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Author(s):	Julia Whitworth, Bill STewart, Abigail Cuthbertson
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The Impact of NRC Guidance on Concentration Averaging on Low Level Waste Sealed Source Disposal - 11424

Julia Whitworth, Bill Stewart, Los Alamos National Laboratory, Los Alamos, NM
Abigail Cuthbertson, National Nuclear Security Administration, Washington, DC

ABSTRACT

As part of its ongoing efforts to revise the Nuclear Regulatory Commission's (NRC) current position on blending to be risk-informed and performance based [1] and its current review of the low-level waste classification codified in 10 CFR 61.55 [2], the Nuclear Regulatory Commission (NRC) has stated that it will review the 1995 "Branch Technical Position on Concentration Averaging and Encapsulation" (BTP) [3], which is still commonly used today. Such a review will have timely advantages, given the lack of commercial disposal availability within the United States for radioactive sealed sources that are in wide beneficial use across the country. The current application of the BTP guidance has resulted in an effective cap on commercial disposal for sources larger than 1.1 TBq (30 Ci). This paper will analyze how the BTP has been implemented with respect to sealed sources, what the implications have been for commercial disposal availability, and whether alternative packaging configurations could be considered for disposal.

BACKGROUND

Sealed sources are defined as a radioactive material "manufactured, obtained, or retained for the purpose of utilizing the emitted radiation" and "contained within a sealed capsule, sealed between layers of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material."[1] Higher activity sealed sources are located in most states of the United States and most countries in the world for numerous beneficial uses including irradiation of blood and medical equipment, well-logging, calibration, cancer treatment (teletherapy), radiographic examination, industrial irradiation, and gauges for numerous applications. Thousands of licensees in the US use sealed sources for beneficial applications. As an example, more than 1,300 Cesium chloride irradiators are in use in the US alone.[2] The number of similar unused and unwanted devices is unknown.

The United States has promulgated a waste classification system for low-level radioactive waste that is codified in 10 CFR 61.55. This system defines Classes A, B, and C low-level waste, as

[1] 10 CFR 835.2

[2] National Academy of Sciences, "Radiation Source Use and Replacement," Washington, DC, 2008.

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Outline

- Background
- Summary of NRC guidance on concentration averaging of sources
- Sources/devices impacted by BTP limits
- Sealed sources disposal impacts of BTP at existing disposal facilities
- Proposal for alternative packaging
- Recommendations

Devices formerly containing high-activity sources, many recovered by GTRI OSRP

Background

- Sealed source definitions - radioactive material "manufactured, obtained, or retained for the purpose of utilizing the emitted radiation" and "contained within a sealed capsule, sealed between layers of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means…"
- Higher activity sealed sources are in wide beneficial use in most states and countries for irradiation of blood and medical equipment, well-logging, calibration, cancer treatment (teletherapy), radiographic examination, etc.
- Thousands of sealed source licensees in the US (example - more than 1,300 Cesium Chloride irradiators in use).
- Lack of disposal for sealed sources has been identified as a national security concern

GTRI OSRP Efforts to Reduce Threat

- GTRI Offsite Source Recovery Project mission – to remove disused and unwanted sealed sources that could pose threat to national security, health, and safety.
- As of January 2011, GTRI OSRP recovered more than 25,000 sources, including 3,100 137-containing sealed sources more than 37,700 Ci) of activity, many of which exceed current disposal facility limits and have no commercial disposal pathway.

NRC Concentration Averaging Guidance

- Low-level radioactive waste (LLW) classes A, B, C, and Greater-than-Class-C (GTCC) defined in 10 CFR 61.55
- Classes based on concentrations of listed radionuclides
- Many very small sealed sources would be defined as GTCC if activity concentration is determined for the source volume only

LLW Classes

Short-lived radionuclides			
Radionuclide	Class A	Class C	
	< Ci/m3	> Ci/m3	< Ci/m3
H-3	40	Not Class C	
Co-60	700	Not Class C	
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7,000
Sr-90	0.04	150	7,000
Cs-137	1	44	4,600
Total of all nuclides with < 5 year half-life	700	Not Class C	
Long-lived radionuclides			
C-14	0.8	0.8	8
C-14 in activated metal	8	8	80
Ni-59 in activated metal	22	22	220
Tc-99	0.02	0.02	0.2
I-129	0.008	0.008	0.08
"Alpha-emitting" TRU nuclides with half-life > 5 years	10	10	100
Pu-241	350	350	3,500
Cm-242	2,000	2,000	20,000

Note: Highlighted isotopes are common in sealed sources

NRC Branch Technical Position on Concentration Averaging

- Published in 1995
- Specific guidance for sealed sources in Appendix C
- Defines "generally acceptable bounding conditions"
  - Maximum solidified volume of "single discrete source" should be 55 gallons.
  - No larger volume should be used for averaging without "a specific rationale..."
  - Encapsulation of multiple sources in larger volumes "may be considered acceptable" if approved by the Commission (Section 3.9).
  - The largest gamma-emitter "generally acceptable for encapsulation is that which, if credit is taken for a 500-year decay period, would result in a dose rate of less than 0.02 mrem/hr at the surface," (about 1.1 TBq (30 Ci) Cs-137 in concrete).
  - The maximum radionuclide quantity should not cause the Class C limit to be exceeded when averaged over the encapsulation volume, corresponding to about 35 TBq (958 Ci) Cs-137 in a 55-gallon drum

Types of Sources/Devices Affected

Primarily impacts Cs-137-containing devices, including the following common devices:

- Gammators containing 420-3,200 Ci Cs-137 originally (13% of devices registered with OSRP)
- IBL 437-C contain up to 5,610 Ci
- Gammacell 1000 and 3000 irradiators
- JLS 143-Series irradiators
- Summary – about 40% of GTRI OSRP-recovered devices not commercially disposable due to BTP limits

Gammator Research Irradiator

Other Device Examples

Source	Common Uses	Example
Non-Actinides		
Co-60	Sterilization facilities (5,000 – 15 MCi); blood and other irradiators (1,500 – 50,000 Ci); teletherapy units (1,000 – 15,000 Ci); industrial radiography (11-200 Ci)	
Cs-137	Sterilization facilities (5,000 – 5M Ci); blood and other irradiators (1,000 – 42,000 Ci); teletherapy units (500-1,500 Ci)	
Sr-90	Radioisotope thermoelectric generators (RTG) (9,000 – 680,000 Ci); calibrations (up to 2 Ci)	

BTP at Existing Disposal Facilities

Only two commercial facilities currently accept sealed source waste:

- Energy Solutions in Barnwell, SC
  - Only accepts sealed sources and LLW from within compact (CT, NJ, SC)
  - 0.4TBq (10Ci) limit on sealed sources, or 1.1TBq (30Ci) case by case
  - Limit applies to isotopes with and without GTCC threshholds (such as Co-60)

- U.S. Ecology in Richland, WA
  - Only accepts sealed sources and LLW (excluding NORM) from the Northwest and Rocky Mountain compacts (WA, OR, ID, WY, MT, UT, AK, HI, NV, CO, NM)
  - Generally average over 55-gallon drum volume (BTP) but may allow averaging over larger volumes
  - Have indicated that Cs-137 sources up to about 36TBq (960Ci) would be accepted in a 55 gallon volume (this would still maintain a below GTCC concentration).

BTP at Existing Disposal Facilities, cont'd

- Waste Control Specialists in Andrews County, TX
  - May accept sealed sources from outside of compact, including 36 states with no disposal pathway (see January 4, 2011 decision of Texas Compact Commission).
  - Acquired LLW license in 2009
  - Not yet receiving LLW, may start accepting compact waste starting Fall 2011.
  - Preliminary indication that site limits for sealed sources will be similar to those at the Barnwell Facility.

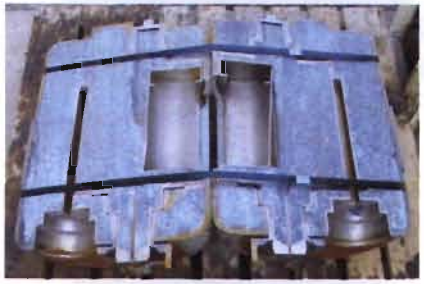
Problem – Lack of Commercial Disposal for Highest-Activity Devices

- Maximum disposal activity at Energy Solutions facility for most isotopes is 30 Ci (case by case). Result - many unwanted sealed sources in the Atlantic Compact have no disposal pathway, must be stored indefinitely.
- U.S. Ecology facility may be willing to accept up to 960 Ci Cs-137 sources, but packaging in a 55-gallon volume with sufficient shielding is not possible. Also, nothing of this activity has ever been disposed at the site.

Problem – Lack of Commercial Disposal for Highest-Activity Devices

- Without successfully disposing of Cs-137 sealed sources with an activity greater than 1.1TBq (30 Ci), any unwanted sealed sources/devices in the Northwest and Rocky Mountain compacts have no approved packaging configuration for disposal and must be stored.

Alternative Packaging Proposal for Large Devices



"Alternative packaging" proposed for high-activity Cs-137 sources/devices:

- Considering BTP limits of a 55 gallon (0.2 m^3) encapsulation volume, alternative packaging of high-activity Cs-137 sources (up to ~36TBq or 960Ci) could allow the container surface dose rate to be acceptable l(i.e, 0.2 µSv (0.02 mrem/hr) after a 500-year decay period.
- Proposal: Use the device as the disposal unit. The majority of high activity Cs-137 sources/devices are self-contained shielded irradiators that could be suitable for disposal with minor modifications, especially after transportation.
  - The irradiator shields that house the sources tend to be manufactured with a steel shell (typically 1/8-1/4 inch thick) in which lead has been poured around a central annulus to house the source and associated sample cavity.
  - External dose rates usually < 0.05 mSv (5 mrem/hr) on contact at the time of manufacture
  - Direct disposal of devices would eliminate the need for removal of sources from their shields prior to disposal, as well as for concrete "conditioning," which only adds weight

Advantage of Alternative Packaging

- To accomplish disposal of high activity Cs-137 sources/devices, credit must be taken for the lead shielding contained in the original shielded container. At present time the BTP does not allow for any lead shielding credit after the 500-yr decay period.
  - Dose rates on the external surface of the container even at the time of disposal would, if credit can be taken for the lead shielding, be significantly less than the required dose rate specified in the BTP.
  - The bare shield could be structurally analyzed if needed to determine integrity due to overburden and additional intrusion scenarios on which the BTP is based.

Recommendations

- Due to the large number of high-activity sources in use, disposal facilities and state regulators should clearly consider and articulate disposal limits for Cs-137 and Co-60 isotopes (including sealed sources) and allowable packaging configurations (including direct device disposal) in their waste acceptance criteria.
- In its review of 10 CFR 61 and the BTP, NRC should better define conditions under which the 55-gallon encapsulation and averaging volume described as "generally acceptable" can be increased.
- Interested parties such as disused sealed source waste generators and state regulators should encourage the NRC to "authorize other provisions for the classification and characteristics of waste," for sealed sources specifically, as suggested in Section 3.9 of the BTP.
- Limits developed for Cs-137 should not be applied to Co-60

Questions for Consideration During BTP Review

- Under what conditions would encapsulation of multiple sources in larger-than-55-gallon volumes be considered acceptable, given the stated concern of avoiding large point sources in a disposal site?
- Is averaging over volumes larger than 55-gallons "acceptable" where sources are in original devices or shielded transportation container liners that exceed that volume?
- Should the 500-year decay period or 0.2 µSv (0.020 mrem/hr) limits be revisited, and if so, what would be the technical basis for alternatives?