CALIBRATION PROCEDURE

TRITIUM GAS CALIBRATOR

MODEL 10017

OVERHOFF TECHNOLOGY CORPORATION
1160 US ROUTE 50, MILFORD, OHIO, USA

TRITIUM GAS CALIBRATOR

Model 10017

1.0. INTRODUCTION

Calibration verification of the Tritium Monitor is performed by injecting a known quantity of tritiated gas into the tritium monitor ionization chamber of a known volume in order to fill the chamber with a calculated activity.

The value of the initial concentration of the tritium content of a gas cylinder is furnished by the manufacturer and is traceable to NIST. This value must be corrected for time decay.

2.0. CONSTRUCTION

The tritium gas calibrator consists of:

1. A cylinder containing a tritiated gas mixture at high pressure. Shipped separately to conform with NRC (National Regulatory Commission) requirements.
2. A pressure regulator to reduce the cylinder pressure to a low and constant value.
3. A metering volume of accurate dimension.
4. A piping manifold with 2 hose connections.

All components are mounted on a flat plate for rigidity and ease of storage, see Figure 1.

3.0. METHOD

The method consists of using the calibrator to produce an accurate quantity (aliquot) of tritium and injecting it into the ionization chamber of the tritium monitor.

This is done by filling the metering volume at a known pressure with tritium gas (of a known concentration) from the cylinder. The contents of the metering volume are then released into the ionization chamber of the monitor.

CAUTION:

TRITIUM MONITORS ARE GENERALLY LONG TERM STABLE. ANY CHANGES IN APPARENT CALIBRATION WHICH EXCEED ABOUT 5 % PER YEAR INDICATE THE NEED FOR MAINTENANCE.

OTHER CHANGES IN CALIBRATION MAY BE INDICATIVE OF COMPONENT FAILURE.

4.0. PROCEDURE

4.1. The calibrator requires a purge procedure so that the gas mixture in the regulator, manifold tubing and the valves is fully mixed and at the proper concentration. It is important because the gas mixture may not be at the full concentration due to mixing with air trapped in the calibrator parts before assembly. Also, purging will allow the regulator settle to the proper outlet pressure as it is adjusted. Without the purging process, readings could be different than the expected value. Purge the Tritium Calibrator as follows:

CAUTION:
The initial purging of the Tritium Gas Calibrator shall be performed outside of the building or indoors with the calibrator output manifold port connected to an exhaust system.

a. Ensure that all five valves on the Tritium Calibrator are closed finger tight, see Figure 1. They are as follows:

1. Gas Cylinder Shut-Off Valve - V1
2. Regulator Outlet Valve - V2
3. Metering Volume Inlet Valve - V3
4. Metering Volume Outlet Valve - V4
5. Metering Volume Flow Valve - V5

The pressure regulator control should be completely relaxed, that is the control knob should be rotated counter clockwise until the internal spring action is disengaged.

b. If the Tritium Calibrator is to be purged indoors, connect the output manifold to an external exhaust hose. See Figure 1

c. Open the gas cylinder shut-off valve (V1) by rotating counter clockwise.

d. Turn the pressure regulator control knob clockwise until the regulator outlet pressure gauge indicates the desired value. See step 4.8.

e. Open the regulator outlet valve (V2) by rotating counter clockwise.

f. Open the metering volume inlet valve (V3) by rotating counter clockwise.

g. Close the regulator outlet valve (V2) and metering volume inlet valve (V3) by rotating clockwise.

h. Open the metering volume outlet valve (V4) briefly by rotating counter clockwise to open and then clockwise to close.

CAUTION:
Tritiated gas is being vented from V4 through the exhaust hose into the exhaust system and eventually to the atmosphere.

I. Repeat steps 4.1.e through 4.1.h as necessary until a stable indication of Pg ($\pm$0.5 p.s.i.g) is obtained on the regulator outlet pressure gauge.

j. If the purging of the Tritium Calibrator was done indoors, disconnect the external exhaust hose from the Tritium Calibrator output manifold connector.

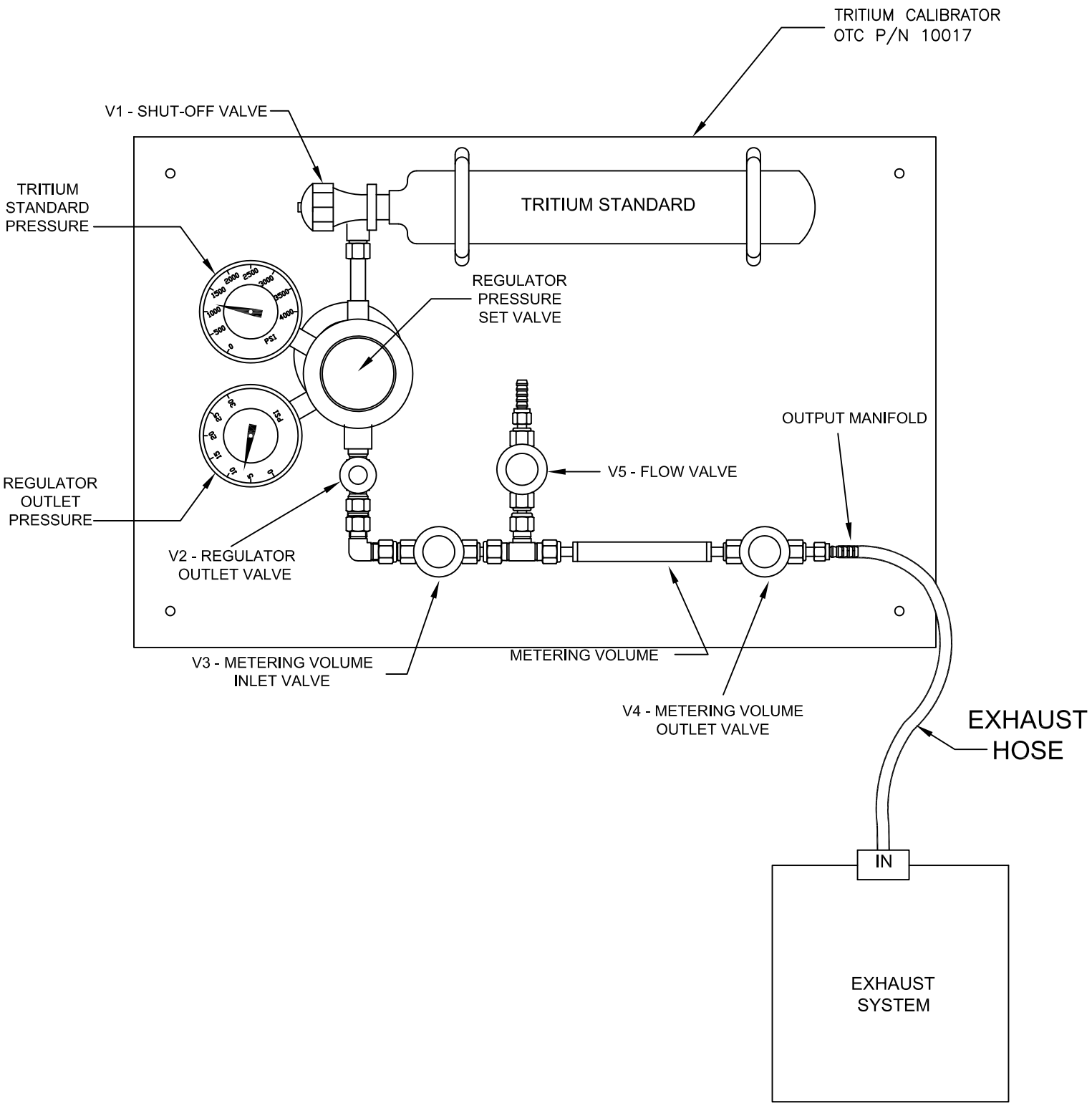

TRITIUM CALIBRATOR
OTC P/N 10017
V1 - SHUT-OFF VALVE
TRITIUM STANDARD
TRITIUM STANDARD PRESSURE
REGULATOR PRESSURE SET VALVE
OUTPUT MANIFOLD
V5 - FLOW VALVE
REGULATOR OUTLET PRESSURE
V2 - REGULATOR OUTLET VALVE
V3 - METERING VOLUME INLET VALVE
METERING VOLUME
V4 - METERING VOLUME OUTLET VALVE
EXHAUST HOSE
IN
EXHAUST SYSTEM

FIGURE 1

4.2. Connection to Unit-Under-Test (UUT).

NOTE: The Tritium Calibrator, shall be both used and stored in a horizontal position.

4.3. Allow the Tritium Monitor to warm up. Zero if necessary.

4.4. Ensure that the four valves listed below are closed finger tight. See Figure 2.

a. Regulator Outlet Valve - V2
b. Metering Volume Inlet Valve - V3
c. Metering Volume Outlet Valve - V4
d. Metering Volume Flow Valve - V5

Note: The Gas Cylinder Shut-Off Valve, V1 remains open

4.5. Remnant tritium gas from a previous use or from the purging process described above may need to be exhausted from the metering volume. Connect the hoses to the UUT and the exhaust hose as shown in Figure 2. Open metering volume Outlet valve (V4) and Flow valve (V5) by rotating counter clockwise. Operate the pump of the UUT for at least five minutes. This will clear out the remnant gas and provide the best conditions for accurate results. Close metering volume Outlet valve (V4) and Flow valve (V5) by rotating clockwise. Disconnect the exhaust hose.

4.6. Arrange the Tritium Calibrator and the UUT Tritium Monitor in a closed loop. Attach hoses as shown in Figure 3 or 4. Figure 3 shows the method using the UUT only. Figure 4 shows the method using the UUT and an additional reference monitor. The preferred method is to use a reference monitor as shown in Figure 4. For best results, the accuracy of the reference monitor should be equal to or better than the UUT. The reference monitor serves as a consistency checker. In practice, the reference reading is compared to the UUT reading. Thus, the inaccuracies of values used for the different volumes and the results of the equation (Section 5) are of less concern. The reading of the Reference monitor is assumed to be more accurate. The reference monitor should be calibrated on regular basis to assure that accurate results are obtained. After connecting the hoses, inspect to insure that the loop is leak free.

CAUTION:
When using a reference monitor it is important to observe the relative volumes and pump capacities of the two monitors. First, determine the normal flow rates of the two instruments. If one flow rate is higher than the other use the pump on the instrument with the lower flow rate. This precaution will prevent the situation where the more powerful pump could damage the other less powerful one.

4.7. Verify that Tritium Calibrator regulator outlet valve (V2) and metering volume inlet valve (V3) are closed (maximum clockwise position). Open metering volume Outlet valve (V4) and Flow valve (V5) by rotating counter clockwise. Operate UUT Tritium Monitor, to the measure mode and/or the pump switch to the ON position. Observe the meter indication on the UUT Tritium Monitor and reference monitor if applicable. The Tritium Monitor(s) should indicate ZERO. Operate the pump for at least five minutes and observe that the zero reading is maintained. This verifies that there is no trace of remnant gas and assures that the most accurate results are obtained. If the ZERO reading is not maintained, return to step 4.5.

4.8. Use the metering volume pressure (Pg) that the Calibrator Unit was set to in the previous section under the purging procedure. Determine per Section 5 and the calculations required for the expected value of M.

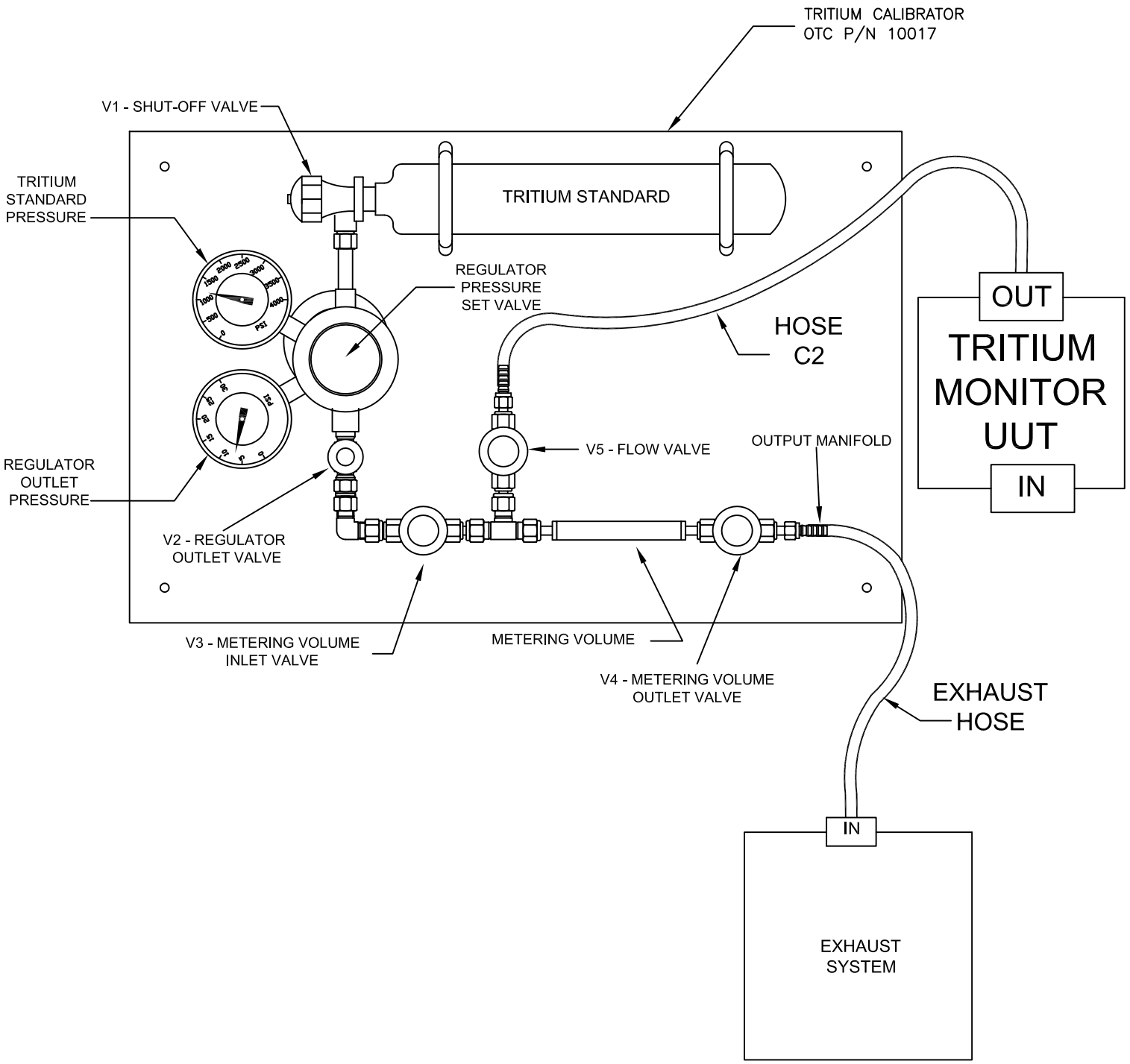

TRITIUM CALIBRATOR
OTC P/N 10017
V1 - SHUT-OFF VALVE
TRITIUM STANDARD
TRITIUM STANDARD PRESSURE
REGULATOR PRESSURE SET VALVE
HOSE C2
OUT
TRITIUM MONITOR UUT
IN
V5 - FLOW VALVE
OUTPUT MANIFOLD
REGULATOR OUTLET PRESSURE
V2 - REGULATOR OUTLET VALVE
V3 - METERING VOLUME INLET VALVE
METERING VOLUME
V4 - METERING VOLUME OUTLET VALVE
EXHAUST HOSE
IN
EXHAUST SYSTEM

FIGURE 2

4.9. Procedure, without the use of a Reference Monitor, See Figure 3

Ensure that the four valves listed below are closed finger tight.

a. Regulator Outlet Valve - V2
b. Metering Volume Inlet Valve - V3
c. Metering Volume Outlet Valve - V4
d. Metering Volume Flow Valve - V5

Note: The Gas Cylinder Shut-Off Valve, V1 remains open

4.10. Open the Tritium Calibrator regulator outlet valve (V2) and metering volume inlet valve (V3) by rotating counter clockwise.

NOTE: The metering volume is now being charged with tritiated gas at the pressure indicated on the Tritium Calibrator regulator outlet pressure gauge. The metering volume inlet valve (V3) shall be left open for 1 or more minutes to allow for pressure stabilization.

4.11. Close the Tritium Calibrator regulator outlet valve (V2) and metering volume inlet valve (V3) by rotating clockwise.

4.12. Open the Tritium Calibrator metering volume outlet valve (V4) by rotating counter clockwise.

4.13. Open Tritium Calibrator flow valve (V5) by rotating counterclockwise.

CAUTION:
Tritiated gas is being injected under pressure into the UUT.

4.14. Operate UUT Tritium Monitor, pump switch to ON. Allow system to stabilize for 1 to 3 minutes.

4.15. Operate UUT Tritium Monitor, pump switch to OFF. Allow system to stabilize for 1 to 3 minutes.

4.16. Record observed indication from the UUT Tritium Monitor. Typically use a ±15 % tolerance of the calculated value for M when comparing it to the actual observed indication. In other words the observed indication should equal M ±15 %. Adjust the calibration potentiometer(s) of the UUT Tritium Monitor accordingly.

4.17. Disconnect hose (C1) from the Tritium Calibrator, output manifold and replace with an external exhaust hose. Operate UUT Tritium Monitor, pump switch to ON.

CAUTION:
Tritiated gas is being vented from V4 through the exhaust hose into the exhaust system and eventually into the atmosphere.

Allow pump to operate until the UUT Tritium Monitor meter indicates zero, to ensure that all traces of tritiated gas are removed from the instrument and hoses. Operate the PUMP switch to OFF position. Disconnect external exhaust hose from Tritium Calibrator output manifold. Reconnect hose (C1) to the Tritium Calibrator output manifold.

4.18. Disconnect hose (C2) from Tritium Calibrator. Operate UUT Tritium Monitor, pump switch to ON position. Observe indication on instrument meter. The UUT Tritium Monitor should indicate zero. Operate the pump switch to OFF position after a stable zero is obtained.

4.19. Close Tritium Calibrator metering volume outlet valve (V4) and flow valve (V5) by rotating clockwise.

4.20. Repeat Steps 4.8 thru 4.13 as desired. Additional injections of gas can be used to check for response at higher concentrations. It is recommended that calibration is adjusted at as high a reading as practical. There are a couple of precautions to consider when using multiple injections. First, each injection is adding pressure to the total loop volume. Ideally, the pressure for the total loop should be as close to one atmosphere as possible. Second, more injections translate into higher gas usage rates.

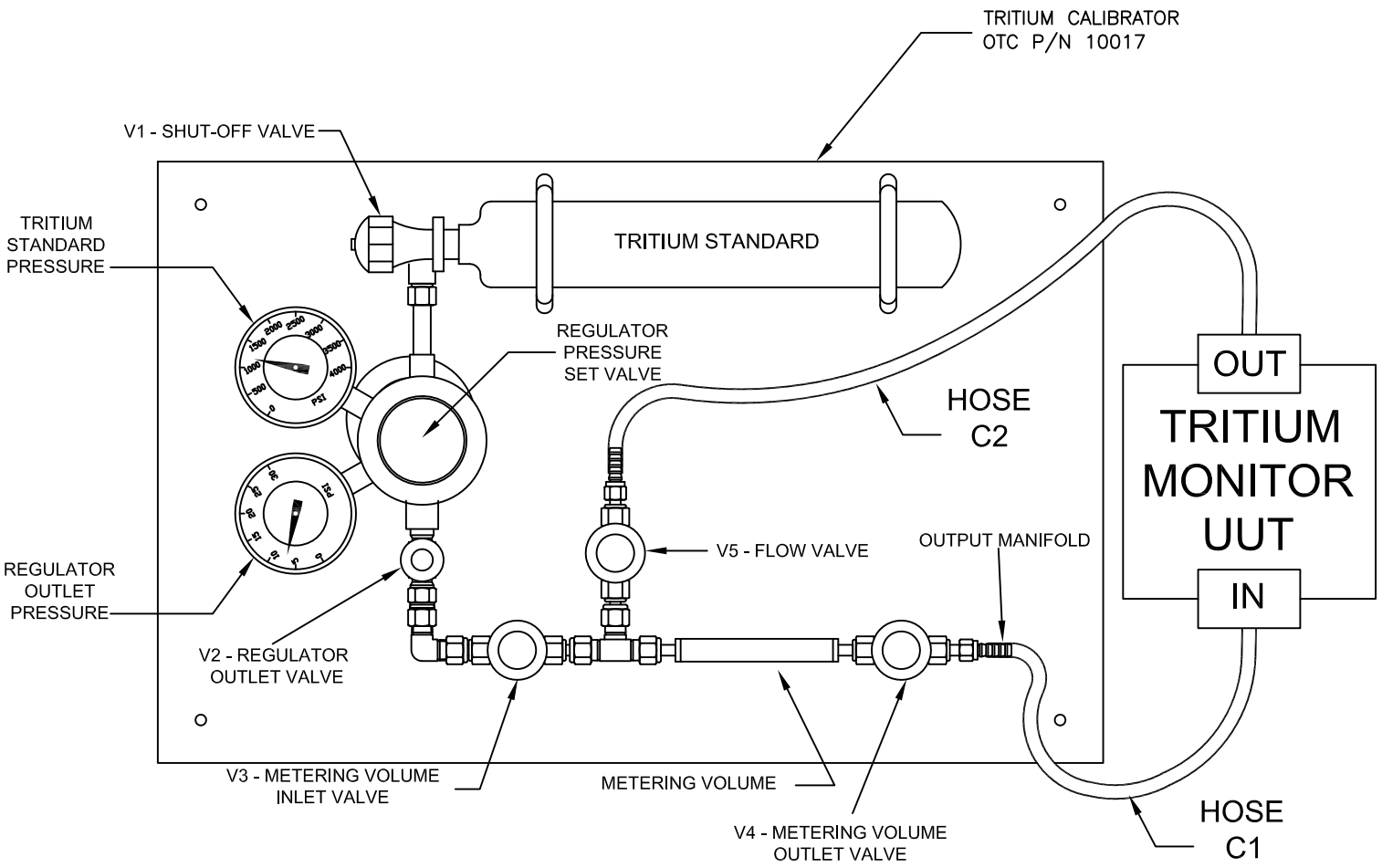

TRITIUM CALIBRATOR
OTC P/N 10017
V1 - SHUT-OFF VALVE
TRITIUM STANDARD
PRESSURE
TRITIUM STANDARD
REGULATOR
PRESSURE
SET VALVE
HOSE
C2
OUT
TRITIUM
MONITOR
UUT
IN
V5 - FLOW VALVE
OUTPUT MANIFOLD
REGULATOR
OUTLET
PRESSURE
V2 - REGULATOR
OUTLET VALVE
V3 - METERING VOLUME
INLET VALVE
METERING VOLUME
V4 - METERING VOLUME
OUTLET VALVE
HOSE
C1

FIGURE 3

4.21. Procedure, with a Reference Monitor, See Figure 4

Ensure that the four valves listed below are closed finger tight.
a. Regulator Outlet Valve - V2
b. Metering Volume Inlet Valve - V3
c. Metering Volume Outlet Valve - V4
d. Metering Volume Flow Valve - V5
Note: The Gas Cylinder Shut-Off Valve, V1 remains open

4.22. Open the regulator outlet valve (V2) and metering volume inlet valve (V3) by rotating counter clockwise.

NOTE: The metering volume is now being charged with tritiated gas at the pressure indicated on the Tritium Calibrator regulator outlet pressure gauge. The metering volume inlet valve (V3) shall be left open for 1 or more minutes to allow for pressure stabilization.

4.23. Close the regulator outlet valve (V2) and metering volume inlet valve (V3) by rotating clockwise.

4.24. Open the metering volume outlet valve (V4) by rotating counter clockwise.

4.25. Open flow valve (V5) by rotating counterclockwise.

CAUTION:
Tritiated gas is being injected under pressure into the UUT.

4.26. Operate pump switch to ON. Allow system to stabilize for 1 to 3 minutes.

CAUTION:
When using a reference monitor it is important to observe the relative volumes and pump capacities of the two monitors. First, determine the normal flow rates of the two instruments. If one flow rate is higher than the other use the pump on the instrument with the lower flow rate. This precaution will prevent the situation where the more powerful pump could damage the other less powerful one.

4.27. Operate pump switch to OFF. Allow system to stabilize for 1 to 3 minutes.

4.28. Record observed indication from the UUT Tritium Monitor. Typically use a ±15 % tolerance of the calculated value for M when comparing it to the actual observed indication. In other words the observed indication should equal M ±15%. Adjust the calibration potentiometer(s) of the UUT Tritium Monitor accordingly to within ±15% of the reading on the Reference Monitor.

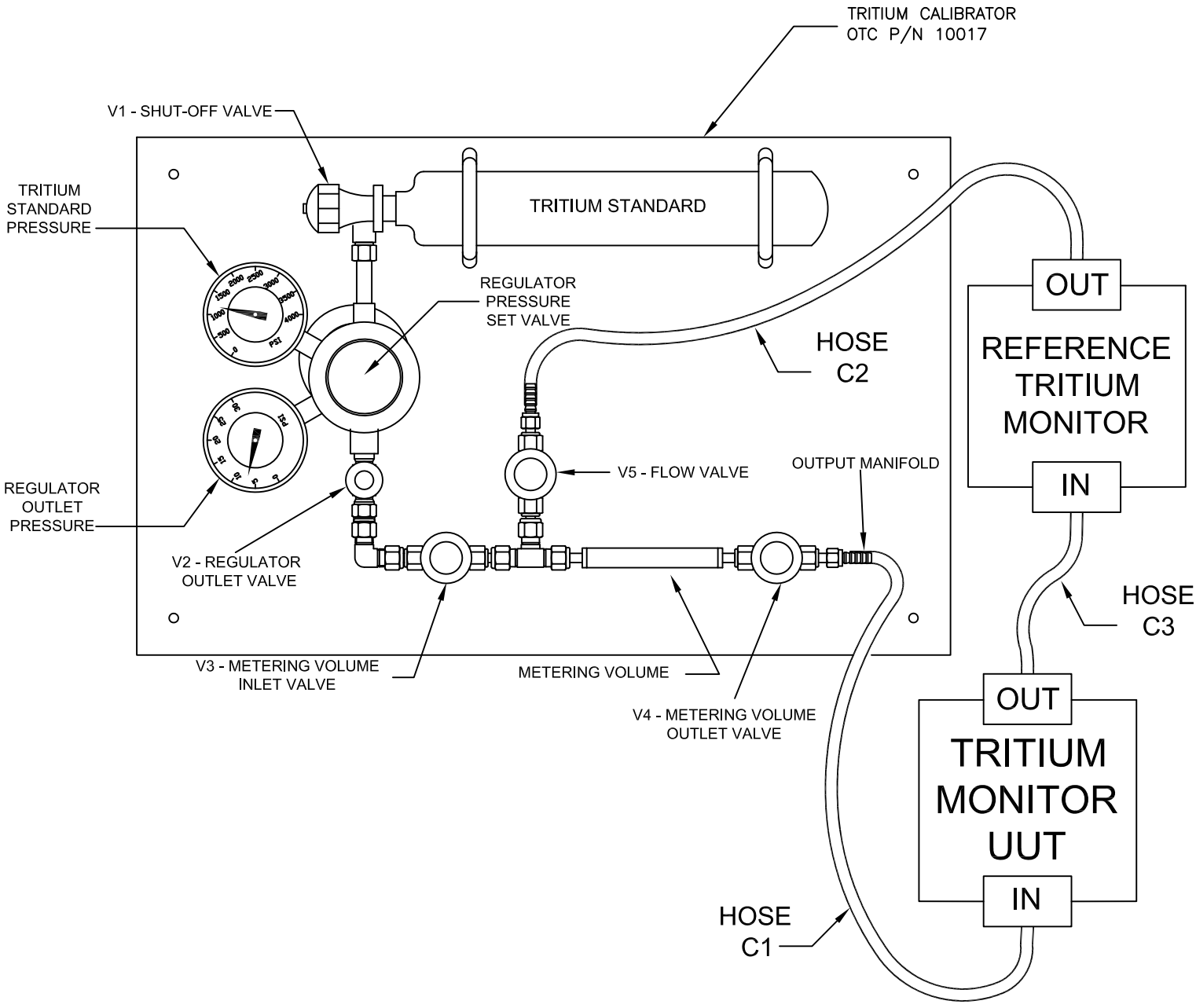
4.29. Disconnect hose (C1) from the Tritium Calibrator output manifold and replace with an external exhaust hose. Operate pump switch to ON.

CAUTION:
Tritiated gas is being vented from V4 through the exhaust hose into the exhaust system and eventually into the atmosphere.

Allow pump to operate until the UUT Tritium Monitor meter indicates zero, to ensure that all traces of tritiated gas are removed from the instrument and hoses. Operate the PUMP switch to OFF position. Disconnect external exhaust hose from output manifold. Reconnect hose (C1) to the output manifold.

4.30. Disconnect hose (C2) from Tritium Calibrator. Operate pump switch to ON position. Observe indication on instrument meter. The UUT Tritium Monitor should indicate zero. Operate the pump switch to OFF position after a stable zero is obtained.

4.31. Close Tritium Calibrator metering volume outlet valve (V4) and flow valve (V5) by rotating clockwise. Refer to Step 4.20. for additional comments.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TRITIUM STANDARD PRESSURE
REGULATOR PRESSURE SET VALVE
HOSE C2
OUT
REFERENCE TRITIUM MONITOR
IN
V5 - FLOW VALVE
OUTPUT MANIFOLD
REGULATOR OUTLET PRESSURE
V2 - REGULATOR OUTLET VALVE
HOSE C3
V3 - METERING VOLUME INLET VALVE
METERING VOLUME
V4 - METERING VOLUME OUTLET VALVE
OUT
TRITIUM MONITOR UUT
IN
HOSE C1

FIGURE 4

5.0. CALCULATIONS

The calculations can be made as follows:

$$M = (C) \cdot (D) \cdot \left(\frac{P_g}{P_a} \right) \cdot \left(\frac{V_m}{V_t} \right) \cdot (N)$$

Where:

M is the expected value of Tritium Concentration in $\mu Ci/m^3$ at ambient conditions.

D is the radioactive decay factor based on a Tritium half life of 12.33 $\pm$0.6 years. See Table 1 for data.

P_g is the metering volume pressure in p.s.i.g.

V_m is the calibrator metering volume in cm^3. Use value furnished with Tritium Calibrator.

Vt is the total wetted volume of the loop in cm^3.

C is the activity, in $\mu Ci/m^3$, at STP (20° C, 760 mm Hg), of the gas in the cylinder at the time the source was delivered. See the Certification for Gas Calibration Standard for actual value. ($\mu Ci/m^3 \times 10^6 = Ci/m^3$)

N is the number of aliquots (injections), (i.e., 1.0).

P_a is the ambient atmospheric pressure in p.s.i.a. To convert in-Hg into p.s.i.a. multiply by 0.4912.

6.0. SAMPLE CALCULATION

A typical example is given below:

1. The value of C is given as 63 x 10^3 μCi/m^3

2. For example; the calibration is performed 12 months after the original date of March 2007, thus D is .945. See Table 1 for Tritium Decay Factors.

3. The expected value of M is unknown.

4. The calibrator metering volume is 14.00 cm^3.

5. The total wetted volume of the loop, containing the calibrator, UUT tritium monitor is 2,100 cm^3 for this sample equation. The total wetted volume must be calculated for the particular test set-up.

6. Assume single injection of gas, (i.e., N = 1.0)

7. Assume ambient atmospheric pressure is 14.70 p.s.i.a.

8. Use a P_g of 15 p.s.i.g.

Thus, the expected value of the reading displayed by the Tritium monitor is:

$$M = (C)\cdot(D)\cdot\left(\frac{P_g}{P_a}\right)\cdot\left(\frac{V_m}{V_t}\right)\cdot(N)$$

$$M = \left(63\cdot 10^3\right)\cdot(.945)\cdot\left(\frac{15}{14.7}\right)\cdot\left(\frac{14}{2100}\right)\cdot(1)$$

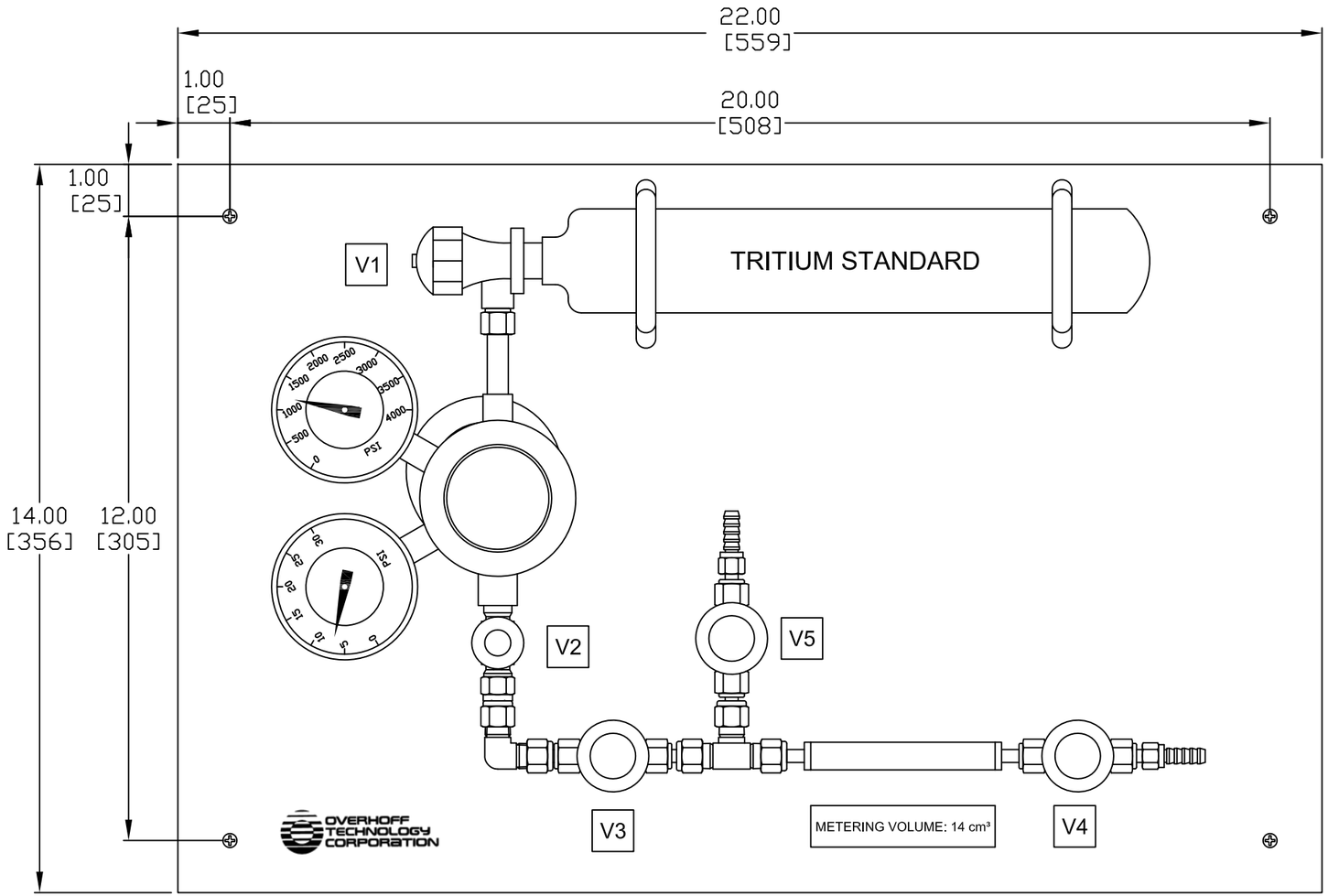
$$M = 405\mu Ci / m^3$$

NOTES

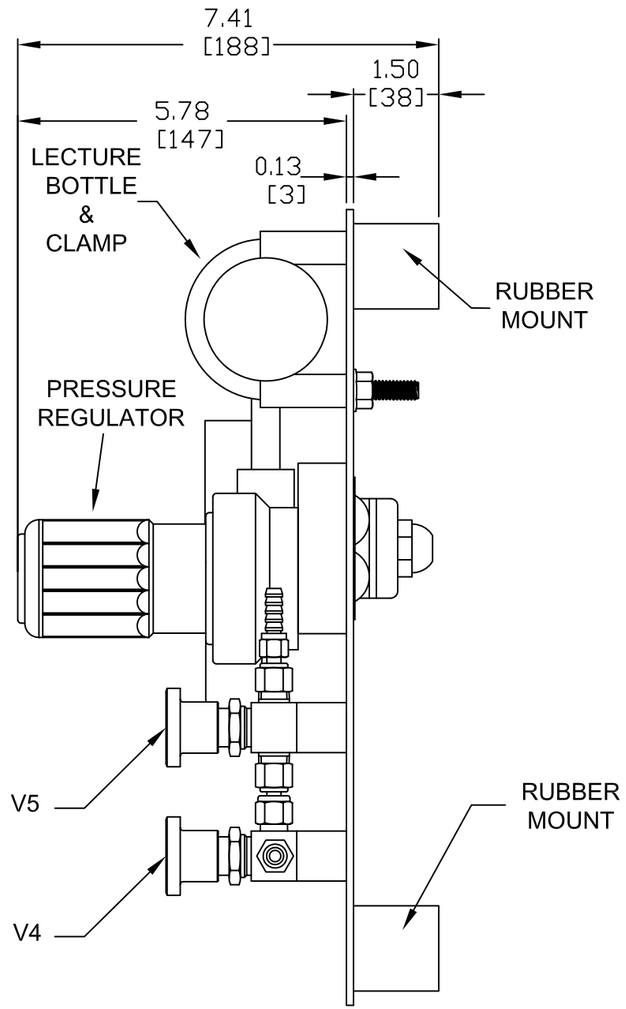
	Months											
	0	1	2	3	4	5	6	7	8	9	10	11
Years	-	-	-	-	-	-	-	-	-	-	-	-
0	-	0.995	0.991	0.986	0.981	0.977	0.972	0.968	0.963	0.959	0.954	0.950
1	0.945	0.941	0.936	0.932	0.928	0.923	0.919	0.915	0.910	0.906	0.902	0.898
2	0.893	0.889	0.885	0.881	0.877	0.873	0.869	0.865	0.860	0.856	0.852	0.848
3	0.844	0.841	0.837	0.833	0.829	0.825	0.821	0.817	0.813	0.810	0.806	0.802
4	0.798	0.794	0.791	0.787	0.783	0.780	0.776	0.772	0.769	0.765	0.762	0.758
5	0.754	0.751	0.747	0.744	0.740	0.737	0.733	0.730	0.727	0.723	0.720	0.716
6	0.713	0.710	0.706	0.703	0.700	0.697	0.693	0.690	0.687	0.684	0.680	0.677
7	0.674	0.671	0.668	0.665	0.661	0.658	0.655	0.652	0.649	0.646	0.643	0.640
8	0.637	0.634	0.631	0.628	0.625	0.622	0.619	0.616	0.614	0.611	0.608	0.605
9	0.602	0.599	0.597	0.594	0.591	0.588	0.585	0.583	0.580	0.577	0.575	0.572
10	0.569	0.567	0.564	0.561	0.559	0.556	0.553	0.551	0.548	0.546	0.543	0.541
11	0.538	0.535	0.533	0.530	0.528	0.526	0.523	0.521	0.518	0.516	0.513	0.511
12	0.509	0.506	0.504	0.501	0.499	0.497	0.494	0.492	0.490	0.487	0.485	0.483

Table 1: Tritium Decay Factor

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	CHANGED V2 & V3 CONNECTION	11-21-08	



TOP VIEW



SIDE VIEW

NOTES:

1. DIMENSIONS = INCHES (MILLIMETERS)

2. V2 LEFT OUT OF SIDE VIEW FOR CLARITY.

TRITIUM GAS CALIBRATOR		OVERHOFF TECHNOLOGY CORPORATION MILFORD, OHIO 45150 U.S.A.			
		TRITIUM GAS CALIBRATOR, MODEL 10017 GENERAL LAYOUT DETAILS			
DRAWN B. SHREVE	DATE 02-19-07	SIZE B	FILE NAME 1021240.dwg	DWG NO. 1021240	REV A
APPROVED B. SHREVE	DATE 02-19-07	SCALE .375:1		SHEET 1 OF 1	