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Tritium Waste Control:
October 1979-March 1980

May 19, 1980

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Monsanto

MOUND FACILITY
Miamisburg, Ohio 45342

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
U. S. DEPARTMENT OF ENERGY

Contract No. DE-AC04-76-DP00053

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Foreword

The work described in the first, second, third and fifth sections is funded or partially funded by WPAS AL 4.6.2.1 AR. The first section, "Catalytic Exchange Detritiation Studies," corresponds to Work Breakdown Structure (WBS) 4.6.2.1.1, the second section, "Electrolysis of Tritiated Water," corresponds to WBS 4.6.2.1.3, the third section "Impurity Removal from CECE Feed Water," corresponds to WBS 4.6.2.1.4, and the fifth section, "Fixation of Aqueous Tritiated Waste in Polymer Impregnated Concrete," to WBS 4.6.2.1.7. The remaining sections are work related to Tritium Waste Control but not directly funded through AL 4.6.2.1 AR.

Previous documents in this series include:

MLM-2484
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MLM-2669

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Summaries

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CATALYTIC EXCHANGE DETRITIATION STUDIES. 5

Modifications have been made to the Combined Electrolysis Catalytic Exchange (CECE) pilot unit aimed at improving flow characteristics to and from the exchange columns. Additional instrumentation has been added to improve operability. Future plans include further study of system components, along with demonstration of continuous operation.

ELECTROLYSIS OF TRITIATED WATER. 6

The 10 Ci/ml test was restarted and run successfully for five weeks after changing the damaged solid polymer electrolyte (SPE) in the General Electric electrolysis cell. After the system was dismantled for a short time to investigate a water circulation problem, an internal electrical short circuit developed in the cell which remained uncorrected after two replacements of the SPE. Because of the difficulty and time required to change the SPE, it was decided to discontinue tests using this cell. A new GE cell has been procured for use in future tests.

IMPURITY REMOVAL FROM CECE FEED WATER. 7

The tritiated liquid wastes produced at Mound Facility contain certain impurities which, if not removed, could be detrimental to components of the Combined Electrolysis Catalytic Exchange (CECE) system. Analyses were done for certain impurities to determine the type and level likely to be encountered. The initial problem appears to be a 1 to 2% oil (mostly insoluble organics) layer. Experimental work aimed at developing a complete oxidation process for the oil was conducted, but it appears that removal by adsorption on activated carbon is a more straightforward method.

FIXATION OF AQUEOUS TRITIATED WASTE IN POLYMER IMPREGNATED CONCRETE. 9

A polystyrene-impregnated, tritiated-concrete waste package has been prepared with 7,921 Ci of tritium. This burial package was added to the drum permeation study on November 28, 1979. The construction of the new addition to the liquid waste handling facility is presently on schedule. Construction started on November 1, 1979, to provide the facility to use the polystyrene-impregnated, tritiated-concrete waste-water burial package.

MANAGEMENT OF HIGH SPECIFIC ACTIVITY TRITIATED LIQUID WASTES 13

The study of tritium release from representative burial packages was continued. The two waste-water drums have the highest tritium release at 24 mCi and 63 mCi. These two drums also contain the highest amounts

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of tritium, originally 34,480 Ci and 52,128 Ci, respectively. There has been no detectable release from the two recently added drums. These drums contain a polymer-impregnated, tritiated-concrete (PITC) waste form and a control package prepared according to the current routine procedures.

GAS GENERATION MEASUREMENTS ON TRITIATED WASTE MATERIALS 15

Gas generation rates caused by radiolysis of tritium waste materials were determined for polymer and non-polymer impregnated tritiated concrete and fixated and non-fixated tritiated waste vacuum pump oil. In addition, the pressure change of hydrogen cover gas over tritiated water on cement-plaster was determined.

Catalytic exchange detritiation studies

T. K. Mills and M. L. Rogers

Background

Tritiated water is produced by several sources, such as irradiated coolant from light water reactors and water produced by oxidation to control airborne emissions. Future sources can be expected to include wastes from fuel reprocessing and fusion reactors. As the quantity of tritium involved increases, heightened interest in containment and recovery will be motivated by both environmental and economic concerns.

Unlike other radioisotopic contaminants, tritium cannot be removed from aqueous streams by conventional chemical or physical methods. Its separation requires the development of processes which differentiate between tritium and other hydrogen isotopes.

The objectives of this study are:

- Determine the technical and economic factors involved in tritium removal by means of the HT/H_2O exchange process.
- Determine the suitability of available system components for use in water detritiation systems.
- Through pilot-scale testing, establish design criteria for detritiation systems suited to DOE site operations and the U. S. power reactor industry.

Initial elements of the study demonstrated that Combined Electrolysis Catalytic Exchange (CECE) is a workable process for recovering tritium from water. Radiolysis studies have assessed the durability of system components under process conditions. Also, preliminary economic evaluations of the process have been performed.

On the basis of information provided by these early investigations, a pilot CECE unit was designed and built. It incorporated Solid Polymer Electrolyte (SPE) electrolysis cells manufactured by General Electric Company and a hydrophobic, precious-metal catalyst which was developed by Atomic Energy of Canada, Limited (AECL) and is now commercially available from Noranda Research Center. This pilot CECE unit was operated for approximately 400 hr during a 4-month period, after which the catalyst beds were purged with hot N_2 and O_2 for 300 hr and 50 hr, respectively, to dry the catalyst and remove any accumulated carbon monoxide. The unit was then operated for approximately 200 hr during a 2-month period. Using data generated during these periods of operation, predictions of catalyst activity were confirmed and it was calculated that, under the range of process conditions studied, mass transfer unit heights of approximately 1.0 m existed within the exchange columns. Following this, the pilot unit was modified by the addition of "cold" liquid reflux and enriched hydrogen storage capabilities. These additions were successfully started up, and their operating characteristics qualitatively investigated.

Accomplishments

It was noted that flow in the liquid lines between the glovebox and the columns was at times difficult or impossible to maintain. This was determined to be caused by blockage of the lines, which was in turn attributed to buildup of sludge washed out of the various catalyst beds in the system. To correct this problem, the process lines running between the glovebox and the columns were replaced with lines of larger diameter. These lines were provided with individual secondary containment, rather than a single secondary containment as had been done with the previous lines. This was done to increase the ease with which lines could be constructed and, if required, repaired.

Concurrently with the replacement of process lines, new instrumentation was added to the pilot unit. This consisted of a number of visual flowmeters to supplement the electronic instrumentation, and three oscillating-ball type electronic flowmeters to replace hot-wire instruments which had been removed because of unsatisfactory operation. Also, a data logger was installed to provide an independent readout of the output from the electronic instrumentation.

Future plans

Future CECE pilot system effort will be directed towards refinement of the process control scheme employed by the unit and the achievement of continuous, unsupervised operation. It is expected that this effort will include the collection of additional separation data, as well as quantitative characterization of recombiner and hydride storage operation.

Electrolysis of tritiated water

R. E. Ellis

Background

At Mound Facility tritiated water is produced as a byproduct of various activities that involve handling of tritium. The tritium content of such water is often high enough to be economically used as feed for existing gaseous hydrogen isotope separation processes. To do this, however, the hydrogen must first be separated from the oxygen by decomposition of the water molecule. Electrolysis, one of the more straightforward water decomposition methods, is used in the Combined Electrolysis Catalytic Exchange (CECE) system under development at Mound. The purpose of this system is to decontaminate low level tritiated water, but the system's vital solid polymer electrolyte (SPE) cells are exposed to high tritium concentrations.

Tests were initiated to establish an expected lifetime for the SPE membrane. These have included a single experiment with a regenerative type cell [Bixel, 1976], a series of three experiments at different tritium concentrations [Ellis, 1978] using an electrolysis cell purchased from General Electric Company, and the present long-term life expectancy test at 1 Ci/ml and 10 Ci/ml [Ellis, 1979].

Accomplishments

The cell used in the high level tritiated water electrolysis tests was reassembled using a new solid polymer electrolyte (SPE). The cell itself was operated successfully once a week during a 5-week exposure to 10 Ci/ml water. However, during these test cycles a problem was encountered in maintaining water circulation in the system. In an effort to find the cause of this problem, the system was dismantled to check for obstructions in the lines.

Although the cell itself was not taken apart, an electrical short circuit developed inside the cell upon reassembly and subsequent operation of the system. The cell was twice disassembled and reassembled in an effort to find the problem. No visual indication such as discoloration, melted material, or holes in the SPE could be found. Each time an attempt was made to operate the cell, however, a high-current flow developed at a voltage far below that necessary for water electrolysis. Since attempts to use this cell were fruitless and very time-consuming, it was decided to abandon the testing program using this cell.

A new cell more closely representing General Electric Company's latest technology has been procured for testing. This cell is designed so that changing SPE membranes will be much easier and less time-consuming than in the old cell. A completely new test system will be required for the new cell. Such a system has been designed and some of the components procured.

Future plans

A test system will be fabricated and the new SPE cell tested using nontritiated water. After this system is operating satisfactorily, it will be installed in the HTO glovebox and 10 Ci/ml tests will be continued.

Impurity removal from CECE feed water

R. E. Ellis

Background

The tritiated liquid wastes produced at Mound Facility are predominantly water. However, depending on the specific operation responsible for the waste, there will also be some impurity content. Various sections of the CECE system are adversely affected by such impurities and it is important that they be removed prior to introduction of the water into the system.

The most obvious impurity appears in the form of suspended particulates. Such material could cause problems in many parts of the system including valves, catalyst columns, piping, and pumps. Another impurity known to be in the water is oil. Oils and emulsions would be particularly damaging to the active areas of the system, e.g., the catalyst and solid polymer electrolyte (SPE).

In addition to these obvious impurity problems, the catalyst and SPE have certain specific impurities to which they are especially sensitive. According to J. P. Butler at AECL, these include CO, NO, and Cu for the catalyst and, as specified by A. B. LaConti at GE, all these plus Fe^{++}, S, $S^{=}$, heavy metals, and peroxides for the SPE. Although the damage to the catalyst is reversible in some cases, that to the SPE is not.

An investigation has been initiated to determine the extent to which significant impurities exist in the feed water, and the processes needed to successfully remove them. The result will be design of a feed water cleanup process for the CECE system.

Accomplishments

The tritiated liquid waste to be considered for this process is produced in several operations in the SW Building at Mound Facility. This material, mostly water, is collected by the Effluent Recovery System (ERS). Samples of this water have been analyzed by various methods for certain inorganic impurities and the results listed in Table 1. As can be seen, only Na and Cl are present in amounts above several parts per million (ppm). The CECE system is not thought to be sensitive to either of these two impurities.

Table 1 - IMPURITY CONTENT OF ERS WATER

Impurity	Quantity (ppm)
F	1.8
Cl	5.6-150
Br	0.5
I	0.4
Na	41.4
K	3.1
Mg	0.05
Ca	0.2-0.5
B	0.5
Al	0.1-0.3
Se	0.6
Fe	0.04-0.1
S	2.3

Estimates of the oil (actually liquids immiscible in water) content were also made by simply measuring column heights of the immiscible layer. These estimates ranged from 1 to 10% by volume. However, sampling procedures are critical in determinations involving such nonhomogeneous mixtures and recent, more precise measurements indicate 1 to 2% oil by volume. This amount of oil is detrimental and must be removed before the water enters the CECE system.

Variations in impurity content probably also occur as a function of time. Water from some processes is not continuously collected by the ERS. Collection periods of several years may take place before waste water actually ends up in the ERS. Furthermore, changes take place in some of the processes over a period of time causing variations in impurity types and levels. For these reasons, it is likely each batch of feed water will require impurity analysis prior to feeding to the CECE system. The analyses reported here serve only as a guide to the impurities and levels which may be present.

The initial cleanup problem with the ERS water is the oil, or insoluble organic layer. If fed to the CECE system this material would coat and deactivate the catalyst, and concentrate in the electrolysis section probably deactivating the cells. It could also plug the lines and/or filters through which the CECE system water flows.

The two basic processes being considered for the removal of the oil layer are: separation by filtering or adsorption, and complete oxidation of the organic material to water and CO_2. The latter process has an advantage: it does not produce a tritiated waste product which must be further processed. A complete oxidation process, however, is complicated to perform. A combination of the two processes is also possible, e.g., filter the oil, then burn it and collect the water for processing in the CECE system.

Some preliminary experimental work has been done on the oxidation process. Using pump oil/nontritiated-water mixtures in place of the ERS water, $KMnO_4$ and H_2O_2 were tried as oxidants. Under even the most stringent conditions (reflux at 100°C, use of surface-active catalysts) the oil layer was not fully oxidized. It is probably possible to develop such a process, but it is apparent that the problems involved will not be trivial.

Although actual experimental work is yet to be carried out, it appears that the use of activated carbon to absorb the oil layer will be a more straightforward method. This method may also remove certain inorganic impurities as well. A critical factor for use of carbon is the amount of oil. If it is large, the carbon beds would have to be changed often and a large amount of tritiated waste would be created which, in turn, would have to be processed for disposal or burial. However, the most recent estimates of the amount of the oil layer are 1 to 2% of the total volume. This amount would contain a very small part of the total tritium and present few disposal problems.

Future plans

Tests will be conducted to determine parameters necessary to remove oil by means of absorption on activated carbon. Methods for analysis of oil as well as inorganic impurities in water will be developed.

Fixation of aqueous tritiated waste in polymer impregnated concrete

J. J. Dauby, R. E. Wieneke and G. E. Gibbs

Background

Mound Facility undertook a program to test and develop the Brookhaven National Laboratory (BNL) polymer impregnation method [Colombo, 1977] for fixation of aqueous tritiated waste and adapt it to current Mound procedures. Concrete has been used at Mound since 1972 as a fixing agent for aqueous wastes containing 0.1 to 0.2 g of tritium per liter. In the polymer impregnation technique, the cured concrete is impregnated with styrene monomer. The monomer fills the pores, then polymerization of the monomer binds and immobilizes the radioactive waste in the concrete. This decreases the tritium release from the concrete and reduces contamination hazards at the burial site.

Because the styrene permeates the concrete the waste is, in effect, "microencapsulated." This will significantly reduce the tritium release rate in the event the containment is breached.

A test program was instituted to measure and compare the release of tritium from tritiated concrete with and without styrene impregnation. All samples were prepared in 16-oz polyethylene bottles containing mixtures of cement-plaster and of Portland Type III cement (high early strength).

Approximately 62.5 ml of tritiated water containing 386 Ci was injected into each of 16 samples containing 250 g of dry mix. This is several times the concentration of tritium in a normal tritiated waste package. Details of the preparation of these "hot" samples may be found in a previous report [Dauby, 1978].

The test method (shown in Figure 1) consists of submerging each sample, still contained in the polyethylene bottle, into 1600 cm^3 of water which is sampled periodically to measure the tritium released from the sample.

Full-scale, cold prototype burial packages have been prepared. Early tests without adequate temperature monitoring revealed unexpected damage to the linear polyethylene (LPE) drum liner. As expected, tests showed that linear high-density polyethylene (LHPE) is more resistant to attack by styrene monomer than is LPE. Options for investigation included: 1) reducing the bulk temperature while styrene monomer is in contact with the drum liner, 2) reducing the contact time of the drum liner and the monomer, and 3) using drums of LHPE or cross-linked high-density polyethylene (CLPE).

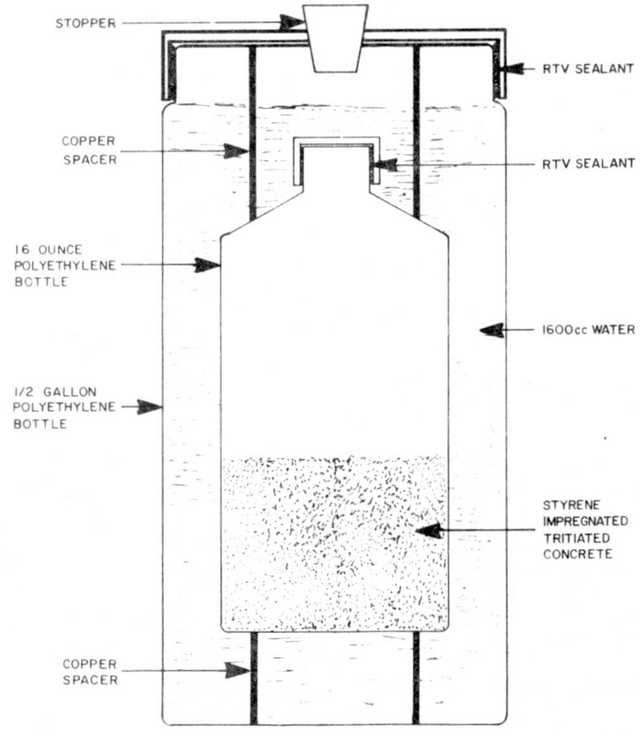

FIGURE 1 - Styrene impregnated tritiated concrete test.

Accomplishments

A full-scale polymer-impregnated tritiated-concrete (PITC) waste package has been prepared. Twenty and one half liters of tritiated water was injected into a 30-gal asphalt-coated steel drum (DOT 17H) with a 27-gal low-density polyethylene drum containing 103 kg of Portland Type III cement. This was prepared in room SW-149, hood #4, and was the first full-scale "hot" PITC package containing actual tritiated waste collected from the Mound tritium operations.

The injection tube was removed from the center of the drum and replaced with a thermocouple and cement to fill the void left by the tube (see Figure 2). After the cement had cured 6 days, it was soaked with 24.7 kg of styrene monomer containing 185 g, 3/4 wt %, catalyst (2,2'-Azobis [2-methylpropionitrile]). Heat was applied, with care taken not to exceed 100°C at the outside surface of the polyethylene drum. The temperature at the cement-polyethylene drum interface was held constant for one hour after reaching 70°C, and the drum heater was then turned off. Polymerization occurred in the next 12 hr. This burial package contained 7,921 curies of tritium. At the same time, a burial package containing 8,114 curies was prepared by the standard procedure. The two liquid waste packages were added to the drum permeation study on Nov. 28, 1979. One drum

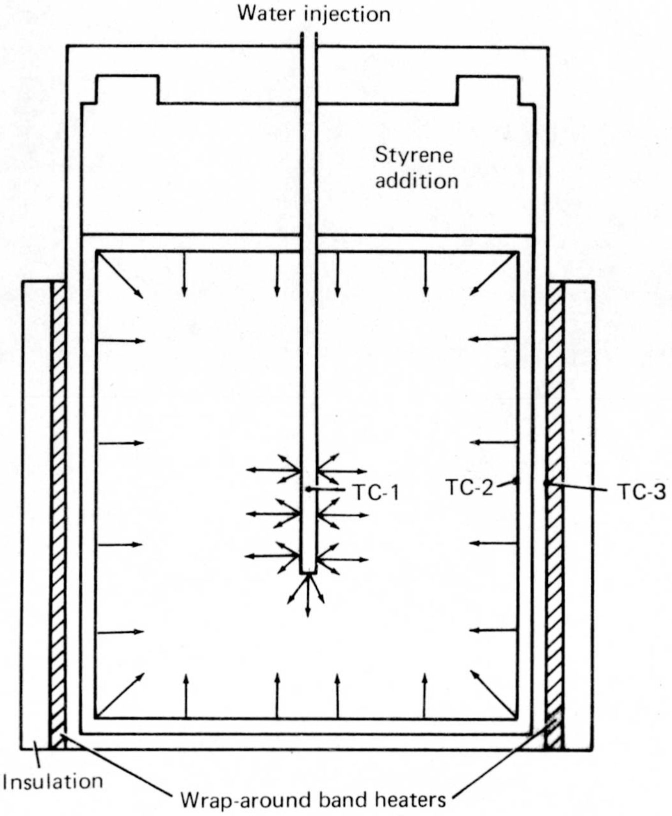

FIGURE 2 - PITC procedure. Drawing shows location of thermocouples used for temperature measurement.

is a PITC-treated package and the second is normal concrete-plaster mix. This will provide a comparison between PITC and current waste packages.

The tritium permeation data for the small test blocks are given in Table 2. The fractional release of tritium as shown in column 11 of Table 2 continues to show the real benefits of the polyethylene bottle in the test package. Note the PITC in Group 4 has improved the tritium containment. The nude cement blocks containing styrene polymer (see column 12 of the table) still contain approximately 50% of the original tritium (Groups 2, 3 and 4) while the cement III block without polystyrene only contained 26% of the original tritium (Group 5). This shows that the use of the PITC process will reduce the leaching of tritium by the water if an accident should open all containment of a burial package.

Column 13 of Table 2 continues to show previously reported conclusions that the amount of catalyst used to polymerize the styrene does affect the quality of the containment.

The PITC process constraints remain:

1) Styrene-polyethylene drum contact time must be minimized.
2) Polyethylene must not be exposed to temperatures in excess of its melting point.
3) Water in cement must not be vaporized (temperatures must not exceed 100°C).

The construction for the SW-149 addition began on schedule on November 1, 1979. This addition will provide facilities to prepare tritiated waste water for burial using the PITC process. The construction of the addition is on schedule with 80% of the brick and block laid.

Table 2 - PERMEATION TESTS

(1) Group	(2) Sample Number	(3) Original Curies	(4) Preparation Date	(5) Type	(6) Water/Dry Mix Ratio	(7) Styrene (%)	(8) Catalyst (%)	(9) Polymerization Temperature (°C)	(10) Total Permeation (Ci)	(11) Fractional Release* from "Test Package"	(12) Fractional Release from "Nude Block"	(13) Fractional Release from "Nude Block"
1	58	386.5	5-10-77	Cement III	0.250	20	5	40	4.75	1.44×10^{-2}/147 wk		
1	59	386.3	5-10-77	Cement III	0.250	20	5	40	250.0			0.77/147 wk
2	63	385.9	5-13-77	1:1 by weight	0.250	23	1/2	55	4.98	1.5×10^{-2}/147 wk		
2	64	386.6	5-13-77	1:1 by weight	0.250	23	1/2	55	146.3		0.44/69 wk	
3	67	386.9	5-13-77	1:1 by volume	0.305	20	1/2	55	151.4		0.46/69 wk	
3	68	386.6	5-13-77	1:1 by volume	0.305	20	1/2	55	8.00	2.44×10^{-2}/145 wk		
4	70	386.6	6-03-77	Cement III	0.250	20	1/2	55	187.4		0.57/69 wk	
4	71	386.3	6-03-77	Cement III	0.250	20	1/2	55	2.67	0.81×10^{-2}/142 wk		
4	72	386.5	6-03-77	Cement III	0.250	20	1/2	55	173.0			0.53/145 wk
5	74	387.0	7-22-77	Cement III	0.250	None	None	None	245.0		0.74/69 wk	
5	75	193.4	7-22-77	Cement III	0.250	None	None	None	2.5	1.47×10^{-2}/135 wk		

$$\text{*Fractional release} = \frac{\text{quantity released into the water}}{\text{total quantity (decayed) injected into the block}}$$

Management of high specific activity tritiated liquid wastes

G. E. Gibbs and J. J. Dauby

Background

Mound generates high-activity tritiated liquid waste from a variety of tritium handling operations and from stack effluent control systems [Rhinehammer, 1973; 1976 - Lamberger, 1978]. There are two general categories of liquid waste: water ($\sim$1000 Ci/liter) and vacuum pump oil ($\sim$50 Ci/liter). Since 1972 these materials have been packaged for disposal in an improved container. Handling is accomplished with virtually no release to the environment and no significant operator exposure. The facility, package, and operating experience have been described in detail in the literature [Mershad, 1977]. Twenty-five liters of waste oil is sorbed on vermiculite in a polyethylene drum, whereas 27 liters of liquid water waste is sorbed on a cement-plaster mixture in the polyethylene drum. The packaging procedure thereafter is the same: containment in a 30-gal drum and finally in a 55-gal drum.

A study of the tritium release rate from actual burial packages was initiated in May 1975 and continues. The study consists of the individual immersion of representative actual burial packages in a known volume of water. The surrounding water is periodically sampled and analyzed for the presence of tritium; a release rate is then calculated from these data. Figure 3 is a schematic of a typical burial package under test.

Two drums containing octane waste (113 and 114), are positioned in the water in a manner similar to the positioning of the oil and water drums -- the internal package, however, is quite different: contaminated octane waste is sorbed on vermiculite contained inside a polyethylene bottle which is then sealed. Three of these bottles are sealed inside a 50-gal steel drum liner. This liner is then sealed inside a 55-gal steel drum, which is in turn sealed inside a 83-gal steel drum. All void volumes within the package are filled with vermiculite and asphalt. These octane wastes were packaged in the 55-gal drum in 1972 and the 83-gal drum was added in 1977.

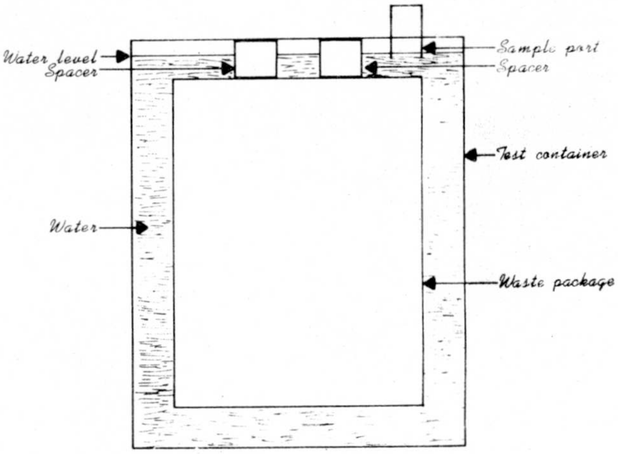

FIGURE 3 - Schematic of test package.

Accomplishments

The drum study monitoring the release of tritium from actual burial packages has continued. Figure 4 shows the fractional release values (total curies permeation ÷ total curies contained) of all packages as a function of the time since the packages were prepared. This illustration takes into account the total curies

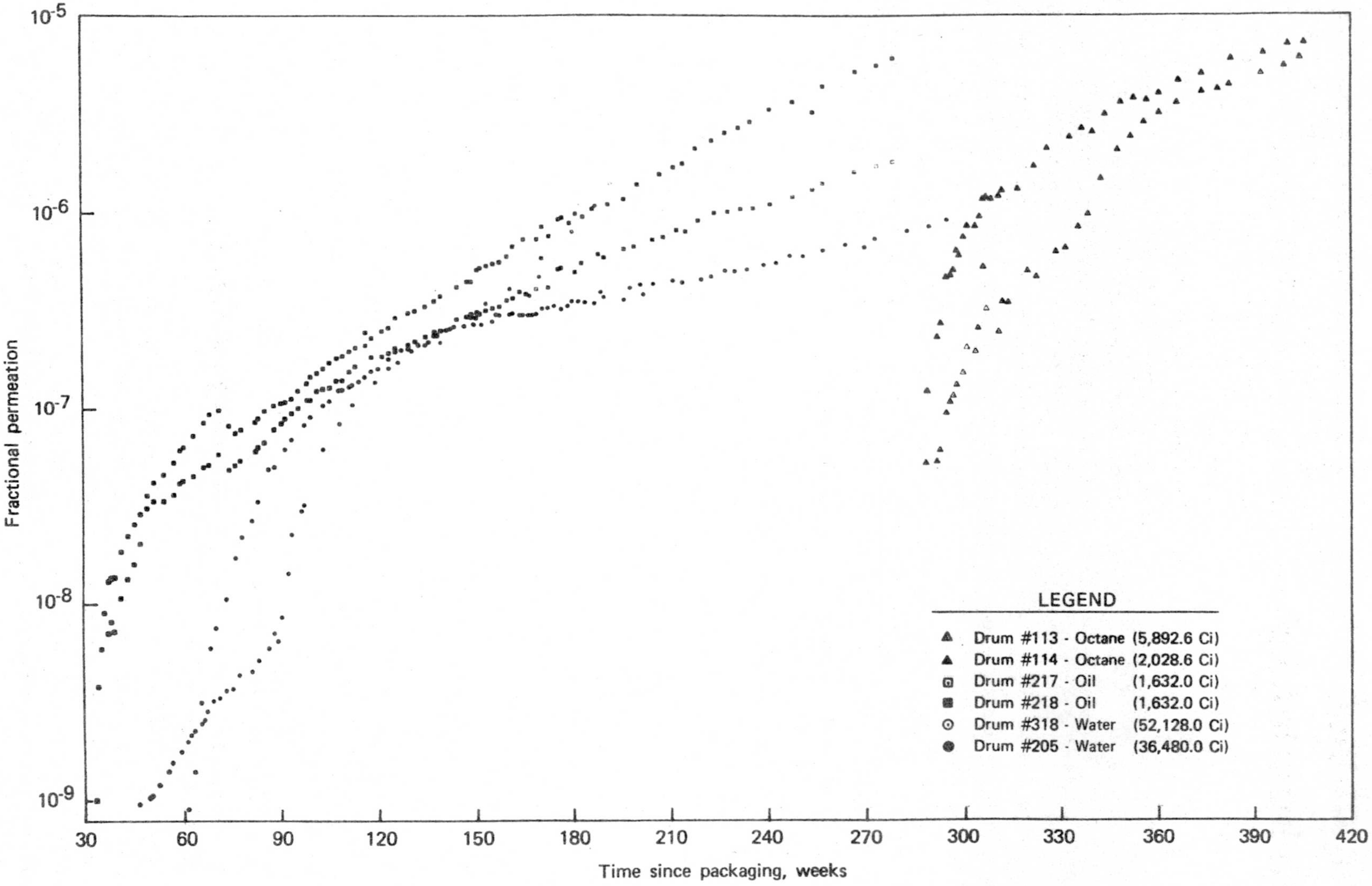

FIGURE 4 - Fractional tritium release from test packages.

actually in each package with consideration given to tritium decay since the burial package was first assembled.

There was a 28-week period (weeks 110-168) when the oil and water drums had essentially the same fractional permeation rates. During the last 130-week period, the fractional permeation rates of the two oil drums have increased slightly faster than the rates of the water drums.

In an effort to improve the usefulness of the existing data, a linear graph (Figure 5) has been prepared which illustrates the total permeation (expressed as millicuries) vs time (expressed in weeks) packaged. This graph illustrates an almost constant permeation rate for the waste drums. It should be noted that the higher the curie value for the drums, the higher the permeation rate (slope). This trait is not as apparent when referring to the fractional release (Figure 4).

The drum release study includes all three types of high-activity tritiated liquid waste generated at Mound. Note that the maximum fractional release rate on these drums is 8.2×10^{-6} and the maximum total permeation is 63 mCi.

Two recently prepared drums of waste water (462 and 464) have been added to the permeation study. The first of these two drums was prepared using the polymer-impregnation method. The comparison of permeation rates between these two drums will indicate any additional benefits from PITC.

Future plans

The waste drum study will continue and the results reported. An attempt will be made to determine the actual tritium and hydrogen release mechanisms.

Gas generation measurements on tritiated waste materials

W. E. Tadlock

Background

As part of an ongoing evaluation of tritium waste packages at Mound Facility, gas generation is measured on samples of polymer and non-polymer concrete and fixated and non-fixated waste vacuum pump oil. In addition, the pressure buildup of hydrogen cover gas over tritiated cement-plaster is studied for a possible hydrogen back reaction. The major thrust of these measurements is to obtain data which may be used to predict gas generation in Mound waste packages. The preparation of the samples has been previously reported [Tadlock, 1978; 1979].

Accomplishments

The rate of gas generation of polymer and non-polymer tritiated concrete is illustrated in Figure 6. These data have been normalized to STP conditions with the use of the equation:

$$\mathrm{cm}^3(\mathrm{STP})/\mathrm{Ci} = \frac{P_1 - P_0}{760}\,\frac{V}{\mathrm{Ci}}\,\frac{273}{298}$$

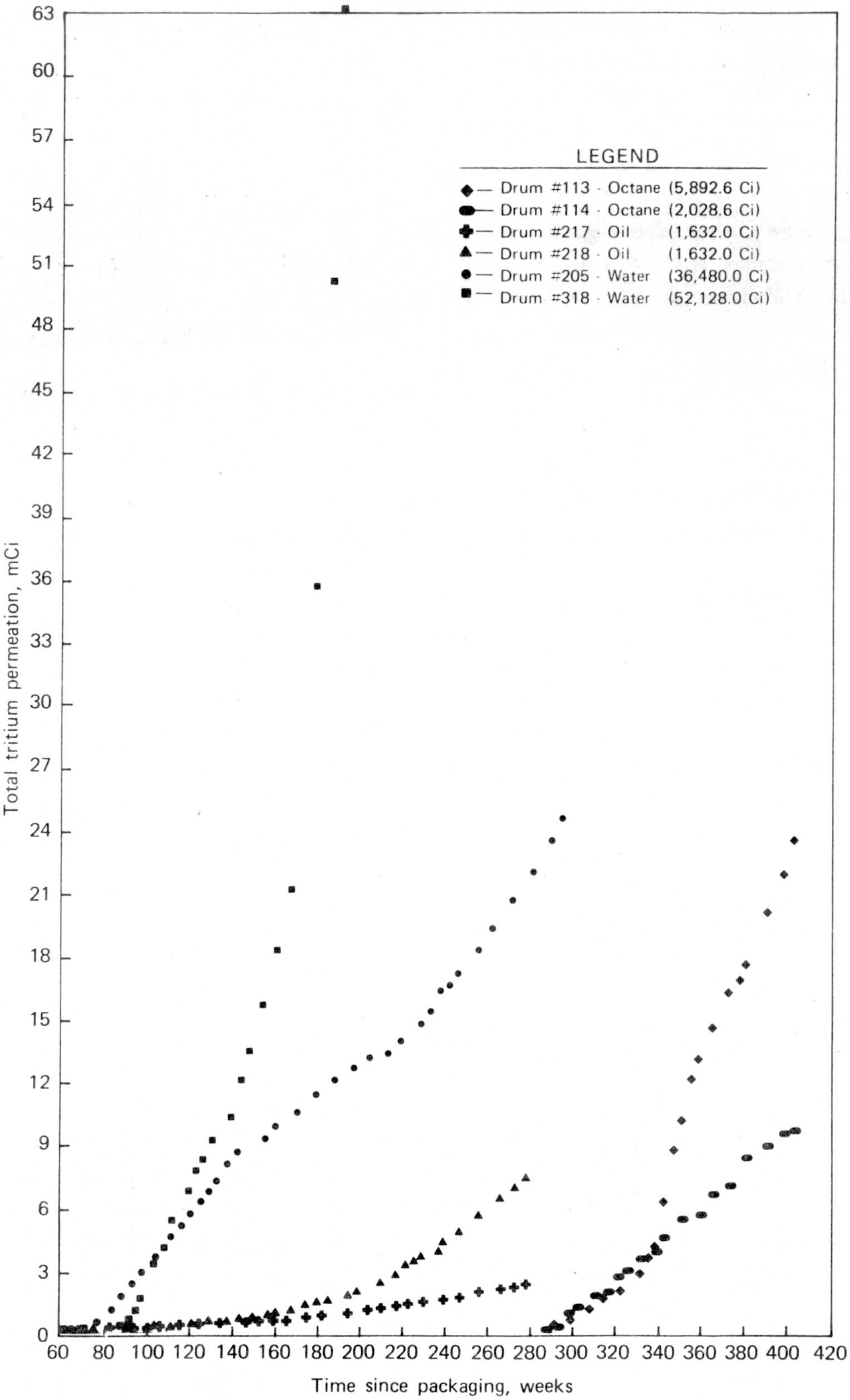

FIGURE 5 - Total tritium release from test packages

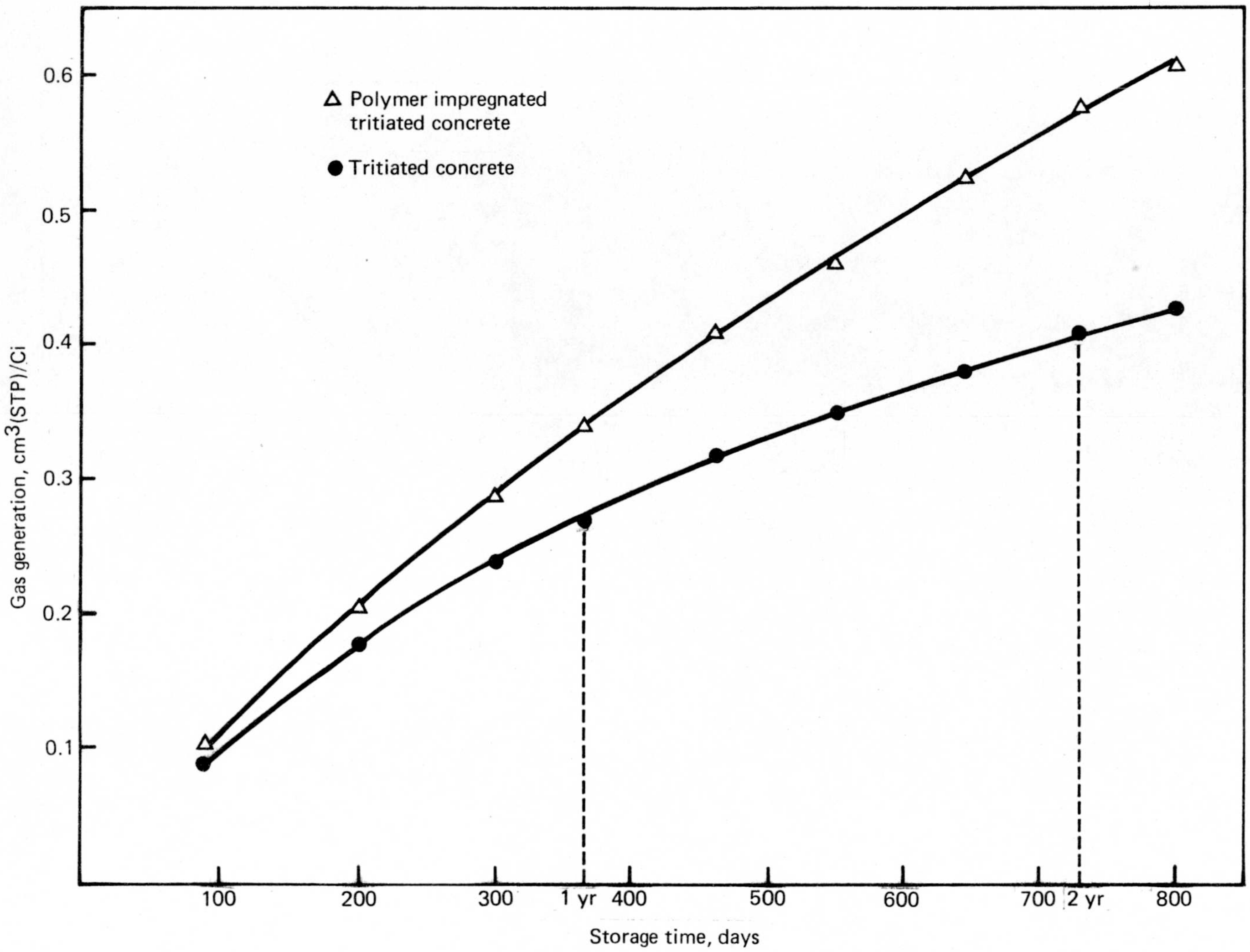

FIGURE 6 - Gas generation by polymer impregnated and non-polymer tritiated concrete.

where P_1 = Final Pressure (Torr)

P_0 = Initial Pressure (Torr)

V = Void Volume

Ci = Activity of material in curies

The effect of fixation on tritiated waste vacuum pump oil is shown in Figure 7.

The rate of pressure change of hydrogen cover gas over cement-plaster is shown in Figure 8. The initial hydrogen pressure of these samples was 35 lb/in.^{2}. No major changes in rate increases are noted for any of the packages.

Future plans

Monitoring of these packages for pressure increase will continue.

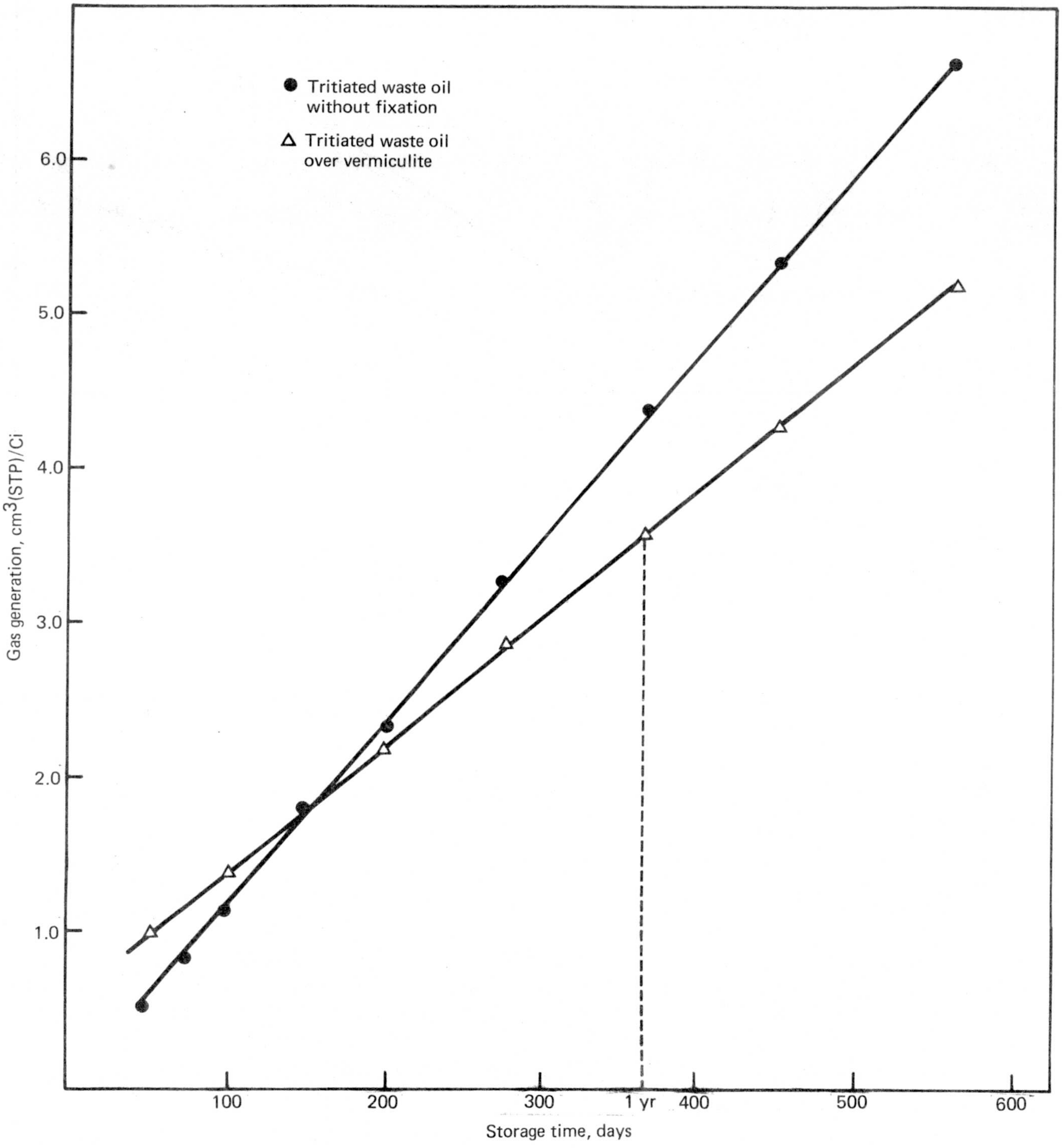

FIGURE 7 - Gas generation by tritiated waste vacuum pump oil.

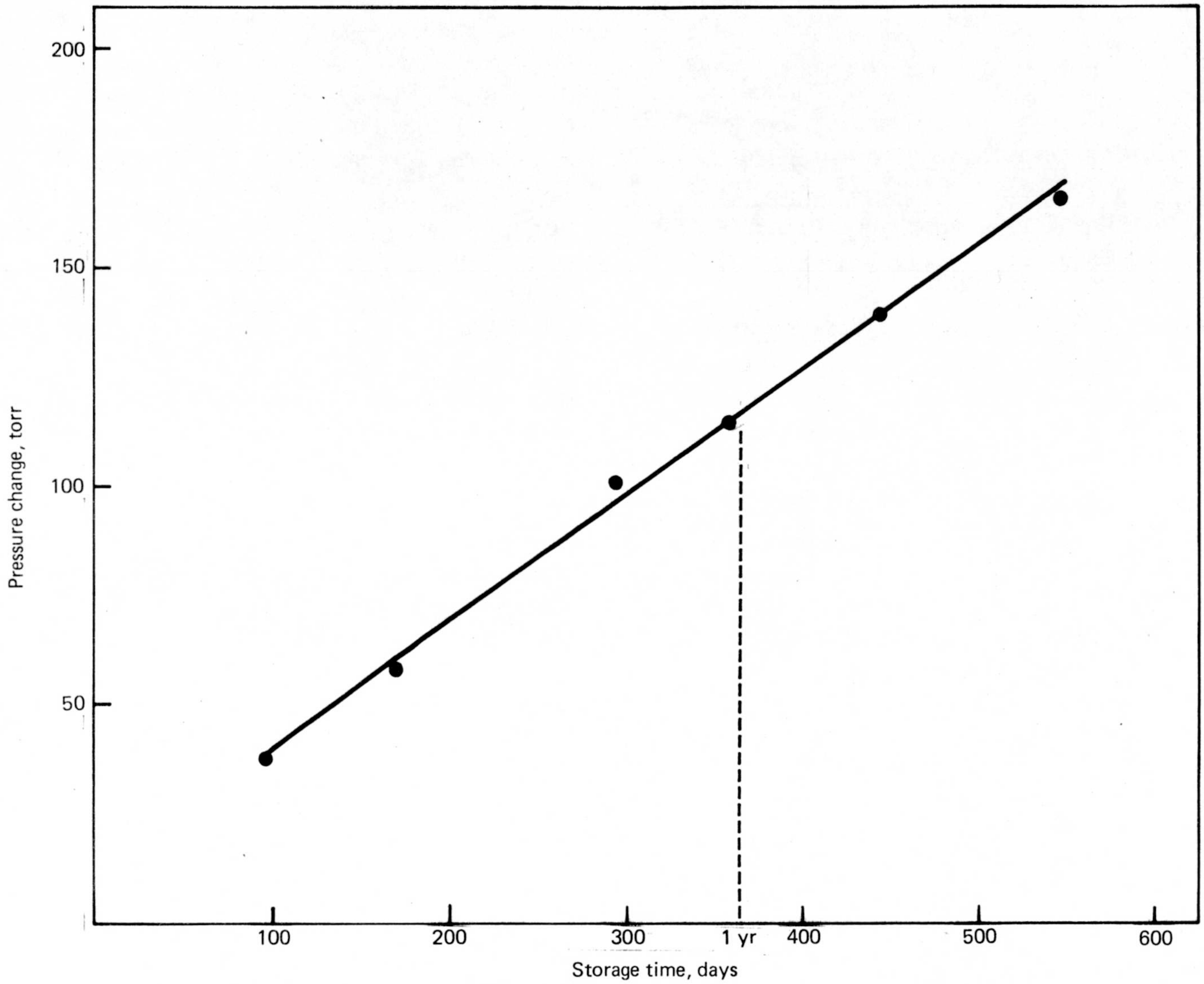

FIGURE 8 - Gas generation by tritiated water on cement-plaster with hydrogen cover gas.

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