Chapter 13

CONTROL AND DISPOSITION OF SEALED SOURCES: RELATIVE TO A CAMPUS SETTING

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OVERVIEW - WHAT IS THE ISSUE FOR RSOS AND SEALED SOURCES?

Sealed sources have been in use in the US since the 1930's (e.g., Ra-226 medical and radiography sources). After World War-II reactor-produced byproduct materials such as Co-60, Cs-137, Sr-90, Am-241, Pu-238, and Pu-239, and sealed sources that incorporated these materials, became readily available for research, medical, and industrial purposes. Tens of thousands of sealed sources have been produced and distributed in the US over the last 50 years.

Disposition of large sealed sources did not become a significant issue until passage in 1985 of Public Law 99-240, which amended the Low-Level Radioactive Waste Policy Act (LLWPA '85). The creation of PL 99-240 defining Greater-Than-Class C Low-Level Waste (GTCC LLW) created a waste stream with no defined disposal path (10CFR61.55). This new class of waste could not be disposed of with high-level waste (HLW), low-level waste (LLW), naturally occurring radioactive material (NORM), or transuranic (TRU) waste. The newness and small volume (<2,000 m^3) of the GTCC waste stream meant that it did not get much attention with respect to planning or actual siting of a disposal unit.

As the nuclear industry in the US matures, there are fewer Nuclear Engineering schools and as a consequence, less need for sealed sources. From the RSO perspective, excess material that may not have a simple or inexpensive disposal path is accumulating. Due to increased sensitivity to the potential for terrorist activity, there is also a need to reduce on-campus security and risk profiles. Security and risk profiles are most readily defined for sealed sources and most readily reduced by dispositioning excess sealed sources.

CONTROL

Since the events of September 11, 2001, everyone in the nuclear community has become sensitized to the potential of having radioactive material (RAM) surreptitiously removed or nuclear facilities attacked. In great part anonymity has protected our individual institutions. When Jose Padillia was arrested in Chicago (June 2002) on an Al Quaeda mission to locate materials suitable for a Radiological Dispersal Device (RDD), where did he plan to find the RAM for terrorist devices? The answer is US Universities, research laboratories, or hospitals with large RAM collections. He only had a vague idea where to look for RAM in the US. What if a like-minded nuclear engineer had been recruited instead of a street criminal? The outcome could have been very different.

It does not take much imagination to generate a scenario where a terrorist attack delivers just 10 grams of Am-241 oxide into a crowded outdoor public venue. Made dispersible by simple physical operations, loaded into a plastic bag with a very small amount of blasting agent, delivered from the air or from the ground, it does not make any difference. The material can be delivered without even causing severe radiological consequences to the terrorist. The only work left for us is to calculate the dose potential to the selected targets. A puff model with the appropriate venue geometry and nominal wind speeds will indicate that thousands could receive committed effective dose equivalents (CEDE) in excess of 25 rem, and hundreds of individuals could receive a CEDE on the order of one thousand rem. Are these non-acute doses life threatening to those individuals? No! Would the public health nightmare created by having to track down tens of thousands of individuals and performance of individual dose evaluations cost many millions of dollars? Absolutely. Would you want your institution's name associated with a lost source traced to an event of this magnitude? No!

The most common regulatory incidents associated with sealed sources in research settings have been loss-of-control type incidents associated with lost, stolen, or damaged sources. There have been several hundred of these incidents since the NRC's Nuclear Material Event Database was started in 1989. Most of these incidents are related to sources stored on ground vehicles. Theft of a vehicle with sources stored aboard is the single most common cause of these source incidents. Most of these sources, but not all, are recovered. These incidents are worrisome to regulators, since sources that are not under regulatory control are potentially subject to abuse and misuse.

Even without the terrorist implications, the presence of unidentified leaking sealed sources can have disastrous consequences. As has been ably pointed out (see Chapter 16), a little loose contamination can go a long way. Dr. Karam uses the following example: 1 μCi of activity can contaminate 20 m^2 to levels greater than the 1000 dpm/100 cm^2 limit for release of control. Since we are assuming uniform material distribution, these numbers scale linearly, so 1 Ci of activity will go a million times farther.

The loss of control incident(s) at Southeast Missouri University (SEMU) are a good case study of how badly things can go wrong. The SEMU problems began with an inventory of sealed sources in a small safe that was moved by an untrained individual. The individual knocked over two small glass liquid scintillation vials and broke them. About 5 mCi of Am-2421 were spilled in the safe. The lack of supervision, experience, training, and monitoring allowed this spill to go unreported and undiscovered for years. The alpha contamination was tracked all over the laboratory facility and into other parts of the campus. More recently at SEMU, a contractor was hired to inventory sealed sources in another small safe. A leaking 100 mCi sealed source intended for X-ray fluorescence work resulted in an uptake by the contractor. After discovery of the leaking source and evaluation of the uptake, a dose of 60 rem CEDE was assigned to the worker. Ultimately, cleanup of the contaminated building and campus cost SEMU over $1,000,000.

The consequences of minor loss of control, aggravated by inept initial cleanup and inattention, caused major financial damage and resulted in a major decontamination activity. Besides the financial damage, there also exists the potential for regulatory actions such as fines or loss of license. The potential for unwanted attention to nuclear research centers and damage to institutional and personal reputations is also substantial.

BASICS OF SEALED SOURCE CONTROL

The first step in gaining control of sealed sources is being able to identify your sources. This is important in that you are expected to control only your sources. There is not the expectation of control for sources that suddenly appear on or near your institution. If your sources are well identified, then much confusion caused by the sudden appearance of sealed sources can be avoided.

Once all of your sources are identified, you must know where those sources are located. A current sealed source inventory is mandatory. Sources will move from lab to lab as experimenters are relocated or their work areas change. One of the most daunting tasks for an RSO can be the maintenance of an up-to-date inventory for a large research institution. Without a current inventory, how can a sealed source control program even begin to demonstrate regulatory compliance? Another part of the inventory program is to know who is physically responsible for using and securing sealed sources at the end of each day. Without a clear chain of responsibility it is easy to develop cavalier attitudes toward sealed source security.

The third attribute of a source control program is the periodic spot check of the inventory. Without confirmatory checks it is impossible to monitor the success of the source control program. If your source inventory is only verified as accurate once a year, should you sleep well knowing that there are 364 other days in the year for these physically small items to be re-located without an inventory update?

WHAT SEALED SOURCES SHOULD BE PERMANENTLY ADDED TO YOUR INSTITUTIONAL INVENTORY?

Short-term needs (1 year or less) for large sources should be addressed by short-term ownership, i.e. borrowing or leasing sources from institutions, manufacturers, and distributors. A simple question to ask is: "Does the cost of buying the source and disposing of it equal the short-term cost of leasing?" Long-term needs (several years) need to be addressed in much the same way. In the long term, however, the issue usually becomes: "Will I be able to dispose of the source at the expected end of life?" It will always be an expensive proposition to pay for commercial disposal at some future date.

One way to address these procurement issues is to require Borrow/ Lease / Buy / Disposal evaluations prior to the purchase of any large new sources. These issues must be dealt with by the RSO through their institutional procurement, legal, and community relations departments. A proactive knowledge of these departments will prevent the institution from accepting ownership and responsibility for radioactive sealed sources without a clear picture of the value or lack thereof to the institution. A clear example of this occurred at University of Texas Medical Branch (UTMB) in the 1990's.

A UTMB researcher had arranged for a large multinational corporation to donate 240 excess 16-Ci AmBe sources to the school. The researcher was actively trying to start a program for *in-vivo* zinc metabolism studies by neutron activation. The researcher had met with the university's legal department and arranged for a transfer of the sources to UTMB's ownership for $1. The UTMB RSO was contacted when the company holding the sources wanted to make the transfer to UTMB.   The RSO office had no place to store the sources and had to setup a small, separate floor-well storage facility off campus, since their local water table is only 2 feet deep. After designing and building the storage facility and getting the sources transferred, the researcher who had initially arranged for these sources to be acquired left for another institution. UTMB was left with ownership of 240 surplus 16-Ci AmBe sources. Since the Greater-than-Class C disposal limit is 100 nCi/g, it was clear that these sources were not suitable for commercial disposal. In early 2003, UTMB was able to have their sources transferred to the DOE's Off-Site Source Recovery (OSR) Project at Los Alamos National Laboratory (LANL). Although the transfer of these sources is nominally free of charge, UTMB had to foot the bill for 50 neutron shielded shipping/storage containers at a price of $3,200 each.

It is easy to see how a simple transfer of material to the institution ended up costing $160,000 just for the shipping packages. The current UTMB RSO said that the incident had changed their relationship with the institutions Legal, Procurement, and University Relations Departments which now knew that UTMB had an RSO and that their area of concern was any radioactive material entering, residing on, or leaving the UTMB campus.

PERIODIC JUSTIFICATION FOR KEEPING LARGE SEALED SOURCES

Many RSOs have large sealed sources on their inventory that they inherited with the job. Some of these sealed sources have not been used in over a decade. If the source is unneeded and unwanted, a plan to eliminate the excess material may be warranted. The disposal plan should include information on what you have: physical dimensions, activity, manufacturer and source model number, device model number, loan lease papers, etc. It is also useful to estimate the approximate cost (today) to get rid of the item, and to assess how likely it is that the current disposal pathway will be available in 2,5, or 10 years.

As discussed above, large sealed sources represent a financial and security liability to the institution at end of life (EOL). The financial risk is obvious if you have possession of a source that you cannot legally dispose of, and for which the disposal cost increases every year. It is also obvious that getting rid of unwanted sources is the surest way of lowering an institutional security and risk profile. In retrospect, projects that generate the need for acquiring large sources need to generate the budget to dispose of those sources at the end of the project

Even if an item is not disposable today, it is useful to identify the legal and political changes necessary to make future disposal or transfer possible. Few institutions realize the value of a well-placed letter to appointed and elected public officials. At a minimum, the recipient of a well written letter will know there is a problem, and will get a sense of how it impacts our teaching, research, and medical institutions. It is safe to say that without a letter those public officials will not have a clue as to the nature of this problem. Similarly, one can be assured that if large costs are associated with sealed source disposal, then long lead times will be required to adjust institutional budgets.

DISPOSITION OF SEALED SOURCES

If you have radioactive LLW, it is expected that your institution could retain a waste broker and dispose of that LLW. If you have a substantial quantity of LLW, then you might subdivide the quantity into whatever number of containers is required to dispose of the material. However, large sealed sources with GTCC quantities are different in that they do not follow this expectation; that is, there is no possibility that sources can be sub-divided for purposes of disposal or re-use. For example, the economics do not currently support start up of a facility in the US to manufacture new large gamma sources using material like Cs-137 that has inherent contamination issues. If the economics do not support a facility for manufacturing new sources, they certainly do not support opening up old Cs-137 sources to sub-divide them.

Very few licensed facilities remain for large source manufacturing. The DOE facility (ORNL, Bldg 3517), where 90% of the western world's Cs-137 sealed sources were manufactured, was shut down in 1987. Most large TRU sealed source manufacturers are also out of business (Mound Laboratories, Monsanto Research Corp., Parkwell Labs, NUMEC, Gulf Nuclear, Gamma Industries, etc.). Very few of the remaining source manufacturers have the ability to reuse large sources, much less actually sub-divide material.

There are very limited options for large source disposal if these sources are GTCC LLW. GTCC is defined in 10CFR61.55 as "Waste which is generally not considered acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified as Type C waste." GTCC LLW is then further defined by the criteria specified in Tables 13-1 and 13-2 for selected short- and long-lived radionuclides.

Table 13-1, GTCC LLW Criteria for Long-lived Radionuclides

Radionuclide	Concentration (Ci/m^3)	Half-life (yr)
C-14	8	5730
C-14 in activated metal	80	5730
Ni-59	220	76,000
Nb-94	0.2	20,000
Tc-99	3	213,000
I-129	0.08	1.57E7
α emitting TRU $T_{1/2} > 5$ yr.	100 [a]	> 5
Pu-241	3.500 [a]	14.4
Cm-242	20,000 [a]	163 days

[a] Concentration in nCi/g

Table 13-2, GTCC LLW Criteria for Short-lived Radionuclides

Radionuclide	Concentration (Ci/m^3)	Half-life (yr)
Ni-63	700	100
Ni-63 in activated metal	7,000	100
Sr-90	7,000	29.1
Cs-137	4,600	30.2

The limits specified in Tables 13-1 and 13-2 were then further modified to allow concentration averaging over a shipping package, within limits. These de facto limits (Table 13-3) are set out in the *Final Branch Technical Position Paper on Concentration Averaging and Encapsulation, Revision in Part to Waste Classification Technical Position* (NRC, January 17, 1995). These limits were intended to mitigate dispersion of waste and to provide shielding to limit external radiation fields throughout a 500-year internment period. This change added another layer of interpretation to what could effectively be disposed of at the two active Class A, B, and C radioactive waste disposal sites in the US. Effectively, sealed source disposal is limited by the activities that commercial waste disposal sites will accept, which is also subject to the licensing State's controls and to economic considerations.

Table 13-3, De facto Limits for GTCC Radionuclides

Radionuclide	Concentration (Ci/55 gal. Drum)	Approximate Cost ($)
Cs-137	30	$4,300
Ra-226	0.300 per drum; 0.100 per source	
Am-241	0.0005 - 0.030	

End Of Life Options for Sealed Sources

You can dispose of most LLW (Class A, B, and C) in the US depending on what state (regional compact) in which you are located. There are no disposal sites for GTCC LLW. Activated metals, and large primary gamma (Cs-137) and TRU sealed sources remain in a disposal quandary. The easiest way to handle LLW is to use a waste broker to settle the packaging and permit issues, and to consolidate small lots of material. It is then just a matter of money. Costs of LLW disposal have been spiraling up for the last 15 years. The Barnwell Disposal site in South Carolina is scheduled to close in 2005. This event will cause a major re-evaluation of the NRC's compact disposal system since many states, including all of the eastern US, will then have no LLW (Classes; A, B, and C) disposal site available to them.

Alternatives for reducing the quantity of activity, such as decay-in-storage, or subdividing, do not work when the material is long lived and has significant contamination issues. Activated metals from nuclear power plant D&D work are being size-reduced and distributed over the drum inventory to preclude classification as GTCC. Another possible method of dispositioning has been to transfer a surplus source to someone who can use it. This is becoming increasingly difficult as more and more GTCC sealed sources become available. There is very little re-use value in most of the GTCC sealed sources. Only very large (>50 Ci nominal) Cs-137 sources have some value, since they have not been manufactured in the US since 1987 and are in relatively short supply.

A real problem exists when the material is a GTCC waste as discussed above. In 10CFR61.55 a.(iv), we learn that GTCC waste is not generally acceptable for near surface disposal. In essence, a geologic repository is required, and DOE is responsible for providing this repository. However, DOE is not working to design, site, investigate, or build such a repository since there are only 2,000 m^3 of this high-activity waste. The Yucca Mountain Project is not even considering most GTCC materials for that repository. The Waste Isolation Pilot Plant (WIPP) in New Mexico is barred, by law, from accepting non-defense sources.

Since there is not yet any disposal solution for GTCC materials, the only other option for secure dispositioning of those sources is for DOE to accept the material for interim storage. In 1999 DOE established the Off-site Source Recovery (OSR) Project at Los Alamos National Laboratory to investigate a program whereby TRU sealed sources would be transferred into the DOE system. Currently, the OSR Project is charged with recovery, packaging, and storage of Am-241 and Pu-238 sealed sources from the public sector. Although some Pu-239 sources have been recovered to date, the OSR Project is not currently authorized to recover additional Pu-239 sources. Table 13-4 indicates the number of sources and activity recovered by the OSR Project since fiscal year (FY) 2000.

TABLE 13-4 Commercial TRU Sealed Sources Recovered by LANL OSR

Isotope	FY'00	FY'01	FY'02	FY'03 (Q1)	Total Sources	Total (Ci)
		Number	**Of Sources**			
^{241} Am	7	8	461	33	509	188
^{241} Am/Be	13	1098	407	885	2403	2105
^{241} AmBe/^{137}Cs	12	267	132	0	411	19
^{238} Pu	0	1561	272	0	1833	6863
^{238} PuBe	0	10	16	1	27	364
^{239} Pu	0	0	0	0	0	0
^{239} PuBe	7	2	1	0	10	29
^{244} Cm	0	0	2	0	2	0.1
Totals	**39**	**2946**	**1291**	**919**	**5195**	**9541**

The OSR Project based at LANL was originally intended to be a ten-year project designed to recover all excess and unwanted commercial TRU sealed sources in the US. The project's plan was to document, recover, package to the WIPP standard, ship, and have interim storage of TRU sources in the LANL TA-54 TRU Waste Storage Facility. Packaging was planned so that WIPP-approved Type A shipping containers could be loaded in the field and shipped to LANL for transfer to the storage facility. This use of a single multifunction container was intended to minimize expense by using only a single package and to keep personnel doses ALARA by precluding needless repackaging work.

In FY'02 the OSR Project received $10 million of Homeland Security Emergency Appropriation to accelerate the rate of recovery of TRU sealed sources to an 18-month schedule. Thus far, accelerated recovery is on schedule.

To take advantage of the OSR Project to disposition TRU sealed sources, you must first register your sources on-line (http://osrp.lanl.gov/). After registration, the sources are assigned a priority according to numbers of sources, activity, site security, and resource availability. Once prioritized, short-term recoveries are scheduled. Many small sites with capability to package and ship are lent DOE shipping containers and instructed on the process for self-shipment. Self-shipments are collected at a consolidator site where OSR Project personnel periodically package material for shipment to LANL. Future challenges for the OSR Project will likely involve authority from DOE to collect ^{239}PuBe sources and perhaps even other beta/gamma source types.

Shipping issues dominate the list of problems for excess sealed sources. The problem is typically associated with a lack of documentation of the “special form” character of sealed sources manufactured prior to 1974. These sources requiring special form documentation contain greater than the A_2 quantities of RAM specified in 49CFR173.435. Sealed sources with greater than A_2 quantities must demonstrate sufficient capsule integrity to withstand normal shipping hazards in a Type A shipping package. Special form character of sealed sources is demonstrated by testing (49CFR173.469) or by engineering evaluation.

Another issue for shippers is a lack of documentation on the institution’s shipping containers. The OSR Project does not use shipping containers other than ones it has purchased. Another type of special form problem has been associated with the fact that many older sources do not have a manufacturer’s model stamped on them. Without clear identification of a model number, it is often impossible to associate a specific sealed source with a manufacturer’s special form test documenting compliance with this requirement.

Record keeping on sealed sources is absolutely necessary. Every large source needs to have a file with the following information: source certificate, shipping papers, special form certificate (or special form test report), smear test history, a physical description (dimensions), and a picture. Do not rely upon the manufacturers to have your records! Most sealed source manufacturers that were in business 25 years ago are long gone (Parkwell, NUMEC, ARCO, MRC, General Nuclear, Nuclear Chicago, Gamma Industries, Gulf Nuclear, etc.). There are very few record repositories where information on individual sealed sources is available. NRC and states licensing agencies have retained only information directly applicable to the license and license termination. Even the NRC sealed source device index is of very limited use for special form documentation purposes (http://www.hsrd.ornl.gov/nrc/sources/index.cfm), since the DOT requires a special form certificate, a test report, or an engineering evaluation. Most out-of-business manufacturers have purged their files. These files need to be maintained until the source is buried in the ground several years!

In conclusion, it should be clear that most sealed sources in the US appear to be controlled in a manner that complies with the spirit and letter of the licensing agency. It is typically only when sealed sources get out of regulatory control or their disposition becomes problematic that outside assistance becomes necessary. Demonstrate control by having a current inventory, controlling what is brought onto the institutional license, and getting rid of excess sealed sources. Disposition of sealed sources is an important method of lowering the institutional risk profile. Maintain the ability to disposition material by recognizing problematic materials and quantities, know your disposition pathways and costs, and keep good sealed source records. The quality of the records will set the tone for what is actually known about your sealed sources.