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Abstract

The philosophy of "concentrate and confine" as applied to work with radioactive materials at UCRL has made possible special packaging and disposal procedures for radioactive wastes. These procedures and their advantages and disadvantages are discussed, and approximate costs are given for the various types of packages produced.

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I. Introduction

The disposal of radioactive waste materials is a major problem facing any installation processing or producing radioactive materials. The University of California Radiation Laboratory at Berkeley is engaged in nuclear research involving all types of radioisotopes, either produced by bombardment on its particle accelerators or obtained from the Atomic Energy Commission or commercial suppliers. There have been problems involving most of the isotopes from element No. 1 to element No. 102, in quantities from tracer levels to kilocuries, depending on the work and the availability of the isotope.

The Health Chemistry Department is charged with the safe handling of radioactive isotopes involved in laboratory research. The philosophy of the department is to keep radioactive materials as confined and concentrated as possible.

One result of the "concentrate and confine" method is that the volume of radioactive waste produced is kept small by avoidance of unnecessary dilution during the processing of radioactive material. Advantages resulting from keeping the volume of waste small include these:

- Less time and labor are needed to process the waste for disposal.
- The small volume of waste can be moved and processed not only more easily but also more safely, because safety features can be incorporated in the small containers that would make large ones very unwieldy.
- Less area and equipment are needed for processing and storage of packaged wastes prior to sea disposal.
- More packages can be shipped to the disposal barge at one time (so that fewer disposal shipments are necessary).

All these savings in time and effort amount to a gratifying economy: as is shown below, the disposal cost per "potential gallon" of liquid waste is less than $1\frac{1}{2}$ cents.

About 200 researchers are continuously carrying on work at millicurie levels or higher in various departments at UCRL. These people depend directly on the waste-disposal services of the Health Chemistry Department. The average waste contribution is about 20 ft^3 of solid waste and 5 gallons of liquid waste per researcher per year. The wastes are packaged as described below for ultimate disposal at sea.

II. The Handling of Radioactive Waste Materials

The wastes produced throughout UCRL include the usual solid, liquid, and airborne types. All nongaseous waste is packaged in concrete. Liquid and airborne wastes (except for short-lived gases that may safely be released to the atmosphere) are solidified or trapped for incorporation in concrete packages. The concrete packages are made so that they can be stored safely for an indefinite period and eventually be safely transported by truck to a barge for disposal at sea at a depth of 1000 fathoms. (Section II D describes the types of waste packages used by UCRL.)

A. Solid Materials

These wastes fall into three categories, defined and handled as follows:

1. Contaminated materials from operations in special enclosures (gloved boxes, manipulator boxes), from animal injections, and from tracer-level work involving counting disks, etc.

The wastes in this category include contaminated glassware, rubber gloves, wipes, and other items removed from the enclosure during the operation or during the decontamination of the enclosure after the experiment. These wastes are collected in multilayer paper sacks and taken to the disposal area where they are incorporated in concrete in 55-gallon metal drums.

The solid wastes from high-level operations in special enclosures in the 6-inch lead cave are discharged into shielded waste containers located underneath the operating enclosure and connected to it by an airtight plastic tube 6 inches in diameter. After the operation the plastic tube is closed by a weld across the tube, the weld is cut, and the waste container with its own mobile lead shield is removed to the waste-processing area. There the waste container is transferred from its lead shield into a specially designed concrete block for sea disposal. The lead shield is returned for further use.

2. Large contaminated equipment that would involve risk and (or) expense beyond justification during decontamination

Examples of items in this category are enclosures that have become so contaminated or corroded as to preclude recovery of the item by decontamination. Such large items are incorporated in concrete blocks measuring about 4 × 4 × 7 ft. As many as four standard enclosures can be disposed of in one of these blocks.

3. Equipment with internal contamination (i.e., the interiors of the metal parts have become radioactive owing to transmutation from accelerator bombardment)

This category includes parts of accelerators and other bulky equipment which cannot be reused or consigned to scrap owing to its internal activity. Such materials can serve as ballast in waste packages or sometimes can be dumped directly from the barge.

B. Liquid Materials

These wastes are classified according to activity level and chemical content.

1. High-level small-volume aqueous wastes (500 ml or less)

As these wastes develop, they are accumulated in polyethylene containers inside the work enclosure during the experiment. When work is completed these wastes are solidified by the addition of a mixture of Portland cement and vermiculite. Either the solidification is done in the enclosure or the polyethylene bottles are removed in sealed plastic containers to a special box used exclusively for the solidification of small volumes of liquid waste. The solidified wastes are then handled for disposal as small items of solid wastes.

2. High-level large-volume aqueous wastes (1 to 50 liters)

These wastes, produced during high-level chemistry work in the 6-inch lead cave, are discharged into specially designed and shielded waste containers. These containers (as for cave solid wastes) are stored behind the shielding and are connected to the cave box by means of plastic tubing.

After the experiment is completed the plastic connecting tubing is sealed off, then cut, and the shielded liquid-waste container is removed to the waste-disposal area. The wastes are then solidified either in the waste container or in a specially-constructed concrete block. (See Section II D 3 b.)

Other high-level large-volume wastes (such as scrubber liquors) are handled in essentially the same way.

3. Low-level large-volume aqueous wastes

These wastes are accumulated in the various laboratories in 5-gallon glass carboys. Whenever it is considered advisable, the carboys are taken to the waste disposal area where the liquids are pumped into a specially prepared 30-gallon steel drum. About 15 gallons of waste are solidified in one drum by the addition of cement and vermiculite.

4. Water-immiscible organic wastes

These wastes are handled in two different ways. Small quantities can be mixed with large quantities of the aqueous waste (up to 3% organics by volume). The mixture is then solidified by the cement-vermiculite process. The other procedure used is to solidify these organic wastes with "Napalm."

5. Nonradioactive high-volume laboratory sink wastes

The techniques and regulations for work with radioactive isotopes at UCRL under the "concentrate and confine" philosophy prevent gross contamination of the general laboratory sewer system. Nevertheless, good safety practices (and good public relations) dictate a check of these wastes for accidental contamination with radioactive materials. Toward this end, all laborabory sink wastes drain from the building through an acid waste system separate from the ordinary sanitary sewer. Though not necessarily noxious, wastes such as cooling water and aspirator discharges run through this system. Before these "acid wastes" are combined with the sanitary sewage they pass through a sampling system. This sampling system removes one-half gallon for every hundred gallons passing through the system. The half-gallon samples are discharged into a tank from which a daily sample is taken for analysis. In this way a historical record of any radioactive contaminant would be available should a contaminant be discharged accidentally into the sewer. Provision has also been made for an 8-hour diversion of building discharge to holdup tanks should an emergency arise.

C. Airborne Materials

These waste materials can be classified as solid, liquid, and gaseous products.

1. Solid aerosols (solid airborne waste materials)

Solid aerosols may be produced during mechanical operations (grinding of powders, machining, sparking, drying of solutions), or during chemical operations (such as smoke-producing reactions).

The disposal of these radioactive solid airborne wastes is dependent upon the type of air-cleaning mechanism used to remove these particulates from the airstream. Several types of air-cleaning devices are used at UCRL. For the standard type of enclosure (gloved box) a boxed filter is used. These are internally loaded filters of various sizes (usually $9 \times 9 \times 10\frac{1}{2}$ in.) and composition and are attached to the enclosure with 3 feet of 2-in. i.d. flexible duct-work. Exhaust air flow from the box through the filter is maintained by a blower or a manifold system attached to the outflow side of the filter. Planning for the particular service needs for an experiment permits scheduling of replacement of the filter as it becomes clogged or highly contaminated. The clogged or contaminated filter is incorporated as solid waste in concrete in a 55-gallon steel drum.

If a liquid-type air scrubber is used in the air-cleaning system of an enclosure, the resulting contaminated scrubber liquors are collected in polyethylene carboys. These liquors are then solidified as liquid wastes by the addition of the cement and vermiculite mixture.

2. Liquid aerosols (liquid airborne waste materials)

Air-suspended liquid waste materials resulting from chemical or physical operations (boiling, gas bubbling through solutions, etc.) are either trapped in de-entrainment devices and collected as liquid waste, or if small in quantity or intermittent in production are permitted to be trapped and dried on the normal air filter. The liquid collected is treated as liquid waste.

3. Gaseous radioactive wastes

Certain radioactive gases are allowed to escape to the atmosphere. Most of these are short-lived, and calculations combined with common sense determine the extent of precaution necessary.

An exception is the case of fission gases arising from the dissolution of irradiated pile slugs. These gases are converted successfully to solid waste-disposal units by collecting them quantitatively in evacuated refrigerated bombs filled with activated carbon. These bombs are closed by means of valves, disconnected from the system, and incorporated in concrete for sea burial.

D. Types of Waste Packages Produced at UCRL, Berkeley

1. Steel drums, dry waste

These are used 55-gallon oil or fuel drums from various sources. One of the ends is cut out and 6 inches of concrete is placed in the bottom of the drum. A length of used 3/8-inch steel cable is placed in the concrete before it hardens. The cable is of sufficient length to form a loop above the top of the drum, for handling of the drum after it has been filled. The prepared drums are filled with sacks of dry waste layered with concrete. During the concreting the concrete is tamped so that voids in the drum are filled as much as possible. About 3.5 ft^3 of dry waste material is disposed of in each 55-gallon drum. A concreted drum must weigh at least 550 lb to sink at sea. The finished drums are stored on their sides in the waste-disposal area until shipment. (Storing the drums on their sides prevents seepage of rain water into possible voids around the rim of the drum. A considerable amount of monitoring work is saved in this way, since all liquid that runs out of a drum must be assayed for radioactivity to ascertain if a container failure has occurred.)

2. Standard concrete blocks

These blocks (approximately 4 × ~~4~~ 6 × 7 ft) are made up from time to time for the disposal of gloved boxes and other bulky equipment. A knock-down form with the exception of one side is built by the carpenters on a wood pallet. The bottom of the block is poured first and permitted to set. The equipment to be disposed of is placed on the concrete bottom in such a way that none of the waste touches the form. The form is then completed by the carpenters and concrete is poured to completely fill it.

In some cases--for example, in the disposal of an enclosure used in a 6-inch cave operation--the air inside the box is slowly expelled through a filter as it is displaced by the concrete actually poured into the box. The concrete pouring is continued until the form and box are completely filled.

3. Special concrete blocks

These blocks are designed to meet specific needs in the disposal of radioactive waste. They vary in size and shape and may provide shielding of up to 18 inches of concrete. Some examples are:

a. Concrete block for disposal of solid-waste containers from a 6-inch lead cave run.

b. Block for disposal of high-level liquid waste. This type of block is usually of the standard 4 × 4 × 7-ft dimensions, but differs from the regular block in having an empty 55-gallon drum centered in the form. The block is then poured so that the drum is completely surrounded by concrete except for three pipes through the lid of the 55-gallon drum. Liquid waste is pumped into the drum and solidified with cement-vermiculite. After solidification, the block is capped with cement and stored until shipment.

4. Steel drums, liquid waste

A package of this type consists of a 30-gallon drum with a special lid which is set into a 55-gallon drum (see II D 1). After solidification is complete the space between the 55-gallon drum and the 30-gallon drum is filled with concrete. The drum, capped with concrete, is then ready for disposal.

E. Average Yearly Amounts of Waste Handled at UCRL, Berkeley

In spite of the fact that large quantities of radioactive materials are handled at UCRL, Berkeley (at one time 10% of the radioisotopes produced at Oak Ridge were being processed at UCRL), the yearly average volume of radioactive wastes produced is quite low. Average volumes for the last three years are as follows.

1. Solid wastes (estimated unprocessed dry volume)

55-Gallon drums	3500 ft^3
Standard blocks	350 ft^3
Special blocks	25 ft^3

2. Liquid wastes (estimated liquid volume before solidification)

Low-level wastes	950 gallons
High-level wastes	30 gallons
Organic wastes	25 gallons

F. Cost of Waste Disposal

A survey made in 1957 established the following cost figures. The figures are estimates based on material and labor costs at that time.

1. Steel drums, dry waste (per drum)

Health Chemistry labor	$ 5	
Other labor	3	
Materials	5	
Miscellaneous (transporation, etc.)	2	
Sea-disposal charge	4	
Cost per drum of dry waste	$ 19	
Cost per ft^3 (3.5 ft^3/drum		$6

2. Standard UCRL concrete Blocks (per block)

Health Chemistry labor	$ 50	
Other labor	140	
Material	140	
Equipment and miscellaneous (transportation, etc.)	15	
Sea-disposal charge	35	
Cost per block	$380	
Cost per ft^3		$9.50

3. Steel drums, liquid waste (per drum)

Health Chemistry labor	$ 4	
Other labor	1	
Materials (special drums, modification, etc.)	20	
Cement-vermiculite	3	
Miscellaneous (transportation, etc.)	1	
Sea disposal charge	4	
Cost per drum	$ 33	
Cost per gallon (average 17.5 g/drum)		$2

The estimate of $2 per gallon of solidified liquid waste may seem high until we consider it in the over-all picture of the cost of waste disposal. Actually it represents a considerable amount of money and time saved. The reason for this is as follows.

About 1000 gallons of potentially radioactive liquid is produced daily in the chemistry laboratories at UCRL, Berkeley. That means that if the "concentrate and confine" procedures were not followed there would be an estimated 1000 gallons of active liquids to dispose of. However, the chemists and technicians working with radioactive isotopes cooperate by using techniques and facilities made available to them by Health Chemistry, and it is possible to keep the radioactive liquid waste to a small volume (about 5 gallons per day) and to segregate it from the nonactive laboratory wastes discharged through the "Acid Waste System." (See Sect. II B 5.) Therefore, instead of decontaminating or disposing of 1000 gallons of liquid waste per day, the Health Chemistry technicians need only solidify 5 gallons of active waste and assay samples from 995 gallons of other liquid to establish that no accidental contamination has occurred.

The adjusted cost for liquid waste disposal at UCRL, Berkeley, based on a potential of 1000 gallons per day, becomes about 1.4 cents per gallon. For example:

Cost to solidify 5 gallons of active waste	$10	
Cost of operation and sampling of "Acid Waste System" per day	4	
Total	$14	
Cost per potential gallon (based on 1000-gallon estimate)		$0.014

III. Conclusions

A system for the safe packaging of laboratory hot wastes for storage or sea disposal has been described. The system is based on quantity control and separation of the radioactive wastes from non-radioactive wastes during laboratory work. In this way economy is achieved and volumes can be kept to reasonable levels to permit packaging in waste containers of such integrity for prolonged surface storage or proper handling for sea disposal. The methods described have been applied safely to laboratory wastes for several years. Extension of these methods to large-volume wastes as encountered in production facilities would require further study.

BIBLIOGRAPHY

"Safe Handling of Radioactive Isotopes," U. S. Department of Commerce, National Bureau of Standards, Handbook 42.

"Radioactive-Waste Disposal in the Ocean," U. S. Department of Commerce, National Bureau of Standards, Handbook 58.

"Disposal of Radioactive Waste at Sea," Chas. E. Renn, Johns Hopkins University, International Conference on the Peaceful Use of Atomic Energy, Geneva 1956, A/Conf. 8/P/569 USA - 30 June 1956.

"The Management and Disposal of Radioactive Waste," A. Wolman, Johns Hopkins University, and A. E. Gorman, USAEC, International Conference on the Peaceful Use of Atomic Energy, Geneva 1956, A/Conf. 8/P/310.

"Study of Waste Disposal Facilities and Related Engineering Problems," John A. Derry, USAEC, Construction and Engineering Memorandum No. 22, January 21, 1955.

"United States Sea Disposal Operations," A Summary to December 1956. A. B. Joseph, WASH-734.

"Radioactive Waste Disposal Practices in the Atomic Energy Industry; a survey of costs." A. B. Joseph, Johns Hopkins University, December 1955, NYO-7830.

"Disposal of Airborne Radioactive Waste Materials," Myron D. Thaxter, Health Chemistry Department, UCRL, Berkeley. Personal communication.