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TRITIUM ACTIVITY, MONITORING, PERSONNEL
PROTECTION, AND DECONTAMINATION

by

LCDR Armand R. Nice, MSC, USN

and

Frank Weinstein, HMCA, (SS), USN

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Bureau of Medicine and Surgery, Navy Department
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TAMINATION**

by
LCDR Armand R. Nice, MSC, USN
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Frank Weinstein, HMCA(SS), USN

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Approved: by
Walter R. Miles, Ph. D.
Scientific Director

Released by:
George F. Bond, Capt., MC, USN
Officer-in-Charge

SUMMARY PAGE

THE PROBLEM

To prepare as a Lesson Plan for use in the Nuclear Medicine Technique School an outline of the material for which at least two members of the Medical Department of each ship should be responsible.

FINDINGS

A comprehensive lesson plan was prepared, which required about four hours to present.

APPLICATIONS

Personnel responsible for Tritium monitoring, personnel protection and decontamination should frequently review the content of this Outline, examine the ship's instructions and emergency bills and initiate refresher training for the assigned monitors at least every six months.

ADMINISTRATIVE INFORMATION

This study was undertaken as a part of Bureau of Medicine and Surgery Research Project MR005.14-3702-4, Field Evaluation of Products or Equipment Affecting the Habitability of Submarines. It has been designated as Report No. 14 on this Subtask and was approved for publication on 30 June 1964.

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TRITIUM ACTIVITY, MONITORING, PERSONNEL PROTECTION, AND DECONTAMINATION

INTRODUCTION

The subject of TRITIUM has been largely declassified and can now be more openly discussed. As the distribution of nuclear weapons becomes more widespread in the Fleet, it is increasingly important that all shipboard Medical Department personnel be aware of their duties and responsibilities in connection with weapons involving nuclear materials. The purpose of this report is to summarize the information available on the subject, to provide in outline form a comprehensive guide for personnel training, and to present additional calculations relative to TRITIUM personnel dosimetry.

While the possibility of a weapons' accident is almost negligible, TRITIUM could present a serious personnel hazard in the event a weapon were severely damaged in some way. The presence of weapons containing this material demands special monitoring equipment and a knowledge of the specific personnel protection measures to be taken and the decontamination techniques required in an emergency situation.

If possible, at least two members of the Medical Department of each ship should be concerned with the personnel hazards of TRITIUM, their nature and effects, and

the emergency action to be taken in case of a weapons' accident. Members of this monitoring team should hold SECRET security clearance in order to make the best use of all available data and instructions, and to have access to all shipboard weapons' spaces.

The monitoring team's training should include, but not be limited to, the following: (1) Background, security regulations, and all applicable instructions concerning TRITIUM and the appropriate weapons' program; (2) Biological, chemical, and radiological properties of TRITIUM; (3) Equipment, methods and frequency of TRITIUM monitoring; (4) Emergency monitoring and decontamination; (5) Personnel monitoring and emergency handling of exposed personnel; (6) Local emergency bills.

Used as a lesson plan, presentation of the material listed in this outline requires about four hours.

Personnel responsible for TRITIUM monitoring, personnel protection and decontamination should frequently review the contents of this Outline, examine the ship's instructions and emergency bills, and initiate refresher training for the assigned monitors at least every six months.

OUTLINE OF LESSON PLAN

TRITIUM ACTIVITY, MONITORING, PERSONNEL PROTECTION, and DECONTAMINATION

OBJECTIVES: To acquaint students with—

1. The background and security regulations concerning Tritium and the Naval weapons program.
2. The biological, chemical, and radiological significance of Tritium.
3. Monitoring equipment, methods and frequency of monitoring on both surface ships and submarines.
4. Decontamination requirements and procedures.
5. The significance of monitoring low concentration Tritium on submarines.

MATERIALS:

1. References:
 - A. BUSHIPS INST 6480.1A of 20 Nov 63; Nuclear Weapons Containing Tritium: Shipboard Safety Criteria and Safe Handling Procedures for.
 - B. BUMED INSTR 6480.1 of 26 Feb 59; Medical Aspects of Tritium.
2. Training Aids:
 - A. Blackboard and chalk.
 - B. Motion picture, "Tritium and Its Detection," 30-87A.

TRITIUM ACTIVITY, MONITORING, PERSONNEL PROTECTION AND DECONTAMINATION

I. Background

A. TRITIUM is used in certain nuclear weapons that are stowed and handled by many ships. These weapons present a potential personnel hazard. The probability, however, of a TRITIUM hazard is negligible, unless the weapon is severely damaged.

B. Regardless of the improbability of an accident, the possible hazards necessitate constant monitoring, personnel protection procedures, and a method of decontamination.

II. Security; The following classification guideline is quoted from Reference A.

A. Unclassified

1. The fact that a ship has nuclear weapons' capability.
2. The fact that a ship has or is to be provided with TRITIUM monitoring equipment.
3. The fact that TRITIUM is used in the nuclear weapons program.
4. The fact that a ship may be known on an unclassified basis to have a delivery capability with a specific nuclear weapon, in no way precludes that it does not or will not transport different types of warheads. Therefore, if installation of TRITIUM monitoring equipment in a given ship or weapons space is not stated as a requirement for a specific weapon, it is unclassified.

B. Secret Restricted Data

1. The association of TRITIUM or TRITIUM monitoring equipment as a requirement for a specific weapon.
2. The form of use of TRITIUM.

III. Discussion

A. Description

1. Radioisotope of hydrogen
2. Atomic weight of 3 atomic mass units

3. Odorless, colorless and tasteless
4. Chemically identical with hydrogen.

B. Chemical Reactions

1. Slightly soluble in water (approx. 1.7%)
2. Reacts with O₂ in the air to form water
$$2 \text{H}_2 + \text{O}_2 \text{ ----> } 2 \text{H}_2\text{O}$$
$$2 \text{T}_2 + \text{O}_2 \text{ ----> } 2 \text{T}_2\text{O}$$
3. Lower explosive limit 4.1%; upper limit 74% by volume

C. Radiological Description

1. Radiological half-life is 12.4 years
2. Pure, weak beta emitter
 - a. Maximum beta energy is 0.018 MEV
 - b. Average beta energy is 0.0056 MEV
 - c. Range in air is one-half inch
 - d. Range in tissue is 5 microns, equals 10⁻⁴ centimeters

Note: Minimum sensitivity for beta detection with the AN/PDR-27 is .2 MEV.

3. TRITIUM gas has a specific activity of 2.6 curies/cc at STP
4. TRITIUM gas has a specific activity of 9.8 x 10³ curies/gram
5. TRITIUM water has a specific activity of 2.7 x 10³ curies/gram

D. Uses

1. Weapons
2. Radioactive tracer in research
3. Autoradiography

E. Biological Reactions

1. Absorption of TRITIUM water by the G. I. tract
 - a. Appears in the bloodstream in 2-9 minutes.
 - b. Maximum blood concentration is reached in 40-45 minutes.
 - c. In 2½ hours it will reach equilibrium with all body fluids

- (selective concentration does not occur in any body fluid).
2. Absorption of TRITIUM water vapor by the lungs:
 - a. There is almost a complete retention by the lung tissue of TRITIUM water vapor.
 - b. About 1½ hours are required to reach equilibrium with all body fluids.
 3. Absorption of TRITIUM water and water vapor through the skin:
 - a. Very readily absorbed through the skin
 - b. Absorption through lungs and skin are approximately equal, if protective action of clothing is neglected.
 4. Absorption of TRITIUM gas by the body
 - a. Soluble in body fluids about 1.6%
 - b. Uptake and elimination is about the same as for an inert gas.
 - c. The body will oxidize the gas at a slow rate.
 5. TRITIUM is about 10,000 times more hazardous in water or water vapor form than it is in the gas form.
 6. Biological half-life is 10-12 days. ($B_{1/2}$)
 7. Effective half-life is 10-12 days. ($E_{1/2}$)
 - a. The effective half life for any isotope is: $E_{1/2} = \frac{B_{1/2} \times R_{1/2}}{B_{1/2} + R_{1/2}}$
 - b. Because of the much shorter $B_{1/2}$ (10-12 days vs the $R_{1/2}$ 12.4 years), the $E_{1/2}$ for TRITIUM equals $B_{1/2}$.
 - c. $E_{1/2}$ is variable with fluid intake (2-3 liters/day is normal)
 - d. Increased fluid intake can reduce the $E_{1/2}$ to as short as 2½ days.
 - (1) Primary treatment method for TRITIUM exposure is increased fluid therapy.

- (2) Limit is 1 pint/hr to a maximum of 5 qt/day when no Medical Department supervision is available.
- (3) Limit is 12 liters/day for a maximum of 2 weeks or until the activity is less than 10 µc/liter of urine, under Medical Department supervision. (Extreme care must be taken when using 12 liters/day due to the possibility of metabolic changes, renal failure, etc.)

8. Maximum Permissible Body Burden.

Basis: 3 millicuries results in a radiological exposure of 0.3 rem/week.

Critical Organ: Total body fluid
Urinalysis equivalent.

60 microcuries/liter (µc/l)
(based on 50 liter man)

9. Maximum Permissible Concentration.

a. Air (Continuous 168 hours/week exposure)

TRITIUM water vapor

5×10^{-6} µc/cc

TRITIUM gas 4×10^{-4}

µc/cc

b. Potable Water 100 µc/l

IV. Monitoring for TRITIUM gas, water and water vapor.

A. Monitoring equipment

1. T-289 Air sampler

- a. Permanently installed.
- b. Consists of separate preamplifier and amplifier sections.
- c. Provides continuous atmospheric monitoring.
- d. Used in conjunction with T-329 urinalysis test kit for urine and condensate analysis.
- e. Operating instructions are given in:

(1) NAVORD SWOP T-289-2

(2) NAVORD SWOP 35-15

2. T-290 Air sampler
 - a. Portable, battery powered
 - b. Used for emergency monitoring of weapon spaces or a weapon that has been damaged.
 - c. Used when the T-289 is out of commission, or in use during urine or condensate analyses.
 - d. Operating instructions given in:
 - (1) NAVORD SWOP T-290A-2.
 - (2) NAVORD SWOP 20-7.
3. T-329 Urinalysis kit
 - a. Used in conjunction with the T-289 for urine and condensate analysis.
 - b. Provided only to those activities having the T-289.
 - c. Ship's Medical Department is responsible for maintenance and operation.
 - d. Operating instructions are given in:
 - (1) NAVORD SWOP T-289A-2.
 - (2) NAVORD SWOP 35-15.
 - e. The T-329 has an upper detectability limit of approximately 2.5×10^4 uc/liter of urine (Ten on the X—1000 scale).
 - f. If the urine activity alarms on the X—1000 scale, add 1cc of urine to 9cc of tap water, mix, repeat the analysis, and multiply the result by 500.
 - g. The total absorbed radiation dose (mrem) will be numerically equal to:

$$D_{\infty} = K_2 \times A_0 \times E_{\gamma}$$

Note: Derivation of the above formula is given in Appendix A.

4. Procurement action has been initiated for new equipment which will ultimately replace the present equipment.

B. Monitoring required

1. Prior to entry into a weapon space which has not been occupied for

a period in excess of 24 hours. Thereafter space monitoring is not required.

2. Weapons involved in an incident or accident shall be monitored immediately with the T-290.
3. Submarine atmosphere shall be continuously monitored by the T-289 which is centrally located in the vicinity of the weapons space(s).

C. No monitoring required

1. When personnel are not in the weapons space.
2. When weapons are in the open or in a well ventilated space.
3. When weapons are being transported on elevators or through passageways during alert operations.
4. When weapons are received by replenishment at sea, in port, along side tenders and during strikedown operations.

V. Shipboard procedures in event of TRITIUM hazard.

A. Contamination: degree should be determined immediately. There is sufficient time for trained personnel to perform these basic functions

1. Locate
2. Isolate
3. Remove
4. Ventilate

B. Surface ships.

1. Isolate the space to prevent spreading of contamination.
2. Evacuate unnecessary personnel.
3. Locate and remove the source.
4. Decontaminate the space.
5. Run urinalysis on exposed personnel.

C. Submarines. There are two situations that could occur.

1. Acute situation—sudden contamination of high magnitude.
 - a. Secure air circulating dampers for the weapons space.
 - b. Secure watertight bulkheads.

- c. Secure air revitalization equipment, especially the hydrogen burners.
 - d. Secure smoking throughout the ship.
 - e. Put on OBA or airline breathing mask and plastic protective clothing.
 - f. Locate source and secure in launching tube. Flood tube if necessary, or under the most severe condition jettison the weapon.
 - g. Surface and ventilate.
 - h. Monitor spaces and decontaminate as necessary.
 - i. Determine personnel exposure by urinalysis and institute treatment.
2. **Chronic situation**—it will be assumed that entire ship is contaminated.
- a. Notify command
 - b. Same as C. 1. f. above
 - c. Same as C. 1. g. above
 - d. Analyze condensate and run urinalysis on selected personnel.
 - e. The other acute situation steps are not necessary.

VI. **Decontamination procedures** — Criteria on the rate of surface contamination, methods for detecting and measuring surface contamination and surface decontamination procedures are not well established at this time. These problems are under study. The following are suggested as precautionary steps for personnel protection.

- A. Decontaminate air by ventilation to safe level of 5 uc/m^3 (.5 on the X10 scale).
- B. Personnel upon entering a contaminated space shall wear protective clothing and follow damage control procedures.
- C. Scrub about 9 ft^2 of surface with a sponge wet with hot water and detergent. A sample of the water from the sponge and a condensate sample from the bulkheads or pipes shall be taken and analyzed.

- 1. If the results indicate a contamination equivalent to an air contamination of 1 uc/m^3 , or greater, the space should be washed down and tests rerun. (0.1 on the X—10 scale or 1.0 on the X—1 scale).
 - 2. Details of the contaminating event, monitoring procedures, results, decontamination procedures, personnel exposures, and treatment (if any) will be reported directly to, Chief, BUSHIPS, with copies to Chief, BUMED. Negative reports will be made.
- D. In event of contamination on board a ship not having an operative T-289 or T-329.
- 1. Force fluids on personnel suspected of having become contaminated.
 - 2. Approximately 45 minutes after suspected exposure, personnel shall void and this sample shall be discarded. A urine sample taken within four hours after the discarded sample, and a condensate sample from the contaminated space should be forwarded to the nearest facility having an analysis capability.
 - 3. During the interim, protective clothing should be worn by those persons working in the affected space.

VII. **Low Concentration TRITIUM Monitoring on Submarines.**

- A. At concentrations up to 10 uc/m^3 of TRITIUM water vapor, the deposit in the body builds up at a sufficiently low rate to permit periodic, indirect determination of the body burden before the maximum permissible body burden is reached.
- B. Consequently the following procedures will be used for monitoring:
 - 1. Continuous operation of T-289 on the X—10 scale with the alarm set at 100 uc/m^3 .
 - 2. TRITIUM water vapor content of the atmosphere at regular intervals (each 6 days) by sampling

condensate from the dehumidifier with the T-329, T-289.

3. Urinalysis will be run on selected ship's personnel at least once every other month. The curves shown in figure (1) show the approximate equilibrium body burden build up for air concentrations of TRITIUM water vapor of $5\text{uc}/\text{m}^3$ and $10\text{uc}/\text{m}^3$. These data can be extrapolated down to about $0.2\text{uc}/\text{m}^3$, provided sufficient time is allowed for the body processes to establish equilibrium.
- C. The following facts and data are provided in support of and for clarification of the procedure for low level monitoring.
 1. $5\text{uc}/\text{m}^3$ concentration of TRITIUM gas will just barely be detected by the T-289 on the X-10 scale.
 2. $5\text{uc}/\text{m}^3$ TRITIUM water vapor will give significant urinalysis after 24 hours.
 3. With $5\text{uc}/\text{m}^3$ TRITIUM water vapor, the body will build up to the maximum allowable TRITIUM deposit of 3000 uc at about the following rate:
 - a. 50% in 10 days.
 - b. 79% in 20 days.
 - c. 94% in 30 days.
 - d. Thus monitoring of the dehumidifier will indicate a situation in a day or two that will not become hazardous for about 30 days.
 4. With $10\text{uc}/\text{m}^3$ of TRITIUM water vapor, the body build up to 3000 uc will be reached in about 10 days.
 - a. MPC for TRITIUM water in the body is 60 uc/liter. The average man can be assumed to contain about 50 liters of body fluids. The Maximum Permissible Body Burden is 3000 uc — 50 liters x 60 uc/liter.
 - b. Thus a urine concentration of 60 uc/l is equivalent to the Maximum Permissible Body Burden of 3000 uc.

APPENDIX A

DERIVATION OF TOTAL ABSORBED RADIATION DOSE FROM TRITIUM

- I. Formulae: $D_{\infty} = K_2 \times A_0 \times E_{1/2}$
- D_{∞} = Dose to infinity.
 - $K_2 = 0.858$ when $E_{1/2}$ is in hours.
 - $K_2 = 20.5$ when $E_{1/2}$ is in days.
 - A_0 = Initial equilibrium body burden expressed in millicuries.
 - $E_{1/2}$ = Effective half-life.
- II. Explanation:
- One Maximum Permissible Body Burden of TRITIUM is 3.0 millicuries = 3000 microcuries = 300 millirem/168 hour week. (Reference BuShips Inst. 6480.1A of 20 Nov 1963).
 - Therefore:

$$K_1 = \begin{cases} \frac{300 \text{ mrem/wk.}}{3 \text{ mc}} = 100 \text{ mrem/wk/mc} \\ \frac{100 \text{ mrem/wk./mc}}{168 \text{ hr/wk.}} = 0.595 \text{ mrem/hr/mc} \\ \frac{100 \text{ mrem/wk./mc}}{7 \text{ day/wk.}} = 14.3 \text{ mrem/day/mc} \end{cases}$$
 - A_0 = Initial equilibrium body burden of Tritium as determined by T-289 & T-329 at $t = 0$ after exposure.
 - A_0 is the physiological equilibrium concentration resulting from an acute dose received over a short finite time.
 - A_0 is determined on the basis of a urine sample collected at time (t) after exposure, when that time is at least 3/4 hr. and not more than 4 hours.
 - Urine activity determined as above equals the equilibrium concentration for the whole body.
 - Dose Rate (DR) due to $A_0 = K_1 \times A_0$
 - 0.595 mrem/hr/mc $\times A_0$ when (t) is in hours.
 - 14.3 mrem/day/mc $\times A_0$ when (t) is in days.
 - $E_{1/2}$ = Effective half-life.

$$E_{1/2} = \frac{B_{1/2} \times P_{1/2}}{B_{1/2} + P_{1/2}}$$
 - $B_{1/2}$ = Biological half-life = 13 days = 312 hours.
 - $P_{1/2}$ = Physical half-life = 12.4 years = 1,526 days = $1,086 \times 10^5$ hours.
 - $E_{1/2} = \frac{13 \times 4.53 \times 10^3}{13 + 4526} = 13 \text{ days} = 312 \text{ hours.}$
 - Therefore, the $E_{1/2}$ is essentially the $B_{1/2}$.
 - λ_E = Body Fluid Elimination Constant
 - $\lambda_E = \frac{0.693}{13 \text{ days}} = 0.0534 \text{ days}^{-1}$
 - $\lambda_E = \frac{0.693}{312 \text{ hrs.}} = 0.00222 \text{ hrs.}^{-1}$
 - Dose rate at any time (t) after exposure:

$$DR = K_1 A_0 e^{-\lambda_E t}$$
 - Dose to infinity is: ($t = \infty$)
 - $D_{\infty} = \int_{t=0}^{t=\infty} K_1 A_0 e^{-\lambda_E t} dt$
 - $D_{\infty} = K_1 A_0 \int_{t=0}^{t=\infty} e^{-\lambda_E t} dt$
 - $D_{\infty} = \frac{K_1 A_0}{-\lambda_E} [e^{-\lambda_E(\infty)} - e^{-\lambda_E(0)}]$
 - $D_{\infty} = -\frac{K_1 A_0}{\lambda_E} [1 - 1]$
 - $D_{\infty} = -\frac{K_1 A_0}{\lambda_E} [0 - 1]$
 - $D_{\infty} = \frac{K_1 A_0}{\lambda_E}$
 - $D_{\infty} = \frac{K_1 A_0 E_{1/2}}{0.693} = K_2 A_0 E_{1/2}$
 - $D_{\infty} = \frac{0.595}{0.693} A_0 E_{1/2} = 0.858 A_0 E_{1/2}$ mrem when (t) is in hours
($K_2 = \frac{0.595}{0.693} = 0.858 \text{ mrem/hr/mc}$)
 - $D_{\infty} = \frac{14.3}{0.693} A_0 E_{1/2} = 20.5 A_0 E_{1/2}$ mrem when (t) is in days
($K_2 = \frac{14.3}{0.693} = 20.5 \text{ mrem/day/mc}$)

APPENDIX B

OPERATION OF THE T-289 AIR SAMPLER, T-329 TEST KIT, AND T-290 PORTABLE AIR SAMPLER

I. T-289 Air Sampler.

A. General Description:

1. The T-289 is an air sampler, with two main sections (amplifier and preamplifier) used to determine the amount of radioactive TRITIUM gas in the atmosphere.
2. A background level is an indication of cosmic rays, radioactive impurities in the compartment, or electronic noise.
3. The ionization chamber consists of six concentric metal cylinders, insulated from each other and coaxial with a central brass-rod electrode.
4. A potential difference of 700 volts is established between the cylinders.
5. Air is drawn continuously through the chamber and exhausted back into the atmosphere by a motor and fan assembly connected to the chamber.
6. Free ions drawn in through the air inlet are removed as the air passes through the five air shells.
7. Ions resulting from the decay of radioactive atoms in the air sample collect on the inner surfaces of the internal cylinder and on the electrode.
8. Electrical impulses caused by the ionization are then sent to the amplifier for positive visual indication as well as a recorded continuous reading.

B. Operation:

1. With AC power off, rotate range switch to ZERO.
2. Operate ALARM OFF-ON switch to OFF, and hold. (Switch is spring loaded.)
3. Operate AC PWR to ON. After it has stabilized (about 3 min) release the locknut on the zero adjust and adjust to zero.

Release ALARM OFF-ON switch.

4. Turn zero adjust control clockwise, until recorder goes past ten and the alarm sounds.
Turn zero switch adjust counter clockwise until recorder reads zero.
5. Rotate range selector switch to test. Recorder should rise slowly to a point on the scale between 6.5 and 8.5, and then slowly fall.
6. Rotate range selector switch to zero and re-zero if necessary.
Tighten zero adjust locknut.
7. Rotate range selector switch to X-1000 scale, allow several minutes to stabilize.
8. Rotate range selector switch to X-100 scale, allow several minutes to stabilize.
9. Rotate range selector switch to X-10 scale, allow five minutes to stabilize before taking counts or background.
10. When not in continuous use, turn AC PWR to OFF.

II. T-329 Urinalysis Test Kit

A. General Description and Basic Principle.

1. This unit provides a means of generating Hydrogen gas (including TRITIUM) by interaction of the urine, condensate or TRITIUM water with Calcium Metal.
2. The gas is collected in an ion chamber which is then inserted into the T-289, in place of the air chamber, for measuring the amount of TRITIUM in the collected gas.

B. Operation

1. Make sure the equipment is grounded.
2. Place control panel in the vertical position.
3. Add one measuring spoonful of me-

tallic calcium to the gas generator. (Be sure it is clean and dry).

4. Grease joints of generator jar with silicone compound and join together, making one half turn to insure a seal.
5. Place generator on spring loaded assembly.
6. Check the AC PWR switch to OFF.
7. Connect cable assembly to AC PWR Supply.
8. Connect tubing to connector on ionization chamber.
9. Close stopcock V-3. Open stopcocks V-1 and V-2.
10. Open ionization chamber valve.
11. Operate AC power control to ON, and allow motor to run until gage on control panel indicates 20 on the left hand scale, then close stopcock V-1 and operate AC power control to OFF.
12. Observe gauge for 3 minutes, tapping gauge occasionally to insure an accurate reading. If gauge indication decreases to less than 20 during this interval, the T-329 is inoperative and should be replaced.
13. Open stopcock V-3 to allow the system to return to atmospheric pressure; then close stopcock V-3.
14. Close stopcock V-4 on the control panel. Fill condenser with clear water.
15. Perform the above procedures (items 8-13) twice more to flush the system.
16. Open stopcock V-1 and keep open until gauge reads 20 on the left hand scale. Close stopcock V-1 and operate AC PWR to OFF.
17. Pour sample into thistle tube on gas generator until it is about $\frac{3}{4}$ full (7 ml.)

CAUTION:

SINCE THE SYSTEM IS UNDER A VACUUM, THERE WILL BE A TENDENCY FOR THE SAMPLE TO BE DRAWN RAPIDLY INTO THE SYSTEM. RESULT-

ING IN EXCESSIVE GAS PRESSURE BEING GENERATED.

18. Carefully and slowly open stopcock V-3. Allow sample to be drawn into the generator assembly. The chemical reaction in the assembly causes the gauge pointer to start moving in a clockwise direction. Continue to add (slowly) sample until pointer falls to a vacuum of one inch, then close stopcock V-3. The pointer should continue to rise until it comes to rest approximately on the first division on the right hand scale.
19. Close stopcock V-2 and disconnect generator assembly at the ball and socket joint. Remove jar assembly and rinse in water. Then wash and dry thoroughly.
20. Open stopcock V-2 for approximately 15 seconds, to allow the system to return to atmospheric pressure.
21. Close T-329 ionization chamber stopcock.
22. Connect T-329 ionization chamber to T-289 and obtain counts in accordance with instructions in Paragraph 1 of Section B of this Appendix.
23. Plot count on Figure 2.
24. When performed in accordance with Notes 1 and 2, this graph is the Comparison Chart necessary for the evaluation of unknown samples.

T-329 NOTES

Note 1: When making a T-329 Comparison Chart, the following routine should be adhered to:

- a. Run through three tap water samples and average them to derive background.
- b. Plot this average point on the ordinate. (On the vertical left hand margin of the graph.)
- c. Run through three TRITIUM samples from the same bottle, average their readings and plot

this point in the body of the graph. (abscissa vs ordinate).

- d. Draw a straight line through the two dots.

(The above is normally done in actual operation; however, for training purposes, RUN ONE OF EACH AND PREPARE YOUR GRAPH.)

Note 2: When preparing a urine or condensate sample, the following routine is adhered to:

- a. Determine a background from the T-289 by counting an air sample in the T-329A ionization chamber after it has been flushed with air at least three times.
- b. Prepare the sample.
- c. Subtract the background reading from the sample.
- d. Determine the sample's activity in uc/liter by reading from the comparison chart.

e. Then, this number x
$$\frac{50 \text{ liters } A_0 \text{ in millicuries}}{1000 \text{ uc/me}}$$

(See Appendix I, Paragraph C in Section II)

Note 3: A graph can be used in lieu of the decay formula (Figure 3) for determining present strength vs age of the TRITIUM water. For class purposes, use the decay formula in your experiment write-up.

Note 4: A change of atmospheric pressure can invalidate the calibration or the results of a sample analysis. When making a Comparison Chart, note the atmospheric pressure and

correct the sample results for changes in excess of 1000 feet (equivalent) of altitude. The correction Formula is:

$$\text{Corrected Sample Activity (uc/l)} = \frac{\text{Determined sample Activity X (Comparison Chart Pressure)}}{\text{(Pressure for Sample Analysis)}}$$

III. T-290 Portable Air Sampler.

A. General Description

1. The T-290 is a portable air sampler, small and compact, issued to determine the amount of low-level radiation gas in an atmosphere not monitored by the T-289. (Missile tubes, box cars, adjoining compts. voids etc.)
2. The operating instructions are plainly visible on the side of the instrument (Therefore will not be covered in this handout).
3. An integrated dose per range vs. time chart is also tacked to the side of the instrument (see sample in Figure 4).
 - a. Dosages indicated may be reduced by a factor of 2 by wearing air packs (OBA, Air-line Breathing, etc.)
 - b. Note that to alarm on the X-I scale we would have already alarmed on the T-289 X-100 scale.
 - c. If the T-289 alarms on the X-100 scale, the maximum detection limit has been reached; therefore, the T-290 is the only means of determining readings in one half hour above 1.0 rep. Compare Figures 4 and 5.

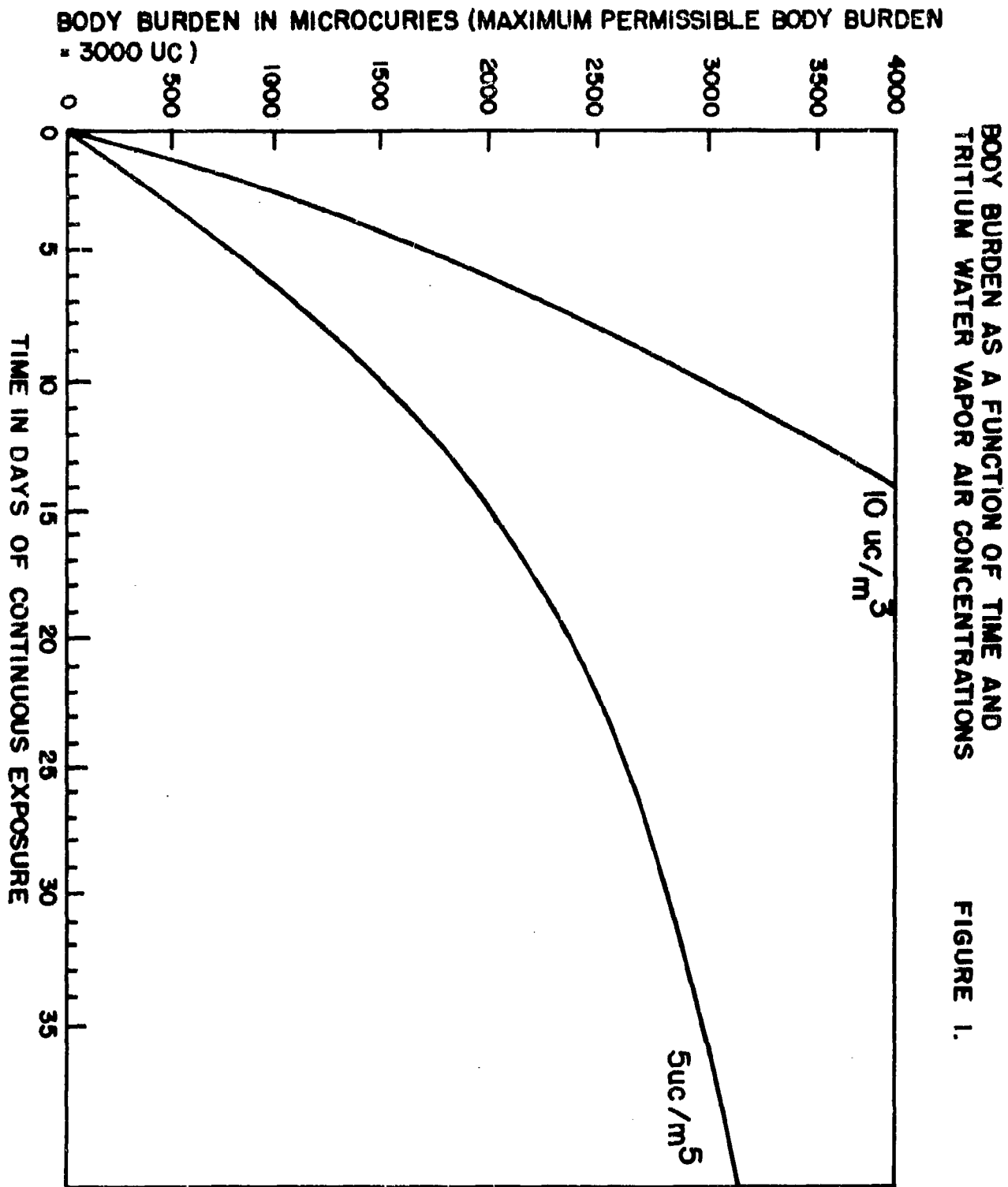
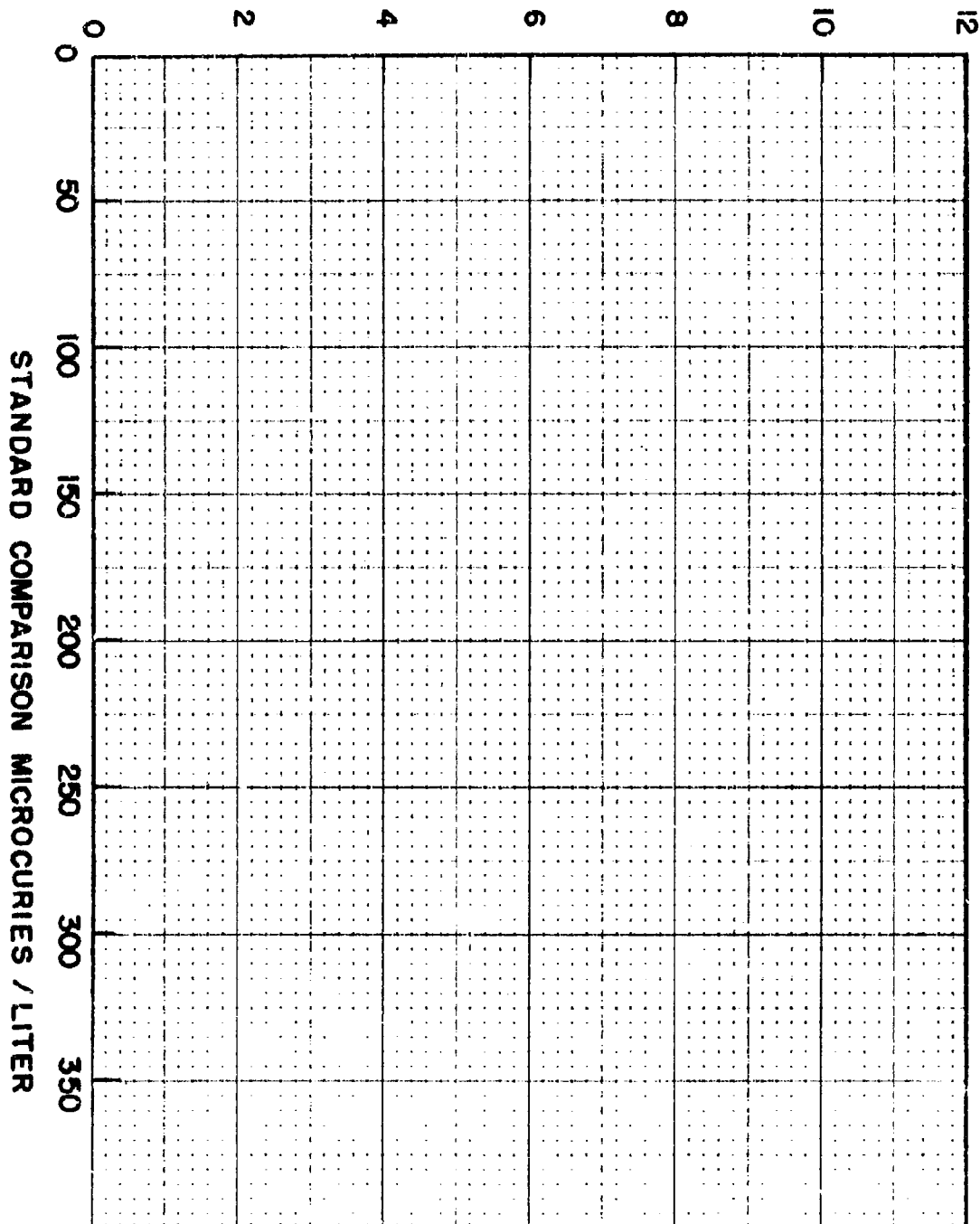


FIGURE 1.

T-289 RECORDER CHART READING SET SCALE MULTIPLIER X10



COMPARISON CHART

Figure 2

USE WITH T-329 & T-289 Date _____ T-329 Ser. No. _____

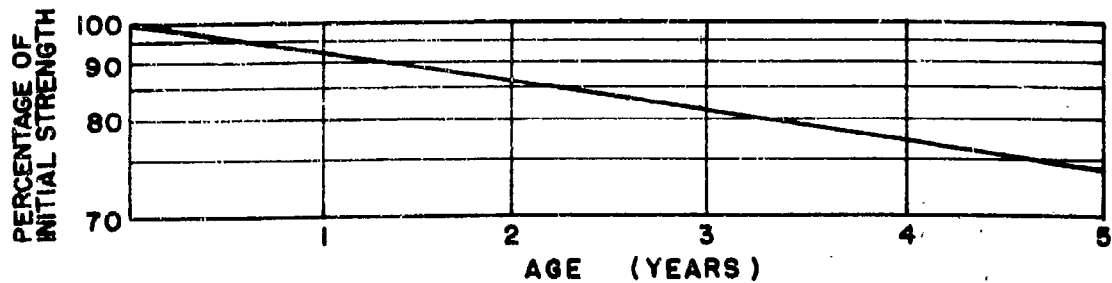


Figure 3.

Note: The above graph can be used in lieu of the decay formula ($A=A_0 e^{-\lambda t}$) for determining present strength vs age of Tritium water. Discard Tritium water after five years.

Figure 4.— T-200 Integrated Dose per Range vs. Time Chart.

Time Interval	Audio alarm on		
	Range X1	Range X10	Range X100
Half hour	.100 Rep	1.00 Rep	10.0 Rep
One hour	.200 Rep	2.00 Rep	20.0 Rep

Figure 5. — T-209 Integrated Dose per Range vs. Time Chart

Time Interval	Audio alarm on			
	Range XI	Range X10	Range X100	Range X1000
Half hour	0.001 Rep	0.01 Rep	0.1 Rep	1.0 Rep
One hour	0.002 Rep	0.02 Rep	0.2 Rep	2.0 Rep

Note: Dosages indicated in Figure 4 and 5 may be reduced by a factor of two by wearing air packs.

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