Report to the President
and the U.S. Congress
Under Public Law 109-58,
The Energy Policy Act of 2005

The 2018 Radiation Source Protection and Security Task Force Report

Submitted by:
The Chairman of the U.S.
Nuclear Regulatory Commission

On Behalf of:
The Radiation Source Protection
and Security Task Force

Executive Summary

The *Energy Policy Act of 2005* (EPAct) [EPAct 2005] established the Interagency Task Force on Radiation Source Protection and Security (hereafter referred to as the "Task Force") to evaluate and provide recommendations to the President and Congress relating to the security of radioactive sources in the United States from potential terrorist threats. These threats include acts of sabotage, theft, or use of a radioactive source in a radiological dispersal device or radiation exposure device. The Task Force presented its initial report to the President and Congress in 2006 [NRC 2006] and has continued to provide reports every 4 years consistent with the EPAct [NRC 2010, NRC 2014b]. Like the reports that precede it, this report includes a discussion of accomplishments of the Task Force and its member agencies over the past 4 years, as well as the status of actions underway by the Task Force to provide further assurance of the security of sources in all stages of their life cycle.

In preparation for this report, the Task Force evaluated the specific topics identified in the EPAct, including the list of radioactive sources that warrant enhanced protection, mechanisms for the safe storage and ultimate disposal of radioactive sources, transportation security, source tracking, import and export, and ways to facilitate the use of alternative technologies to replace radioactive sources, as appropriate. Based on its evaluation, the Task Force concluded that there are no significant gaps in the area of radioactive source protection and security that are not already being addressed through continued attention by appropriate Task Force agencies. Notwithstanding, the Task Force remains engaged in activities to address ongoing challenges involving end-of-life management of risk-significant sources.

During this report cycle, the Task Force completed four recommendations from previous reports, leaving only seven ongoing recommendations from the 2006, 2010, and

MEMBERS OF THE TASK FORCE AS MANDATED BY THE ENERGY POLICY ACT

- *Chairman of the U.S. Nuclear Regulatory Commission (Chair)*
- *Secretary of Homeland Security*
- *Secretary of Defense*
- *Secretary of Energy*
- *Secretary of Transportation*
- *Attorney General*
- *Secretary of State*
- *Director of National Intelligence*
- *Director of the Central Intelligence Agency*
- *Administrator of the Federal Emergency Management Agency*
- *Director of the Federal Bureau of Investigation*
- *Administrator of the U.S. Environmental Protection Agency*

OTHER INVITED DEPARTMENTS, OFFICES, AND ORGANIZATIONS

- *U.S. Department of Health and Human Services*
- *Office of Science and Technology Policy*
- *Organization of Agreement States*[1] *(nonvoting member)*

[1] Agreement States are States that have entered into formal agreements with the U.S. Nuclear Regulatory Commission (NRC), pursuant to Section 274 of the *Atomic Energy Act of 1954* (AEA) (Public Law 83-703), to regulate certain quantities of AEA material at facilities located within their borders [AEA 1954]. Under the Act, the NRC relinquishes portions of its regulatory authority to license and regulate byproduct materials (radioisotopes), source materials (uranium and thorium), and certain quantities of special nuclear materials to Agreement States. With the Commission's recent approval of an agreement with the State of Wyoming, there are now 38 Agreement States.

2014 reports.[2] In addition, the Task Force has completed several important accomplishments over the course of the past 4 years. These include:

- The U.S. Department of Energy (DOE) completed the "Final Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste and GTCC-Like Waste" (Final EIS) and submitted the Report to Congress identifying and describing the alternatives under consideration for the disposal of greater-than-Class-C (GTCC) low-level radioactive waste, as required by Section 631 of the EPAct. Although the Final EIS and Report to Congress do not constitute a final decision on disposal of GTCC low-level radioactive waste, their completion represents a major accomplishment in progress toward establishing a disposal pathway for certain risk-significant radioactive sources. See Chapter 2 for more details.

- The NRC issued certificates of compliance to DOE's National Nuclear Security Administration for two new transportation packages—the Model 435-B container in 2014 and the Model 380-B container in 2017. Together, the new containers will help to enable shipment of nearly all commercially used devices containing high-activity cobalt-60 and cesium-137 radioactive sealed sources.

- The National Science and Technology Council (NSTC) Interagency Working Group on Alternatives to High-Activity Radioactive Sources completed its best practices guide for Federal agencies. The guide provides measures that Federal agencies can consider to facilitate the transition to alternative technologies in their long-term strategic planning in a way that meets technical, operational, and cost requirements [NSTC 2016].

- The United States continued to elevate the international radioactive source safety and security framework. For example, the Nation continues to support International Atomic Energy Agency (IAEA) efforts to encourage Member States to make a political commitment to act in accordance with the IAEA "Guidance on the Import and Export of Radioactive Sources" (Import/Export Guidance), issued in March 2005 [IAEA 2005] and updated in May 2012 [IAEA 2012]. In addition, the United States was instrumental in finalizing Supplementary Guidance to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, "Guidance on the Management of Disused Radioactive Sources," issued in April 2018 [IAEA 2018].

The Task Force continues to focus on actions to advance end-of-life management for risk-significant radioactive sources through efforts to establish expanded disposal capability and to identify opportunities to leverage best practices for the management of sources once they become disused. The Task Force also continues to focus on efforts to advance the research, development, and use of alternative technologies to replace radioactive sources, as appropriate; and coordinate strategies to enhance the protection of radioactive sources from potential cybersecurity threats. These actions will provide an enhanced level of protection and security for risk-significant sources, beyond the regulations currently in place.

The report is divided into three chapters that detail advances in the security and control of radioactive sources, the status of the recovery and disposition of radioactive sealed sources,

[2] To call attention to the efforts of the Task Force in advancing the security of radioactive sources, text boxes throughout the report describe the recommendations completed during the 2014–2018 cycle. Appendix I to this report presents a table identifying the specific recommendations that remain ongoing, as well as those that were closed during this report cycle.

and progress in the area of alternative technologies. Collectively, these chapters substantiate the Task Force's conclusion that substantial progress has been made since the events of September 11, 2001, to enhance the protection of radioactive sources from terrorist threats, and that there are no significant gaps in the area of radioactive source protection and security that are not already being addressed through continued attention by the appropriate Task Force agencies.

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Chapter 1: Advances in the Security and Control of Radioactive Sources

During this report cycle, the Radiation Source Protection and Security Task Force (Task Force) assessed the need for changes to the list of radioactive sources and thresholds that warrant additional protection. The Task Force determined that both the list and the thresholds remain appropriate as the framework for identifying those sources that warrant enhanced protection. Currently, this threshold includes Category 1 and Category 2 quantities of material identified in Title 10 of the Code of Federal Regulations (10 CFR) Part 37, "Physical Protection of Category 1 and Category 2 Quantities of Radioactive Material," Appendix A, "Category 1 and Category 2 Radioactive Materials" [NRC 2013]. The Task Force also assessed existing strategies to protect against the use of a radioactive source in a terrorist event, including consideration of the security of sources in use, storage, and transit. Task Force agencies have made progress in evaluating the vulnerability of radioactive materials to theft as a result of cyber attacks and assessing the need for further measures to protect sources in international commerce. While the Task Force determined that current measures for the security and control of radioactive sources are appropriately protective of risk-significant quantities of radioactive material, Task Force agencies are pursuing actions to communicate best practices in these areas in the interest of continuous improvement. The Task Force also continues to focus on efforts to identify strategies for the timely management of sources once they become disused.

I. Reevaluation of Radioactive Source Lists

In 2006, the Task Force recommended that the U.S. Government periodically reevaluate the list of radioactive sources that warrant enhanced security and protection to assess its adequacy in light of the evolving threat environment [2006 Recommendation 3-1]. In its 2010 report, the Task Force presented the results of the reevaluation of the list of sources and associated thresholds that are to be used by the U.S. Government as the appropriate framework for considering which sources warrant enhanced security and protection. For the 2014 Task Force report, the Task Force considered whether a full reevaluation was necessary based upon review of key factors: changes in the threat environment and gathered intelligence, changes in isotope production, changes in isotope usage, and changes in primary consequences of concern. To formalize this review process, changes were made to the Task Force Charter to document the factors described above that will be considered for each subsequent reevaluation. Formalizing the reevaluation process for this and future work allowed the Task Force to close 2006 Recommendation 3-1 in 2014, as this requirement is now contained within and directed by the Task Force Charter.

In preparing its 2018 report, the Task Force reviewed and considered key factors to determine whether changes to the list of radioactive sources or threshold levels are warranted. Although the United States still faces a general threat of terrorism using radioactive sources, the Task Force did not find any specific threat against a specific target in this reporting period. The

consequences of concern to the United States that were referenced in 2010 Recommendation 1,[3] namely prompt fatalities and deterministic effects (based on the International Atomic Energy Agency "Code of Conduct on the Safety and Security of Radioactive Sources," or Code of Conduct [IAEA 2004]) with additional consideration of economic consequences, remain valid. Finally, the global use of radioactive sources has remained stable both in terms of isotopes and quantity such that the addition of radionuclides or changes in thresholds for the existing list are not justified at this time. The Task Force will continue to monitor the threat environment and global production, use, and commercial availability of radioactive sources, and should changes occur, member agencies will take prompt action to reevaluate the source list as appropriate.

II. Security Measures and Initiatives

Licensees possessing risk-significant radioactive material continue to implement the physical security requirements in 10 CFR Part 37, which became effective on May 20, 2013. U.S. Nuclear Regulatory Commission (NRC) licensees were to implement the requirements by March 19, 2014, and the Agreement States adopted adequate and compatible 10 CFR Part 37 requirements by March 19, 2016. Upon implementation of 10 CFR Part 37 by NRC licensees and compatible requirements by Agreement State licensees, the NRC and Agreement States rescinded orders and applicable license conditions that had been put in place following the attacks of September 11, 2001. As of this report, all such orders and applicable license conditions have been rescinded as requirements have been developed and implemented for the approximately 1,300 licensees possessing risk-significant quantities of radioactive material (i.e., Category 1 and Category 2 quantities).

AGENCY-SPECIFIC PROTECTION STRATEGIES

In 2018, Task Force member agencies confirmed completion of 2010 Recommendation 2, which states the following:

The Task Force recommends that the U.S. Government agencies should reevaluate their protection and mitigation strategies to protect against [a] significant [radiation exposure device] RED or [radiological dispersal device] RDD attack using both potential severe immediate or short-term exposure and contamination consequences to public health, safety, and the environment as the consequences of concern. Agencies should use the Task Force-endorsed definitions, radionuclides, and thresholds for a significant RED and RDD and the associated assumptions and parameters as common guidance in the assessment of risk and management of homeland security activities.

In completing this action, agencies considered the Task Force definitions of "significant radiation exposure device" and "significant radiological dispersal device" and reevaluated established protection and mitigation strategies, as appropriate.

The NRC and Agreement State regulators continue to routinely inspect licensees to ensure they are meeting security requirements that provide for reasonable assurance of adequate protection

[3] 2010 Recommendation 1: The Task Force recommends that U.S. Government agencies use the radionuclides and the associated Category 2 threshold quantities in Table II, "Radionuclides that Warrant Enhanced Security and Protection" (as shown on page 11 of this [the 2010] report), as the appropriate framework for considering which sources warrant enhanced security* and that they adopt the definitions for a significant RED and a significant RDD (as shown on page 8 of this [the 2010] report) for prioritizing and allocating resources to eliminate, control, or mitigate risks of malevolent radiological incidents.
*By "warrants enhanced security and protection" is meant enhanced in comparison to the security and protection applied to radioactive sealed sources before September 11, 2001.

against theft or diversion of risk-significant radioactive sources in the United States. In 2016, the NRC completed a comprehensive evaluation of the effectiveness of 10 CFR Part 37 for NRC licensees. Specifically, Section 403(a) of Division D of the *Consolidated and Further Continuing Appropriations Act, 2015* (Public Law 113-235) [CFCAA 2014] directed development of a report by the NRC that evaluates the effectiveness of the requirements of 10 CFR Part 37 considering inspection results and event reports from the first 2 years of implementation of 10 CFR Part 37 for NRC licensees. The NRC expanded the scope of the review beyond the congressionally mandated review areas to perform a comprehensive, integrated review of the rule's effectiveness and to consider relevant insights and recommendations, such as those made by the U.S. Government Accountability Office (GAO) in its performance audits, GAO-12-925, "Nuclear Nonproliferation: Additional Actions Needed to Improve Security of Radiological Sources at U.S. Medical Facilities" [GAO 2012], and GAO-14-293, "Nuclear Nonproliferation: Additional Actions Needed to Increase the Security of U.S. Industrial Radiological Sources" [GAO 2014]. Through this evaluation, the NRC determined that the requirements in 10 CFR Part 37 are effective in that they provide reasonable assurance of adequate protection in ensuring the security of risk-significant radioactive sources during use, storage, and transport when implemented appropriately by licensees.[4] An analysis of events as part of this review demonstrated that there was a limited number of thefts that have occurred since the issuance of the security orders in comparison to the number that occurred prior to the security orders.[5] In all the events, carelessness or human error contributed to the thefts, and had the existing regulatory requirements in effect for the storage and control of the licensed material been followed, the thefts could likely have been prevented. The security orders and 10 CFR Part 37 have enhanced the level of protection against theft and diversion of risk-significant radioactive materials by minimizing the opportunities for these acts to occur.

Notwithstanding the determination that the existing regulatory requirements are effective, the NRC concluded that enhancements to the rule and guidance, both of which are currently under development, could improve the clarity of the rule and consistency in its implementation. The NRC also determined that licensees would benefit from further outreach to explain common implementation issues related to 10 CFR Part 37 identified by the NRC staff. To achieve this end, on January 22, 2018, the NRC issued Regulatory Issue Summary 2018-01, "Common Violations Cited During First 2 Years of 10 CFR Part 37, 'Physical Protection of Category 1 and Category 2 Quantities of Radioactive Material,' Implementation and Guidance Documents Available to Support Rule Implementation" [NRC 2018].

Consistent with its mission to advance the Nation's protection against radiological terrorism, the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) continues to implement voluntary enhancements to augment the security of radioactive sources. To date, nearly 575 licensees (representing almost 950 buildings containing risk-significant sources) have partnered with DOE/NNSA to upgrade their physical security measures. These upgrades are complementary to, but do not replace, 10 CFR Part 37 security requirements, which provide for reasonable assurance of adequate protection. Rather, the upgrades provide additional

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[4] The NRC transmitted its report on the effectiveness of 10 CFR Part 37 to Congress on December 14, 2016. Additional information about the program review and the report to Congress can be found at https://www.nrc.gov/security/byproduct/10-cfr-part-37-program-review.html [NRC 2017c].

[5] Thefts and losses of Category 1 and 2 sources have been rare. Since May 2006 (when the security orders went into effect), there have been no thefts of Category 1 quantities of radioactive material and six thefts of Category 2 quantities of radioactive material. Of these six reported thefts, five of the sources were recovered and returned to the licensee. The source that was not recovered decayed below the threshold deemed risk-significant.

protection beyond that required for compliance with the requirements in 10 CFR Part 37. DOE/NNSA has advanced its efforts to offer voluntary security enhancements and replacement of sources with alternative technologies through its 2020 Cities Initiative, which prioritizes radioactive source security enhancements in major cities where the effects of radiological terrorism would likely be most acute. DOE/NNSA also offers additional security enhancements for mobile sources used in well logging and industrial radiography and takes steps to further integrate local law enforcement into radiological theft response planning, training, and alarm monitoring services to facilitate a cohesive response to potential theft events. Security controls and equipment provide reasonable assurance of protection against the illicit use of radioactive materials; however, the use of alternative technologies, where feasible, provides permanent risk reduction. DOE/NNSA has ongoing efforts to reduce the number of cesium-137 sources in use in the United States by offering incentives to replace the sources with nonradioisotopic alternatives.

A. Tracking and Licensing Support for the Radioactive Source Security Program

The National Source Tracking System (NSTS),[6] the Web-Based Licensing (WBL) System,[7] and the License Verification System (LVS),[8] which comprise the NRC's Integrated Source Management Portfolio, continue to be the information technology systems used by the regulators (NRC and Agreement States) and licensees to support the national radioactive source security program. NSTS contains details on over 80,000 individual sealed sources and records more than 1,000 source transactions per week.[9] The NRC routinely shares NSTS data with its Federal partners, specifically the Federal Bureau of Investigation (FBI) and the U.S. Department of Homeland Security (DHS), to enhance the Nation's capability to respond to emergency events that affect risk-significant radioactive sources. Licensees continue to verify the inventory of sources captured in the NSTS annually and reconcile that information with their current records per the NRC regulation in 10 CFR 20.2207, "Reports of Transactions Involving Nationally Tracked Sources." DOE continues to report Category 1 and 2 radioactive source transactions between DOE and the NRC and Agreement State licensees, exports, and imports to the NSTS and completes the verification and reconciliation of DOE inventory information with the NSTS annually. Reporting and documenting Category 1 and 2 radioactive sealed source transactions in NSTS as transactions occur have strengthened the accountability for risk-significant radioactive sources throughout each of the life-cycle stages—manufacture, shipment, receipt, disassembly, and end-of-life disposal.

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6 The NSTS is a secure computer system that provides accountability for risk-significant radioactive sources from the time they are manufactured or imported through the time of their disposal or export, or until they decay to below a Category 2 quantity. NSTS transactions include manufacture, receipt, transfer (shipment), disassembly, and disposal of Category 1 and 2 radioactive sealed sources.

7 The WBL system is an up-to-date repository of NRC and Agreement State licenses that authorize possession of Category 1 and 2 quantities of radioactive materials.

8 LVS is used by radioactive materials licensees, such as manufacturers and distributors, to confirm, with the regulatory agency that issued the license, that a license is valid and that a licensee (often a customer) is authorized to acquire the quantities and types of radioactive materials being requested. LVS performs automated verification checks using data that reside in the WBL system and the NSTS, which enables the licensee to determine if the requested material is authorized.

9 Information related to source tracking in the NSTS can be found on the NRC's Integrated Source Management Portfolio Web site at https://www.nrc.gov/security/byproduct/ismp.html [NRC 2017e].

The NRC and Agreement States have undertaken activities to ensure that the source security and accountability infrastructure continues to be adequate to protect public health and safety and maintain common defense and security. Specifically, the area of licensing has been of particular interest. On July 15, 2016, the GAO published a report documenting the results of a radioactive material licensing audit and investigation in GAO-16-330, "Nuclear Security: NRC Has Enhanced the Controls of Dangerous Radioactive Materials, but Vulnerabilities Remain" [GAO 2016]. After analyzing the findings and recommendations in GAO-16-330, the NRC enhanced the radioactive materials licensing program, particularly by revising the existing 2008 prelicensing guidance used by the NRC and Agreement States to provide a basis for confidence that radioactive material will be used as specified in a license. The NRC is also considering actions to address concerns related to individuals obtaining a valid license by using a fictitious company or by providing other false information. The NRC staff updated the Commission on its activities and actions on February 17, 2017, in SECY-17-0025, "Update on Source Security and Accountability Activities" [NRC 2017a], and subsequently presented recommendations to the Commission related to materials safety and security in SECY-17-0083, "Re-Evaluation of Category 3 Source Security and Accountability in Response to SRM-COMJMB-16-0001," dated August 18, 2017 [NRC 2017b].

B. Cybersecurity

In 2014, the Task Force recommended that U.S. Government agencies assess the adequacy of, and coordinate strategies for, preventing and mitigating cybersecurity vulnerabilities related to Category 1 and 2 radioactive sources [2014 Recommendation 1]. The Task Force agencies have made progress on this recommendation, which remains ongoing pending completion of further agency-specific initiatives relating to cybersecurity for licensees that possess risk-significant quantities of radioactive material.

On May 11, 2017, the DHS role in strengthening the security and resilience of Federal networks and the Nation's critical infrastructure, including Federal computer networks, was reaffirmed when the President signed Executive Order (EO) 13800, "Strengthening the Cybersecurity of Federal Networks and Critical Infrastructure" [EO 2017]. In addition to directing agencies to implement the National Institute of Standards and Technology Cybersecurity Framework [NIST 2014] for risk management, the EO also enhanced the ability of DHS to support owners and operators in their efforts to strengthen cybersecurity critical infrastructure. This includes coordinating with other departments and agencies to identify Federal resources and capabilities best suited to protect critical infrastructure where a cybersecurity incident could have catastrophic effects. The cybersecurity of nuclear and radioactive materials, as part of the Nuclear Critical Infrastructure Sector defined in the National Infrastructure Protection Plan, is key to the security and resilience of the Nation as a whole. Activities in this area are connected by the Sector Partnership Model managed by the Nuclear Sector-Specific Agency, as well as the National Cybersecurity and Communications Integration Center - DHS' cybersecurity situational awareness, incident response, and management center.

In 2017, the NRC completed its evaluation of cybersecurity for licensees possessing risk-significant quantities of radioactive material. In conducting this evaluation, the NRC and the Agreement States examined the potential consequences if the availability, integrity, or confidentiality of digital assets associated with physical protection, information and records management, and emergency response were compromised. In addition, the NRC evaluated the consequences if devices or equipment containing risk-significant quantities of radioactive material were compromised by a cyberattack under specific scenarios. From this evaluation,

the NRC concluded that risk-significant radioactive materials licensees do not rely solely on digital systems to ensure either safety or physical protection. Rather, these licensees employ a suite of measures, such as doors, locks, barriers, human resources, and operational processes, to ensure security, reflecting a defense-in-depth approach to physical protection of risk-significant quantities of radioactive material and associated equipment or systems. Further, the NRC determined that a compromise of any of the digital assets would not result in a direct dispersal of risk-significant quantities of radioactive material or exposure of individuals to radiation, without a concurrent and targeted breach of the physical protection measures in force for these licensees.[10] Although 10 CFR Part 37 does not specifically address cybersecurity requirements, for areas in which a licensee may rely on digital devices and systems (monitoring, detection, assessment, and response), the rule includes provisions that ensure the presence and availability of a reliable and independent secondary system, device, or process to perform the functions that the primary system is designed to perform should it happen to fail. The NRC concluded that the implementation of 10 CFR Part 37 provides reasonable assurance of security from the potential consequences of a cyberattack and determined that additional regulatory changes were not warranted. In an effort to leverage best practices developed for other facility types and to enhance licensee awareness and protection against cybersecurity vulnerabilities, the NRC is developing a generic communication to relay effective cybersecurity practices for licensees' consideration.

Additionally, DOE/NNSA is analyzing, from a cybersecurity perspective, those facilities that have received voluntary security enhancements to ensure that cybersecurity vulnerabilities are not introduced to partner sites and to determine appropriate risk-reduction strategies. DOE/NNSA is also analyzing potential vulnerabilities that could be posed by a blended cyber/physical attack on such a facility and best practices that would help sites mitigate potential cyber vulnerabilities. The primary cybersecurity scenarios being considered by DOE/NNSA include a cyberattack overriding a facility's existing network controls and physical security measures, facilitating a physical attack that could result in theft of radioactive sources; exploitation of digital assets to gain access to a site's network(s) to carry out a cyberattack (e.g., installing ransomware or stealing proprietary or other sensitive information); and use of social engineering (e.g., phishing e-mails or phony Web pages) to exploit unknowing insiders to gain access to physical security systems, networks, and related subsystems without the need to hack or conduct a cyberattack using cyber tools. The goal of this effort is to promote cybersecurity best practices, which will be informed by the results from the pilot cybersecurity reviews.

Task Force member agencies will continue to coordinate cybersecurity strategies and actions such as the sharing of best practices and training materials, as well as the coordination of outreach efforts with Federal and State partners and stakeholders. In addition, the Task Force will leverage, as appropriate, and not be duplicative of, the efforts associated with ongoing Federal initiatives such as EO 13800. As a result of the many initiatives related to cybersecurity

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[10] The scope of the evaluation of cybersecurity included industrial, medical, and academic licensees possessing risk-significant radioactive material. For medical applications, the assessment was limited to an evaluation of software systems used by the radiation safety and physical protection authority and activities of the U.S. Food and Drug Administration (FDA) to ensure that software systems inherent to the operation of medical treatment devices (e.g., software controlling length of treatment time or treatment locations) are both safe and effective. Descriptions of FDA's activities, role, and expectations for continued cybersecurity of medical devices can be found at https://www.fda.gov/downloads/medicaldevices/digitalhealth/ucm544684.pdf [FDA 2017].

being pursued by Task Force member agencies, 2014 Recommendation 1 remains ongoing, pending completion of the above-described activities.

III. Transportation Security

The IAEA Implementing Guide, "Security in the Transport of Radioactive Material," Nuclear Security Series No. 9 [IAEA 2008], states that radioactive material is most vulnerable during transport. The U.S. Government and its international counterparts have worked to increase the security of facilities that use risk-significant quantities of radioactive materials, as well as the security of those sources while in transit. Since 2014, initiatives have been completed or are well underway to improve the transport security of radioactive sources, as described below.

In an effort to ensure appropriate focus on radiological material shipments and response to emergency events, DOE/NNSA and the FBI cosponsor a series of tabletop exercises (Isotope Crossroads) that are designed to promote interagency communication and situational understanding in support of radiological transport. The exercises are 1-day events that include representatives from a State's law enforcement, emergency operations, radiological health, and transportation agencies, as well as DHS, the NRC, and motor carriers (e.g., FedEx, DHL Express). Since 2014, DOE/NNSA and the FBI have conducted 17 Isotope Crossroads tabletop exercises.

COOPERATION ON TRANSPORT SECURITY

During this report cycle, the Task Force completed a key recommendation related to interagency transport security cooperation—namely, 2006 Recommendation 5-1, which states the following:

The Task Force recommends development of a Transport Security Memorandum of Understanding to serve as the foundation for cooperation in the establishment of a comprehensive and consistent transport security program for risk-significant sources.

The memorandum of understanding (MOU) for the secure transport of radioactive material was completed and signed in January 2015. The parties to the MOU are DHS, the U.S. Department of Transportation (DOT), and the NRC. The goal of the subject MOU is to ensure that the transportation of radioactive material in the United States and across U.S. borders is carried out in a secure manner that protects the public health and safety and does not impact the common defense and security of the Nation.

In addition, Task Force agencies have advanced the state of science in transport security. Specifically, DOE/NNSA has developed a system that combines real-time tracking of shipments with a cargo/container intrusion detection system to improve the security of materials in transport. Equipped with redundant communication systems, the T-STAR (Transport—Security, Tracking, and Report) system is designed to enhance response through early detection, assessment, and communication of an abnormal event. DOE/NNSA is working to make this technology, which can be installed on any type of conveyance, available to the industry. In addition, DOE/NNSA has partnered with industry to enhance the security of mobile radiography cameras and well-logging sources by adopting a tracking system that provides notification of the source's location while in storage, in transit, and in the field (the Mobile Source Transit Security System).

IV. Import and Export Controls

The U.S. Government continues to promote the implementation of the IAEA "Guidance on the Import and Export of Radioactive Sources," (Import/Export Guidance) issued in March 2005 [IAEA 2005] and updated in 2012 [IAEA 2012]. The U.S. Government was instrumental in developing the Import/Export Guidance, which is the only international export control framework for radioactive sources. Promoting the implementation of the Import/Export Guidance is a U.S. priority because it provides the basis for improving the security of legitimate cross-border transfers of sources and preventing the diversion of materials potentially usable in a radiation exposure device or a radiological dispersal device. As of March 2018, 113 nations, including the United States, have made a political commitment to act in accordance with the Import/Export Guidance, up from 90 nations in 2014. The United States continues to maintain an active role in assisting and cooperating bilaterally and coordinating with IAEA on matters related to the safe and secure use of radioactive sources. For example, the United States encourages coordination and appropriate information sharing among IAEA Member States and encourages Member States to make political commitments in support of the Code of Conduct and its supplementary guidance in several international forums. Such forums have included the IAEA annual Code of Conduct review meeting, a German-sponsored international workshop on the effectiveness of the Code of Conduct in September 2016, and the IAEA international conferences on nuclear security. The United States continues to assist partner countries in the development and maintenance of national radioactive source registries. These efforts to improve accounting for radioactive sources have resulted in countries recovering abandoned or legacy radioactive sources.

V. End-of-Life Management

In 2006, the Task Force established a recommendation (2006 Action 10-2) for the U.S. Government to encourage suppliers to provide arrangements for the return of sources once they become disused and to examine means to reduce regulatory impediments that made that option unavailable. At the time, the recommendation focused on return to supplier within the context of imports and exports of radioactive material. While the Task Force has made progress in this area since 2006, further work remains to ensure that strategies have been fully considered to optimize end-of-life management for risk-significant sources in the United States, regardless of the sources' origins.

As acknowledged in the Executive Summary of this report, the United States was instrumental in finalizing Supplementary Guidance to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources, "Guidance on the Management of Disused Radioactive Sources." The United States participated in consultations with other IAEA Member States since October 2014 to draft the guidance and achieve alignment on its contents. The guidance, ultimately endorsed by the IAEA policymaking bodies in September 2017, contains specific, nonlegally binding guidance for IAEA Member States on managing their disused sources. IAEA is encouraging all Member States to make a political commitment in support of, and to act in accordance with, the guidance. Task Force member agencies are currently reviewing the guidance to recommend whether the United States should make such a commitment to the new guidance.

Notwithstanding the outcome of that process, given the continued challenges discussed in Chapter 2 regarding the recovery and disposition of radioactive sources and the importance of effective end-of-life management of radioactive sources, the Task Force members will continue to assess strategies for end-of-life management for risk-significant radioactive sources.

Potential areas of focus include evaluating the feasibility, benefits, and challenges of additional interagency efforts to reduce the number of sources in storage and the number of sources that meet the criteria for recovery through DOE/NNSA's Off-Site Source Recovery Program (OSRP). Due to continuing efforts in these areas, 2006 Action 10-2 remains ongoing. These efforts will complement actions being taken to facilitate the management and disposition of sealed sources described in Chapter 2.

Chapter 2: Status of the Recovery and Disposition of Radioactive Sealed Sources

During this report cycle, Task Force member agencies continued to make progress in increasing commercial disposal options for most Class A, B, and C sealed sources and in addressing a lack of transportation and disposal options for sealed sources with the highest activity. The NRC staff completed a scoping study and rulemaking plan that recommends to the Commission that the financial assurance requirements in 10 CFR 30.35, "Financial Assurance and Recordkeeping for Decommissioning," be expanded to include all Category 1 and 2 byproduct material radioactive sealed sources tracked in the NSTS. The NRC issued certificates of compliance to DOE/NNSA for the Model 435-B container in 2014 and for the Model 380-B container in 2017. These containers will enable shipment of nearly all commercially used devices containing high-activity cobalt-60 (Co-60) and cesium-137 (Cs-137) radioactive sealed sources. Also, DOE issued the Final Environmental Impact Statement addressing disposal of greater-than-Class-C (GTCC) low-level radioactive waste (LLRW) and submitted the Report to Congress as required by Section 631 of the EPAct. Lastly, the NRC issued revised guidance on concentration averaging to provide more flexibility and increased disposal options for higher activity Class B and Class C sealed sources. While progress has been made on these issues, end-of-life source management continues to be an area of focus for the Task Force. Moving forward, DOE will continue its ongoing efforts to develop GTCC LLRW disposal capability, and the Task Force member agencies will continue to evaluate waste disposal options for disused radioactive sealed sources, and to investigate options for disposal of sources recovered from U.S. owners that contain foreign-origin americium or plutonium radioactive material.

I. Management and Disposal of Commercial Disused Sealed Sources[11]

Progress has been made in addressing the commercial sealed source management and disposal challenges in the United States, many of which have been identified in previous Task Force reports. Commercial disposal options for most Class A, B, and C sealed sources are now available, and there has been progress in addressing the lack of transportation and disposal options for the highest activity sealed sources.

Nonetheless, challenges remain. For example, source generators have little incentive to dispose of their disused sealed sources in a timely fashion rather than keeping these sources in storage, potentially until facility decommissioning. In addition, the impact of updated NRC

[11] The IAEA Code of Conduct defines a disused sealed source as "a radioactive source that is no longer used, and is not intended to be used, for the practice for which an authorization has been granted." To meet this definition, a licensee or owner of the sealed source must be clearly identifiable. Disused sealed sources should not be confused with abandoned or "orphan" sources, which are sources identified by regulatory or other authorities for which there is no determinable responsible party. The challenges with regard to orphan sources often overlap with, but are not identical to, the challenges (and solutions) addressed in most of this chapter.

guidance on the disposal of high-activity Class B and C sources has not been evaluated, and as noted later (Section II of this chapter) in the discussion related to the NRC's 2015 "Concentration Averaging and Encapsulation Branch Technical Position" (CA BTP) [NRC 2015], further assessment of the impact of its use is planned. Disposal options are still unavailable for Category 1 and 2 sources that are classified as GTCC LLRW.

A. Progress in Commercial Sealed Source Management and Disposal Since 2014

Since 2012, commercial LLRW generators have had access to commercial disposal at the Waste Control Specialists (WCS) commercial LLRW disposal facility in Texas. Prior to this, licensees in 36 States had no commercial sealed source disposal option, which contributed to an increase in the number of disused sealed sources in storage.[12] However, commercial disposal of higher activity Class B and C sources remained constrained even after the opening of the WCS facility. To help address this constraint and other LLRW disposal challenges, the NRC revised its 1995 "Concentration Averaging and Encapsulation Branch Technical Position" [NRC 1995] in February 2015. In order to classify waste (i.e., Class A, B, C, or GTCC) before disposal, commercial LLRW generators may average the activity of the waste over its volume. In the 2015 revision to the CA BTP, the NRC provided updated guidance to waste generators on how to calculate these averages given the physical and radiological characteristics of the waste. The revisions include increased "generic" radioactivity limits for any LLRW disposal facility licensed under 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," or corresponding Agreement State regulations, as well as provisions that would enable disposal of Class A, B, and C sources above those limits when consistent with public health and safety.

All of the States that regulate commercial disposal facilities (South Carolina, Texas, Utah, and Washington) allow LLRW generators to use part or all of the 2015 CA BTP. The 2015 CA BTP incorporates risk-informed, performance-based approaches that support the disposal of some higher activity sealed sources compared to the 1995 CA BTP. For example, the 2015 CA BTP recognizes that site-specific concentration averaging approaches may be appropriate in certain circumstances. Implementation of the revised 2015 CA BTP should facilitate, in some situations, the commercial disposal of higher activity Class B and C sources at LLRW disposal facilities, thereby reducing the number of disused sources in storage (see Section II of this Chapter for further discussion).

In an effort to further enhance disposal options available to LLRW generators, on June 20, 2014, WCS filed a Petition for Rulemaking with the Texas Commission on Environmental Quality (TCEQ) requesting the State of Texas to revise certain provisions of the Texas Administrative Code to remove prohibitions on disposal of certain wastes, including GTCC LLRW at its TCEQ-licensed facilities. On January 30, 2015, TCEQ sent a letter to the NRC requesting guidance on the State of Texas's authority to license disposal of these wastes. This matter is currently under review by the NRC.

DOE/NNSA, through the Off-Site Source Recovery Program (OSRP), continues to remove risk-significant sources that have the potential to present public health and safety or national

[12] The precise number of disused sealed sources in storage is unknown because licensees that use sealed sources are not currently required to identify or report when their sealed sources become disused.

security concerns, if uncontrolled.[13] While the security requirements of 10 CFR Part 37 provide reasonable assurance against the theft or loss of disused sources, "the longer sources remain disused or unwanted the chances increase that they will become unsecured or abandoned" [NRC 2014a]. Since 2001, as an interim measure to address these concerns, DOE/NNSA's OSRP has recovered over 3,500 Category 1 and 2 sources from across the United States. OSRP recoveries are prioritized according to risk-reduction criteria developed in coordination with the NRC and Agreement States. However, as viable disposal options increase, government involvement in the recovery of disused sources should decrease accordingly. In 2014, the Task Force noted the following:

> Sealed source disposal arrangements between private entities (such as licensed users, brokers, transporters, and disposal facilities) should function efficiently and effectively without government involvement beyond the regulatory frameworks and supporting activities that ensure the security, health, and safety of licensees and the public [NRC 2014b].

In addition to the progress made to further enhance disposal options for LLRW, significant progress has been made in the availability of Type B containers certified to transport high-activity disused sources (usually Class B, C, or GTCC LLRW). Previously, challenges existed in the timely disposal of radioactive sources due to the limited availability of these containers. Changes to 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," in 2004 to align domestic packaging certification requirements with international transport regulations contributed to this limited availability. In 2010 Recommendation 8, the Task Force recommended that the U.S. Government take action to address this issue. DOE/NNSA developed two new transportation containers to meet this challenge (the 435-B and the 380-B), and both containers were certified by the NRC.

The new containers will enable shipment of nearly all commercially used devices containing high-activity Co-60 and Cs-137 (see the text box on this page for additional details). Additionally, DOE is developing a new Type B package design for storage, transport, and disposal of

TYPE B CONTAINERS FOR SOURCE RECOVERY AND TRANSPORTATION

During this report cycle, the Task Force completed actions to enhance the availability of Type B containers to support the recovery and transportation of Category 1 and 2 sources commonly used in commercial applications. These actions completed 2010 Recommendation 8:

The Task Force recommends that the U.S. Government enhance support of short-term and long-term research and development of certified Type B containers for use in domestic and international source recovery efforts.

DOE/NNSA procured vendor services for the design, development, testing, and certification of two new Type B packages: the 435-B and the 380-B. The development, testing, and certification of these containers were completed in 2014 for the 435-B container and in 2017 for the 380-B container. The new containers will enable shipment of nearly all commercially used devices containing high-activity Co-60 and Cs-137.

[13] Through its OSRP, the DOE/NNSA removes risk-significant sources that are disused and unwanted, at the request of NRC and Agreement State licensees. These sources remain under the control of licensees until they are transferred to DOE/NNSA.

disused radiological sources. The package's stainless steel structural components are designed to provide long-term performance against corrosion during dry storage (more than 50 years); thus, it may be possible to subsequently transport the package, without repackaging, directly to a disposal facility. A Safety Analysis Report for the new Type B package design is being prepared for DOE review in 2019.

II. Ongoing Challenges in Commercial Sealed Source Management and Disposal

As noted above, advances have been made in the availability of commercial disposal pathways for sealed sources. Many sources may remain in storage unless generators are compelled to dispose of them in a timely manner. In addition, the most risk-significant sealed sources commonly used in medicine and industry still present disposal challenges once they become disused and unwanted.

With respect to the challenge of timely disposal of risk-significant sealed sources, the 2014 Task Force report noted that current NRC regulations focus on ensuring safety and security of sources whether in storage or disposal and therefore provide only limited incentive for LLRW generators to dispose of sealed source waste in a timely fashion. Unlike many types of nonsealed source LLRW, disused sealed sources require only limited storage space or in-storage maintenance. In addition, disposal of sealed sources is costly; time and funding are required for packaging, transportation, and burial at a licensed commercial LLRW disposal facility. Without incentives, licensees that use sealed sources may delay initiating these activities. Although risk-significant quantities of radioactive material are subject to the physical protection requirements established in 10 CFR Part 37, additional measures may help to encourage more timely disposal. The Task Force will continue to maintain a focus on options to incentivize the timely disposal of risk-significant sealed sources.

To help address this challenge, the Task Force evaluated options to facilitate the timely disposal of sealed sources. Consistent with 2014 Recommendation 2 (see the text box on the next page), the NRC staff completed its scoping study to assess the need to establish financial assurance requirements for all Category 1 and 2 sealed sources. NRC regulations in 10 CFR 30.35, "Financial Assurance and Recordkeeping for Decommissioning," provide decommissioning funding requirements for byproduct material. However, decommissioning financial assurance is not required for a majority of Category 1 and 2 (and lower category) sources. In addition, these requirements do not address the cost of managing disused Category 1 and 2 sources during operations. Financial assurance requirements addressing disposal of Category 1 and 2 sources could encourage licensees to dispose of disused sources in a timely fashion because the funds for source disposal would have been previously set aside. This would also help users to make more accurate life-cycle cost comparisons with increasingly available nonisotopic alternative technologies. The Task Force acknowledged that while implementation of 10 CFR Part 37 (or compatible Agreement State requirements) provides reasonable assurance that sources are secure in storage, permanent disposal represents the most effective means of risk reduction.

FINANCIAL ASSURANCE REQUIREMENTS FOR THE DISPOSITION OF DISUSED SOURCES

During this report cycle, the Task Force completed the actions associated with 2014 Recommendation 2:

The Task Force recommends that the NRC evaluate the need for sealed source licensees to address the eventual disposition/disposal costs of Category 1 and 2 quantities of radioactive sources through source disposition/disposal financial planning or other mechanisms. Disposition costs should include the cost of packaging, transport, and disposal (when available) of these sources.

In April 2016, the NRC staff completed a scoping study to determine whether additional financial planning requirements were needed for end-of-life management of byproduct material, particularly radioactive sealed sources (see SECY-16-0046, "Results of the Byproduct Material Financial Scoping Study," dated April 7, 2016 [NRC 2016a]). As part of the scoping study, the NRC staff solicited stakeholder input, reviewed current NRC regulations and guidance, and examined relevant internal and external reports. Based on the results of the scoping study, the NRC staff recommended to the Commission in SECY-16-0115, "Rulemaking Plan on Financial Assurance for Disposition of Category 1 and 2 Byproduct Material Radioactive Sealed Sources," dated October 7, 2016 [NRC 2016b], that the financial assurance requirements in 10 CFR 30.35 be expanded to include all Category 1 and 2 byproduct material radioactive sealed sources tracked in the NSTS. In making its recommendations to the Commission, the NRC staff noted that requiring financial assurance for disposition of Category 1 and 2 byproduct material radioactive sealed sources (RSSs) could yield the following benefits:

1. Ensure that licensees possessing these risk-significant RSSs are financially prepared for the costs of end-of-life dispositioning.
2. Complement the existing regulatory framework to ensure safe and secure management of Category 1 and 2 byproduct material RSSs by facilitating timely disposition when these RSSs become disused or unwanted.
3. Help ensure that dispositioning costs are borne by those who receive the associated economic benefits from the use of these sources.

However, the NRC staff also noted that the proposed rulemaking would result in increased regulatory costs, and its implementation would require additional NRC and Agreement State resources. These costs, as well as DOE/NNSA's annual expenditure on its OSRP, should be included in the regulatory analysis conducted during the regulatory basis phase of the NRC's rulemaking process if the Commission approves moving forward with the rulemaking.

Another challenge being considered by the Task Force is the disposal of disused sources exceeding current facility disposal limits. Some common types of sealed sources associated with this challenge include (1) certain high-activity Class B and C sources, (2) sealed sources classified as GTCC LLRW, and (3) certain sealed sources that contain foreign-origin material (e.g., americium-241 (Am-241), plutonium-238 (Pu-238), and plutonium-239 (Pu-239)). The Task Force continues to work on three existing recommendations to address this distinct challenge. Each of the recommendations is discussed respectively in the sections that follow (namely, Chapter 2 Sections II.A, II.B, and II.C), along with progress made in that respective area since the last report.

A. High-Activity Class B and C Sealed Sources

In 2010, the Task Force developed a recommendation to address the lack of available disposal options for high-activity Class B and C sealed sources, including Cs-137 and Co-60 sources used in medical applications such as blood irradiation and cancer treatment.

Specifically, 2010 Recommendation 4 states the following:

> The Task Force recommends that the U.S. Government, regional compacts, and States continue to evaluate disposal options for disused radioactive sources, including options for handling a potentially large number of disused cesium chloride sources that may be replaced once viable alternatives are available.

Since 2014, progress has been made in identifying disposal options for high-activity Class B and C sealed sources through achievements such as the issuance of the 2015 CA BTP, which expands potential commercial disposal options, and in NRC efforts to amend 10 CFR Part 61 to risk-inform the regulation and provide a mechanism to ensure the safe disposal of LLRW while meeting the performance objectives for land disposal of LLRW.

The 2015 CA BTP and Alternative Approaches for Averaging for Disposals

The 2015 CA BTP provides guidance on the disposal of higher activity discrete items, including Cs-137 and Co-60 sealed sources. The BTP increases the "generic" activity limit for disposal of Class C sources containing Cs-137 from 30 curies (Ci) to 130 Ci and includes new provisions to potentially enable the disposal of Cs-137 sources up to the Class C limit of 957 Ci.[14] The 2015 CA BTP also clarifies the 140 Ci "generic" Class A limit for Co-60 sources and stipulates that because of its relatively short half-life, there is no activity limit on the disposal of Co-60 sources as Class B waste.

The 2015 CA BTP includes detailed guidance on "alternative approaches for averaging" that licensees can use to request approval from LLRW disposal facility regulators to dispose of sealed sources that exceed the generic radioactivity levels discussed in the 2015 CA BTP. If approved by the disposal facility regulator, the use of alternative approaches could significantly expand the activity range of Class C sealed sources that are disposed. This could include common Cs-137 devices, such as disused blood and research irradiator sources, with current activities below the 957 Ci Class C limit.

As a pilot implementation of the 2015 CA BTP, DOE/NNSA used the "alternative approaches for averaging" in September 2017 to dispose of sources as Class C LLRW. The device selected for the pilot was a relatively common irradiator model licensed in a State with access to the U.S. Ecology commercial LLRW disposal facility in Washington State. The device contained two Cs-137 source capsules with a combined activity of 563 Ci. The alternative approach justification, developed in coordination with U.S. Ecology, was based on relatively standard features of the device and packaging configuration, as well as relevant disposal facility features, such as depth to disposal and emplacement of the irradiator source within an engineered concrete barrier. The facility regulator, the Washington State Department of Health, approved the disposal, and the device was transported to and disposed of at the U.S. Ecology facility in September 2017.

Although regulator review and approval are required for each proposed disposal, WCS and U.S. Ecology have both indicated that they are likely to be able to accept high-activity Cs-137 sources similar to those disposed of in the DOE/NNSA pilot conducted in September 2017. Due

[14] In 10 CFR 61.55, "Waste Classification," the NRC identifies a Class C limit of 4,600 curies per cubic meter ($Ci/m^{3)}$ for Cs-137. Averaged over the volume of a 55-gallon drum (0.2082 m^3), this results in a total activity of 957.7 Ci (i.e., 4,600 Ci/m^3 x 0.2082 m^3 = 957.7 Ci).

to the updated guidance in the 2015 CA BTP, alternative approach proposals are not necessary for the disposal of common Category 1 and 2 Co-60 sources at these facilities, such as high-activity radiography cameras and teletherapy devices. Both facilities can accept such sources as Class B waste. Table 2-1 summarizes the available commercial disposal options for sealed radioactive sources.

Table 2-1: Commercial Sealed Source Disposal Options

Compact*	# of States	Revised Cs-137 Class C Generic Limit**	Disposal Option
Northwest and Rocky Mountain Compacts	11	130 Ci	Richland
Atlantic Compact	3	10 Ci/130 Ci	Barnwell/WCS***
Texas Compact and All Other States/Compacts	36	130 Ci*	WCS

* The *Low-Level Radioactive Waste Policy Amendments Act of 1985* (LLRWPAA) authorizes States to enter into compacts for the establishment and operation of regional low-level radioactive waste disposal facilities and authorizes Compact States to impose certain restrictions on disposal of LLRW generated outside the compact region.

** The cited generic Class C limits are for Cs-137. Prior to the 2015 CA BTP revisions, the Cs-137 limit was also applied to other common sealed sources, including Co-60.

*** Atlantic Compact generators may dispose of Cs-137 and other common sources up to 10 Ci at the Barnwell facility; these generators also have access to WCS for sealed sources that exceed 10 Ci.

The NRC staff has conducted training on how to implement the 2015 CA BTP guidance, including training for NRC regional inspectors and Agreement State inspectors. The NRC staff expects that the additional flexibility provided by the 2015 CA BTP guidance will increase the availability of commercial high-activity Class B and C sealed source disposal pathways in the future. However, due to the limited use of the new provisions (i.e., alternative approaches) by sealed source licensees to date, the full impact of the 2015 CA BTP in addressing high-activity Class B and C sources is not known. The Task Force will continue to evaluate the impact of the 2015 CA BTP on disposal of these sources, as well as the extent to which it is being used during the coming report cycle, and determine if additional actions are warranted to promote increased awareness and/or further usage of the BTP.

10 CFR Part 61 Rulemaking

In a related effort, and to address 2010 Recommendation 4, the NRC is currently conducting a rulemaking to amend its regulations in 10 CFR Part 61, which govern LLRW land disposal facilities. These amendments would continue to ensure that LLRW can be disposed of safely. The amendments would also increase the use of site-specific information, thereby risk-informing the regulation for the disposal of LLRW, including sealed sources.

The NRC staff submitted a draft final 10 CFR Part 61 rule to the Commission in September 2016. On September 8, 2017, the staff received direction from the Commission in Staff Requirements Memorandum SECY-16-0106, “Final Rule: Low-Level Radioactive Waste Disposal (10 CFR Part 61)” [NRC 2017d], to substantively revise the draft final rule in several key areas, and to gain a more complete understanding from additional stakeholder engagement of the broader and more fully integrated, but reasonably foreseeable, costs and benefits to the

U.S. waste disposal system resulting from the proposed rule changes, including pass-through costs to waste generators and processors. The NRC staff continues to revise the specifics of the rulemaking; however, the staff expects that once complete, the revisions could increase the availability of commercial high-activity Class B and C sealed source disposal pathways.

With the issuance of the 2015 CA BTP and possible amendment of 10 CFR Part 61, the Task Force has made notable progress toward increasing the availability of disposal options for high-activity Class B and C sealed sources. Notwithstanding this progress, 2010 Recommendation 4 remains ongoing, pending completion of further actions in this area, including issuance of the final rule to amend 10 CFR Part 61, efforts to support implementation of the 2015 CA BTP, and continued efforts to communicate national disposal needs for disused sealed radioactive sources to Compacts and States that host LLRW disposal facilities.

B. Disposal of Sealed Sources Classified as GTCC LLRW

Pursuant to the LLRWPAA [LLRWPAA 1985], the Federal Government is responsible for disposal of GTCC LLRW generated by NRC and Agreement State licensees, including sealed sources that are determined to be waste and classified as GTCC LLRW.[15] DOE is the Federal Government agency responsible for GTCC LLRW disposal. Common examples of GTCC LLRW sources are Cs-137 sources greater than 957 Ci and Am-241, Pu-238, and Pu-239 sources greater than 27 millicuries. In 2006, the Task Force developed a recommendation to facilitate disposal capability for GTCC LLRW—namely, 2006 Action 9-1, which states that "The DOE should continue its ongoing efforts to develop GTCC [LLRW] disposal capability." In February 2016, DOE issued its "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (Final EIS).[16] The Final EIS included a preferred alternative for disposal at generic commercial facilities or at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. This preferred alternative could provide a disposal path for many Category 1 and 2 sealed sources.

In addition to completing the Final EIS, in November 2017, DOE submitted the Report to Congress, describing the alternatives considered in the Final EIS and other related information, as required by Section 631 of the EPAct. While the Final EIS and Report to Congress do not constitute a final decision on GTCC LLRW disposal, their completion represents a major accomplishment in progress toward establishing a disposal pathway for certain risk-significant radioactive sources. 2006 Action 9-1 will remain ongoing until DOE issues its Record of Decision.

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15 Pursuant to the LLRWPAA, the Federal Government is also responsible for disposal of LLRW owned or generated by DOE, LLRW owned or generated by the U.S. Navy as a result of the decommissioning of U.S. Navy vessels, and LLRW owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon. The Task Force did not consider challenges related to disposal of this waste. The challenges discussed in this chapter relate to disposal of commercial sealed sources that are classified as Class A, B, C, and GTCC LLRW.

16 Background information about this effort, including the 2016 Final EIS and the submission of the Report to Congress in 2017, can be found at http://www.gtcceis.anl.gov [DOE 2016].

C. Sealed Sources Containing Foreign-Origin Am-241, Pu-238, and Pu-239

Sealed sources manufactured with foreign-origin Am-241, Pu-238, and Pu-239 material present unique disposal challenges. DOE/NNSA has the authority to recover sealed sources under the OSRP; however, the OSRP is not currently recovering foreign-origin Am-241, Pu-238, and Pu-239 sources without an identified path to disposal. Although disposal options under consideration in DOE's Final GTCC EIS may eventually address these sources, they are currently without commercial or Federal options for disposal. The Task Force developed 2010 Recommendation 5 to address this challenge, stating the following:

> The Task Force recommends that Federal and State Governments investigate options such as providing short-term secured storage of sources recovered from U.S. owners that contain foreign-origin americium-241 radioactive material, so that these sources can be recovered now, and increase efforts to investigate options for disposal of these sources.

Since the publication of the 2014 Task Force report, DOE/NNSA has continued to investigate options for disposal of certain radioactive sealed sources that may be recovered by DOE/NNSA for which there is currently no identified disposal path, including foreign-origin Am-241, Pu-238, and Pu-239 sealed sources. This recommendation will remain ongoing as such options are being investigated and pursued.

Chapter 3: Progress in the Area of Alternative Technologies

During this report cycle, the Task Force member agencies have worked to research and assess the viability of alternative technologies, coordinate with industry to share best practices, and develop actionable strategies to support the transition to nonradioisotopic technologies in cases where those technologies meet users' technical, operational, and cost requirements. Specifically, as of July 2018, the DOE/NNSA has completed the replacement of 43 cesium-137 (Cs-137) irradiators for blood and medical research applications with nonradioisotopic devices and has more than 100 additional replacements in progress. In addition, as a result of interagency efforts, awareness of the capabilities and challenges related to alternative technologies in numerous applications has advanced, including internationally. These efforts include the completion of a best practices guide for Federal agencies in 2016 by the National Science and Technology Council (NSTC) Interagency Working Group on Alternatives to High-Activity Radioactive Sources (GARS) [NSTC 2016], as well as public, private, and government coordination on alternative technologies through the DHS Alternative Technology Working Group (ATWG), and international outreach and cooperation bilaterally, through the IAEA, and at the annual Ad Hoc Meeting on Alternative Technologies.

I. Background

In the *Energy Policy Act of 2005* (EPAct) [EPAct 2005], Congress directed the Task Force to identify and recommend "appropriate regulations and incentives for the replacement of devices and processes" that use Category 1 and 2 sealed sources. The EPAct specified alternative technologies or replacement of existing radiation sources with those radiation sources that could pose a lower risk to public health and safety as options to achieve this mandate. The Task Force member agencies have made considerable progress in evaluating the capabilities of, and challenges remaining for implementation of, alternative technologies. Where viable alternatives exist to radioisotopic applications, Task Force member agencies have also advanced the use of nonradioisotopic alternative technologies in an effort to provide permanent risk reduction in the interest of enhancing national security.

As additional progress in the technical, operational, and financial feasibility of nonradioisotopic replacements is made, the Task Force will continue to coordinate its activities to ensure that broad communication on alternative technologies is conducted among Federal agencies, State and local governments, industry, and other impacted organizations, as well as with international partners. The Task Force will also continue its efforts with respect to two specific recommendations related to alternative technologies (2010 Recommendation 9 and 2014 Recommendation 3). Further, the Task Force recognizes the importance of the U.S. Government continuing to pursue strategies to facilitate education and information sharing among appropriate stakeholder organizations including the private sector regarding the status, capabilities, user considerations, and challenges for alternative technology development and implementation. These efforts should use existing mechanisms when possible.

II. Research and Development for Alternative Technologies

The 2008 National Academy of Sciences (NAS) report [NAS 2008] that was mandated by the EPAct[17] identified specific areas where research and development of alternative technologies for cesium chloride (CsCl) and other applications should be pursued. In 2010, the Task Force issued 2010 Recommendation 9, calling for "the U.S. Government [to] enhance support of short-term and long-term research and development for alternative technologies." Since 2014, a wide range of Category 1 and 2 radioactive source replacement technologies has been developed for medical and industrial applications. Examples of technological progress include a superconducting linear accelerator that was developed and validated during this report cycle and is now being utilized in a 5-year plan to develop multiple commercial x-ray sterilization facilities; an FDA approved multiple linear accelerator-based teletherapy device for cancer treatment; and the transition to electronic x-ray devices for blood irradiation away from traditional Cs-137 devices.

Despite these advances, technological, operational, and/or economic challenges with the adoption of alternative technologies remain. For example, the use of nonradioisotopic alternative technologies for well logging has proven to be particularly difficult, due not only to the technical requirements for the application, but also due to operational requirements, such as durability and smaller size constraints. In addition, legacy data issues for well logging applications pose an important challenge (i.e., correlating historical data to the data provided by the potential replacement devices). These and other challenges are the focus of ongoing research and development efforts in both the public and private sectors. Table 3-1 provides a brief summary of current and potential alternative technology research and development projects, including identification of common devices, primary isotopes, and potential replacement technology, along with primary replacement challenges. These challenges may impact all users of the particular application, such as in the well-logging example, or only a subset of the users of the application.

Specific actions are planned with respect to 2010 Recommendation 9 over the coming years. For example, DOE/NNSA will conduct additional research, development, and testing during fiscal years 2018, 2019, and 2020 to advance the development of alternative technologies. DOE/NNSA will also perform analyses to identify the remaining technological gaps that prevent the adoption of alternative technologies in specific applications, as appropriate (e.g., industrial radiography and industrial sterilization). Because further efforts are underway to research alternative technologies and address challenges that currently impede the use of alternative technologies in specific applications, 2010 Recommendation 9 remains ongoing.

[17] The EPAct called for the NAS to develop a comprehensive technical assessment of replacement options and policy approaches to guide future efforts.

Table 3-1: Current and Potential Alternative Technology Research and Development Projects

Sector Application	Common Devices, Primary Isotopes	Potential Replacement Technology	Primary Replacement Challenges	Current/Potential Research and Development Projects
Medical. Blood irradiation	Self-shielded irradiators, Cs-137	3 FDA-approved x-ray alternatives; technology currently being implemented	User preference	Blood irradiator using flat panel x-ray sources
Medical, Industrial. Research irradiation	Self-shielded irradiators, Cs-137 and Co-60	X-ray replacement increasingly viable; technology currently being implemented	Technical requirements, user preference, and legacy data issues	Modular Addressable Research irradiator using flat panel x-ray sources; technology comparison studies (i.e., study correlating historical data to x-ray technology)
Medical. Cancer treatment	Teletherapy and radiosurgery treatment machines, Co-60	Linear accelerators used for most applications	Technical requirements, user preference	Advanced accelerator structures and treatment systems to provide more precise dose delivery
Industrial. Medical device sterilization; food irradiation; phytosanitary irradiation	Panoramic irradiators, Co-60	Electron beam and x-ray facilities available	Technical requirements, regulatory requirements, operational requirements, and high replacement cost	Efficient, high-power accelerator systems; studies of the impact of different radiation modalities on commonly sterilized materials; other technology comparison studies
Industrial. Petroleum well logging	Neutron and gamma-ray well-logging devices, Am-241/ beryllium (Be) and Cs-137	Deuterium-based neutron generators, acoustic and magnetic resonance technologies	Technical requirements, including measurement capabilities, durability requirements, size constraints, and legacy data issues	Dense plasma focus and deuterium-based neutron generators; compact electronic x-ray source (study correlating historical Am/Be data to the data provided by the potential replacement devices)
Industrial. Non-destructive inspection/ evaluation. Quality assurance, defect analysis	Radiography and fixed industrial gauges, Co-60, Cs-137, iridium-192, and selenium-75	X-ray, acoustic, magnetic, or eddy current technologies are widely used in less challenging environments	Technical and operational requirements in challenging environments	Advanced betatron for x-ray generation; wider application of x-ray and ultrasonic technologies may require further miniaturization of these devices

III. Transition to Alternative Technologies

While the development of alternative technologies has been a priority for several years, in 2014, the Task Force acknowledged the need to support users in transitioning from radioisotopic-based technologies to alternative technologies where viable options exist. In order to achieve this end, the Task Force set forth 2014 Recommendation 3, which states the following:

> The Task Force recommends that the U.S. Government, as appropriate,[18] investigate options such as voluntary, prioritized, incentivized, programs for the replacement of Category 1 and 2 radioactive sources with effective alternatives. The Task Force further recommends that U.S. Government agencies, where appropriate, lead by example in the consideration of and transition to alternative technologies that meet technical, operational, and cost requirements.

Efforts to replace Category 1 and 2 radioactive sources with effective alternatives have become increasingly successful for blood irradiation, in large part due to technological advances that have improved the reliability and cost of nonradioisotopic blood irradiation devices. During this report cycle, DOE/NNSA successfully piloted a program to support the replacement of Cs-137 irradiators, with an initial focus on blood irradiator replacements. The success of the pilot and subsequent stakeholder engagements have led to wider implementation of DOE's Cesium Irradiator Replacement Project (CIRP).[19] The success of CIRP was evidenced in December 2017, when licensees from all 15 medical and academic facilities within New York City (part of the New York Agreement State program) committed to transitioning from Cs-137 to x-ray devices through CIRP. As of July 2018, the transition has been completed at three facilities. In 2017, the University of California system similarly committed to replacing as many cesium- and cobalt-based irradiators as possible with x-ray devices across its 10 campuses and 5 medical centers. In addition to these broad initiatives, approximately 70 individual sites nationwide are in queue for replacement or in the process of enlisting in the program. Efforts to replace Cs-137 based irradiators with x-ray devices will continue for the coming years, under the umbrella of CIRP and DOE/NNSA's 2020 Cities initiative. In its National Progress Report for the 2016 Nuclear Security Summit, the United States noted its objective to facilitate the replacement of 34 Cs-137 irradiators with nonradioisotopic alternatives by 2020, a goal that has already been exceeded.

The White House National Science and Technology Council created the GARS as a first step in addressing the Task Force recommendation for Federal agencies to lead by example in

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[18] NRC's statutory mandate precludes it from promoting one technology over another for non-safety or [non-] security reasons. The NRC would review in accordance with its procedures any new license application for new technologies.

[19] CIRP is entirely voluntary and program participants are responsible for selecting the nonisotopic replacement device that meets their technical, operational, and financial requirements. CIRP support includes removal and disposal of the CsCl irradiator. Costs related to new device training, as well as the purchase of a warranty or maintenance agreement for the new device, are the responsibility of the program participants. To help ensure that program participation supports permanent risk reduction, CIRP participants sign a disposition agreement acknowledging the purpose and goal of the project. In addition, disbursement of financial incentives to CIRP participants takes place only after the removal of the CsCl device is complete. Further information on CIRP can be found at https://nnsa.energy.gov/aboutus/ourprograms/dnn/gms/rs/cesium-irradiator-replacement-project-fact-sheet [DOE 2017].

consideration and adoption of alternative technologies. The GARS was tasked with developing best practices on how Federal agencies that use high-activity sources can incorporate the transition to alternative technologies into their strategic plans.

The GARS[20] concluded that alternatives are available for a number of Category 1 and 2 sealed source applications. The GARS report includes background information and recommendations to Federal departments and agencies on best practices for transitioning from high-activity radioactive sources to nonradioisotopic technologies that meet the technical, operational, and cost requirements for end users. The report highlighted four categories of Federal practices: (1) Federal procurement and grant-making, (2) agency priorities, (3) education and outreach, and (4) research and development. It also concluded that use of Category 1 and 2 sources without alternatives was likely to continue for a considerable time. DOE/NNSA and the National Institutes of Health co-chair a follow-on GARS working group to further identify and support Federal efforts related to alternative technologies.

The Task Force will continue to focus on enabling Federal agencies to encourage the adoption of replacement technologies that meet technical, operational, and cost requirements. Federal agencies procuring Category 1 and 2 sealed sources and devices can document their assessments regarding the replacement of those devices in comparison with available nonradioisotopic alternatives. Both the development and sharing of this information may help purchasers become familiar with replacement opportunities, trends, and decision factors, and could also be used to assess overall progress in conversion efforts. Similar assessment requirements could also be included in Federal research grant applications. These assessments would not only encourage consideration of potential replacement technologies during purchase and funding decisions, but would also serve as an important mechanism to inform stakeholder communities with regard to alternative technology options.

In addition to the study, research, and development of alternative technologies, it is also important that these potential alternatives be communicated to non-federal government stakeholders so that they can voluntarily transition to the alternative technology when it meets users' technical, operational, and cost requirements. To further communications related to alternative technologies and the Task Force work, DHS initiated the ATWG, a public-private stakeholder engagement, to inform stakeholders about the potential for replacement of radioactive sources with alternative technologies, including the identification of both technical and nontechnical challenges related to the various applications. The ATWG has helped to identify applications for which nonisotopic replacements have become increasingly viable and commercially available, including certain industrial radiography and cancer treatment applications.[21] ATWG membership and participation has included subject matter experts from across the major radioactive materials applications, who have provided essential input to

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20 The GARS report may be read at https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ndrd-gars_best_practices_guide_final-.pdf.

21 DHS's Critical Infrastructure Partnership Advisory Council (CIPAC) framework facilitates consultation between the Federal Government and the appropriate private sector entities on subjects related to critical infrastructure protection and resilience. The ATWG falls under the CIPAC framework to form a private-public sector stakeholder engagement addressing alternative technologies. For more information, see https://www.dhs.gov/critical-infrastructure-partnership-advisory-council [DHS 2018].

support these considerations, including the following:

- evaluation of application-specific technical, operational, and cost requirements for replacement technologies and devices

- assessment of application-specific approaches that may be effective in supporting technology transitions when users deem appropriate

2014 Recommendation 3 remains ongoing given the continued focus that will be placed on implementation of DOE/NNSA's CIRP in the coming years and the fact that efforts are currently underway by Task Force member agencies to: (1) ensure full consideration of alternative technologies in their agency activities, and (2) facilitate broad awareness and information sharing related to alternative technologies.

The Task Force agreed that an inclusive partnership among Federal and State agencies, manufacturers, industry, end users, standard-setting bodies, and technical consultants is important for the evaluation, demonstration, regulation, and promotion of innovative alternative technologies. Thus, Task Force member agencies will continue to pursue initiatives to share information related to alternative technologies with private and public partners. These efforts may include educational workshops to facilitate common understanding of alternative technologies, along with the development of a publicly available online repository of information on alternative technologies (e.g., capabilities, limitations) across applications.

2018 Task Force Report Conclusion

During this report cycle, the Task Force completed 4 of the 11 recommendations and actions that remained in process at the start of this reporting period and concluded that there are no significant gaps in radioactive source protection and security that are not already being addressed. However, the Task Force continues to focus on end-of-life management of risk-significant sources. The Task Force will continue to advance its efforts to complete the remaining seven recommendations and actions and will coordinate routinely to identify and mitigate any gaps in source protection and security that may emerge in the future.

Consistent with the EPAct, the Task Force has continued its efforts to evaluate the security of radioactive sources and make related recommendations[22] to the President and Congress. The Task Force has made substantial progress since the events of September 11, 2001, to enhance the protection of radioactive sources from terrorist threats and concludes that the United States is well positioned to continue to protect public health and safety and promote the common defense and security through the existing missions and activities of Task Force member agencies.

[22] Appendix I to this report lists the recommendations from the 2006, 2010, and 2014 reports along with their current status as of publication of this report. The Task Force maintains an Implementation Plan to monitor progress on existing recommendations and to identify actions needed to complete each recommendation. This plan is updated biennially and is available at the NRC's public Web page (https://www.nrc.gov/security/byproduct/task-force.html). The next update will be available in 2019.

Appendix I: Summary Table of Recommendations and Actions

Recommendation	Description	Status
2006 Recommendation 5-1	The Task Force recommends development of a Transport Security Memorandum of Understanding to serve as the foundation for cooperation in the establishment of a comprehensive and consistent transport security program for risk-significant sources.	Complete
2006 Action 9-1	The DOE should continue its ongoing efforts to develop GTCC [LLRW] disposal capability.	Ongoing
2006 Action 10-2	The U.S. Government should encourage suppliers to provide arrangements for the return of disused sources and examine means to reduce regulatory impediments that currently make this option unavailable.	Ongoing
2010 Recommendation 2	The Task Force recommends that U.S. Government agencies should reevaluate their protection and mitigation strategies to protect against [a] significant RED or RDD attack using both potential severe immediate or short-term exposure and contamination consequences to public health, safety, and the environment as the consequences of concern. Agencies should use the Task Force-endorsed definitions, radionuclides, and thresholds for a significant RED and RDD and the associated assumptions and parameters as common guidance in the assessment of risk and management of homeland security activities.	Complete
2010 Recommendation 4	The Task Force recommends that the U.S. Government, regional compacts, and States continue to evaluate disposal options for disused radioactive sources, including options for handling a potentially large number of disused cesium chloride sources that may be replaced once viable alternatives are available.	Ongoing
2010 Recommendation 5	The Task Force recommends that Federal and State Governments investigate options such as providing short-term secured storage of sources recovered from U.S. owners that contain foreign-origin americium-241 radioactive material, so that these sources can be recovered now, and increase efforts to investigate options for disposal of these sources.	Ongoing
2010 Recommendation 8	The Task Force recommends that the U.S. Government enhance support of short-term and long-term research and development of certified Type B containers for use in domestic and international source recovery efforts.	Complete
2010 Recommendation 9	The Task Force recommends that the U.S. Government enhance support of short-term and long-term research and development for alternative technologies.	Ongoing
2014 Recommendation 1	The Task Force recommends that U.S. Government agencies assess the adequacy of and coordinate strategies for preventing and mitigating cybersecurity vulnerabilities related to Category 1 and 2 radioactive sources.	Ongoing
2014 Recommendation 2	The Task Force recommends that the NRC evaluate the need for sealed source licensees to address the eventual disposition/disposal costs of Category 1 and 2 quantities of radioactive sources through source disposition/disposal financial planning or other mechanisms. Disposition costs should include the cost of packaging, transport, and disposal (when available) of these sources.	Complete
2014 Recommendation 3	The Task Force recommends that the U.S. Government, as appropriate,[23] investigate options such as voluntary, prioritized, incentivized, programs for the replacement of Category 1 and 2 radioactive sources with effective alternatives. The Task Force further recommends that U.S. Government agencies, where appropriate, lead by example in the consideration of and transition to alternative technologies that meet technical, operational, and cost requirements.	Ongoing

[23] NRC's statutory mandate precludes it from promoting one technology over another for non-safety or [non-] security reasons. The NRC would review in accordance with its procedures any new license application for new technologies.

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