Radioactive waste management at academic and medical institutions involves dealing with shorter lived isotopes, lower volumes of generated waste, generally lower energy gamma emissions, and a variety of waste forms that include other hazards.

(Above) The Radiation Safety Office's corner of the Medical Center. The white truck is at the loading dock, and the offices connect to the dock. Packages are received here, and the truck is used to transport waste from the River Campus. (Right) The Radiation Safety truck, used to transport radioactive waste from River Campus to the loading dock. This truck is less than a year old, replacing an ancient van.

Waste Management by a One-Man Band

Managing a University and Medical LLRW Program

By P. Andrew Karam

The use of radionuclides in an academic and medical setting differs in many respects from their use in the industrial and power generation sectors. These differences include the use of shorter lived isotopes, lower volumes of generated waste, generally lower energy gamma emissions, and a variety of waste forms that include other hazards. In addition, hospitals and universities do not always have the luxury of full-time staff to deal exclusively with waste issues and may not have the budget or space to construct specially designed waste storage or treatment facilities. These differences result in different operating constraints and, in many cases, a different operating philosophy than is the case in other sectors. The University of Rochester's (U of R's) low-level radioactive waste (LLRW) program provides an example of one way to address these factors.

Short-Lived Beta Emitters

Most isotopes used for research and medical purposes are short-lived beta emitters with relatively low decay energies. The few gamma emitters in common use also tend to be low-energy emitters that are, again, short-lived. A summary of the relevant properties of the most widely used academic and medical nuclides is found in Table I.

Our radioactive waste storage, treatment, and disposal strategies are set by the nuclides we use most frequently. Since these are, typically, short-lived beta emitters, our primary concern is the ability to store compacted materials that can be easily tracked and cataloged. Shielding is not a primary concern.

Space and Staffing—Not Much

Like many other places, including virtually every hospital and university in the United States, the U of R has only a limited amount of money and space to make available for radiation safety. Within those constraints, we must prioritize our services to assure a safe working environment for staff and visitors, comply with all

Table I
The Relevant Properties of the Most Widely Used Academic and Medical Nuclides

Isotope	Half-Life	Radiation Emitted	Energy (keV)*	Use
H-3	12.3 yrs	—	18	Research
C-14	5730 yrs.	—	156	Research (e.g., labeling high-molecular weight markers for DNA sequencing)
P-32	14.1 days	—	1710	Research, some medical treatment
P-33	25.3 days	—	248	Research
S-35	89 days	—	167	Research (e.g., DNA sequencing)
Ga-67	3.3 days	—		Diagnostic nuclear medicine
Tc-99m	6.01 hrs	—	143	Diagnostic nuclear medicine and nuclear cardiology
Pd-103	17 days	—	39.8	Medical treatment (e.g., seeds for cancer treatment)
I-125	60 days	—	35	Research (e.g., iodinating proteins), medical treatment (e.g., seeds for cancer treatment)
I-131	8.1 days	— —	606 364	Diagnostic and therapeutic nuclear medicine (e.g., thyroid disease treatment)

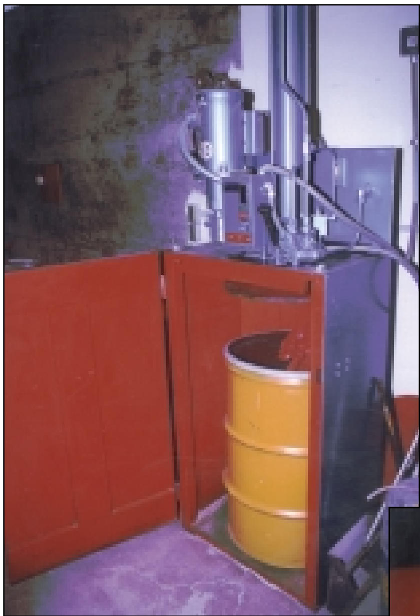
**For beta-emitting nuclides, energy is given as the maximum beta energy. The average beta energy is roughly one-third of this value.*

applicable regulations, and provide as much service to our "customers" as possible.

As a result, we have approximately one full-time-equivalent (FTE) staffer available for all aspects of our radioactive waste program. In actuality, this FTE is split among two or three staff members, all of whom have other responsibilities as well. The result is that we have no single person who "lives and breathes" LLRW (figuratively, of course, not literally). As a result, with no dedicated in-house LLRW "guru," we rely on our waste brokers to assist with any nonroutine questions or problems we may have with unusual forms of waste or nuclides with which we have little experience. Staffing limitations also dictate that we have most researchers deliver their waste to our accumulation area. Since more than 90 percent of our "hot labs" are in a single complex of linked buildings, this can be accomplished without the need to transport radioactive materials outdoors or through public spaces. Radiation safety staff pick up waste from those researchers who are not within the Medical Center complex.

In addition, the space available for our waste program is limited, and we must pay rent for the space we maintain. This gives us multiple reasons to try to do as much as possible in

University of Rochester LLRW processing room. In the foreground is the vial crusher with the waste compactor just past it. Technician Chuck Surre is wearing his protective equipment—a lab coat, gloves, safety glasses, and plastic sleeves. Extensive air sampling has never shown evidence of airborne radioactivity



the smallest space. Our waste areas, while not cramped, are decidedly cozy, and waste shipments or other infrequent activities often take advance planning. A corollary of the relative lack of space is that our waste storage and processing areas were not designed for this purpose at their time of construction. Rather, they were existing spaces adapted for that use. This results in sometimes awkward operations in order to accomplish our work without violating good work practices or safety considerations. Finally, our waste area is in an out-of-the-way part of the medical center that used to house an accelerator and some radioactive materials work areas before those programs were closed down. This is ideal from the standpoint of shielding and isolation but is also inconvenient for radiation safety and research staff to reach.

(Above) The waste compactor uses a hydraulic ram to compress waste, usually achieving a compaction ratio of about 2 to 1. The door prevents the spread of contamination to the room. Post-work contamination surveys are performed inside and outside the compactor. (Right) Decontaminating the interior of the compactor. Since we work primarily with beta-emitters, radiation levels are very low, so we prefer to decontaminate frequently.

Waste Segregation

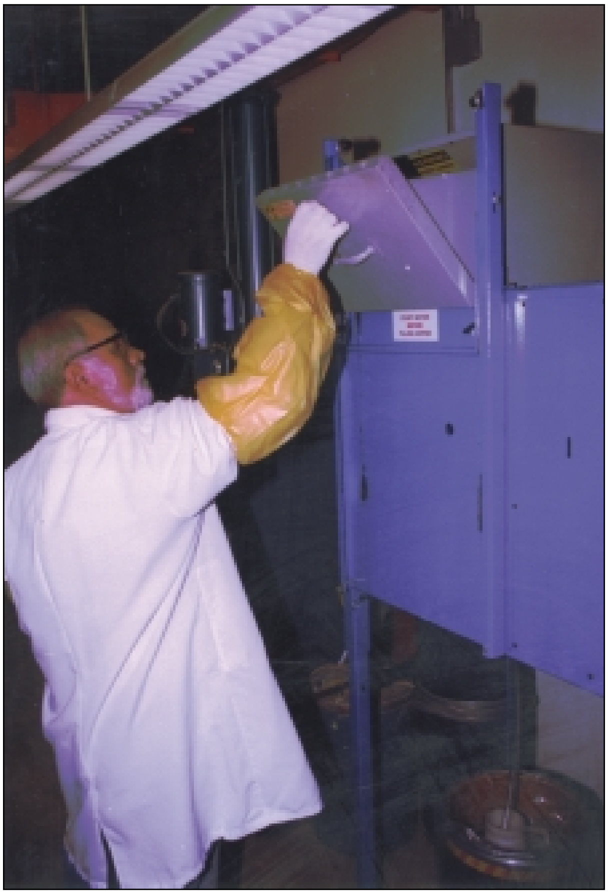
Because the highest and most uncertain cost associated with radioactive waste in our setting is that of disposal for long-lived isotopes, we make every effort to reduce the activity and volume of radioactive waste sent off for treatment and land burial. We encourage the use of short-lived isotopes by a surcharge imposed on each radio-active materials purchase; the surcharge for long-lived isotopes is significantly higher than for short-lived isotopes, reflecting the added cost resulting from land burial versus decay-in-storage (DIS). In addition, by requiring researchers to segregate their waste, we are able to further reduce both staff time and disposal expense. For this reason, waste segregation bears further discussion.

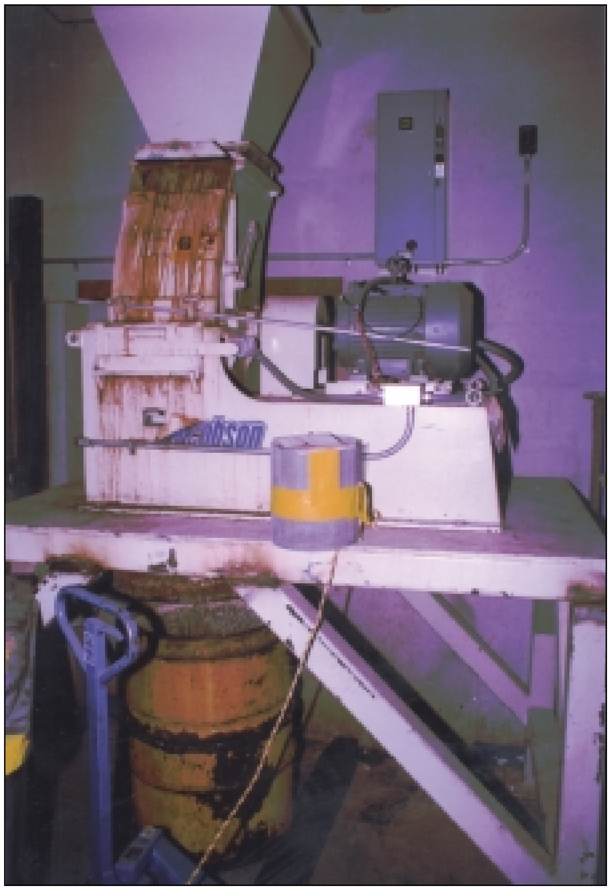
Our most fundamental form of segregation is into solid and liquid waste streams. Liquid wastes are further segregated into aqueous, organic, and mixed wastes. Nonhazardous aqueous wastes may be disposed of in the sanitary sewer system, provided accurate records are maintained to ensure that concentration or activity limits are not exceeded. Organic wastes and hazardous aqueous liquids are separated for disposal through DIS or at a waste disposal site. Mixed wastes are treated as such, and their disposal costs are billed back to the lab generating them.

Solid wastes are first segregated into long- and short-lived containers. We encourage researchers to maintain separate containers for each short-lived nuclide, since they must be stored for at least 10 half-lives prior to disposal. Long-lived waste is further segregated into incinerable and nonincinerable containers because we can send materials off for incineration far less expensively than the cost of land burial. In addition, we have a strict policy that no "sharps" (i.e., sharp or pointed objects) may be included in any waste container other than an approved sharps shelter.

In addition, we recently released a request for proposals for our waste disposal contract. Even though our waste disposal costs are not high (between $25 000 and $45 000 yearly), the winning bid had an estimated contract cost of less than half that of the next highest bidder. Our former contractor actually turned in the highest bid of the three companies that competed for this contract. These cost savings will, in turn, be passed on to our researchers because our program is supported entirely by user fees.

The use of biodegradable scintillation cocktail is mandatory at the U of R, so the resultant liquid can usually be discharged into the sanitary sewer system after sampling.





(Left) Loading scintillation vials into the vial crusher's bin. Liquid is drained into the bottle at the lower right, and the crushed glass and plastic go into a separate drum. (Right) The old vial crusher could only be used by climbing a ladder to dump vials into the funnel. This unit is now in the process of being decontaminated and removed for disposal.

Ambulatory Patients and Medical Radioactive Waste

Patients receiving therapeutic doses of iodine-131 are usually ambulatory and, aside from their thyroid problems, are often healthy. This means that they walk around their rooms, use the restroom facilities, and so forth. Since iodine leaves the patient through perspiration, moisture in the breath, feces, and urine, the entire room must be considered contaminated, and some effort is put into preparing the room for use to minimize postpatient decontamination. The paper, plastic, and tape used to prepare the room are removed as radioactive waste along with any trash generated during the patient's stay, and the bed linens are stored for decay before returning them to housekeeping for laundering. These materials are stored in a separate room near the hospital waste area.

Many patients receiving diagnostic doses of radioactivity are not required to remain in the hospital as inpatients because the risk to the public is negligible. However, if these patients remain in the hospital following their diagnostic procedures, they can inadvertently leave contaminated "normal" waste such as paper tissues or adult diapers (in the case of incontinent patients) in a regular waste container. Under the right circumstances, the amount of radioactivity in such waste can set off radiation alarms at landfills. To avoid this possibility, we have installed portal monitors in the hallway leading to our hospital waste dock so that all waste is surveyed prior to leaving the medical center. These detectors are as sensitive as those at local landfills and are sufficient to identify such wastes. If there is an alarm, the workers have been trained to set the bag of waste to the side and contact Radiation Safety.

Stockpiling Waste in the Lab

In addition to what has been noted previously, academic institutions in particular may have the problem of researchers stockpiling waste in their laboratories. This is done for a number of reasons, chief of which are the unwillingness to pay for disposal of radioactive waste and the unwillingness to arrange for waste disposal. In addition, the research environment is less amenable to imposing strict or draconian requirements that do not have an immediately obvious regulatory or safety basis. Any solutions imposed must weigh the relative benefits for both researchers and radiation safety staff as well as the risks involved, the likelihood of acceptance by the research community, and other factors. And all of this, of course, must be viewed in light of regulatory requirements and legitimate safety considerations because, regardless of any other considerations, we cannot endanger personnel or violate regulations.

An unwillingness to pay for disposal is more characteristic of those programs that charge researchers for radioactive waste disposal. With grant dollars increasingly tight, many researchers may feel that they can save money by simply stockpiling waste in unused lab or storage areas. One university, when it approved a "waste amnesty" program to collect all stockpiled materials, collected more 2000 cubic feet of waste, some of it more than 20 years old. Processing and disposal of this waste cost more than $200 000. Previous radiation safety officers at the U of R helped to minimize this problem by instituting "up-front" surcharges on all radioactive materials ordered. Researchers need to order radioactive materials in order to do their research, and if they have already paid for disposal costs at the time they order, there is no reason for them to stockpile waste in their laboratories. This results in a very small amount of radioactive waste actually present in most laboratories.

The other reason for stockpiling waste—the inconvenience of arranging for waste disposal—is less easily addressed. In this case, many researchers simply do not wish to take the time to calculate activity, fill out the necessary documents, perform container surveys, and do the other tasks required for waste disposal. Given staffing and budget limitations, we can provide only a limited amount of assistance in this area, although we are trying to simplify our administrative requirements.

The University of Rochester LLRW Program

Much of our waste program has already been described. This section attempts to fill in the blanks, as it were, as well as discuss how all these factors fit together into a single, coherent program.

In a sense, our waste program starts at the time radioactive materials are ordered. All orders must be placed through the radiation safety office, which places the order, pays for the isotopes, and bills that cost to the researcher's account. This not only gives Radiation Safety positive control over our radioactive materials inventory, but also ensures that the appropriate surcharge is billed to each order.

Our vendors and the most commonly used delivery companies have been instructed to deliver *all* U of R radioactive packages to our office. Radiation Safety receives the packages, performs receipt inspections, enters packages into our inventory system, and delivers them to the laboratories. At no time after receipt are packages transported over public roads; they are transported on a cart or hand-carried. Each stock vial is assigned a unique number and is delivered with an inventory sheet.

All waste is segregated into either 5-gallon carboys or 2-ft^2 cardboard containers that are lined with plastic bags. Researchers are required to note the isotope(s), activity, date, stock vial number, specific chemicals present, and contact information. Researchers within the Medical Center are asked to seal and deliver full containers of solid waste to our waste room, and Radiation Safety picks up solid waste from nonconnected buildings. We pick up all liquid waste. At the time of waste pickup (or drop-off), new containers are left or made available as appropriate.

"New" containers of waste are entered into our inventory system (maintained with the *HP Assistant* software package), and the disposed activity is debited from each researcher's inventory based on the stock vial number. DIS waste is entered into a tracking system that alerts us when a package has passed the 10 half-lives point at which it can be surveyed, inspected to ensure all radiation markings are removed or obliterated, and released as "normal" waste. Other wastes are treated appropriately (i.e., stored for shipment or discharged into the sanitary sewer system).

We use two methods of processing waste, compaction and vial crushing. Most wastes are compacted into 55-gal drums to reduce storage space and to reduce the potential for inadvertently damaging a package. Liquid scintillation vials are milled, and the liquid is removed from the crushed glass and plastic. The use of biodegradable scintillation cocktail is mandatory at the U of R, so the resultant liquid can usually be discharged into the sanitary sewer system after sampling.

Anticipated Changes

All in all, our radioactive waste system appears to be working well. However, in light of additional laboratory space to be added to our Medical Center along with the anticipated elimination of backlogged waste, we anticipate some changes in the next few years. Specifically, we are hoping to reduce the space currently occupied by our LLRW storage facilities by continued removal of the several hundred cubic feet of waste that was allowed to accumulate in the past. This will allow the consolidation of our operations into fewer rooms and will require less transportation of waste from room to room. This, in turn, will not only save rent on the occupied space, but will help us to make better use of our technician time and should increase the efficiency of our program noticeably.

Secondly, once we have completed processing our backlog of materials, we are hoping to begin picking up all Medical Center radioactive waste, solid and liquid. We feel that this is a service we can provide to our "customers" that will enhance our program in a number of ways. ■

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