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TECHNIQUES AND FACILITIES FOR HANDLING AND PACKAGING TRITIATED LIQUID WASTES FOR BURIAL

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ABSTRACT

Methods and facilities have been developed for the collection, storage, measurement, assay, solidification, and packaging of tritiated liquid wastes (concentrations up to 5 Ci/ml) for disposal by land burial. Tritium losses to the environment from these operations are less than 1 ppm. All operations are performed in an inert gas-purged glovebox system vented to an effluent removal system which permits nearly complete removal of tritium from the exhaust gases prior to their discharge to the environment. Waste oil and water from tritium processing areas are vacuum-transferred to glovebox storage tanks through double-walled lines. Accommodations are also available for emptying portable liquid waste containers and for removing tritiated water from molecular sieve beds with heat and vacuum. The tritium concentration of the collected liquids is measured by an in-line calorimeter. A low-volume metering pump is used

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to transfer liquids from holding tanks to heavy walled polyethylene drums filled with an absorbent or cement for solidification. Final packaging of the sealed polyethylene drums is in either an asphalt-filled combination 30- and 55- gallon metal drum package or a 30-gallon welded stainless steel container.

INTRODUCTION

At Mound Laboratory, low-level tritiated liquid wastes are currently placed on absorbents for shipment and burial. Because of the low tritium concentrations ($<40\ \mu Ci/ml$), there are no significant tritium effluents or health hazards associated with solidification and packaging of these large-volume wastes. However, the hazards and effluents from handling medium- to high-level tritiated liquid wastes are very significant. Unlike tritium gas (HT), tritium oxide (HTO) is readily absorbed (>99%) through the lungs and skin. Its greater radiological hazard is reflected in the radioactivity concentration guide (RCG) for HTO in air of 5 $\mu Ci/m^3$ as compared to 2000 $\mu Ci/m^3$ for elemental tritium.* Tritium is also rapidly absorbed into the body if tritiated oil comes into contact with the skin.

High-level tritiated water wastes are usually of low volume and are contaminated with oil, solvents, or undissolved solids.

*Laboratory workers for 40-hr exposure.

Water wastes contain tritium in concentrations ranging from 100 μCi/ml to 5 Ci/ml; oil wastes normally contain less than 30 Ci/liter. The feasibility of recovering tritium for reuse is very dependent upon the tritium concentration and impurities. Since oil wastes and many water wastes do not meet the criteria for economical recovery using current technology, these wastes must be disposed of by burial.

Sources of tritiated liquids typical to Mound Laboratory or other contractors who handle tritium and tritium compounds include: 1) water from tritium effluent removal systems, 2) water from recirculating inert-gas purification systems, 3) oil from vacuum and gas transfer pumps, 4) solvents and liquids from decontamination operations, and 5) R & D processing operations. The first three categories constitute 95% of the liquid wastes processed for burial at Mound Laboratory.

Effluent removal or recovery systems (ERS) are designed to collect tritium contaminated process gases and vapors originating from vacuum pump exhausts, passboxes, processing equipment, etc. An ERS removes tritium gas (HT) by oxidation of the gas to tritiated water (HTO) which is collected on molecular sieves before the gas is discharged to the atmosphere. Inert-atmosphere glovebox lines are equipped with recirculating gas purification systems which extract HTO on molecular sieves. Upon regeneration, tritiated water is collected in condensate containers for subsequent disposal. Oil from gas and vacuum pumps becomes contaminated with both HT and HTO through solubility, entrainment, and isotope exchange. Development and process operations also generate liquid or gaseous wastes. The gaseous wastes are often converted by catalytic "burning" over Pd or CuO to water for low volume waste disposal. Some decontamination wastes, because of high tritium levels, also require special handling to prevent the release of tritium to the environment.

Special techniques and facilities for processing these tritiated liquids for burial were developed in order to provide the necessary personnel protection and to meet AEC directives "to reduce tritium effluents to as low as practicable" while still conforming to AEC and Department of Transportation (DOT) shipping regulations for radioactive wastes. Three concepts of operation were adopted in order to achieve these goals. These are: 1) secondary containment of liquids and process functions, 2) utilization of purged-atmosphere gloveboxes for all operations not doubly contained, and 3) discharge of glovebox atmospheres to an effluent removal system for tritium removal.

HANDLING AND SOLIDIFICATION

A layout of the waste handling facility, which occupies an area of about 210 ft^2, is shown in Figure 1. Processing functions include transfer and collection of liquids, storage, volume measurement, sampling, tritium assay by calorimetry, solidification, and packaging for burial.

All operations are performed in purge-type inert-atmosphere gloveboxes vented to the plant effluent removal system (ERS) in order to contain all tritium effluents and to provide protection against fire when organic wastes such as oils and solvents are handled. Various effluent removal systems which would meet the exhaust needs of this type waste packaging facility have been described elsewhere (1).

Pressure inside the gloveboxes is controlled at -1 in. of water using Fisher 4610-1 regulator valves on the argon supply and Fisher 66-112 vacuum regulators on the exhaust ducts which are connected to the effluent removal system. During non-operating periods, the argon purging rate to the ERS is controlled at a nominal 2 ft^3/hr. The argon flow is increased to 200 ft^3/hr during waste processing in order to maintain low tritium levels within the gloveboxes. Increased purging levels minimize the possibility of tritium effluents to the laboratory atmosphere and provide necessary operator protection. This additional argon is added through manually operated supply valves, and the desired flow rate is regulated via appropriate flowmeters. The exhaust gas from the gloveboxes is continually monitored by an ionization chamber.

Each glovebox is protected from pressurization or evacuation which might occur if a valve or regulator should fail on the argon supply or exhaust lines. Emergency oil bubblers allow air to bubble into the box if the pressure becomes less than -3 in. of water; box atmosphere is vented directly to the stack if the pressure exceeds +3 in. of water. Because of the mildly corrosive nature of some of the liquid wastes, all lines, tanks, and processing equipment are fabricated from type 304 stainless steel.

Tritiated water and oil waste collected by the plant effluent removal system is transferred by vacuum to the waste handling facility via one of two stainless steel double-walled transfer lines connecting the two areas. Portable metal waste containers containing tritiated water from inert-gas purification systems and oil from vacuum pumps are brought into waste collection gloveboxes A and B (Figure 1) for emptying. Entry to the glovebox line is through a full-size glove-ported door as shown in Figure 2. The operator has the option of discharging the exhaust of glovebox A to the ERS or to the stack depending upon the tritium level. By appropriate valving, the glovebox becomes a high airflow fume hood for personnel protection when it is necessary to pass waste containers in or out of the glovebos system.

Two types of portable oil waste containers currently in use are shown at the left and center of Figure 3; a water waste collection container appears on the right in the same figure. The oil containers are either a simple 2-gal steel cylinder fabricated in-house or an empty commercial 3-gal Freon container modified with quick disconnect fittings. The 4-gal water container is fabricated of stainless steel which is chemically and heat treated for corrosion resistance. It is equipped with ball valves, a liquid-level sight glass, and Cajon fittings. All containers are fitted with gages so that any pressure build-up from radiolysis of water, or organics if present, can be ascertained.

By means of vacuum transfer lines in glovebox B these waste liquids are transferred from the containers to one of two calibrated 20-gal holding tanks located in glovebox C, one for wastes which are predominately oil and the other for water.

Here volume measurements and sampling for tritium analysis can be made. A typical holding tank with sight glass, Figure 4, allows volume measurements to be made with an accuracy of ±1%. All transfers, whether from effluent removal system collection tanks or portable waste containers, are accomplished by evacuating the appropriate oil or water holding tank and allowing atmospheric pressure to move the liquids through the half-inch transfer lines.

Waste containers are decontaminated for reuse with water or solvents in glovebox A. After decontamination the purge of the box at 200 ft^3/hr is contained for 30 min or until the monitor indicates that offgassing has stopped and the glovebox is nearly free of contamination.

When sufficient quantities of liquid waste have been accumulated for solidification, the waste liquids in the holding tank are thoroughly mixed by sparging with compressed air which is vented to the effluent removal system. Connecting lines to the holding tanks are also purged in order that representative and homogeneous samples can be obtained. A one-liter sample is immediately withdrawn into a calibrated polyethylene bottle for calorimetric analysis.

An in-line calorimeter, mounted in the glovebox floor and having a tritium sensitivity of 30 Ci/liter, is used to determine the amount of tritium in the waste liquids. Since only the sample side of the calorimeter is open to the glovebox atmosphere, the reference side of the twin-bridge calorimeter, the water bath, and the electrical readout system are kept free of contamination. A secondary calorimeter can, shown in Figure 5, designed to hold the 1-liter polyethylene sample bottle, is used to minimize contamination of the calorimeter. Figure 6 shows the calorimeter can being inserted into the sample side of the calorimeter prior to assay.

The collected liquid wastes are packaged in a 27-gal heavy-walled (0.062 in.) polyethylene drum, a 30-gal type 17H open-head steel drum, and a 55-gal type 17H steel drum as shown in Figure 7. Both steel drums are coated inside and outside with asphalt paint to retard corrosion. The polyethylene drum is inserted into a tight-fitting plastic bag so that when inserted into the 30-gal metal drum the plastic bag top can be rolled over the edge of the metal drum to protect it from contamination during filling and solidification of the waste.

The polyethylene drum is then filled with the appropriate solidifying material, either a mixture of one part cement and three parts perlite gypsum plaster; Zorball or Auto-Dri (commercial absorbents); vermiculite; or Pel-e-Cel (pelletized corncobs) (2). The choice of absorbent is dependent upon the type of waste being processed. For water the cement-plaster solidification method is preferred; for oils and solvents a commercial clay-like absorbent is favored. A void volume is provided in the polyethylene drum to minimize pressure build-up by limiting the amount of absorbent and waste liquid.

The metal drum containing the polyethylene drum and absorbent is placed on a track-mounted dolly in a fume hood adjacent to the solidification station, glovebox E. The dolly is then moved on the track so as to position the drum under the solidification station. Actuation of an elevator in the floor directly under the dolly seals the drum against a thick rubber gasket on the bottom of the glovebox. Figure 8 shows the plastic bagged drum in place under the solidification glovebox.

Access for filling the drum with waste liquid is through a 15-in. diameter O-ring sealed door in the bottom of the glovebox. Liquid is pumped into the polyethylene drum through one of the open bungs. To ensure that the capacity of the absorbent is not exceeded, the amount of liquid pumped into the drum is restricted to 28 liters on 20-gal of absorbent; when plaster-cement solidification mixtures are used, up to 40 liters of water can be accommodated on 18-gal of the mixture in the 27-gal polyethylene drum. The filling operation through the bung of the polyethylene drum, as seen through the window of the solidification station glovebox, is shown in Figure 9.

A calibrated liquid-metering pump is used to transfer the waste liquids from either of the two holding tanks to the solidification station. The total amount of liquid transferred is controlled by a speed control on the pump and a timer located outside the glovebox. The volume of liquid transferred can also be measured through a calibrated sight glass located on each of the two holding tanks.

To seal the polyethylene drum, a bung seal coated with silicone rubber sealant is threaded into the bung of the drum. The sealed polyethylene drum is then allowed to remain in position under an inert atmosphere purge of 200 ft^3/hr to the ERS for 30-60 min. This allows for offgassing and vaporization of any spilled liquids that had not been cleaned up after the solidification operation.

PACKAGING

When the activity level in the exhaust duct from the solidification glovebox has decreased to less than 90 $\mu Ci/m^3$, the door in the floor of the glovebox is closed and the drum is transferred to the adjacent high-airflow fume hood for final packaging.

The void volume in the metal drum is filled with non-hardening asphalt (bituminous coating compound to conform with MIL-C-102A). Figure 10 shows the polyethylene drum partially covered with asphalt. The plastic liner around the polyethylene drum is folded over the asphalt; more asphalt is added as required to level off the top of the drum; and the drum lid is bolted in place.

The plastic bag, used around the exterior of the 30-gal metal drum to protect against contamination, is removed. After being monitored for offgassing or leakage (none has been found after one year of operation), the drum is removed for additional packaging. For storage or shipment for burial, the 30-gal drum is lowered into a 55-gal steel drum containing 3-gal of asphalt. The remaining void is filled with asphalt to create an additional tritium barrier and to minimize corrosion of the 30-gal secondary container.

The use of a hydrogenous barrier such as asphalt in the metal drums was suggested by studies conducted at Los Alamos which showed that coatings of beeswax, paraffin, and asphalt are excellent barriers to the passage of tritium (3). A mechanism suggested for this barrier effect is that hydrogen is so tightly bound in the hydrogeneous material that isotopic exchange is extremely slow. The fact that the barrier is highly impervious to moisture (H_2O or HTO) may also be a contributing factor. Sealants which are impervious to water also serve to prevent entry of groundwater and therefore reduce leaching and exchange.

In the past most commercial as well as AEC burial grounds assumed that the burial or waste package will not provide any long-term containment of radioactivity. Hence, the burial sites have been selected to meet the requirements of primary containment and no credit for containment is taken by the packaging. The operating philosophy of many burial facilities, however, is rapidly changing and long-life packaging is now being recommended or required for tritium wastes.

As an alternative to the asphalt-filled, triple-drum container described above, and to provide an unlimited-life container, a welded stainless steel drum may be used in lieu of the 30- and 55-gal metal drums. The facility and methods described earlier are all applicable. The polyethylene drum containing the absorbent is placed directly in the stainless steel drum, filled, and sealed in the manner described above. Although the permeability of polyethylene to tritium is high, there are no health physics hazards or tritium effluents during the short time necessary for welding of the stainless steel drum.

COSTS

Operating and material costs are moderate in light of the benefits obtained from these waste handling facilities. As shown in Table 1, total material costs for solidification and packaging are less than $75 per waste package prepared for shipment and burial. This is the material cost for solidifying and packaging 28 liters of tritiated oil or 40 liters of tritiated water. Absorbent and solidification materials are the minor costs which will vary depending upon the choice of materials.

The alternate method of waste disposal by packaging in a polyethylene drum and a welded stainless steel drum will cost from $400 to $600. Larger quantities of liquid might be accommodated. Void space allowance to reduce pressurization is of lesser importance in a welded package.

Capital costs for the physical facilities are relatively high. However, the costs can be distributed against other tritium effluent reduction operations. Since the facility is needed only 2-5 days per month for waste processing, two gloveboxes (A and B) can become multipurpose boxes for maintenance and decontamination of highly contaminated equipment. Experience at Mound Laboratory has shown that a very significant amount of tritium can be released during maintenance and repair operations. With gloveports on adjacent sides of these gloveboxes, even heavy equipment can be handled with the aid of a small hoist.

CONCLUSIONS

Two major operating concepts can be identified as keys to effective waste handling and packaging: 1) double or secondary containment and gloveboxes for all operations, and 2) an effluent removal system for decontamination of processing and glovebox gases.

The four major benefits obtained from the foregoing waste handling methods and facilities are:

1. No personnel exposures. After one year of operation, no tritium uptake has been detected in the urine of any workers.
2. Tritium effluents of less than 1 ppm. Tritium losses to the laboratory or environment have been less than 1 ppm even when water waste with tritium concentrations up to 5 Ci/ml were processed. Containers which have been stored up to six months have shown no effluents or outgassing.

3. Long-term burial package. Although not having the integrity of a welded stainless steel container, the 3-drum burial package with the use of asphalt produces a more economical and longer-life package than any other method employed to date.

4. An effluent control bonus. Through the use of two of the five gloveboxes for maintenance and decontamination of equipment, this facility becomes multipurposed and eliminates another important source of tritium effluents.

REFERENCES

1. T. B. Rhinehammer and P. H. Lamberger, Tritium Control Technology, WASH-1269, Monsanto Research Corporation, Miamisburg, O. (1973), pp. 218, 232, 234.

2. T. B. Rhinehammer and P. H. Lamberger, op. cit., pp. 257-262.

3. L. A. Emelity, C. W. Christenson, and J. J. Wanner, "Tritium Loss from Coated Cement Paste Blocks," in Tritium, A. A. Moghissi and M. W. Carter (ed.), Messenger Graphics, Phoenix, Ariz., May 1973, pp. 776-784.

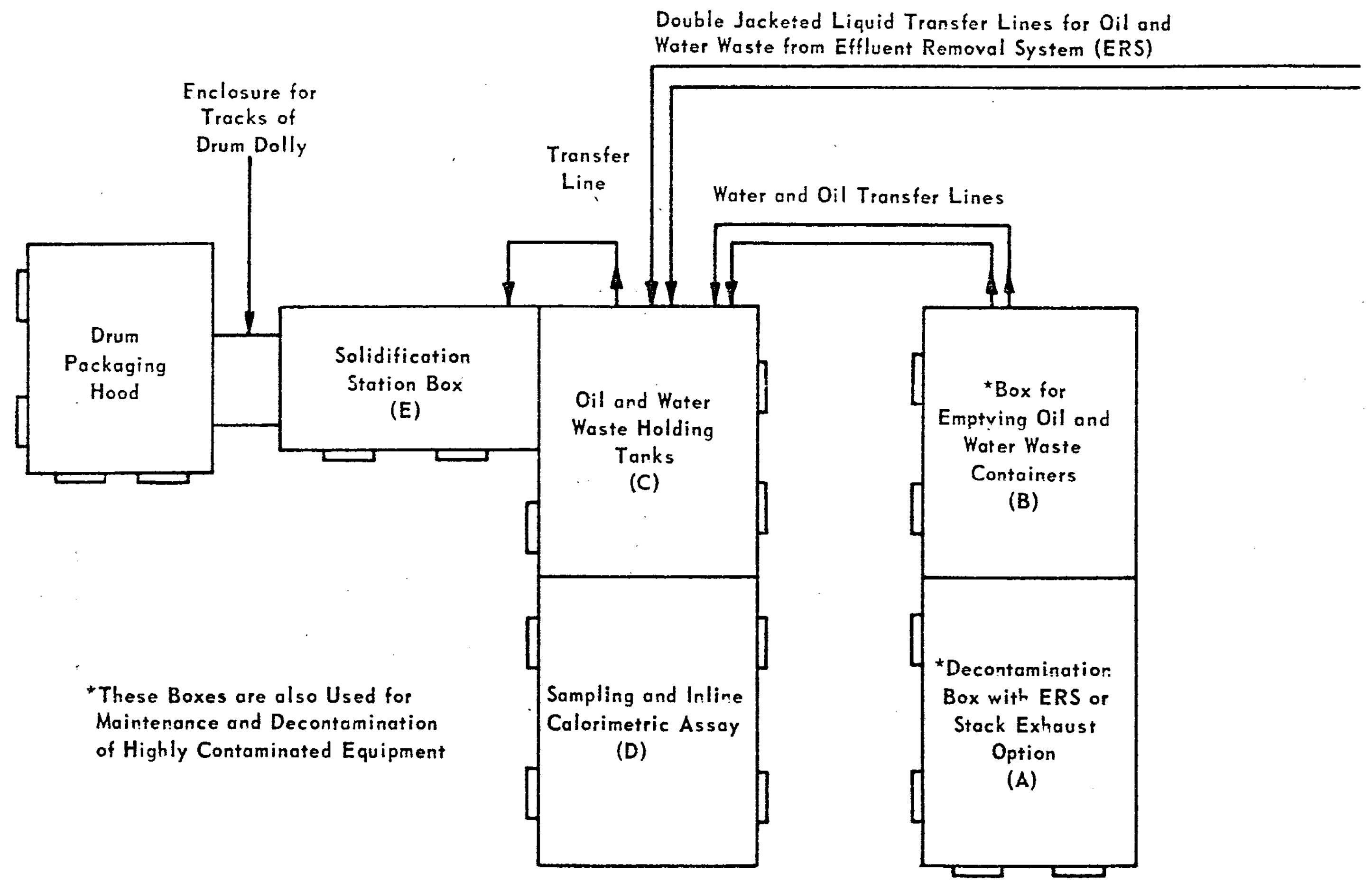

FIGURE 1 - Glovebox layout of tritiated liquid waste solidification and packaging facilities.

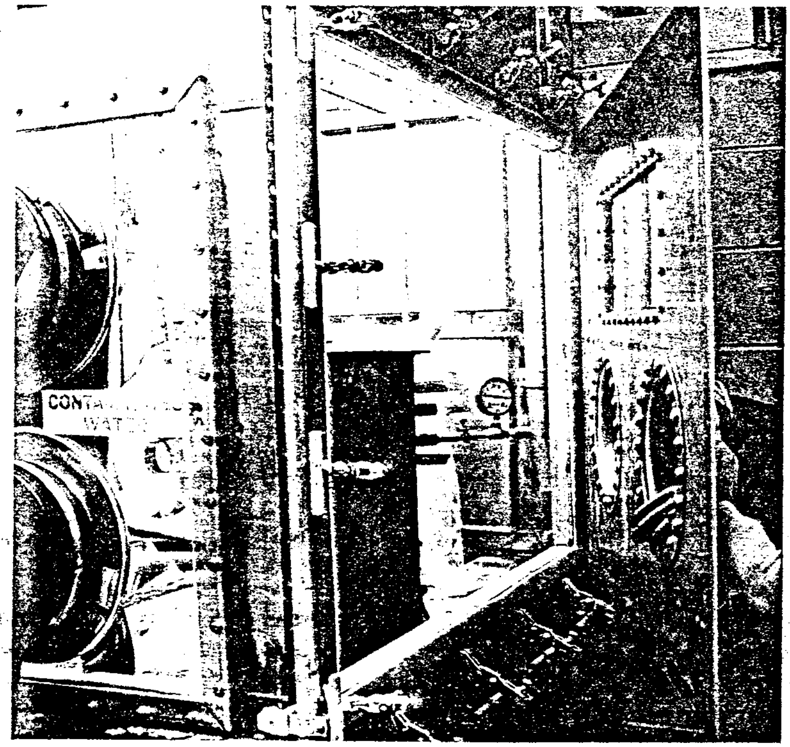

FIGURE 2 - Decontamination glovebox showing the large glove-ported entry door for liquid waste containers - exhaust option to stack or to effluent removal system.

FIGURE 3 - Two- and three-gallon metal containers used for collecting tritiated oil (two on left) and tritiated water wastes (on right).

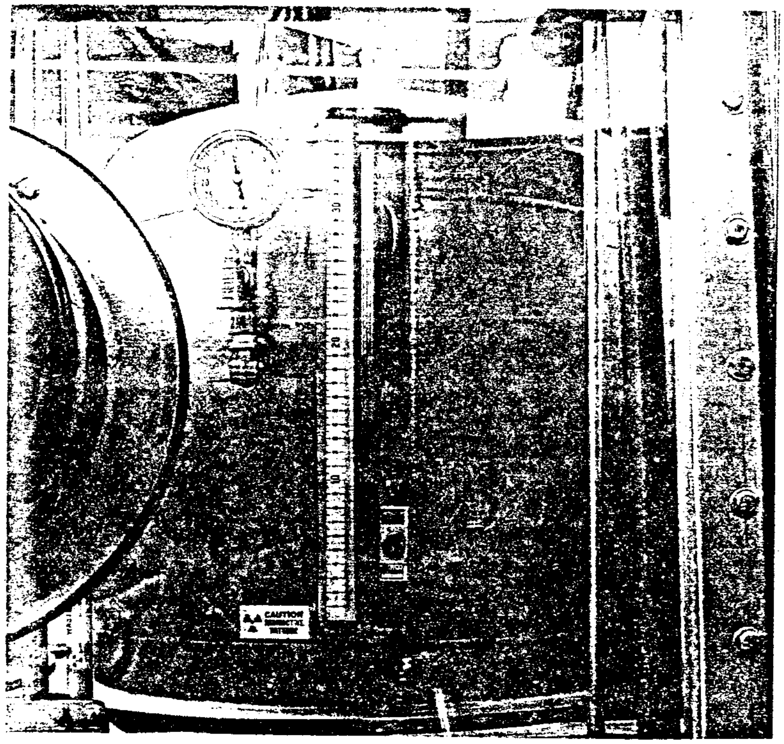

FIGURE 4 - One of two 20-gallon glovebox holding tanks for tritiated liquid waste showing pressure gage and calibrated sight glass.

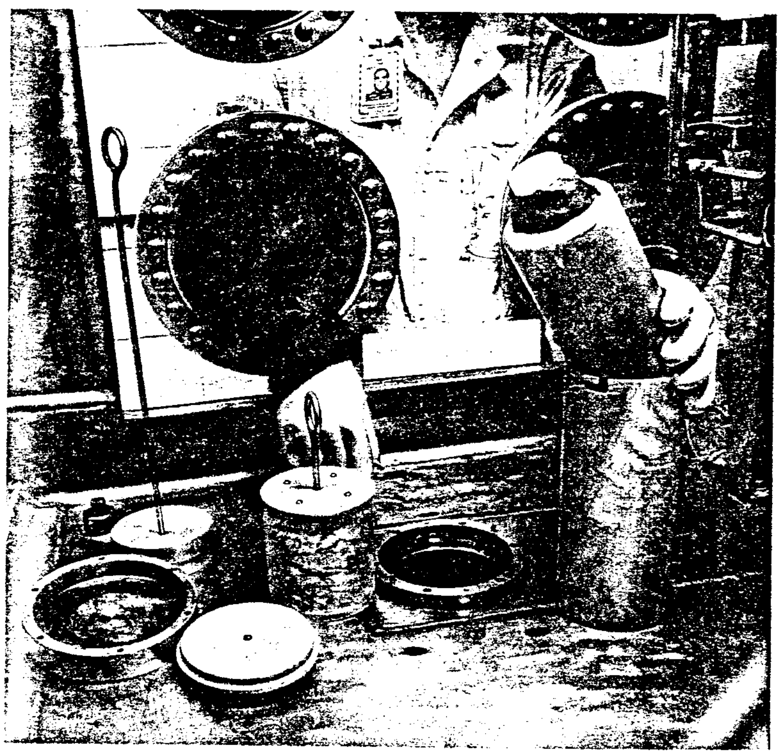

FIGURE 5 - A 1-liter polyethylene sample bottle of tritiated liquid waste is placed in a calorimeter sample can in preparation for tritium assay.

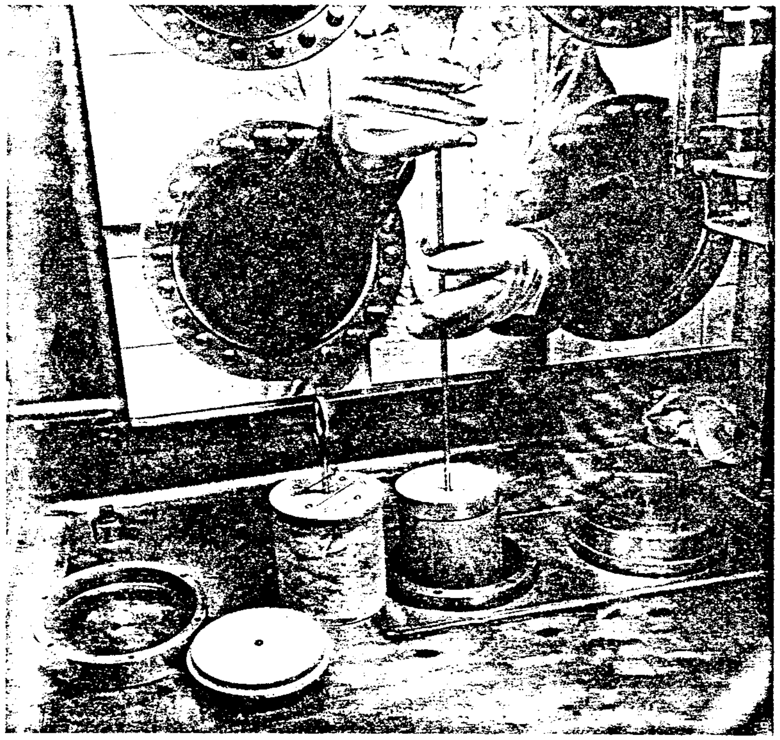

FIGURE 6 - A calorimeter can containing a bottle of liquid waste is inserted into the sample side of the glovebox calorimeter prior to assay.

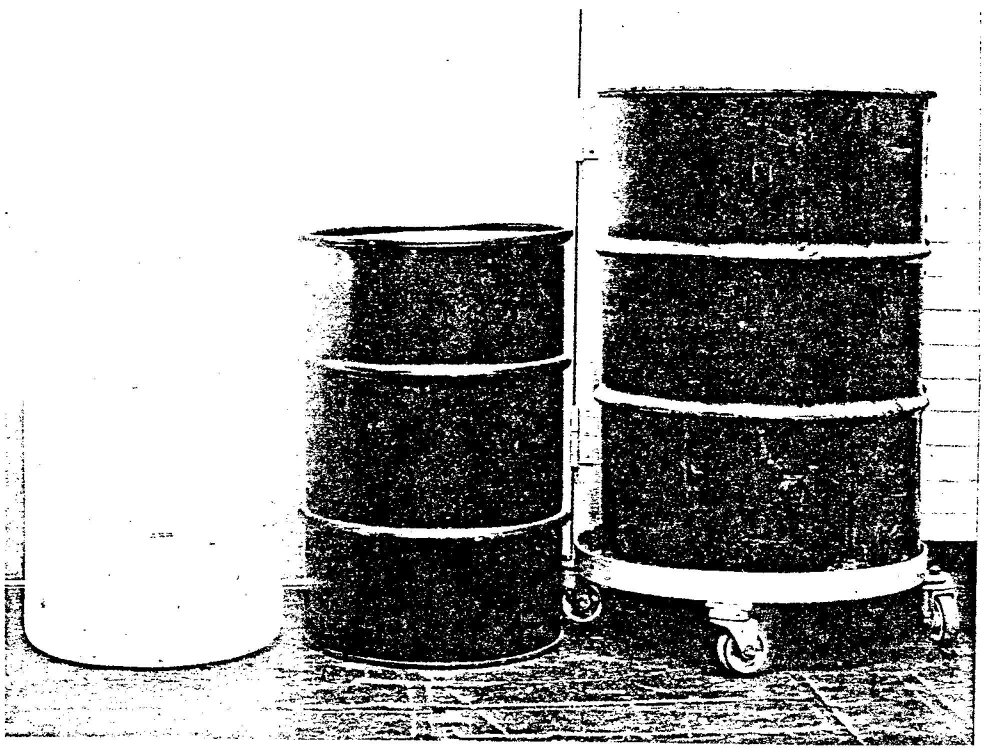

FIGURE 7 - Polyethylene drum (primary), 30-gallon metal drum (secondary) and 55-gallon metal drum (tertiary) used in the packaging of tritiated wastes.

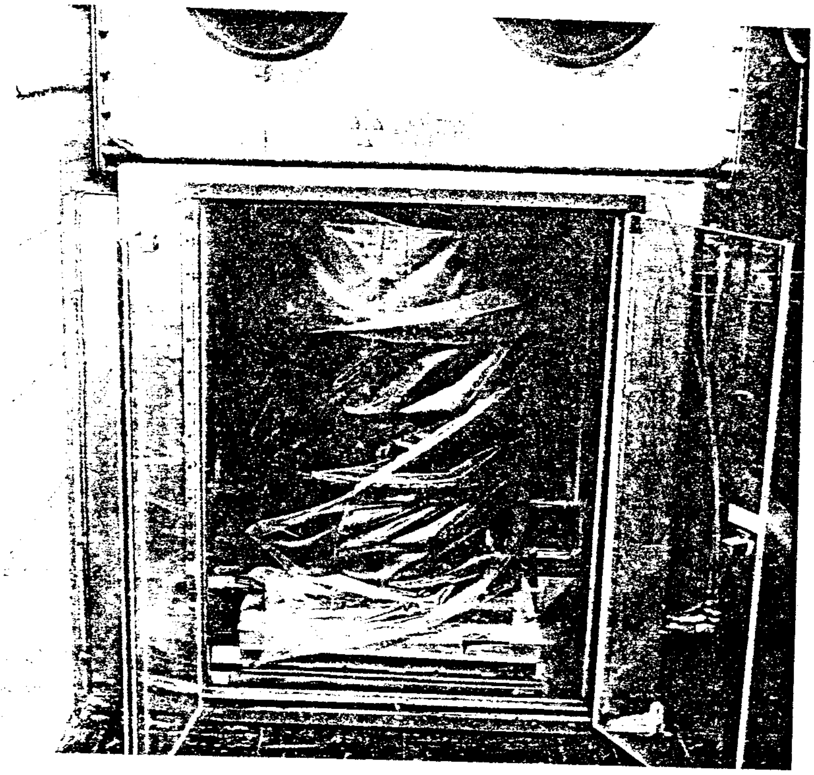

FIGURE 8 - A 30-gallon drum containing the polyethylene drum and an absorbent is raised by an elevator and sealed against the bottom of the solidification glovebox.

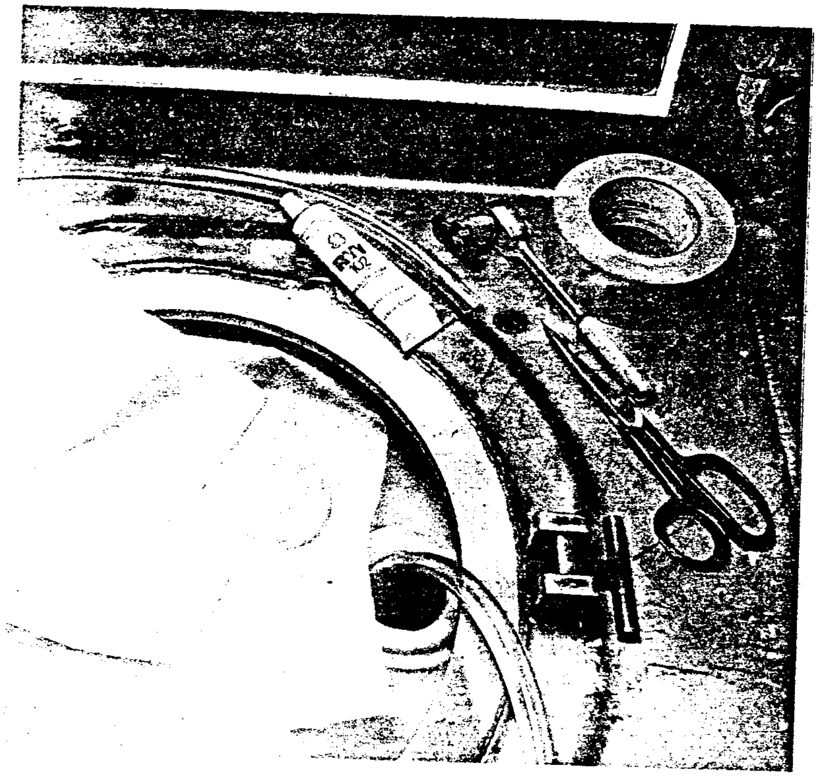

FIGURE 9 - Liquid waste filling operation through the bung of the polyethylene drum as seen through the window of the solidification glovebox.

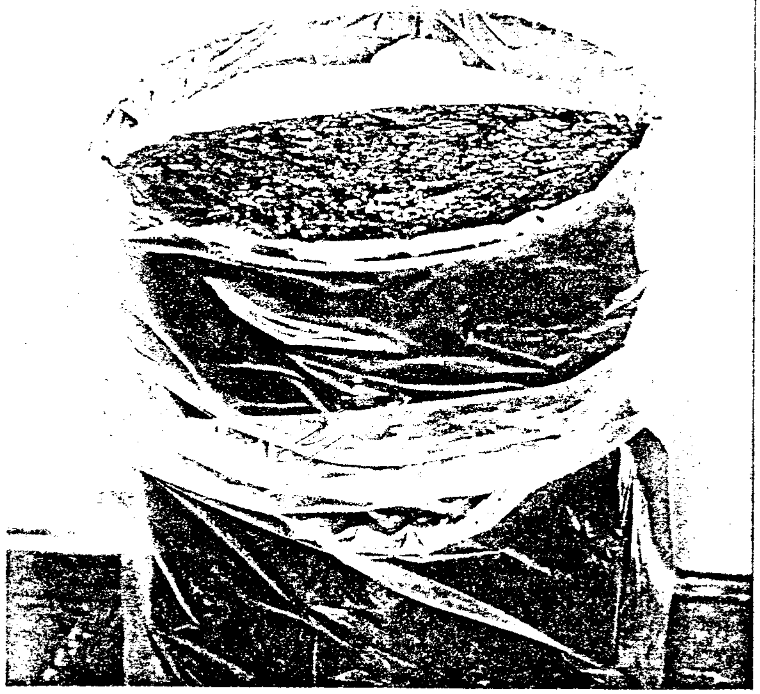

FIGURE 10 - A 30-gallon drum of solidified waste showing the void volume above the polyethylene drum partially filled with nonhardening asphalt.

Table 1

MATERIAL COSTS FOR SOLIDIFYING AND PACKAGING 28-LITERS OF OIL OR WATER BY ABSORPTION OR 40-LITERS OF WATER BY SOLIDIFICATION

Item	Cost
Solidification or Absorbent Materials	$ 7
Polyethylene Drum	$16
30-gallon Metal Drum	$19
55-gallon Metal Drum	$13
Asphalt	$20
Total	$75