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 well as Greater-than-Class-C (GTCC) waste, which is "not generally acceptable for near-surface disposal" and must be disposed in a deep geological repository. The classification system

[1] 10 CFR 835.2

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

differentiates between long-lived and short-lived isotopes, providing activity concentration threshholds for a short list of each type of isotopes and designating waste containing all unlisted isotopes as Class A waste. Of particular interest are the types of sealed sources that exceed Class C thresholds. The highest-activity devices that make use of radioactive material comprise Co-60, Cs-137, and Sr-90 sealed sources. Co-60 does not meet the definition of a Class C radioactive waste shown in 10 CFR 61.55 [2], but the Class C threshold for Cs-137 is shown as 170 TBq/m^3 (4,600 Ci/m^3), or about 36 TBq (960 Ci) in a 55-gallon volume. Large Sr-90 sources exceeding the 259 TBq/m^3 (7,000 Ci/m^3) GTCC threshold are limited in application primarily to radioisotope thermal generators, most of which have been removed from the public sector. For that reason, this paper will focus on Cs-137 sources.

Because this standard is based on volume or mass activity concentration and sealed sources contain a large quantity of radioactive material in a very small volume, virtually all unwanted sealed sources comprising isotopes that are listed in the tables in 10 CFR 61.55 [2] (which excludes Co-60 from Class C and higher categorization) might be considered to be Greater-than-Class-C waste at first glance. However, 10 CFR 61.55 (a)(8) allows averaging of the concentration of radionuclides over total waste volumes, opening up the possibility of averaging the activity contained within the source over a volume larger than that of the source itself.

SUMMARY OF BRANCH TECHNICAL POSITION LANGUAGE

The Branch Technical Position on Concentration Averaging and Encapsulation (BTP) was published by the Nuclear Regulatory Commission (NRC) in 1995.[3] It "defines a subset of concentration and averaging practices that the NRC staff would find acceptable" to determine radionuclide activity concentrations in waste. According to the memo accompanying the position paper, the authors hoped to develop language that states hosting radioactive waste disposal sites would accept. However, as will be seen, the few states with functioning disposal facilities are not applying this guidance uniformly, at least with respect to sealed source disposal.

The guidance specific to sealed sources is shown in Appendix C of the BTP. It correctly encourages encapsulation to minimize dispersion of radionuclides, but cautions that the volume over which activities can be averaged should be limited so that "extreme measures cannot be taken solely for the purposes of dilution" and large point sources in a disposal site are avoided. Specifically, the following "generally acceptable bounding conditions" are provided:

- Maximum solidified volume of a "single discrete source" should be 0.2 m^3 (the approximate volume of a 55-gallon drum). This appears to mean that only one source can be encapsulated into a single 55-gallon drum or similar volume.

[3] Nuclear Regulatory Commission, "Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation," January 1995.

- Although sources can be encapsulated into larger volumes, no credit beyond the 55-gallon volume should be taken in determining the activity concentration "unless a specific rationale is provided."
- Encapsulation of multiple sources in larger volumes "may be considered acceptable" if approved by the Commission as suggested under Section 3.9 of the BTP.
- The maximum activity of a gamma-emitter such as Cs-137/Ba-137m "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 0.2 μSv (0.02 mrem/hr) at the surface. This corresponds to about 1.1 TBq (30 Ci) of Cs-137 if concrete is the encapsulating medium.
- The maximum radionuclide quantity should not cause the Class C limit to be exceeded when averaged over the encapsulation volume. Analysis: This corresponds to about 35 TBq (958 Ci) of Cs-137 in a 55-gallon drum.

SUMMARY OF HIGH-ACTIVITY DEVICE MODEL TYPES THAT EXCEED BTP LIMITS

The National Nuclear Security Administration (NNSA) Offsite Source Recovery Project (OSRP) administered by the Global Threat Reduction Initiative (GTRI) has been recovering high-activity sealed sources since 2004 as part of its mission to remove radiological material that could pose a threat to national security, public health, and/or safety. As of October 2010, the program has recovered more than 2,700 Cs-137-containing sealed sources totaling more than 1254 TBq (33,850 Ci) of activity, many of which exceeded the 1.1 TBq (30 Ci) limit mentioned previously and have no commercial disposal pathway. Of the most common disused and unwanted device models registered with OSRP at http://osrp.lanl.gov [6], many contain Cs-137, including the following:

- Gammators (Models 50B, B, B-34, RAMCO 50) containing about 16 TBq (420 Ci) originally and Gammators (Models M, M-34, M-38, and others) containing up to 119 TBq (3,200 Ci) – comprising 13% of all identifiable devices registered with OSRP, as shown in Figure 1
- CIS-US IBL 437-C containing up to 208 TBq (5,610 Ci) originally – comprising 12% of identifiable OSRP registrations
- Gammacell 1000 and 3000 irradiators containing up to 120 TBq (3,246 Ci) originally – together comprising 10% of identifiable OSRP registrations
- Best Theratronics GC-40 containing up to 16 TBq (4,200 Ci) originally – comprising 2.6% of identifiable OSRP registrations
- JLS 143-Series Irradiators, Models -35 and -45, originally containing up to 122 TBq (3,300 Ci) (depending on specific model) – comprising 2.6% of identifiable OSRP registrations

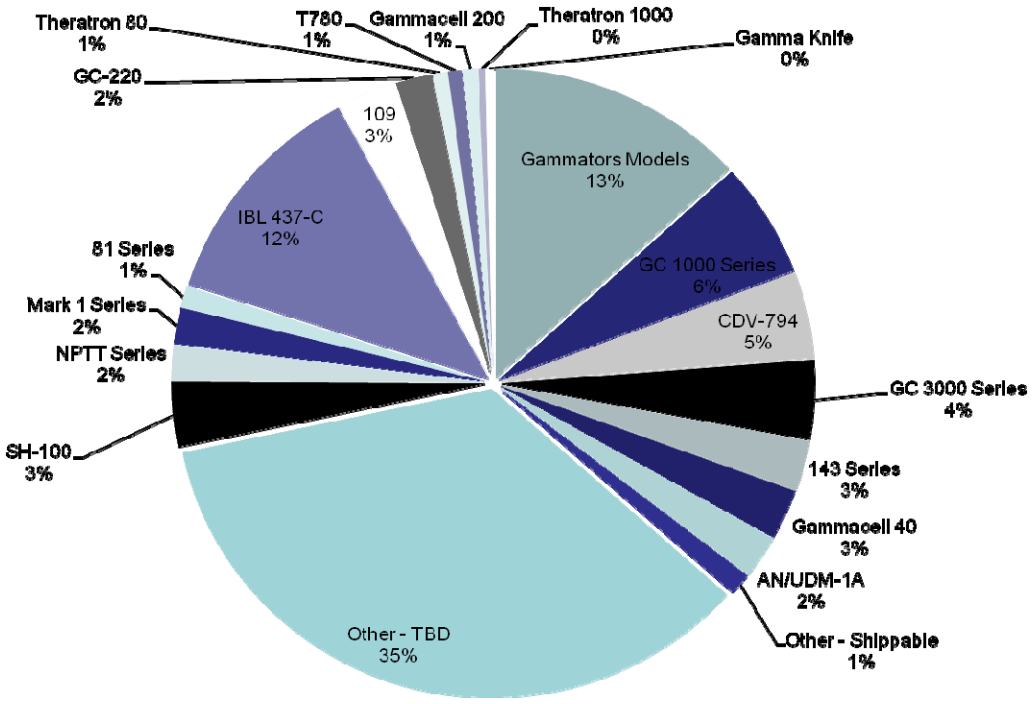

Figure 1: High-Activity Disused and Unwanted Devices Registered with OSRP

In summary, more than 40% of the disused and unwanted device models registered with OSRP contain larger quantities of Cs-137 that have few or no commercial disposal pathways largely because they greatly exceed the maximum activity described as “generally acceptable” for encapsulation and near-surface disposal in the BTP .

The interagency community has been particularly concerned about Cesium Chloride (CsCl)-containing devices for some time. A report issued in August 2008 by the CsCl Working Group of the Radiation Source Protection and Security Task Force formed as part of the 2005 Energy Policy Act [7] concluded that an immediate phase-out of CsCl in devices was not possible due to their wide use and the lack of suitable replacement technologies, but that a gradual phase-out could be feasible as alternatives become viable and disposal pathways are identified. NRC separately evaluated the question of whether such devices should be phased out, concluding based on stakeholder input that “… near term replacement of devices or CsCl sources in existing blood, research, and calibration irradiators is not practicable and would be disproportionately detrimental to patient health, longstanding research, and emergency response capabilities. Furthermore, a clear strategy for the end-of-life management of these sources, which is the

responsibility of the government, is not mature and likely will not be for some time."[4] NRC staff recommended tightening security for such devices during use, but did not recommend addressing the lack of disposition at the end of life.

More recently, the Removal and Disposition of Disused Sources Focus Group created under the Department of Homeland Security's Nuclear Critical Infrastructure Protection Advisory Council (CIPAC) issued a report stating [9] that "The lack of disposal pathways for radioactive sealed sources… poses a national security concern," and that, despite the beneficial applications for such sources, their high activity and portability make them attractive for use in radiological dispersal devices or "dirty bombs," with "possible economic impacts in the billions of dollars and significant social disruption."[5] Also, the 2010 Radiation Source Protection and Security Task Force Report [10] identified lack of disposal for disused sealed sources as one of two major challenges and recommended that "the U.S. Government and States continue to evaluate waste disposal options for disused radioactive sealed sources." [4] The report also summarizes the work of the Task Force in defining what constitutes a "significant Radiological Dispersal Device (RDD)" and refining the list of radionuclides of greatest concern for use in RDDs. Cs-137 and Co-60 are on this list, as well as several actinides, with quantities "that warrant enhanced security" due to potential consequences if used in an RDD ranging from 0.3-1 TBq (8-27 Ci) for these isotopes.

IMPLEMENTATION AT COMMERCIAL DISPOSAL FACILITIES

There are currently only two operating low-level radioactive waste disposal facilities in the United States currently accepting sealed sources, with a third one licensed and under construction. These facilities are as follows:

- Energy Solutions in Barnwell, SC
- American Ecology in Richland, WA
- Waste Control Specialists (WCS) in Andrews, TX

The application of concentration averaging at these facilities has a substantial impact on whether or not many sources can be disposed in these near-surface land disposal facilities. The Barnwell facility will accept sealed sources (as well as other low-level radioactive waste) only from within the three states of the Atlantic compact. Barnwell has articulated that it has a 0.4 TBq (10 Ci) limit for disposal of sealed sources, although up to 1.1 TBq (30 Ci) can be disposed under case-by-case exemptions. It is worth noting that this limit seems to apply not only to potentially

[4] Nuclear Regulatory Commission. SECY-08-0184, "Strategy for the Security and Use of Cesium-137 Chloride Sources." November 24, 2008.
[5] "Sealed Source Disposal and National Security - Problem Statement and Solution Set," Removal and Disposition of Disused Sealed Sources Focus Group, December 9, 2009.

Greater-than-Class-C Cs-137 sources, but also Co-60 sources (of which there are currently more than 20 disused sources 0.4 TBq (> 10 Ci) registered with OSRP) , which cannot be GTCC.

The American Ecology facility and the Washington DEQ [11] have indicated their willingness to allow averaging of radionuclide concentrations over volumes larger than 55-gallon, as well as articulating that the facility can accept sealed sources greater up to about 36 TBq (960 Ci) Cs-137 in a 55-gallon volume. However, it may not be possible to shield this much activity in this volume sufficiently to lower external dose rates to acceptable levels, or at least not using concrete. A bare 16.3 TBq (976 Ci) Cs-137 point source encapsulated in concrete in a 55-gallon drum would result in a roughly 2.7 Sv (270 R/hr) maximum contact dose rate on contact with the drum exterior (or 21R/hr at one meter). GTRI/OSRP is currently providing technical assistance to the Council of Radiation Control Program Directors (CRCPD) to pilot a commercial disposal of a sealed source-containing device containing more than 1.1 TBq (30 Ci), but it is clear already that a larger volume than 0.2 m^3 (55 gal) may be required for this effort. If the pilot is successful, the terms under which alternative conditions may be considered should be promulgated and published, or at least a maximum acceptable activity and averaging volume should be articulated in the disposal facility Waste Acceptance Criteria so that it does not remain a mystery to generators and brokers. However, even with a success here, the ability to dispose of 1.1TBq (> 30 Ci) sealed sources/devices will be available only for generators in the 11 states of the Northwest and Rocky Mountain low-level waste compacts due to compact restrictions.

The new WCS disposal facility in west Texas is likely to have limits similar to those used at Barnwell and articulated in the BTP, although no such limits have yet been promulgated or published.

ALTERNATIVE PACKAGING

The packaging configuration called out in the BTP references averaging over the approximate size of a 55 gallon drum (0.2 m^3). To dispose of beta/gamma emitting sources greater than 1.1 TBq (30 Ci), the calculated activity in the BTP, alternative packaging configurations need to be considered. The majority of the sources/devices mentioned above are self-contained shielded irradiators that could be considered suitable for disposal almost as-is with slight modification. These irradiators typically contain source holders shielded with lead and the external dose rates tend to be less than 0.05 mSv (5 mrem/hr) on contact at the time of manufacture. The quantity of shielding in these containers would allow the maximum dose rate after 500 years to be well below the 0.2 μSv (0.02 mrem/hr) limit specified in the BTP without any additional shielding considered from the concrete conditioning. The irradiator shields that house the higher activity Cs-137 sources tend to be a steel shell in which lead has been poured around a central annulus to house the source and associated sample/exposure cavity. The structural configuration of these containers can easily be evaluated to determine integrity due to overburden and additional

intrusion scenarios. These shields would also satisfy the requirement in the BTP stating that the encapsulating material, in this case the irradiator shield, would require mechanical assistance to move the encapsulating material during an intrusion scenario. If direct disposal of shielded devices that can be safely and compliantly transported could be accomplished without the need for overpacking into a drum configuration and additional encapsulation in concrete, disposal could be greatly simplified.

Due to the quantity of higher activity Cs-137 and Co-60 sources in use today, it would be beneficial to the commercial sector to have a confirmed disposal outlet that accommodates this alternative packaging to dispose of such units in a similar configuration that they are presently used. Improving commercial disposal access helps to address the national security threat posed by these materials, especially when they are no longer in use.

CONCLUSIONS

Clearly, the BTP guidance has had a substantial impact on commercial availability of disposal for many of the more common and highest risk high-activity source-containing devices in use today. The following recommendations would greatly clarify the disposal picture for concerned source/device owners:

1. Disposal facilities should clearly consider and articulate disposal limits for Cs-137 and Co-60 isotopes (including sealed sources) and allowable packaging configurations in their waste acceptance criteria.
2. NRC should better define conditions under which the 55-gallon encapsulation and averaging volume described as “generally acceptable” in the BTP can be increased.
3. 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.

Many questions remain regarding interpretation of the BTP requirements that NRC may wish to address during its review of this guidance. For example,

1. Is averaging over volumes larger than 55-gallons “acceptable” where sources are in original devices or transportation container liners that exceed that volume?
2. 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?
3. 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?

NNSA looks forward to continuing already-initiated discussions with NRC to develop answers to these questions.

REFERENCES

1. U.S. Nuclear Regulatory Commission (NRC), "Blending of Low-Level Radioactive Waste," SECY-10-0043, 2010.
2. 10 Code of Federal Regulations (CFR) 61.
3. Nuclear Regulatory Commission, "Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation," January 1995.
4. 10 CFR 835.2.
5. National Academy of Sciences, "Radiation Source Use and Replacement," Washington, DC, 2008.
6. National Nuclear Security Administration Offsite Source Recovery Project homepage, http://osrp.lanl.gov.
7. "Report on Assessment of Feasibility of Phasing out the Use of CsCl in a Highly Dispersible Form," Radiation Source Protection and Security Task Force CsCl Working Group, August 14, 2008.
8. U.S. NRC, "Strategy for the Security and Use of Cesium-137 Chloride Sources," SECY-08-0184, November 24, 2008.
9. "Sealed Source Disposal and National Security - Problem Statement and Solution Set," Removal and Disposition of Disused Sealed Sources Focus Group, December 9, 2009.
10. "The 2010 Radiation Source Protection and Security Task Force Report," U.S. NRC, August 11, 2010.
11. Email from M. Ault, U.S. Ecology, to B. Stewart (OSRP) re: "Requested Information," October 4, 2010.