Sealed Source Security Challenges and Solutions: The Impact of Increased Commercial Disposal Access – 16557

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ABSTRACT

Several recent developments have transformed the sealed source disposal landscape in the United States in ways unimaginable just a few years ago, including the initiation of operations at the first new commercial LLRW facility to open in the United States in decades; publication by the Nuclear Regulatory Commission (NRC) of revised commercial low-level radioactive waste (LLRW) disposal guidance; and the development and certification by the Department of Energy National Nuclear Security Administration (DOE/NNSA) of new transportation package designs for high-activity sources/devices. These developments will likely enable LLRW generators to dispose of risk-significant radioactive sealed sources that for decades have been without a commercial disposal pathway. However, challenges remain with regard to ensuring that these new commercial disposal pathways are effective, and that sealed source licensees take advantage of the new options in a timely manner. These challenges include costs related to both transportation and disposal that are likely much higher than most generators expected when they purchased their sources. DOE/NNSA is actively engaged with Federal, State, regional, private sector partners to address these challenges, including measures to encourage financial planning for end-of-life management of radioactive sealed sources.

INTRODUCTION

There are approximately 80,000 International Atomic Energy Agency (IAEA) Category 1 and 2 sealed sources currently licensed in the United States to about 1,400 NRC licensees. [1] Although not tracked by the NRC, the number of Category 3 sources is likely much higher. Table I identifies the most common Category 1 to 3 devices and their associated isotope and activity levels.

TABLE I: Common IAEA Category 1 to 3 Sealed Sources*

Device/Use	Isotope	Typical activity per source (TBq)	Typical activity per source (Ci)	IAEA Category
Medical/Industrial Irradiation	Cs-137	74 to 555	2,000 to 15,000	1
	Co-60**	55 to 93	1,500 to 2,500	1
Gamma Knife	Co-60	260	7,000	1
Teletherapy	Co-60	555	4,000	1
	Cs-137	19	500	1
Industrial Radiography	Co-60	2.3	60	2
	Ir-192	3.7	100	2
Brachytherapy	Co-60	0.37	10	2
	Cs-137	0.11	2-3	3/4
	Ir-192	0.22	6	3
Calibration	Co-60	0.75	20	2
	Cs-137	2.3	60	2
	Am-241	0.37	10	3
	Pu-239/Be	0.11	3	3
Industrial Gauges	Co-60	0.04 – 0.19	1 - 5	3
	Cs-137	0.07 – 0.19	2 - 5	3
Well Logging	Am-241/Be	0.56 – 0.75	15 - 20	2/3
	Cs-137	0.07	2	3

*Adapted from Table A in the NRC "Interagency Working Group Report on Financial Assurance for Disposition of Category 1, 2 and 3 Radioactive Sealed Sources." [2]
**Many Co-60 devices contain multiple sources in the activity ranges show here, often totaling tens to hundreds of thousands of curies per device.

In contrast, commercial sealed source disposal access in the United States has long been limited to thresholds far below the activity levels commonly utilized in commercially licensed devices. For decades, LLRW generators in 39 States have been unable to commercially dispose of disused radioactive sealed sources (DRSS) exceeding 0.37 Tbq (10 Ci). From 2008 to 2012, generators in 36 of these 39 States were entirely without commercial sealed source disposal access. LLRW generators in the remaining 11 States were unable to commercially dispose of sources greater than 1.11 Tbq (30 Ci).[a] Table II provides a summary of these disposal access and activity constraints.[b]

[a] The Energy*Solutions* Barnwell facility, SC facility accepted sealed sources up to 10 Ci from generators nationwide from its establishment in 1971 until July 2008, after which access for all LLRW was limited to waste generators in the three States with membership in the Atlantic Compact (Connecticut, New Jersey, and South Carolina). The Energy*Solutions* Clive, Utah facility, which has long accepted low-activity LLRW from generators nationwide, has never been licensed to accept sealed source waste, but did receive a one year license variance to dispose of sealed sources that expired in 2014.

[b] The curie thresholds cited here reflect the waste acceptance criteria for beta/gamma sealed sources such as Cs-137 and Co-60 at the Energy*Solutions* LLRW disposal facility near Barnwell, SC and at the US Ecology Low-Level Radioactive Waste (LLRW) disposal facility near Richland, WA. Although also

TABLE II: Historical Commercial Sealed Source Disposal Access and Activity Limits

Years	State Compact	# of States	Activity Limit	Disposal Option
Pre-2008	Northwest and Rocky Mountain Compacts	11	1.11 TBq (30 Ci)	Richland
	Atlantic Compact	3	0.37 TBq (10 Ci)	Barnwell
	All Other States/Compacts	36	0.37 TBq (10 Ci)	Barnwell
2008 to 2012	Northwest and Rocky Mountain Compacts	11	1.11 TBq (30 Ci)	Richland
	Atlantic Compact	3	0.37 TBq (10 Ci)	Barnwell
	All other States/Compacts	36	***No Disposal Options***	

NNSA AND COMMERCIAL SEALED SOURCES

The terrorist attacks of September 11, 2001 significantly increased the National security, public health, and safety concerns related to the potential misuse of radioactive sealed sources commonly used in medical, industrial, and research applications. [3, 4, 5, 6] By 2010, the Federal interagency Radiation Source Protection and Security Task Force (RSPS Task Force) concluded that "[b]y far the most significant challenge identified is access to disposal for disused radioactive sources," identifying it as one of two major sealed source protection and security challenges that require attention at higher levels of government.[c] [7]

The NNSA Office of Radiological Security (ORS) is responsible under its authorities for the management of several programs supporting the protection and security of radioactive sealed sources, including the Off-Site Source Recovery Project (OSRP), administered by Los Alamos National Laboratory. OSRP recovers commercially licensed risk-significant DRSS. Since 2001, NNSA/OSRP has recovered over 35,000 such sources from generators across the U.S. OSRP recoveries are prioritized according to risk-reduction criteria developed in coordination with the NRC. Thousands of additional DRSS remain registered with OSRP, and hundreds of new sources are added each year to this list.

Utilizing similar risk-reduction criteria, ORS also provides voluntary security enhancements on a cost-share basis to commercial facilities that use high-activity

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important from a risk-reduction perspective, disposal of transuranic (TRU) waste, including Am-241 and Pu-238 sources, is regulated differently.

[c] The Task Force is chaired by the NRC and comprised of 14 Federal agencies, as well as Organization of Agreements States. Congress established the Task Force to "evaluate and provide recommendations to the President and Congress relating to the security of radiation sources in the United States from potential terrorist threats, including acts of sabotage, theft, or use of a radiation source in an RDD or RED." [7]

radiological devices. These enhancements supplement the security measures that these licensees must implement in accordance with NRC requirements. As of December 2015, ORS has completed these upgrades at over 90% of the facilities in the U.S. that use Category 1 sealed sources.

DISPOSAL CHALLENGES AND SOLUTIONS

Increased Commercial Disposal Access: WCS and the BTP

Several recent developments have impacted significantly the potential for commercial LLRW generators to dispose of risk-significant DRSS. First, and most importantly, Waste Control Specialists (WCS) initiated operations in April 2012 at its newly developed commercial LLRW disposal facility located in Andrews County, Texas. The WCS facility is the first new commercial LLRW disposal facility to open since Congress established the current regional policy framework for LLRW disposal in 1980. [8] Furthermore, while the primary purpose of the new facility is to serve generators in States with membership in the Texas Compact—currently just Texas and Vermont—WCS may also accept LLRW from generators located in States outside the Texas Compact. As a result, all DRSS generators in the United States once again have commercial disposal access, at least up to the activity limits at the Texas facility.

Second, in February 2015, the NRC published significant revisions to its "Concentration Averaging and Encapsulation Branch Technical Position" (BTP), a guidance document which describes methods that LLRW generators may use to classify different types of waste, including radioactive sealed sources, for disposal.[d] [9] The 2015 BTP supersedes the 1995 version which had, in effect, set the maximum limits for commercial disposal of radioactive sealed sources at currently operational facilities at levels far below the Class C limits the NRC stipulates in its corresponding regulations for the same radionuclides.[e] For example, application of the 1995 guidance resulted in a 1.1 Tbq (30 Ci) limit for Cs-137 sealed source waste, even though the regulatory limit for Cs-137 LLRW disposed is 35.4 TBq (957 Ci) if disposed in a 55 gallon drum.

The revised BTP includes several provisions important for the disposal of risk-significant sealed sources:

- An increase in the "generic" disposal limit for Cs-137 sealed sources from 1.11 TBq (30 Ci) to 4.81 Tbq (130 Ci);

[d] NRC's regulations at 10 CFR Part 61 require commercial LLRW generators to classify their waste as Class A, B, C, or "Greater-than-Class C" (GTCC), depending on the concentration of certain radionuclides in the waste. The BTP then provides guidance to generators for calculating those concentrations, including identification of "generic" limits for common radionuclides such as Cs-137 generally acceptable at LLRW facilities licensed by the NRC.

[e] The BTP addresses disposal of Class A, B, and C waste at "near surface" disposal facilities, such as those currently in operation. GTCC LLRW must be disposed in a facility developed and licensed according to separate, more stringent requirements.

- New, detailed criteria for site-specific "alternative approaches" that may be used to consider disposal of sealed sources up to the regulatory class limits;
- The ability, under the alternative approach provisions, to use container volumes larger than a 55 gallon drum for DRSS waste classification (which increases the activity of the sealed sources which may be disposed as Class C waste).

While an increase of the generic limit for Cs-137 from 1.1 Tbq (30 Ci) to 4.81 Tbq (130 Ci) is significant and highly beneficial, the ultimate impact of the revised guidance from a risk reduction perspective clearly depends upon implementation of the alternative approach provisions at the existing LLRW disposal facilities.

Alternative Approaches and the Disposal of Risk-Significant DRSS[f]

For Cs-137, the alternative approach provisions are expected to enable commercial disposal of Cs-137 up to its Class C limit. If disposed in a 55 gallon drum, as stipulated in the 1995 BTP, this would enable commercial disposal of sources up to a Class C limit of 35.4 TBq (957 Ci).[g] However, as described in the new guidance, alternative approach disposals could include disposal of DRSS in larger volume containers. As a result, the potential exists for Cs-137 sources exceeding 35.4 TBq (957 Ci) to be disposed as Class C waste.

For Co-60, the case is a bit different. LLRW disposal facilities have tended to apply the Cs-137 limit to Co-60 sealed sources by default. However, unlike the 1995 document, the revised BTP affirms that, due to its short half-life, there is no regulatory Class C limit on the disposal of Co-60. That is, from a regulatory standpoint, the potential has always existed for currently operational facilities to accept even the highest activity Co-60 sources for disposal as Class B waste. Implementation of the revised BTP, particularly given the alternative approach provisions, is thus likely to result in waste acceptance criteria for Co-60 at two of the three facilities that accept sealed sources more reflective of this regulatory allowance.

Both WCS in Texas and US Ecology in Washington have already received approval from their regulators to use the new guidance, although the limits that will apply to specific types of sources using alternative approaches have yet to be determined.[h] NNSA/ORS is currently working with the Conference of Radiation Control Program Directors (CRCPD) Source Collection and Threat Reduction (SCATR) program and both

[f] Over 90% of the high-activity disused sources recovered by NNSA/OSRP are Cs-137, Co-60, or Am-241. However, because it is a transuranic (TRU) material, disposal of Am-241 is regulated differently than gamma emitting radionuclides such as Cs-137 and Co-60. This paper focuses primarily on the disposal of gamma-emitting sources.

[g] 35.4 TBq (957 Ci) is the 4600 Ci/m^3 Class C regulatory limit for Cs-137 averaged over the volume of a 55 gallon (0.2 m^3) drum.

[h] Regulators in South Carolina have indicated that they do not intend to revise the waste acceptance criteria for sealed sources at the Barnwell facility.

disposal facilities on potential alternative approach disposals significantly above the prior limits. Table III compares the Table II historical limits to the revised BTP thresholds to demonstrate the significant current and potential impact of these developments.

TABLE III: Historical and Current Commercial Sealed Source Disposal Limits*

State Compact(s)	# of States	Prior Activity Limit(s)	Revised BTP Limit (Generic)	Revised BTP Limit (Potential)*	Sealed Source Disposal Option(s)
Northwest and Rocky Mountain Compacts	11	1.11TBq (30Ci)	4.81TBq (130Ci)	≤ 35.4TBq (957Ci)	Richland
Atlantic Compact	3	0.37TBq (10Ci)	4.81TBq (130Ci)	≤ 35.4TBq (957Ci)	Barnwell/ WCS
All Other States/Compacts	36	No Access or 0.37TBq (10Ci)	4.81TBq (130Ci)	≤ 35.4TBq (957Ci)	WCS
* Although the more conservative estimate is identified here, the new guidance could enable the disposal of Cs-137 and Co-60 sources exceeding the 35.4TBq threshold, if a container larger than 55 gallons is used.					

Transportation Challenges and Solutions

NNSA is also facilitating solutions to challenges related to the availability of Type B transportation containers necessary to ship high-activity DRSS and devices. The expiration in 2008 of many previously certified packages created a shortage that impacted both government and private sector radioactive material transporters. Furthermore, due to the lack of commercial disposal access, the incentive for the private sector to develop and certify new containers—an expensive and time-consuming process—was significantly diminished.

To enable continued OSRP recovery and disposition of high-activity sources, NNSA, in conjunction with Los Alamos National Laboratory, procured vendor services for the design, testing, and certification of two new Type B transportation containers. Certification of the first package design was completed in 2014, with certification of the second expected in 2016. These new packages will enable the shipment of nearly all the high-activity devices currently in use. In order to further facilitate the timely disposition of DRSS, NNSA is providing the certified container designs to qualified private sector entities for commercial fabrication and use.

FINANCIAL PLANNING AND FINANCIAL ASSURANCE FOR DISPOSAL OF SEALED SOURCES

Sealed Source Management and Disposal

It is widely accepted as a radioactive material management best-practice that storage

of DRSS should be a temporary measure. The longer radioactive sources remain disused or unwanted the chances increase that they will become unsecured or abandoned. [10, 11, 12] For this reason, 2004 IAEA *Code of Conduct on the Safety and Security of Radioactive Sources*, "expects that every State should ensure that sealed sources are not stored for extended periods of time in facilities that have not been designed for the purpose of such storage." [12] The United States Government has formally endorsed the code, and encourages other countries to do the same.

Under Federal and State law and regulations, the radioactive material licensees who receive the economic benefits from commercially licensed radioactive sealed sources are responsible for their proper management once those benefits have been exhausted. However, even when commercial disposal access is available, sealed source licensees have little regulatory incentive to dispose of their DRSS prior to license termination. In 2006, the RSPS Task Force Report noted that, "[h]olding a source in storage longer than 24 months usually indicates the lack of a strategy to use or dispose of the source," and that:

> Due to high costs, some licensees do not want to pay or cannot pay to dispose of disused sealed sources, which may be acceptable for disposal at the two existing commercial disposal facilities. As a result, these sources may remain in storage indefinitely or, in some situations, possibly misused, abandoned, lost, or stolen if there are no other disposition alternatives, such as recycling or reuse. [5]

Furthermore, commercial sealed source disposal costs for most generators are likely to be even higher than expected when the 2006 assessment was undertaken. LLRW disposal costs at the WCS facility in Texas, which is the only facility to which most US sealed source generators have access, are driven primarily by the activity of the waste. For Texas Compact generators, the disposal cost for sealed sources stipulated in Texas regulations is $.55 per 0.037Gbq (1mCi), up to a limit of $220,000 (a threshold reached at approximately 14.8Tbq (400 Ci)).[i] Texas law and regulation also stipulates that the price for non-Compact generators exceed the price for Texas generators by approximately 30%. Packaging and transportation costs for higher activity sealed sources could easily add tens of thousands of dollars in addition.

NRC Financial Assurance Requirements

Current NRC financial assurance requirements are intended to facilitate the overall decommissioning of user facilities upon termination of business operations. They are not aimed at source disposition by typical users during the operational life of the facility. Neither the thresholds for a fixed financial assurance amount of $113,000, nor the higher thresholds that would require a licensee to submit an actual cost estimate, are correlated with the IAEA security categories for radionuclides of concern. As

[i] WCS facility disposal rates are set determined in accordance with Texas law and regulation as stipulated in Texas Senate Bill (SB) 1504, 82nd Legislature, 2011, and the Texas Administrative Code at TAC §336.1310.

result, the curie amounts that trigger requirements for common risk-significant sources such as Cs-137 and Co-60 are far above their IAEA Category 1 thresholds.

In fact, of the 20 sealed radionuclides included in the NRC's National Source Tracking System (NSTS), no sealed source type at its Category 1 threshold level requires financial assurance based on a cost estimate, and 14 of the 20 require only the fixed $113,000 financial assurance amount intended to cover the entire cost of facility decommissioning. The remaining six of the 20 require no financial assurance at all until they are well above the Category 1 threshold. For all of the radionuclides, the current financial assurance thresholds are well above the IAEA Category 2 lower bound. Table IV compares the current NRC financial assurance requirements with the thresholds for the common IAEA Category 1 to 3 sources types identified in Table I above.

TABLE IV: Current NRC Financial Assurance (FA) Requirements and IAEA Category Thresholds

Radionuclide	Threshold (Ci) for a Fixed $113,000 FA Amount	Threshold (Ci) for FA Based on a Specific Cost Estimate	Category 1 Threshold (Ci)	Category 2 Threshold (Ci)	Category 3 Threshold (Ci)
Am-241	>100	>10,000	1,600	16	1.6
Am-241/Be	>100	>10,000	1,600	16	1.6
Co-60	>10,000	>1,000,000	800	8	.8
Cs-137	>100,000	>10,000,000	2,700	27	2.7
Ir-192	>1,000	>100,000	2,200	22	2.2
Pu-239/Be	>100	>10,000	1,600	16	1.6

Financial Planning Rulemaking

Due to these concerns, the NRC is currently considering financial planning requirements aimed at the timely disposal of disused sources. [13] Congress initially directed the RSPS Task Force to consider source-specific financial assurance requirements in 2005. [14] However, because of the limitations on both commercial disposal access and certified Type B transportation packages, the Task Force concluded that rulemaking would be premature. [2] In 2014, recognizing the significant progress that has been made on both issues, the Task Force recommended that the NRC revisit the topic. [1] NRC Staff is expected to release the results of its scoping study on the topic in spring 2016, as well as a memo to the Commission that includes rulemaking options and a recommendation.

As described in the 2014 RSPS Task Force Report, financial planning requirements have the potential to both encourage and facilitate the timely DRSS. [1] Such requirements may also improve the lifecycle management of sealed sources more generally. Financial planning requirements at the time of purchase can help to ensure

that sealed source licensees understand and properly assess the full lifecycle costs and benefits of the sealed sources they are considering for use, including options and costs related to source disposition. As a result, both the seller and potential purchaser of a sealed source would be encouraged to clarify the conditions, including the costs to each party, under which the device may be accepted for return to the manufacturer for disposal. Similar information is also more likely to become available with regard to reuse or recycle options.

A financial assurance component of financial planning could ensure that licensees (or regulators, if necessary) have adequate funds available for timely disposal once sources become disused and unwanted. As described in Recommendation 2 of the 2014 RSPS Task Force report, financial assurance considerations should include the cost of packaging, transport, and commercial disposal, when available. Even when the cost of commercial disposal is not included, disposition costs may include processing, packaging, and transportation costs related to storage, recycle, or return to the manufacturer. [1]

CONCLUSIONS

National security concerns after September 11, 2001, in combination with the reduction in commercial disposal options for DRSS following the closure of Barnwell to non-compact States, resulted in increased government involvement in commercial sealed source management and disposal. However, as noted in the 2014 report of the RSPS Task Force, there is general agreement that:

> [A]s commercial disposal options increase, government involvement should decrease accordingly. 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. [1]

The recent and expected increases in commercial disposal access will enable licensees to take greater responsibility than was previously possible for the lifecycle management of the sealed sources they purchase and use.

REFERENCES

1. U.S. Nuclear Regulatory Commission, “2014 Radiation Source Protection and Security Task Force Report,” Washington DC, 2014.

2. U.S. Nuclear Regulatory Commission, “Interagency Working Group Report on Financial Assurance for Disposition of Category 1, 2 and 3 Radioactive Sealed Sources,” Washington, DC, 2010.

3. U.S. Department of Energy and U.S. Nuclear Regulatory Commission, “Radiological Dispersal Devices: An Initial Study To Identify Radioactive Materials of Greatest Concern and Approaches to Their Tracking, Tagging, and Disposition,”

Washington DC, May 2003;

4. U.S. Government Accountability Office, “DOE Action Needed to Ensure Continued Recovery of Unwanted Sealed Radioactive Sources,” GAO-03-483, April 2003;
5. U.S. Nuclear Regulatory Commission, “2006 Radiation Source Security and Protection Task Force Report,” Washington DC, 2006;
6. U.S. Department of Homeland Security, “Sealed Source Disposal and National Security: Problem Statement and Solution Set,” Washington DC, 2009.
7. U.S. Nuclear Regulatory Commission, “2010 Radiation Source Protection and Security Task Force Report,” Washington DC, 2010.
8. Low-Level Waste Policy Act of 1980 (P.L. 96-573).
9. U.S. Nuclear Regulatory Commission, “Concentration Averaging and Encapsulation Branch Technical Position, Revision 1,” Washington DC, 2015.
10. International Atomic Energy Agency, Strengthening Control Over Radioactive Sources in Authorized Use and Regaining Control Over Orphan Sources, IAEA-TECDOC-1388, Vienna, 2004;
11. U.S. Nuclear Regulatory Commission, 2006 Radiation Source Security and Protection Task Force Report, Washington DC, 2006;
12. IAEA, Management of Disused Sealed Radioactive Sources, IAEA Nuclear Energy Series No. NW-T-1.3, Vienna, 2014.
13. U.S. Nuclear Regulatory Commission, “Financial Planning for Management of Radioactive Byproduct Material,” Federal Register Notice, Vol. 80, No. 148, at 46057. [Federal Rulemaking Docket ID NRC–2015–0182].
14. Energy Policy Act of 2005 (Public Law 109-58).