National Institute for Occupational Safety and Health
National Personal Protective Technology Laboratory
P.O. Box 18070
Pittsburgh, PA 15236

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DETERMINATION OF ORGANIC VAPOR (CARBON TETRACHLORIDE) SERVICE LIFE TEST, POWERED AIR-PURIFYING RESPIRATORS WITH CARTRIDGES STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedure for ensuring that the level of protection provided by powered air-purifying respirators (PAPR) with cartridges submitted for Approval, Extension of Approval, or examined during Certified Product Audits, meet the minimum organic vapor service life test requirements set forth in 42 CFR Part 84, Subpart L, Section 84.207 and 84.1157(f).

2. GENERAL

This STP describes the Determination of Organic Vapor Service Life Test, Air-Purifying Respirators with cartridges test in sufficient detail that a person knowledgeable in the appropriate technical field can select equipment with the necessary resolution, conduct the test, and determine whether or not the product passes the test.

3. EQUIPMENT / MATERIAL / REFERENCES

3.1. The list of necessary test equipment and materials follows:

3.1.1. Miller Nelson Research Model 401 Flow-Temperature-Humidity Control System (250 lpm) or equivalent. Air flow control accuracy is ± 2% F.S. Temperature control accuracy is ± 1° C. Humidity control accuracy is ± 3% R.H.

3.1.2. Edge Tech Dew Prime II Hygrometer, Model 2000 or equivalent. Accuracy is ± 0.2° C, ±0.5% RH.

3.1.3. Miran Ambient Air Analyzer, Model 1A with closed loop system or equivalent. The analyzer is a single beam variable filter spectrometer with a variable pathlength gas cell.

3.1.4. Mass Flow Controllers, Brooks Instruments model series 5850S and 5853S with Read Out and Control Electronics, Brooks Instruments model 0154, variable flow rate depending on use. Accuracy is 0.7% set point & 0.2% FS.

3.1.5. American Meter Co. Dry Test Meter Model DTM-325.

3.1.6. Amersham Biosciences High Precision Pump, Model P-500 with reservoir. Flow rate range: l ml/hr to 400 ml/hr ± 1.5% of setting.

3.1.7. Electronic balance with an accuracy of 0.01grams.

3.1.8. Miller Nelson Research, Model SV-2000 Vaporizer system or equivalent. Used for vaporizing carbon tetrachloride solution.

3.1.9. Carbon tetrachloride, ACS grade, 99.9%.

3.2. Test fixture for mounting PAPR cartridges inside the test chamber. PAPR cartridges are tested on their blower units if possible, with the breathing tube attached to the outlet port, or on suitable substitutions, if the unit is too large for the test chamber. All adapters are checked for leak-tightness with soap solution.

3.3. The test chamber consisting of an air tight box, with 2 clamp type locks on the door opening lined with gasket material, and appropriate inlet, outlet and sampling ports. This fixture is not commercially available.

3.4 Refer to the following Work Instructions for further information on performing this test:
TEB-RCT-APR-WI-1002 – Laboratory Safety Procedures for Carbon Tetrachloride Tests
TEB-RCT-APR-WI-1102 – Calibration Procedures for Carbon Tetrachloride Tests
TEB-RCT-APR-WI-1202 – Start–Up and Shut–Down Procedures for Carbon Tetrachloride Tests
TEB-RCT-APR-WI-1302 – Using the LabView System for Carbon Tetrachloride Tests
TEB-RCT-APR-WI-1402 – Reporting Results for Carbon Tetrachloride Tests

4. TESTING REQUIREMENTS AND CONDITIONS

4.1. Prior to beginning any testing, all measuring equipment to be used must have been calibrated in accordance with the testing laboratory's calibration procedure and schedule. All measuring equipment utilized for this testing must have been calibrated using a method traceable to the National Institute of Standards and Technology (NIST) when available.

4.2 Any laboratory using this procedure to supply certification test data as a contractor to NIOSH will be subject to the provisions of the NIOSH Supplier Qualification Program (SQP). This program is based on the tenets of *ISO/IEC 17025, the NIOSH Manual of Analytical Methods* and other NIOSH guidelines. An initial complete quality system audit and follow on audits are requirements of the program. Additional details of the Program and its requirements can be obtained directly from the Institute.*
***Note** 4.2 does not apply to Pretest data from applicants as required under 42 CFR 84.64.

4.3 Precision and accuracy (P&A) must be determined for each instrument in accordance with laboratory procedures and NIOSH/NPPTL guidance. Sound practice requires, under *NIOSH Manual of Analytical Methods,* demonstrating a tolerance range of expected data

performance of a plus or minus 25% of a 95% confidence interval of the stated standard requirement. NIOSH/NPPTL P&A tolerance can be higher but not lower.

4.4 The precision and accuracy of this method was determined by validation testing of a single lot of commercially available multi-gas type cartridges. The results of these tests are shown in the table below.

TEST TYPE	MEAN SERVICE LIFE (MINUTES)	STD. DEV.
AS RECEIVED	80.54	1.58
EQUIL. 25% RH	186.07	2.89
EQUIL. 85% RH	66.55	8.51

4.5. Normal laboratory safety practices must be observed. Please refer to Material Safety Data Sheets and the current NIOSH Pittsburgh Health and Safety Program for the proper protection and care in handling, storing, and disposing of the chemicals used in this procedure.

4.6 Carbon tetrachloride is a suspected human carcinogen. Containers of carbon tetrachloride are typically used inside the laboratory fume hood. If there is a release of carbon tetrachloride such as a spill outside the hood, sound an alarm, and any personnel in the laboratory should immediately exit from the building. Carbon tetrachloride is considered hazardous waste by EPA and must be disposed of accordingly.

4.7 CARBON TETRACLORIDE BENCH TEST FOR CARTRIDGES

4.7.1. Resistances and airflows for tight fitting PAPR will be taken before and after each test. Airflows only for loose fitting PAPR will be taken before and after each test. The standard testing procedures are described in TEB-APR-STP-003, TEB-APR-STP-007 and TEB-APR-STP-0012.

4.7.2 Test conditions as required by 42 CFR 84.207.

SAMPLE	CONDITION	EQUILIBRATION CONDITIONS FOR 6 HOURS				TEST CONDITIONS				TEST CONCENTRATION	BREAKTHROUGH CONCENTRATION
		TEMP. ° C	AIRFLOW TIGHT FITTING LPM	AIRFLOW LOOSE FITTING LPM	R.H. %	TEMP. ° C	AIRFLOW TIGHT FITTING LPM	AIRFLOW LOOSE FITTING LPM	R.H. %	PPMV CCl4	PPMV CCl4
1-3	AS RECEIVED	NA	NA	NA	NA	25	NA	NA	50	1000	5
4-5	EQUIL. 25% R.H.	25	115	170	25	25	115	170	50	1000	5
6-7	EQUIL. 85% R.H.	25	115	170	85	25	115	170	50	1000	5

Tolerances:

PARAMETER	TOLERANCE
25°C	± 2.5°C
115 LPM	± 2.0 LPM
170LPM	± 2.0 LPM
25% R.H.	± 3% R.H.
50% R.H.	± 3% R.H.
85% R.H.	+0/-5% R.H.
1000 ppmv	± 10%

NOTES: R.H. levels greater than 85% are difficult to maintain and may cause rapid degradation of service life.

Tolerance on accuracy of air flow rates exceeds specification on Miller Nelson control unit because flow rates are calibrated for every test. This improves the precision of the measurement and allows for the tighter tolerance on short-term drift.

4.7.3 All equilibrated cartridges will be resealed, kept in a position such that the direction of airflow would be horizontal, at room temperature, and testing shall begin within 18 hours.

5. PROCEDURE

Note: Reference Section 3 for equipment, model numbers and manufacturers.
Work Instructions are to be used in conjunction with standard NIOSH test apparatus.

5.1 Set up the test equipment as shown in Figure 1.

5.2 For carbon tetrachloride detection with the MIRAN 1A, the wavelength is set to 12.6 µm and the pathlength to 20.25 meters. Minimum detectable concentration is 1.1 ppm. The closed loop system consists of a stainless steel bellows pump, septum and tubing with a sample volume of 5.64 liters. For calibration procedures, refer to the user manual. Inject 0.11 µL of carbon tetrachloride into closed loop system of the IR as described in the user manual. Refer to section 8.2 for this calculation. Once stabilized, the analyzer should read 5 ppmv. Make adjustment for Labview software to read 5.0 ppmv. Disconnect closed loop system and allow IR to return to zero reading.

5.3 Establish the correct humidity and temperature for the sample being tested as per the test requirements in paragraph 4.7.

5.4 Set the airflow to the required level for the sample being tested as per the test requirements in paragraph 4.7. Calibrate the total airflow, including any additional flow arising from hygrometer flow rates, from the test fixture using the dry test meter.

5.5 Weigh the PAPR cartridge(s) and record the weight.

5.6 Measure initial inhalation and exhalation resistances of the PAPR cartridge(s) mounted on the respirator if the test sample is a tight-fitting PAPR. as described in TEB-APR-STP-003 and TEB-APR-STP-007. Measure airflows of PAPR cartridge mounted on blower assembly with the entire respirator as described in TEB-APR-STP-0012. Record values on the data sheet.

5.7 Make sure diverter valve in the system is diverting the challenge concentration airflow to discharge and not into the testing chamber.

5.8 Mount PAPR cartridge(s) and blower assembly onto test fixture, and place in testing chamber.

5.9 Fill pump reservoir with carbon tetrachloride. Insert needle from pump to septum tee in airline.

5.9 Set the high precision pump for delivery of calculated carbon tetrachloride to obtain 1000 ppmv at the testing airflow. See appendix 8.2. Turn on injection tee heater.

5.10 Start flow from the high precision pump to the needle.

5.11 Record the initial weight of the carbon tetrachloride reserve and start test.

5.12 Monitor and record challenge and breakthrough temperatures, challenge RH and breakthrough values and times throughout testing.

5.13 Run test until breakthrough of 5.0 ppmv is observed or minimum service life shown in section 6.2 is surpassed by 10%. Weigh and record the final weight of the carbon tetrachloride reservoir.

5.14 At end of test, system will automatically direct challenge concentration airflow through diverter valve to discharge.

5.15 Calculate and record the challenge concentration of the carbon tetrachloride (see attachment 8.2).

5.16 Dismount PAPR cartridge(s), weigh and record final weight, and take final inhalation and exhalation resistances mounted on the respirator if the test sample is a tight-fitting PAPR as described in TEB-APR-STP-003 and TEB-APR-STP-007. Measure airflows of PAPR cartridge mounted on blower assembly with the entire respirator as described in TEB-APR-STP-0012. Measurement of the final inhalation and exhalation resistances is required for certification and audit testing.

5.16 If there is another sample to test, repeat steps 5.5 – 5.15.

5.17 After all tests are completed for the shift, set temperature and humidity to zero on the Miller Nelson system and allow clean air to pass through the system for 30 minutes. Purge the breakthrough detector with clean air for 15 minutes.

6. PASS/FAIL CRITERIA

6.1. The legal basis for passing this test is set forth in 42 CFR Part 84, Subpart L, Section 84.207 and 84.1157(f).

6.2 Minimum service life requirements for cartridges are shown below.

Cartridge	Test condition	Test atmosphere		Flowrate (l.p.m.)[2]	Number of tests	Penetration [1] (p.p.m.v.)	Minimum life [2,3] (min.)	Minimum life [2,3] (min.)
		Gas or vapor	Concentration (p.p.m.v.)				Cartridge for One Type of Gas	Cartridge for More Than One Type of Gas
Organic vapor	As received	CCl_4	1000	115 / 170	3	5	50	25
Organic vapor	Equilibrated	CCl_4	1000	115 / 170	4	5	25	12.5

[1]Minimum life will be determined at the indicated penetration.
[2]Test flowrate shall be 115 lpm for tight fitting facepieces and 170 lpm for loose fitting facepieces.
[3]Where a respirator is designed for respiratory protection against more than one type of gas or vapor, as for use in organic vapor and ammonia, the minimum life shall be 25 minutes for as received samples, and 12.5 minutes for equilibrated samples. Where a respirator is designed for respiratory protection against organic vapor alone (one type of gas), the minimal life shall be 50 minutes for as received samples, and 25 minutes for equilibrated samples (see Table entries).

7. RECORDS/TEST SHEETS

7.1. Record the test data in a format that shall be stored and retrievable.

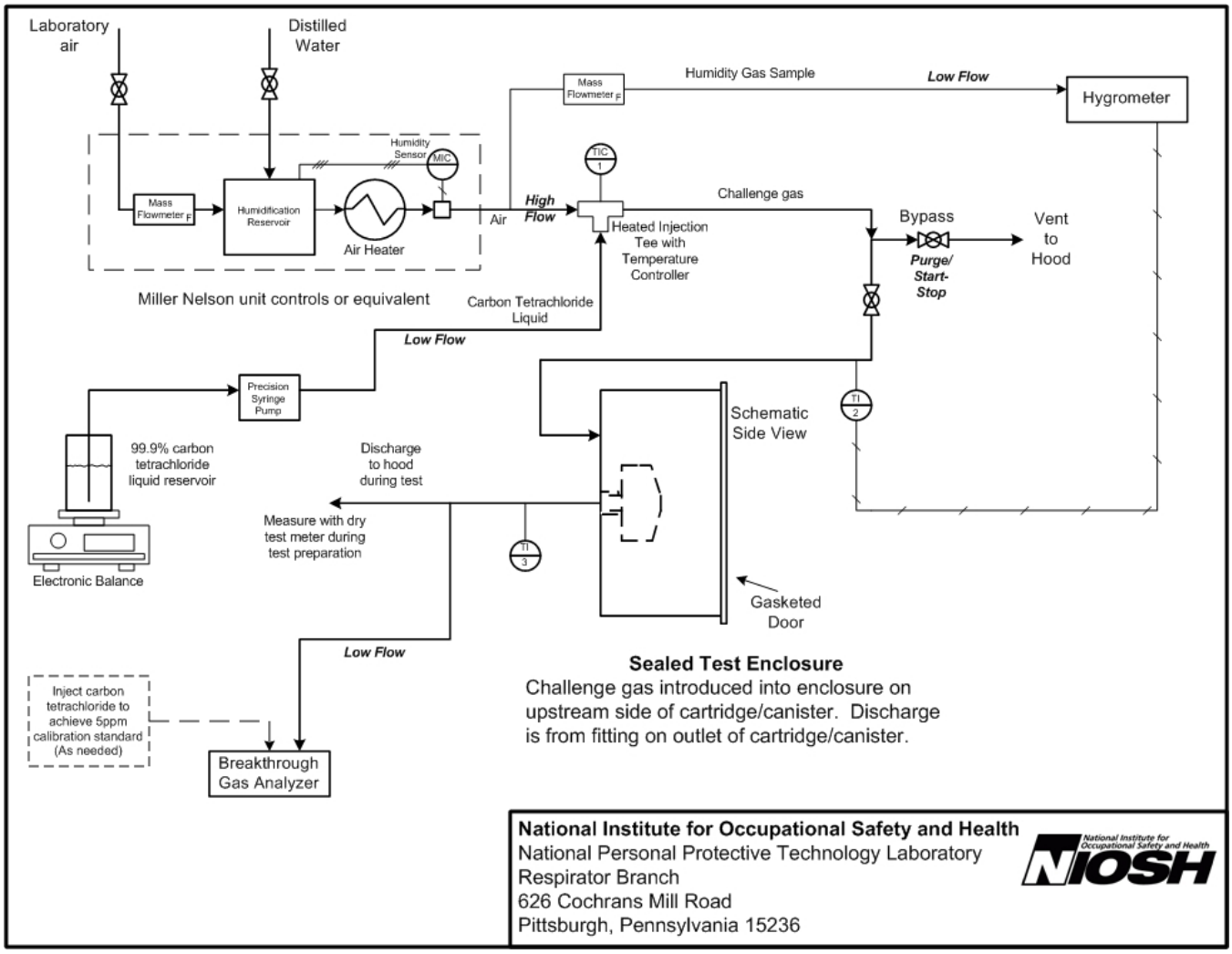
8. ATTACHMENTS

8.1. Bench Top Set-up

8.2 Calculations for carbon tetrachloride

8.3 Data Sheet

8.1 Bench Top Set-Up



8.2: Calculations for carbon tetrachloride

Carbon tetrachloride:

Molecular weight = 153.8 g/mol
1 ppmv = 6.29 mg / m^3 @ 25 ^oC ; 760 mm Hg

1. Calculations for injection rate of carbon tetrachloride.

$$\text{Injection rate (ml/hr)} = \frac{\text{Conc (ppmv) X 6.29 ((mg / m}^3\text{)/ppmv) X Airflow (L/min) X 60 min}}{\text{1000 (mg/g) X 1000 (L/m}^3\text{) X 1.59 (g/ml)}}$$

	170 Lpm	115 Lpm
1000 ppmv	40.35 ml/hr	27.30 ml/hr

2. Calculations for actual challenge concentration.

$$\text{Conc (ppmv)} = \frac{\text{amount delivered (g) X 24.45 (L/mol) X 1,000,000}}{\text{Airflow (Lpm) X Test time (min) X 153.8 (g/mol)}}$$

3. Calculations for calibrating downstream concentration using closed loop system.

$$\text{Microliter injection amount} = \frac{\text{Conc (ppmv) X 5.64L X 153.8 g/mol X 1x 10}^6\ \mu\text{L / L}}{\text{1 X 10}^6\text{ X 24.45 L/mol X 1.59 g/mL X 1000 mL/L}}$$

For 5 ppmv:

$$\text{Microliter injection amount} = \frac{\text{5ppmv X 5.64L X 153.8g/mol X ~~1,000,000~~ µL/L}}{\text{~~1,000,000~~ X 24.45 L/mol X 1.59 g/mL X 1000 mL/L}}$$

$$= 0.11\ \mu L$$

8.2 Data Sheet.

RB - RESPIRATOR CERTIFICATION TEAM
GAS & VAPOR RESPIRATOR TEST DATA SHEET (Ref.33-48,50,62) **STP No.: [_____]**
Task Number: TN-_____ Gas Name:
Manufacturer: _____ Item Tested:

RESISTANCE	Maximum Allowable Resistance (mm of H_2O)				Actual Resistance (mm of H_2O)				Result
Test	Inhalation		Exhalation		Inhalation		Exhalation		
			Initial		Initial	Final	Initial	Final	
1									
2									
3									
4									
5									
6									
7									

Overall Results: Pass Fail Comment:

WEIGHTS AND AIRFLOWS	**WEIGHTS (gm)**					**AIRFLOW (Lpm)**			
		Con'd			**Conc.**	**Test Rate**		**(PAPR Only)**	
Test					**(ppmv)**	RH%	Lpm	Initial	Final
1									
2									
3									
4									
5									
6									
7									

Overall Results: Pass _____ Fail _____ Comment:

DATA TABLE	**Test Cond.**	**Final Time (min)**	**Leakage (ppmv)**	**Temperature (°C)**		**Corrected Time (min)**
Test				**Dns tream**	**Chall enge**	
1						
2						
3						
4						
5						
6						
7						

Overall Results: Pass _____ Fail _____ Comment:
Was all testing equipment in calibration throughout all testing: Yes _____ No
Signature: _____ Date:

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GAS & VAPOR RESPIRATOR TEST DATA SHEET (Ref.33-48,50,62) **STP No.: [_____]**

Task Number: TN-_____ **Gas Name:**

Manufacturer: _____ **Item Tested:**

Additional Comments:

Signature: _____ **Date:**

Revision History

Revision	Date	Reason for Revision
1.0	March 8, 2002	Historic document
1.1	June 6, 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method
2.0	19 December 2006	Significant rewrite of RCT-APR-STP-0046. Changes affect form and provide clarification of technical content.