplied HEU between themselves and other countries, they were required to obtain additional approval (prior consent) from the U.S. Government to do so. Requests for prior consent are processed as “subsequent arrangements” by NNSA in accordance with Section 131 of the AEA as amended. In a limited number of cases, based on international agreements and requirements for HEU exports in effect at that time, no additional U.S. approval was required. The NRC identified 13 requests to use U.S.-supplied HEU for purposes other than what was originally authorized (Table 2). The NRC did not locate records indicating whether these 13 requests for alternative uses were approved by the U.S. Government or whether the HEU was in fact used for the requested alternative use.

Year of Exportation and Importation

Since 1957, the United States has exported a total of approximately 22,600 kg of HEU for use as fuel or targets in RTRs and imported approximately 7,700 kg of that previously exported HEU. Tables 3 and 4 provide a breakdown of the total exports and import returns per year.

Historically, the bulk of the HEU exports occurred in the 1960s and 1970s with nearly 95 percent of HEU exports occurring before 1990 (Figure 1). Most of this HEU was exported to France, Germany, and Canada. These HEU exports have dropped off dramatically and, at present, the United States continues to export HEU for use in a limited number of facilities in Canada and Europe.

Nearly 80 percent of U.S. imports of U.S.-supplied HEU occurred prior to 1990 (Figure 2). Much of the HEU returns also took place from 1964 to 1988 under the Off-Site Fuels Policy. NNSA/GTRI continues to work with foreign governments to return additional amounts of fresh and irradiated U.S. HEU to the United States; however, not all U.S. HEU is eligible for return. Specifically, NNSA/GTRI can only bring back those materials that have an approved disposition pathway and meet the program's eligibility criteria.

Adequate Protection Against Theft and Unauthorized Access

This report primarily addresses physical protection of U.S. HEU at foreign facilities. The HEU returned to the United States is stored and processed at a small number of DOE facilities as well as at NRC-licensed facilities. The physical protection measures at these U.S. facilities are maintained, as appropriate, in accordance with either DOE or NRC requirements and they are sufficient to ensure adequate protection of the HEU against unauthorized access and theft.

Information about the adequacy of physical protection measures for U.S. HEU at foreign facilities is provided in the non-public Annex to this report. Consistent with the current NRC export licensing criteria, physical protection measures at foreign facilities were assessed against recommendations in IAEA publication Information Circular (INFCIRC) 225 Revision 4 (corrected), June 1999, ''The Physical Protection of Nuclear Material and Nuclear Facilities'' (INFCIRC/225). For high-risk nuclear materials, the primary means that the NRC relies upon to determine the adequacy of physical protection measures are bilateral physical protection information exchange and assessment visits to the foreign country.[13] These visits are conducted by a U.S. interagency team of experts and involve exchanges of technical physical protection information as well as site-level security assessments. To date, the U.S. Government has conducted over 170 assessment visits to foreign facilities. When appropriate, a determination as to whether the measures employed at a facility provide protection at least comparable to the INFCIRC/225 guidelines is made on a country-wide basis.[14]

The NRC staff has neither any evidence to suggest nor any reason to believe that any U.S.-exported HEU has been stolen or diverted from a foreign facility. No country has ever notified the U.S. Government that they lost or did not receive U.S.-supplied HEU or that they relinquished control over the material once they were finished with it. International safeguards containment, surveillance, and verification measures, and IAEA inspections provide additional confidence that no U.S. HEU has been stolen or diverted.

As reaffirmed by heads of state participating in the 2010 and 2012 Nuclear Security Summits, recipient countries are responsible for maintaining safety and ensuring the adequacy of physical

[13] For the purposes of this report, the high-risk materials include Category II and Category I quantities of nuclear materials. For HEU, these correspond to the material quantities containing greater than or equal to 1 kg but less than 5 kg uranium-235 (Category II HEU), and greater than or equal to 5 kg uranium-235 (Category I HEU). For material irradiated to greater than 100 r/h at 1 m, the material category is reduced by one.

[14] Country-wide determinations are usually made for lower risk, Category III or less materials (less than 1 kg uranium-235); and for nuclear sites, which have not received a U.S. Government assessment team visit, but which are located in countries where such visits have occurred. In all cases, a country-wide determination involves consideration of available public and non-public sources.

protection measures for nuclear materials they receive from the United States and other countries. As part of the U.S. export licensing process, the responsible foreign government authority in the recipient country must confirm on a case-by-case basis that a facility is authorized to receive and possess the material and agree to maintain protection at least comparable to the recommendations in the current version of INFCIRC/225. The U.S. Government must receive these and other written assurances, including commitments to convert to LEU fuel or targets from the receiving country as part of the NRC export licensing process.

HEU RECORD-KEEPING AND DATA UNCERTAINTIES

As discussed in this section, there are gaps and uncertainties in the historical records available to the NRC staff. The following reasons explain why the NRC was unable to fully document the status and location of all HEU exported by the United States:

- HEU transfers: Most records of HEU exports only provide "first destination" data. First destination data shows only the country to which the HEU was shipped from the United States (the first foreign recipient of the material). However, the first destination is not necessarily the ultimate destination for the exported HEU. U.S.-exported HEU has been routinely re-transferred from the country of first destination to another country. For example, consider an HEU export to France for fabrication into fuel for use in an RTR located in another EURATOM country. The exported HEU would be usually recorded as a delivery to France, not to the RTR in another EURATOM country. In some cases, the material subsequently would be moved again for use in yet another country. In the above example, the irradiated HEU could have been subsequently re-transferred back to France and reprocessed, and the recovered HEU would be fabricated into fuel and shipped to an RTR in another EURATOM country. While a report might be made to document such re-transfers, there is no legal requirement for EURATOM to provide such information to the United States and not all records covering such re-transfers are available to the NRC staff.

- Material losses and waste: A significant fraction of the HEU exported from the United States was transferred to foreign countries in the form of HEU metal or other compounds. Foreign recipients used complex chemical and physical transformation processes to fabricate the U.S.-supplied HEU into RTR fuel elements and targets. Some HEU materials, such as irradiated HEU fuel and targets, were subsequently reprocessed to recover residual HEU and medical isotopes. Each processing step generates HEU-contaminated waste and effectively reduces the HEU inventories. Additional material losses occurred due to material spills and other process upsets. In many cases, HEU processing operations took place during the first decades of U.S. HEU exports and at facilities that no longer exist. Estimating the amount of material losses is often difficult and the foreign countries are not required to report HEU process losses to the United States.

- HEU consumption in reactors: The uranium-235 enrichment content of irradiated HEU fuel is less than the uranium-235 content of the fresh HEU fuel. During the irradiation of HEU, some of the uranium-235 is consumed. The extent of consumption depends on the reactor design and operating history and, in certain cases, it may be significant. The consumption of HEU effectively reduces the HEU inventory. Some irradiated HEU was reprocessed, and, after addition of fresh HEU, was reused as RTR fuel. The foreign nuclear facilities are not required to report HEU consumption or recycle to the United States and thus specific consumption information was not available for this report.

- HEU down-blending: In some cases, for example, at the chemical reprocessing plants in France and the United Kingdom, HEU fuel was reprocessed together with non-HEU fuel and the output was LEU. This down-blending effectively results in HEU elimination. The NRC staff does not have specific information about the quantities of the down-blended HEU and the associated reduction in HEU inventories and had to rely on less accurate estimates. The foreign nuclear facilities are not required to report to the United States the quantity of U.S. HEU down-blended to LEU.

- Co-mingling of U.S. and non-U.S. HEU: In some cases, U.S.-supplied irradiated HEU fuel was co-reprocessed with irradiated HEU supplied by other countries (e.g., the United Kingdom, France, or Russia). The co-reprocessed HEU was subsequently placed in storage and/or re-used. Documenting and maintaining the “nationality” of such material is a challenge after the co-reprocessing occurs.

- Co-mingling of RTR and non-RTR HEU: While the report attempts to capture information on HEU used as fuel or targets in foreign RTRs, significant quantities of HEU were exported for use in prototype power reactors such as high-temperature gas reactors and fast-neutron reactors. In certain cases, the HEU was not used for its stated original purpose in power reactors (for example, due to non-completion of the reactor construction or reactor shutdown). Instead the material was made available for use in approved research reactors.

- National classification information laws: Because of national classification laws, some countries do not share specific information about locations and size of HEU inventories with the U.S. Government.

The U.S. Government continues to work with its foreign partners to reconcile historical records for the disposition of the past U.S. HEU exports and to maintain an appropriate level of awareness regarding the disposition of the current and future U.S. HEU exports.

OBSERVATIONS AND CONCLUSIONS

The United States continues to lead the effort to reduce and eliminate the use of HEU for use in RTRs and medical isotope production. Some of the outcomes of the 2010 and 2012 Nuclear

Security Summits were statements endorsing the minimization of HEU and possibly replacement of HEU use in the further production of medical isotopes.

Table 1

Disposition of U.S. HEU
Used as Fuel or Targets in a Nuclear Research or Test Reactor

Countries that received HEU (Direct exports from the U.S.)	Countries that no longer possess U.S. HEU for these purposes (1)	Countries with less than 1 kg of U.S. HEU for these purposes (1)
Argentina Australia Austria Belgium Brazil Canada Colombia Denmark France Germany Greece Indonesia Iran Israel Italy Japan Mexico Netherlands Pakistan Philippines Portugal Republic of Korea Romania Slovenia South Africa Spain Sweden Switzerland Taiwan Thailand Turkey United Kingdom	Austria Chile Colombia Denmark Greece Mexico Philippines Portugal Republic of Korea Romania Slovenia Spain Sweden Taiwan Thailand	Australia Brazil Jamaica South Africa Turkey **Countries with 1 kg or more of U.S. HEU for these purposes (1)** Argentina Belgium Canada France Germany Indonesia Iran Israel Italy Japan Netherlands Norway Pakistan Switzerland United Kingdom

(1) Three countries – Chile, Jamaica, and Norway – received U.S. HEU from other countries, not directly exported from the United States.

Table 2

Requests to Use U.S.-Supplied HEU
for Purposes Other Than What Was Originally Authorized

Country	Original use	New use
Japan	KUHFR	KUR
	KUHFR	KUR
	KUHFR	KUR
	JMTR	JRR-4
	KUHFR	KUR
	KUHFR	KUR
	KUHFR	KUR
	KUHFR	samples
	YAYOI	Down blend
Argentina	RA-3 &RA-6	Down blend
South Africa	SAFARI	Storage
Canada	Chalk River	Dounreay

Total U.S. HEU 112.5 kg

KUHFR = Kyoto University high Flux research Reactor
KUR = Kyoto University Reactor
JMTR = Japan Material Test Reactor
JRR-4 = Japan Research Reactor #4
YAYOI = Research Reactor located in Japan
RA-3 = Argentina Research Reactor #3
RA-6 = Argentina Research Reactor #6
SAFARI = South African Research Reactor
Chalk River = Canadian nuclear site
Dounreay = United Kingdom nuclear site
Down blend = convert HEU into LEU

Note: The NRC did not locate records indicating whether these 13 requests for alternative uses were approved by the U.S. Government or whether the HEU was in fact used for the requested alternative use.

Table 3

Exports of U.S. HEU
Used As Fuel or Targets in a Nuclear Research or Test Reactor

Year	Total (kg)	Year	Total (kg)
1957	26.34	1991	180.27
1958	13.68	1992	55.66
1959	18.12	1993	-
1960	59.01	1994	-
1961	282.91	1995	-
1962	333.76	1996	-
1963	354.65	1997	-
1964	806.88	1998	0.48
1965	2,493.61	1999	22.50
1966	1,481.67	2000	50.73
1967	2,676.97	2001	90.99
1968	850.92	2002	19.97
1969	1,238.62	2003	79.27
1970	1,013.79	2004	14.94
1971	2,204.84	2005	15.19
1972	740.65	2006	100.03
1973	713.98	2007	30.47
1974	293.87	2008	17.46
1975	299.69	2009	-
1976	549.80	2010	93.01
1977	1,313.30	2011	7.46
1978	457.58	2012	196.12
1979	343.78	**Total**	**22,611.91**
1980	454.86		
1981	532.60		
1982	392.31		
1983	144.42		
1984	165.52		
1985	164.11		
1986	376.52		
1987	0.27		
1988	355.97		
1989	246.15		
1990	236.21		

Table 4

Imports of U.S. HEU
Used As Fuel or Targets in a Nuclear Research or Test Reactor

(HEU returned to the United States)

Year	Total (kg)	Year	Total (kg)
1957	-		
1958	1.67	1991	0.65
1959	-	1992	-
1960	4.25	1993	-
1961	3.89	1994	18.66
1962	2.09	1995	14.25
1963	22.00	1996	43.66
1964	62.86	1997	162.65
1965	35.11	1998	140.99
1966	109.50	1999	183.65
1967	268.90	2000	118.45
1968	89.84	2001	150.44
1969	13.88	2002	114.59
1970	63.47	2003	105.75
1971	443.18	2004	12.94
1972	736.65	2005	91.08
1973	434.68	2006	104.27
1974	344.98	2007	106.15
1975	174.20	2008	77.48
1976	384.24	2009	17.42
1977	172.88	2010	63.99
1978	846.56	2011	6.69
1979	204.94	2012	85.60
1980	217.21	Total	**7,691.33**
1981	292.70		
1982	252.75		
1983	163.19		
1984	120.02		
1985	155.47		
1986	126.68		
1987	174.77		
1988	111.97		
1989	37.22		
1990	0.22		

Figure 1

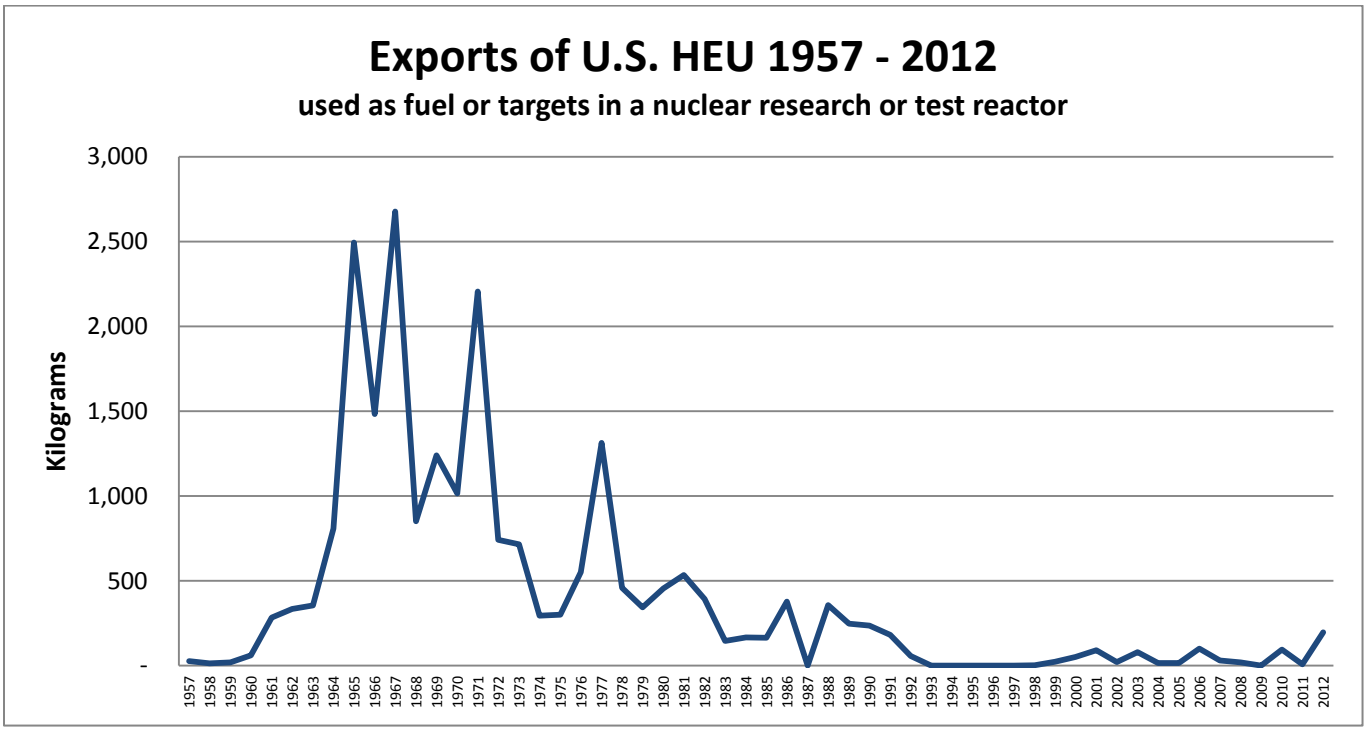

Figure 2