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MONSANTO/MOUND LABORATORY TRITIUM EFFLUENT CONTROL SYSTEMS

E. A. Mershad

Monsanto Research Corporation
Mound Laboratory*
Miamisburg, Ohio 45342

ABSTRACT

Multigram quantities of tritium are routinely handled at Mound Laboratory in inert atmosphere gloveboxes for processing and recovery, and in various production, research, development and analytical systems; some of which are enclosed in high-velocity fume hoods. Effluents from these functions, as well as from passboxes, vacuum pumps, and maintenance operations, must be processed to remove tritium, tritium oxide, and tritiated pump oil vapors before the effluent gases are released to the environment. Mound Laboratory has designed and constructed practical and efficient systems that provide for this very important containment and tritium effluent control capability. These systems coupled with other design and procedural changes have resulted in a significant decrease in tritium contamination to personnel and tritium release to the environment.

*Mound Laboratory is operated by Monsanto Research Corporation for the U. S. Energy Research and Development Administration under U.S. Government Contract No. E-33-1-GEN-53.

Mound Laboratory is the primary ERDA site for recovery of tritium from tritiated waste solids. The recovered tritium (Figure 1) is purified by cryogenic absorption techniques and then enriched to 99+ mole percent tritium by thermal diffusion. Multigram quantities of tritium are routinely handled at Mound Laboratory in inert atmosphere gloveboxes for processing and recovery, and in various research, development and analytical systems.

Because of increased emphasis on minimizing tritium release to the environment, considerable effort has been expended in areas of containment, safe handling and disposal of tritiated materials. Some of the techniques utilized to date include:

1) Better administrative control of tritium operations including education and motivation of involved personnel.
2) Procedural changes for passbox operations, decontamination, maintenance, etc., resulting in the routing of all airborne effluents to an ERS (Effleunt Removal System).
3) Modification of systems to prevent and/or better contain tritium leakage. Examples include double containment of tanks and lines, drybox glove purge systems, and glovebox atmosphere detritiation systems.
4) Addition of miscellaneous new equipment, such as leak-tight vacuum pumps, in-line calorimeters, and decontamination and maintenance gloveboxes.

The installation of an ERS and a Waste Packaging Facility have been the major technological improvements made to date. These systems have contributed significantly to the success of Mound effluent control efforts.

Essentially all effluents from tritium handling drybox and process systems are exhausted to an elaborate Effluent Removal System (ERS) for removal of tritium before release of the effluents to the environment. The system (Figure 2) operates on a continuous basis and can process effluents at a rate of 60 ft^3/min. An evacuated emergency storage tank of 1600 ft^3 capacity is connected to the inlet of the ERS and automatically opens to provide uninterrupted storage of excess effluent if capacity of the system is exceeded or if failure occurs and/or repair or replacement of components of the ERS is required.

The incoming effluent passes through a refrigeration system heat exchanger, operating at approximately -70°F, to freeze out condensable vapors such as tritiated water and pump oil vapors, then is pumped by oil-less compressors into storage tanks.

As the effluent stream exits the storage tanks, it passes through several molecular sieve-filled dryers where the last traces of water and pump oil vapors are removed. The waste stream is then electrically preheated to approximately 800°F, prior to entering Hopcalite reactors, where an oxidizing material (MnO and CuO) converts the hydrogen to water vapor at a temperature of ~800°F. To insure total oxidation of trace pump oil vapors the gas is further processed through a palladium catalyst heated to 1100°F.

Upon exiting the catalyst reactors, the stream is cooled to room temperature by air-cooled heat exchangers, and the tritiated water formed by the reactors is removed by passage of the stream through several Kemp dryers packed with type 3A molecular sieve.

An ionization chamber samples and measures the amount of tritium in the outlet. The system automatically releases or recycles the outlet stream depending upon the ionization measurement. The tritium contaminated liquid wastes generated by the ERS and other systems are processed in a Waste Packaging Facility (Figure 3) under total containment conditions prior to shipment for burial. Tritiated waste liquids (pump oils, water and organic solvents) are measured, calorimetered, solidified and packaged for burial with a near-zero release of tritium to the atmosphere.

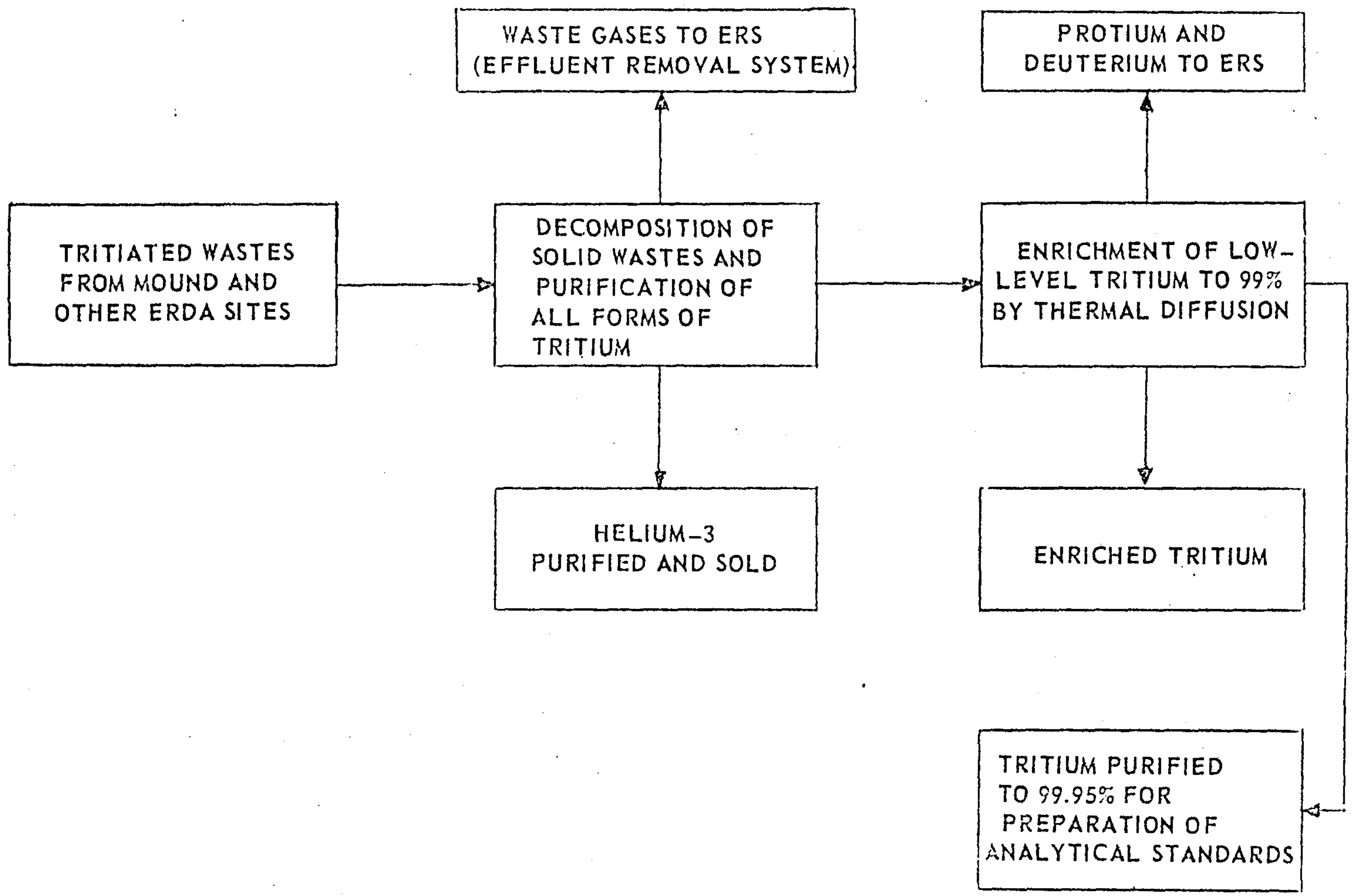
Liquid waste to be buried is first transferred (Figure 4) to a polyethylene drum liner (that has been inserted in a 30-gallon steel drum) and is solidified with a dry cement-plaster mixture, Absorbal, or Vermiculite, depending on the type of waste. The void space between the drum and drum liner is filled with asphalt and the 30-gallon drum is sealed and checked for leakage. This sealed 30-gallon drum is centered in a 55-gallon steel drum containing ~3 gallons of asphalt in the bottom. Vermiculite is then poured between the two drums to a level ~2 inches below the top of the 30-gallon drum lid. The remaining void volume is filled with more asphalt and the 55-gallon drum lid is sealed in place.

To assess the integrity of our waste drum package several experiments were conducted. Figure 5 shows the experimental apparatus that was used to determine the permeation constant (k) and the total rate of permeation (R_{HTO}) for HTO through polyethylene. Table 1 shows the data obtained for a 16 oz. polyethylene bottle with an average wall thickness of 0.446 cm, containing 350 Ci in 200 cc of H_2O fixed in various materials. If we applied these data to a 27 gallon polyethylene drum containing a hypothetical quantity of 10,000 Ci in 35 liters of water fixed in cement-plaster, the R_{HTO} would be 0.426 Ci/month (0.004%/mo).

Presently we are determining the permeation rate through our final drum package. Figure 6 shows the experimental apparatus; Figures 7 through 10 give the permeation rates to date and the projected annual permeation rates for several actual waste drums previously packaged under routine conditions. The data thus far are very favorable and serve to verify the integrity of our present waste package.

Pressure testing of the total package was also conducted (Figure 11) and the data indicate that it will hold pressures up to ~25 psig.

In conclusion, Mound Laboratory effluent control efforts have resulted in a significant decrease in tritium contamination to personnel and the environment (Figures 12 through 16). These efforts will continue as we strive for an "as low as practicable" emission rate.



TRITIUM RECOVERY AND ENRICHMENT

FIGURE 1

TRITIATED EFFLUENT REMOVAL SYSTEM

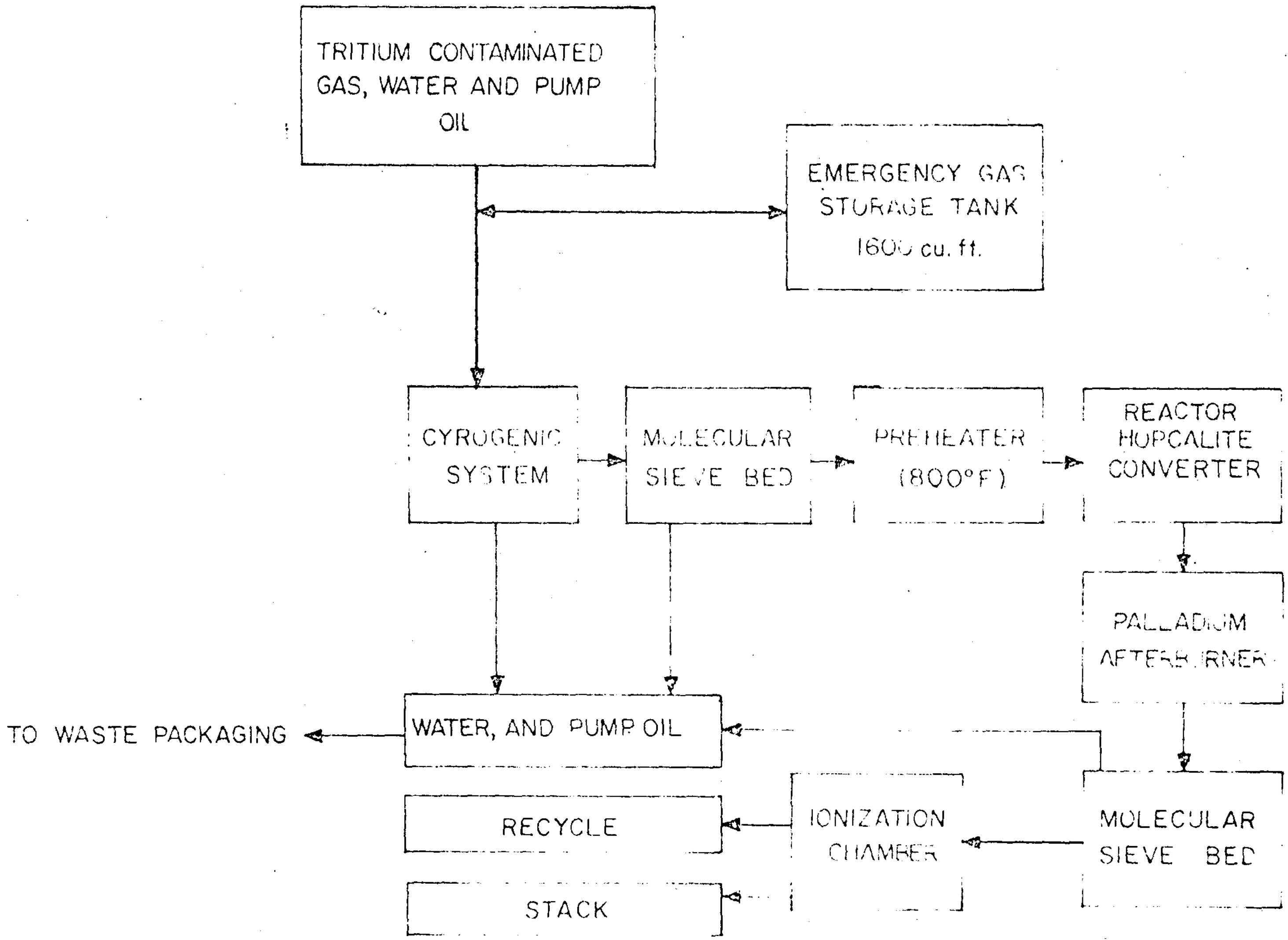


FIGURE 2

TRITIATED LIQUID & SOLID WASTE PACKAGING

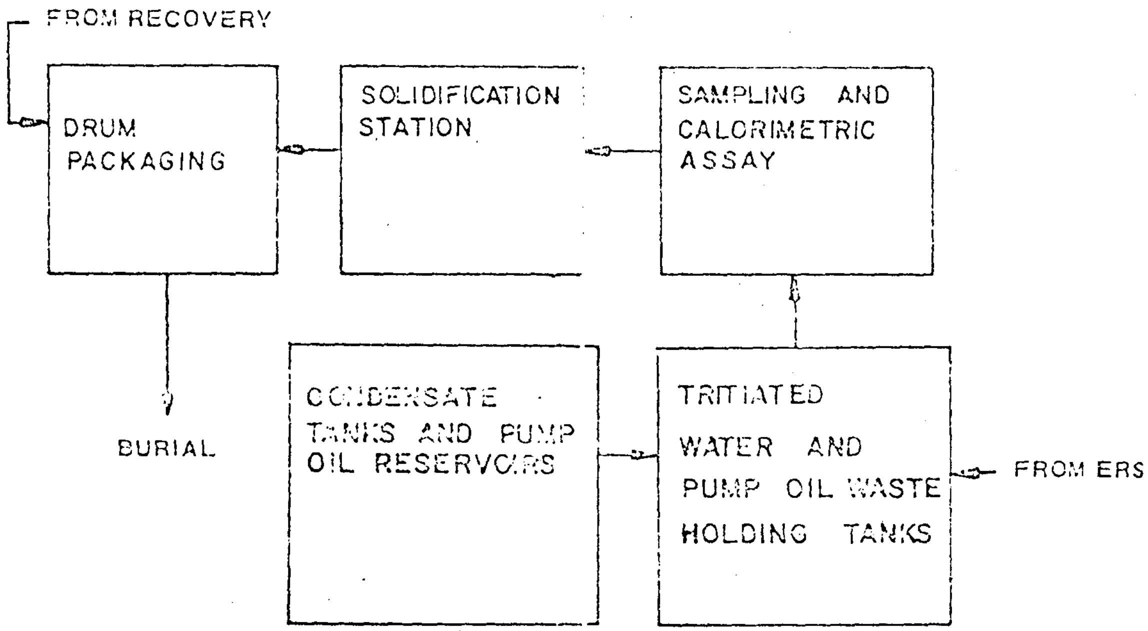
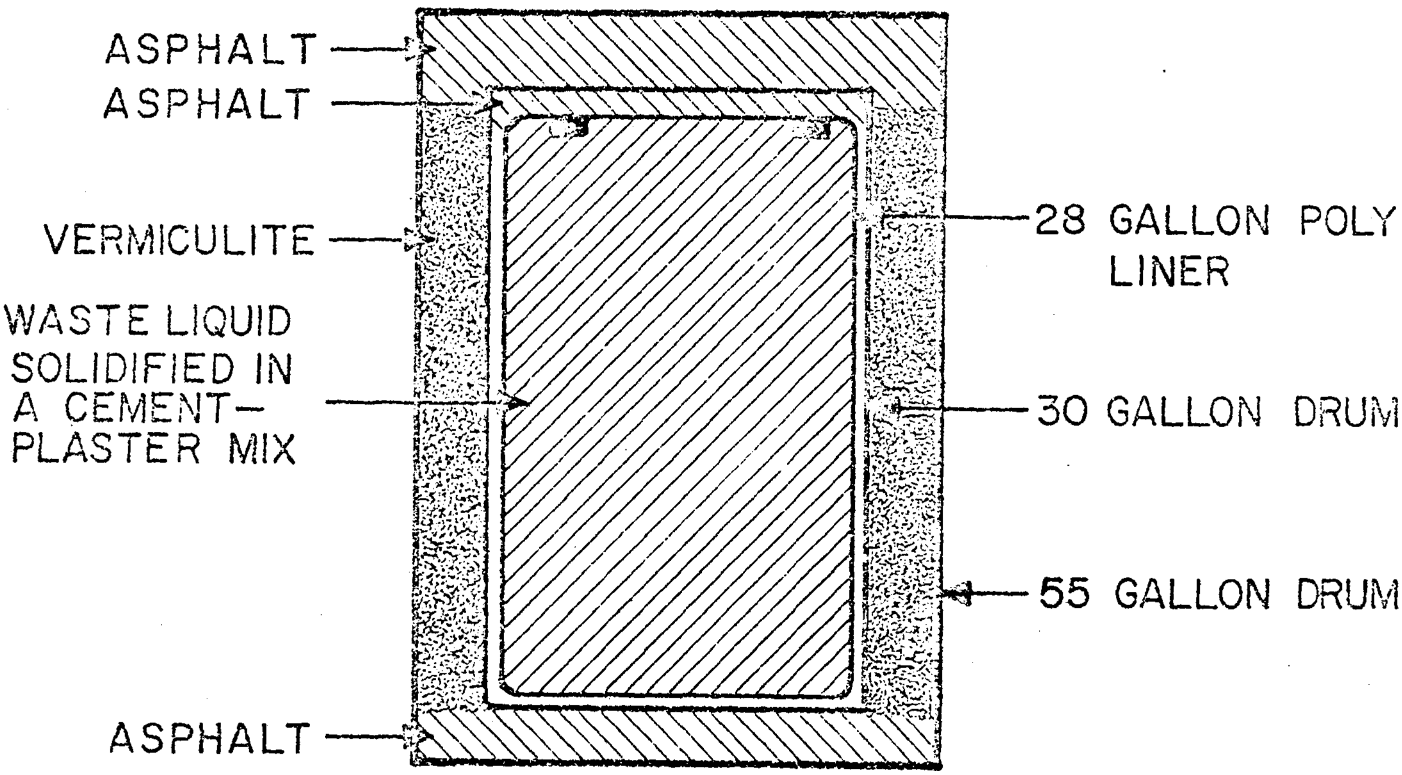
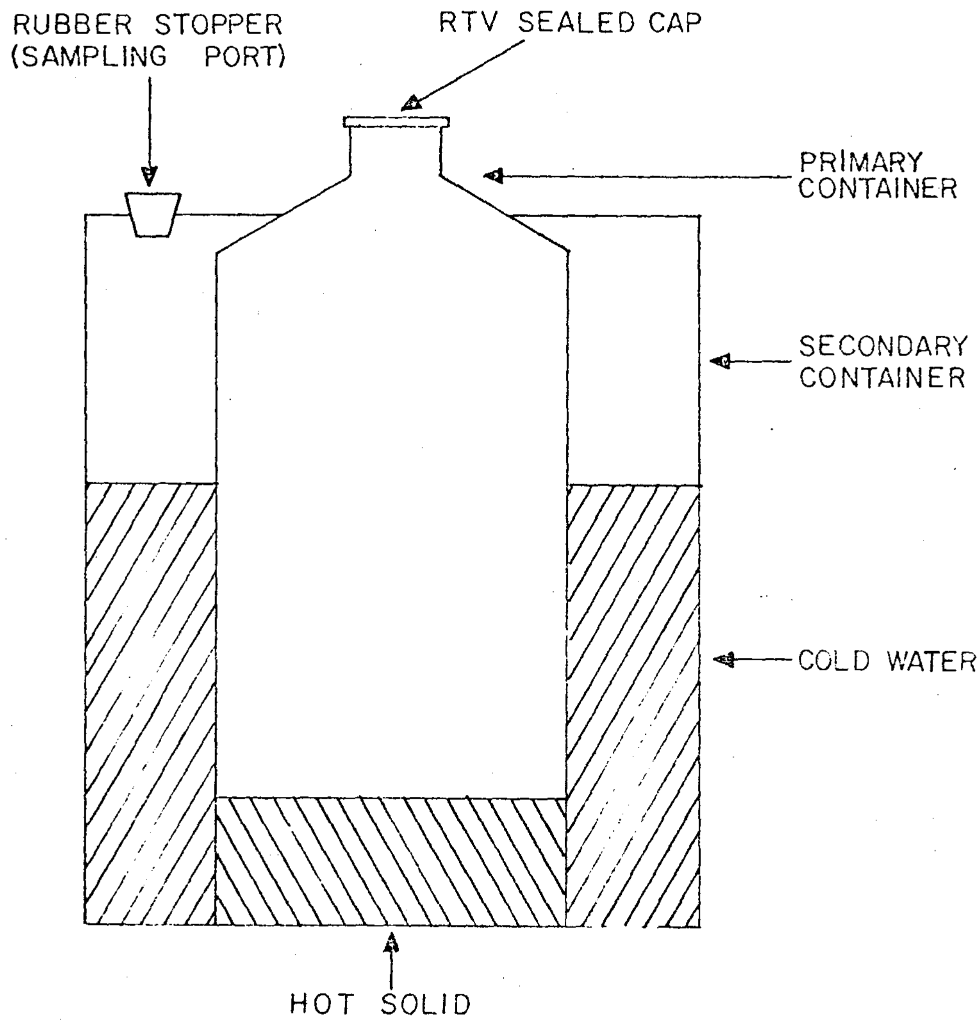


FIGURE 3



TRITIATED WASTE PACKAGE

FIGURE 4



TRITIUM PERMEATION THRU POLYETHYLENE TEST APPARATUS

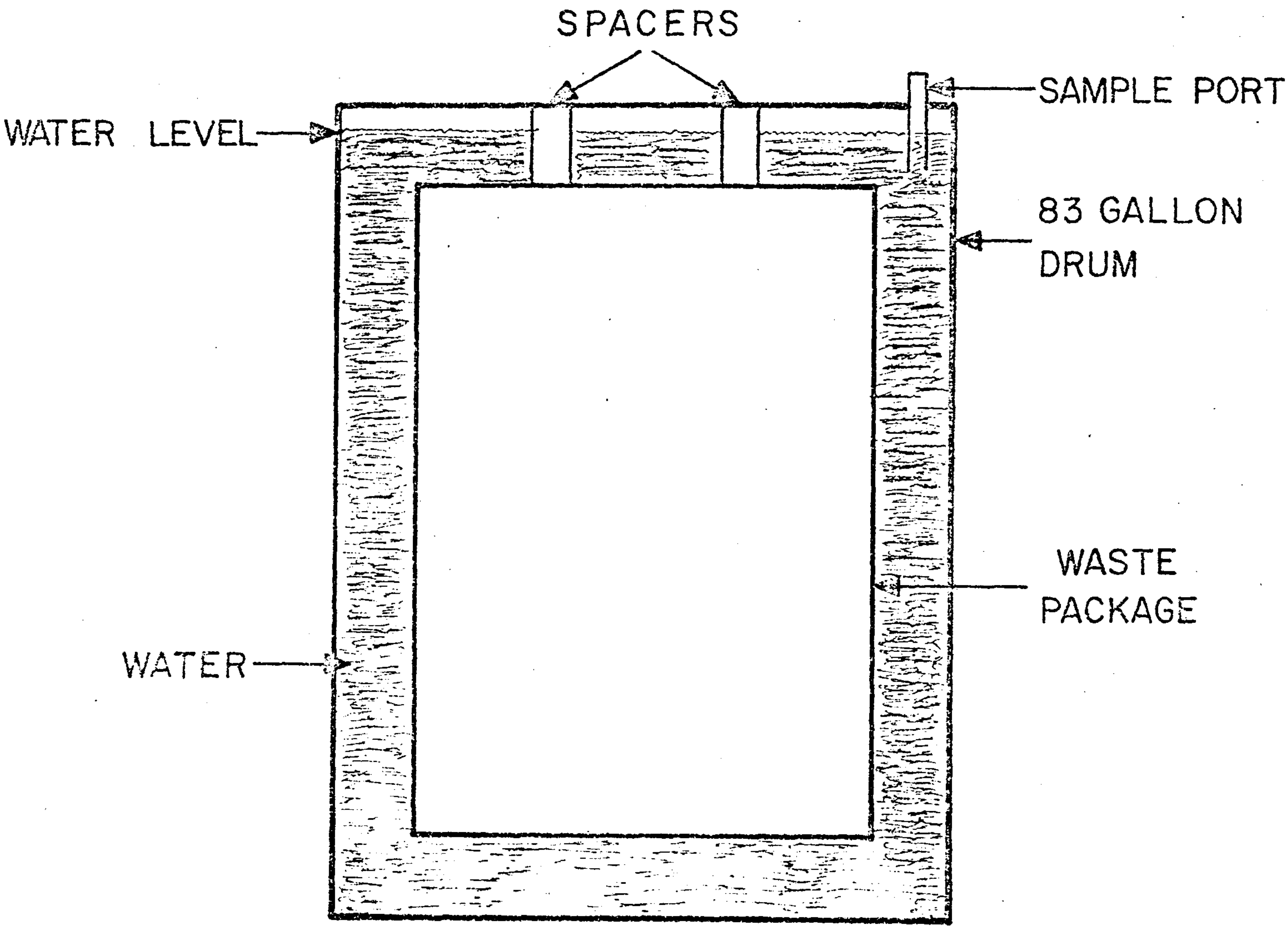
FIGURE 5

TABLE 1

HTO PERMEATION CALCULATION

FIXATION MATERIAL	MONTHLY PERMEATION RATE (R_{HTO})	SURFACE AREA COVERED (A)	PERMEATION CONSTANT (κ)
VERMICULITE	0.104 CI	330 CM^2	8.05×10^{-8}
CEMENT-PLASTER	0.073 CI	245 CM^2	7.59×10^{-8}
WATER	0.038 CI	155 CM^2	6.29×10^{-8}

DATA DERIVED UTILIZING POLYETHYLENE CONTAINER (WITH WALL THICKNESS OF 0.446 CM) CONTAINING 350 CI IN 200 CC H_2O.



TRITIATED WASTE PACKAGE
PERMEATION TEST

FIGURE 6

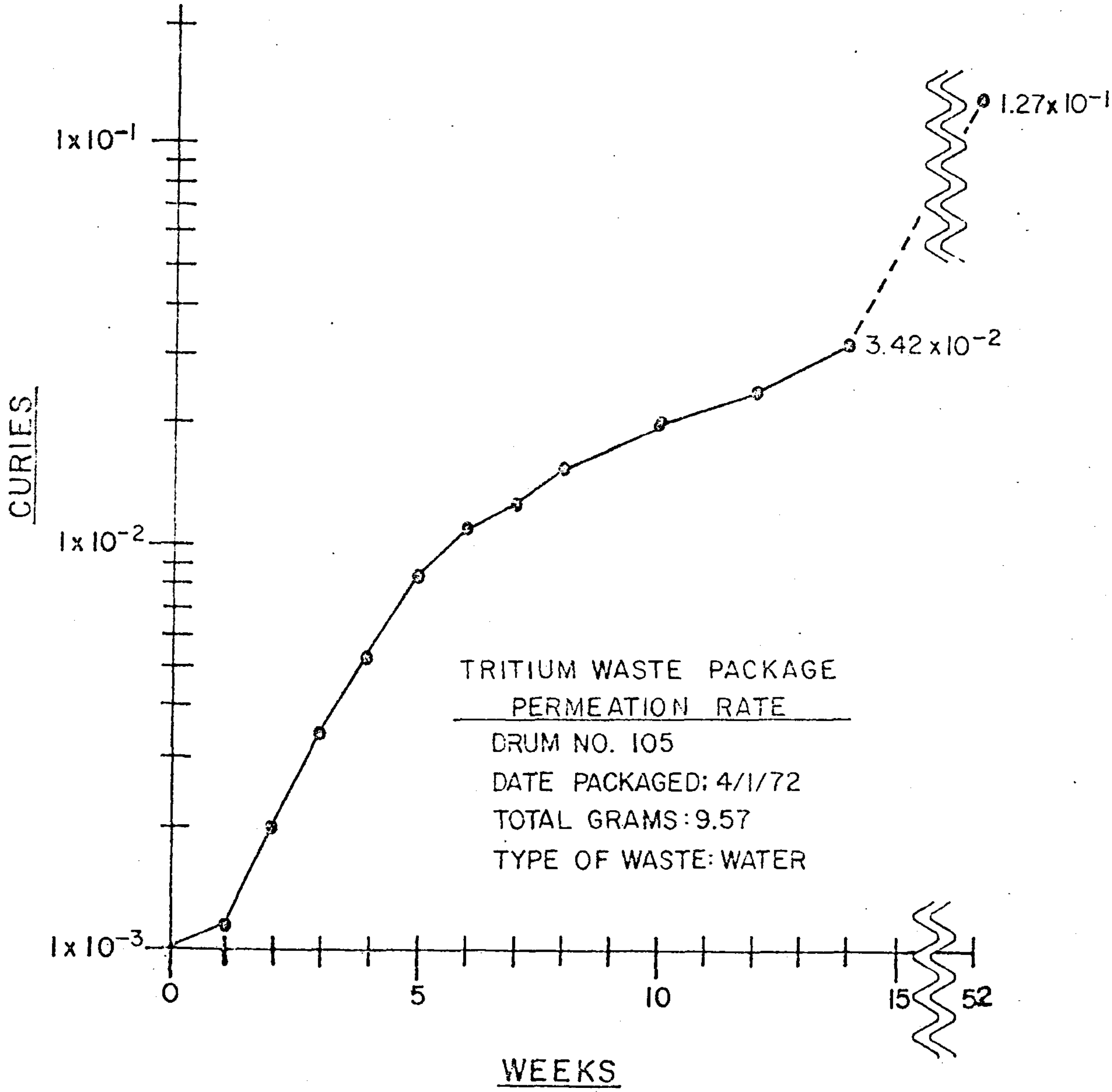

1.27 x 10⁻¹
3.42 x 10⁻²
1 x 10⁻¹
1 x 10⁻²
1 x 10⁻³
CURIES
TRITIUM WASTE PACKAGE
PERMEATION RATE
DRUM NO. 105
DATE PACKAGED: 4/1/72
TOTAL GRAMS: 9.57
TYPE OF WASTE: WATER
0
5
10
15
52
WEEKS

FIGURE 7

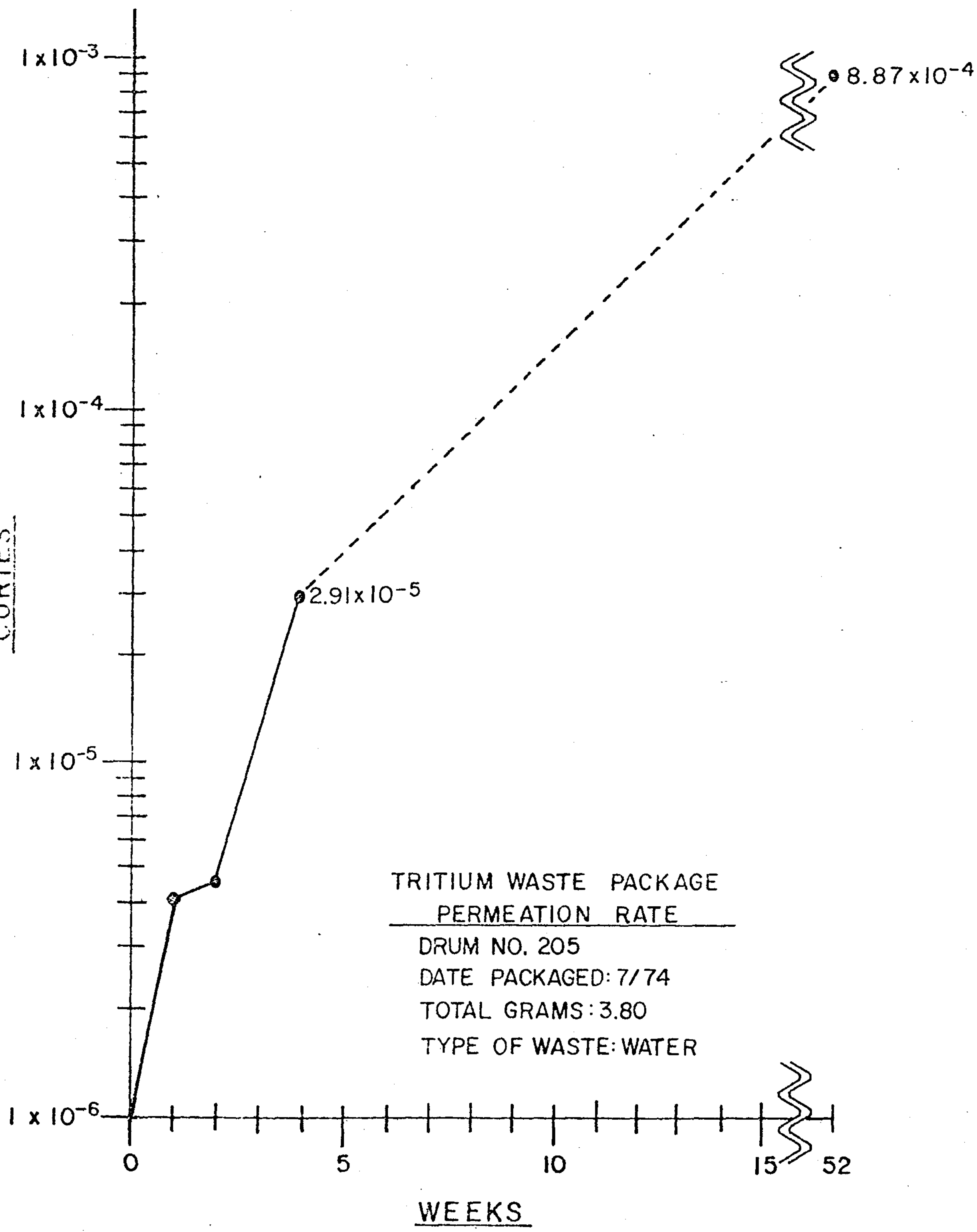
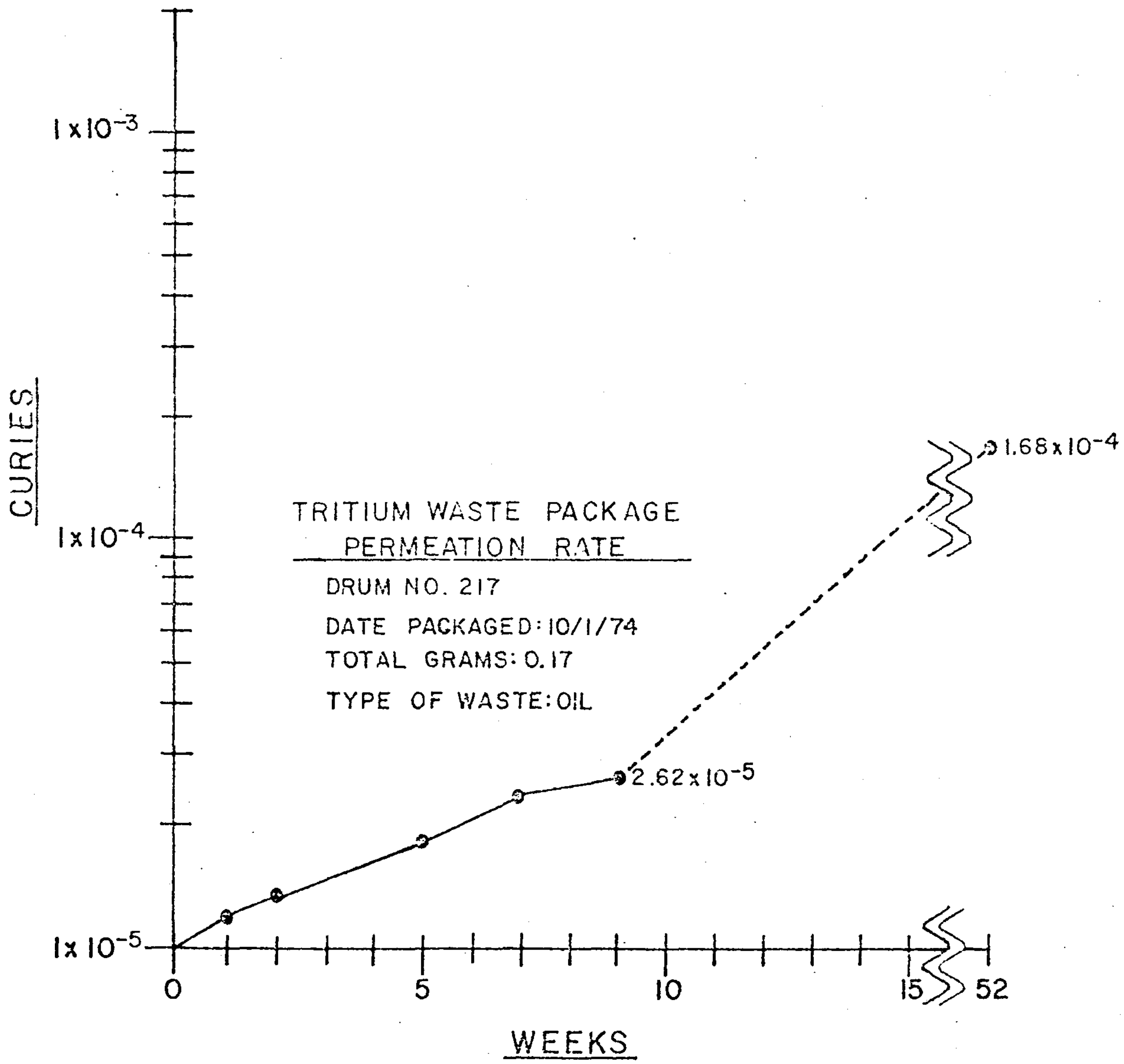
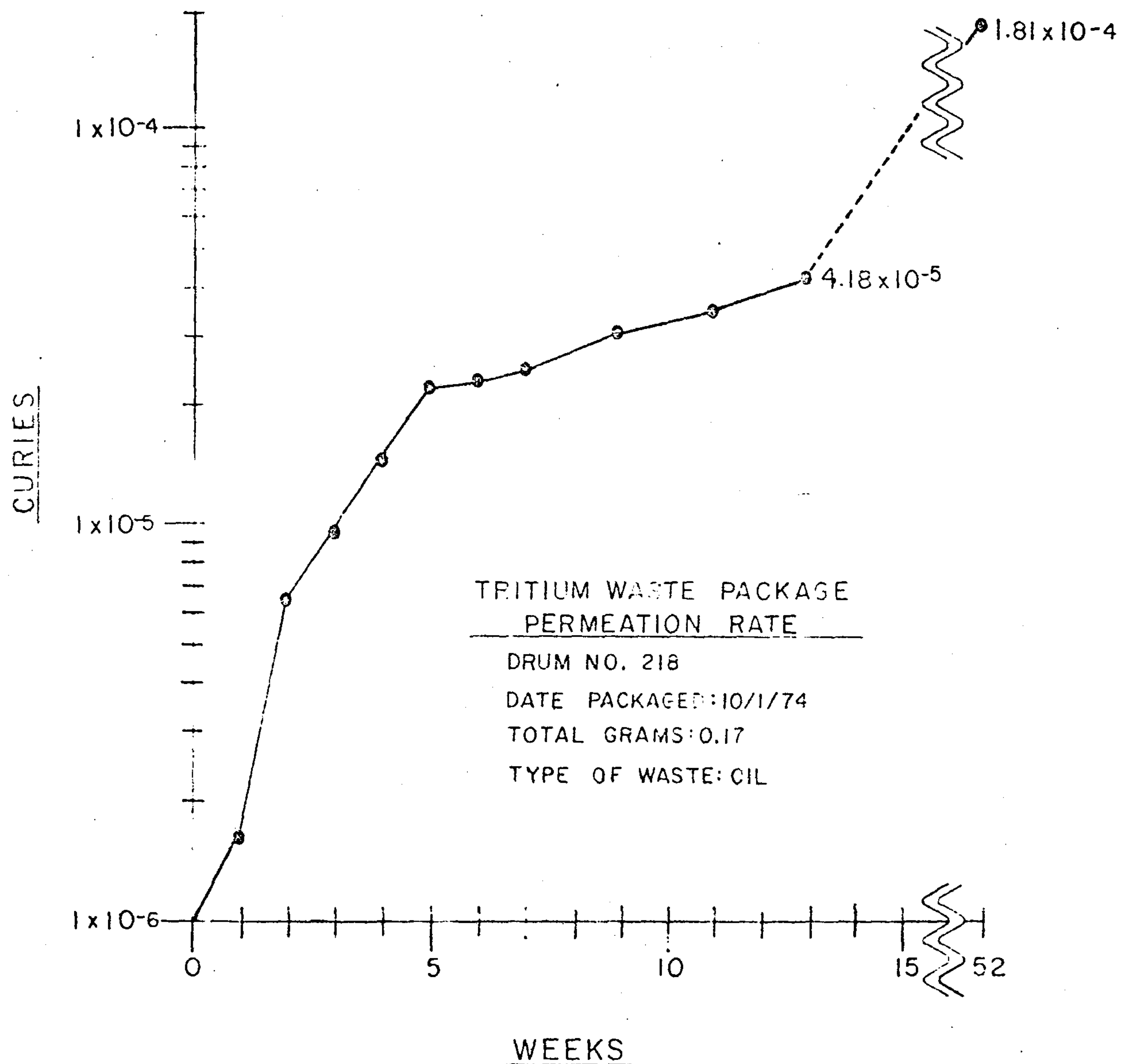

1 x 10^-3
1 x 10^-4
1 x 10^-5
1 x 10^-6
CURIES
8.87 x 10^-4
2.91 x 10^-5
TRITIUM WASTE PACKAGE
PERMEATION RATE
DRUM NO. 205
DATE PACKAGED: 7/74
TOTAL GRAMS: 3.80
TYPE OF WASTE: WATER
0
5
10
15
52
WEEKS

FIGURE 8



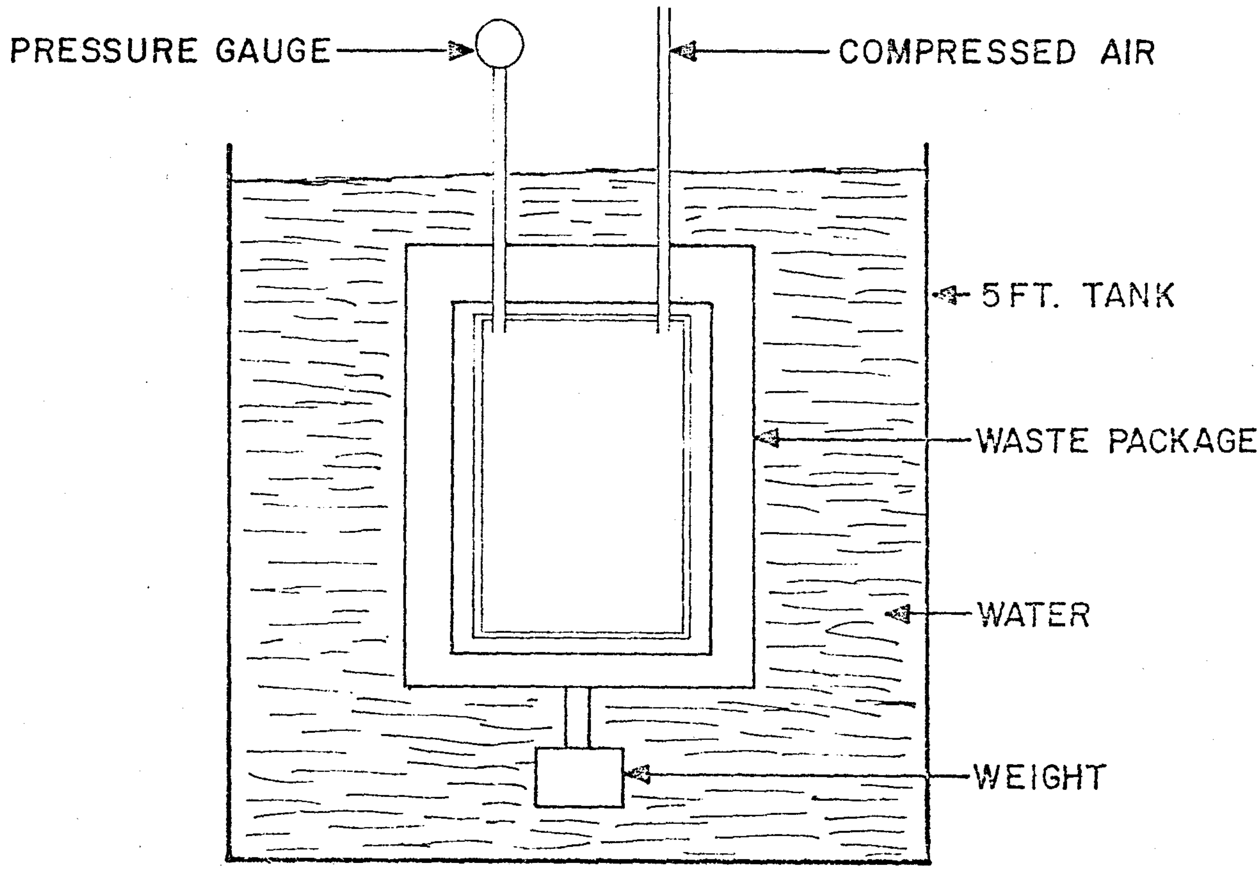
CURIES
1x10^{-3}
1x10^{-4}
1x10^{-5}
TRITIUM WASTE PACKAGE PERMEATION RATE
DRUM NO. 217
DATE PACKAGED: 10/1/74
TOTAL GRAMS: 0.17
TYPE OF WASTE: OIL
1.68x10^{-4}
2.62x10^{-5}
0
5
10
15
52
WEEKS

FIGURE 9



CURIES
1 x 10-4
1 x 10-5
1 x 10-6
1.81 x 10-4
4.18 x 10-5
TRITIUM WASTE PACKAGE
PERMEATION RATE
DRUM NO. 218
DATE PACKAGED: 10/1/74
TOTAL GRAMS: 0.17
TYPE OF WASTE: OIL
0
5
10
15
52
WEEKS

FIGURE 10



DRUM PRESSURE TEST ON WASTE PACKAGE

FIGURE 11

TRITIUM EXPOSURES

>2.5 REM

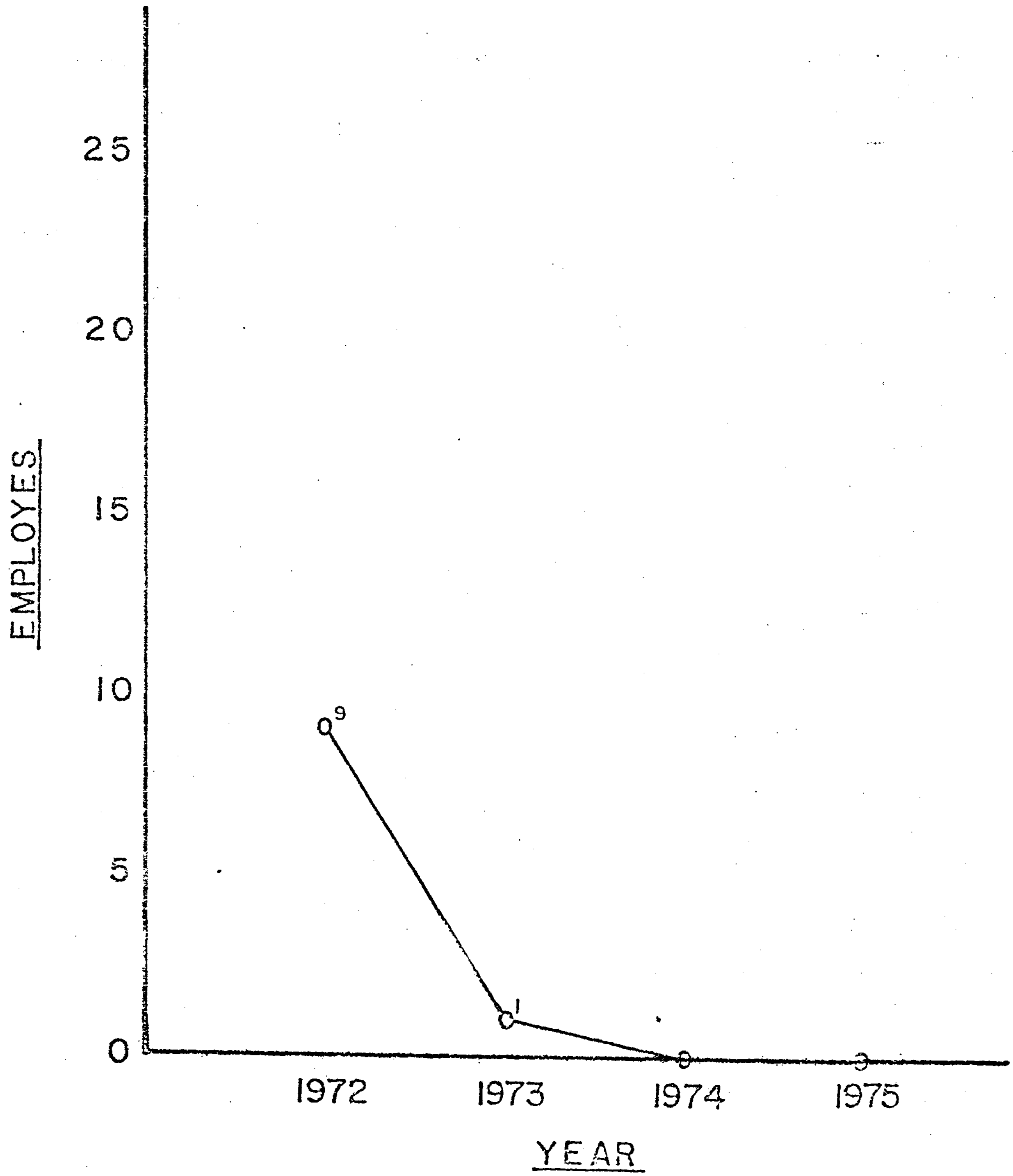
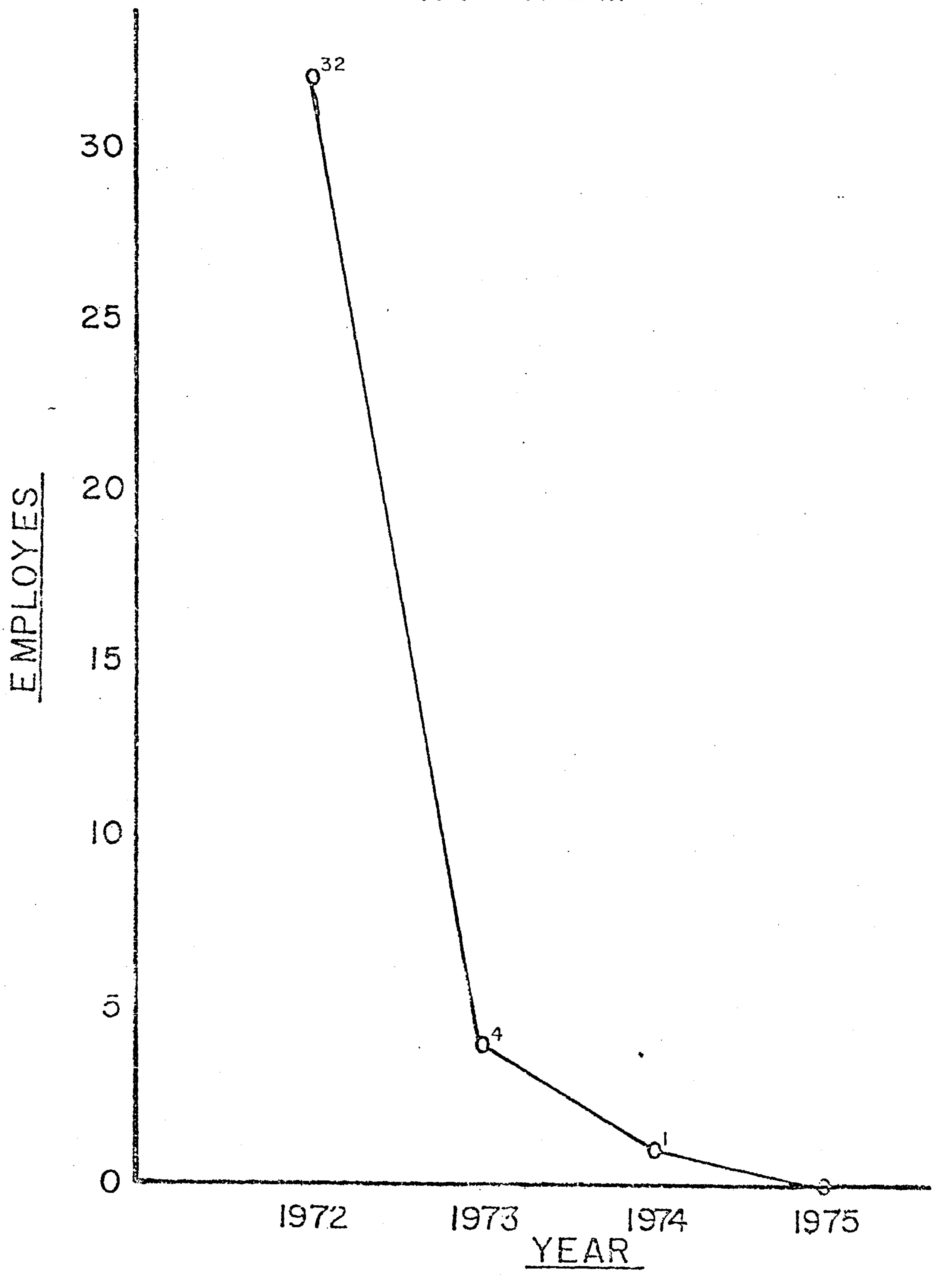


FIGURE 12

TRITIUM EXPOSURES

>1.0 REM



FIGURE

TRITIUM EXPOSURES

AVERAGE REM/PERSON

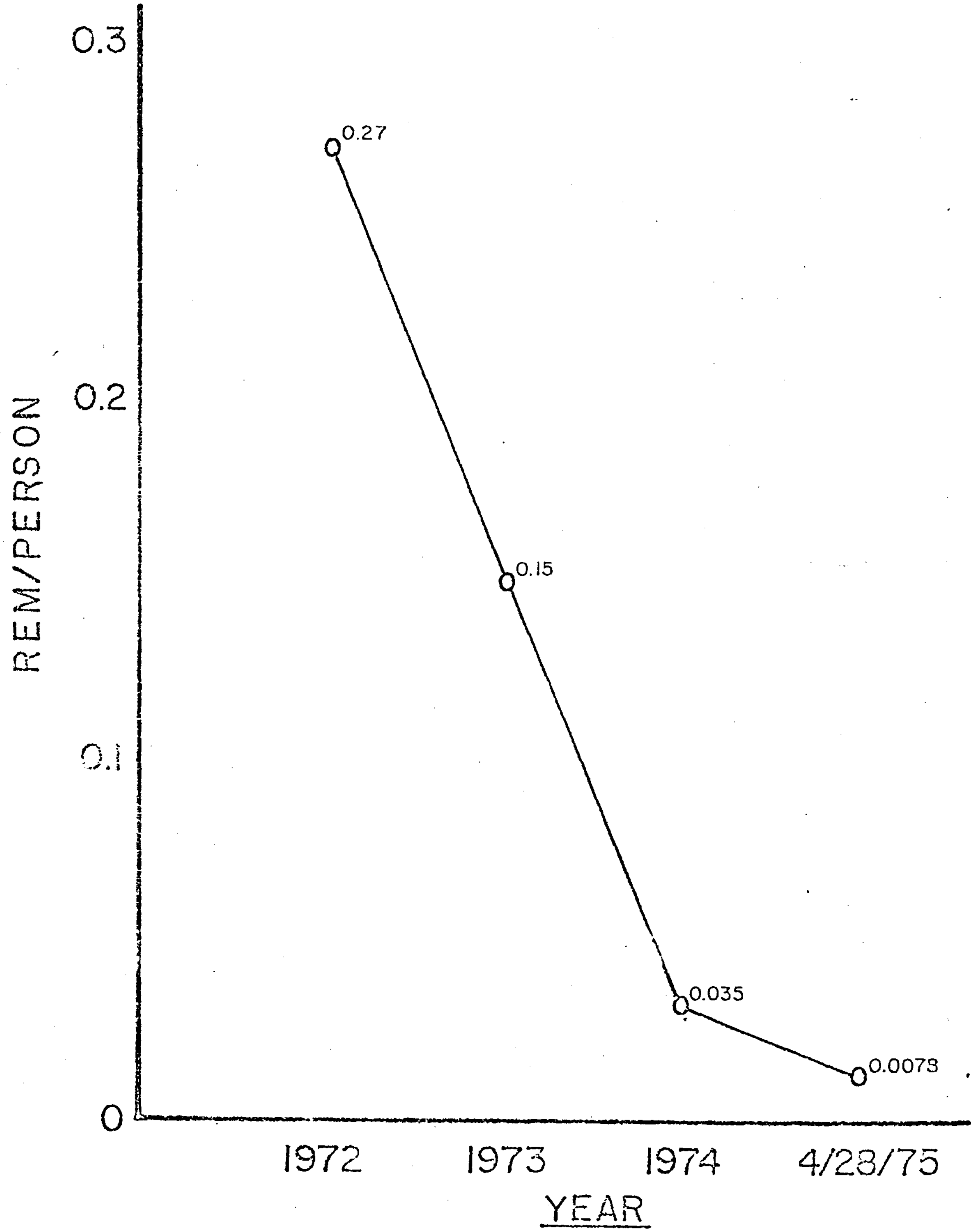


FIGURE 14

TRITIUM DISCHARGE IN LIQUID EFFLUENTS

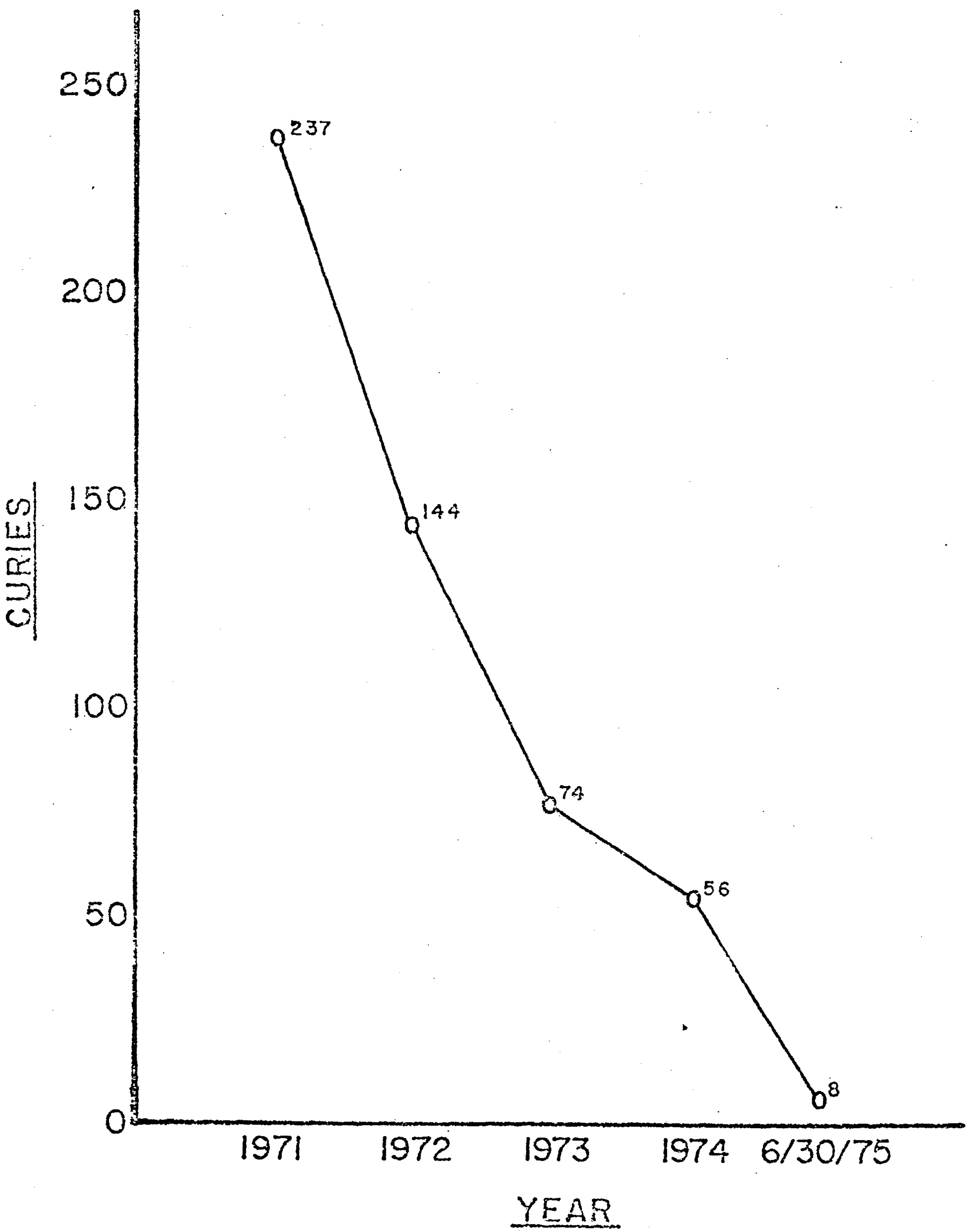


FIGURE 15

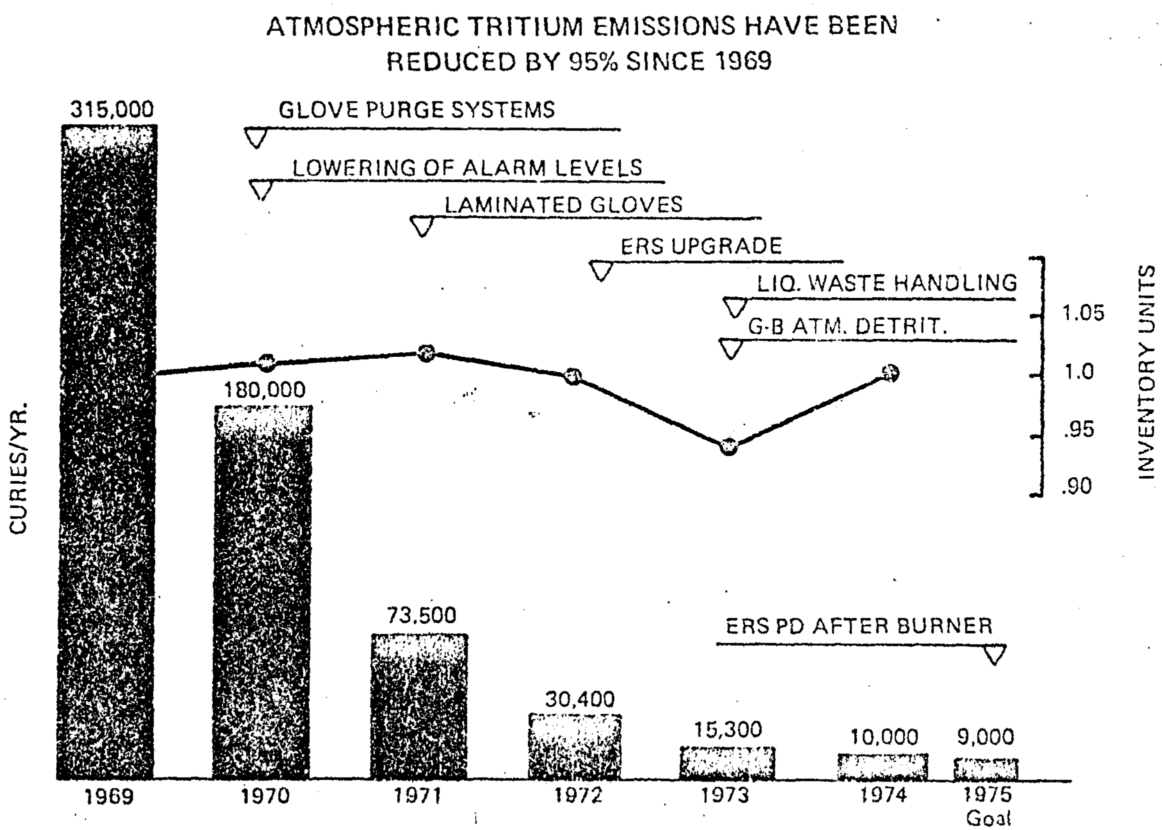

ATMOSPHERIC TRITIUM EMISSIONS HAVE BEEN REDUCED BY 95% SINCE 1969
315,000
GLOVE PURGE SYSTEMS
LOWERING OF ALARM LEVELS
LAMINATED GLOVES
ERS UPGRADE
LIQ. WASTE HANDLING
G-B ATM. DETRIT.
1.05
1.0
.95
.90
INVENTORY UNITS
180,000
CURIES/YR.
73,500
ERS PD AFTER BURNER
30,400
15,300
10,000
9,000
1969
1970
1971
1972
1973
1974
1975 Goal

FIGURE 16