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

Procedure No. RCT-APR-STP-0044	Revision: 1.1	Date: 25 July 2005

DETERMINATION OF MERCURY VAPOR SERVICE LIFE TEST, AIR-PURIFYING RESPIRATORS STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedure for ensuring that the level of protection provided by the mercury vapor service life requirements on chemical cartridges air-purifying respirators submitted for Approval, Extension of Approval, or examined during Certified Product Audits meet the minimum certification standards set forth in 42 CFR Part 84, Subpart G, Section 84.63(a)(c)(d) and Subpart L, Section 84.190(b); Volume 60, Number 110, June 8, 1995.

2. GENERAL

This STP describes the Determination of Mercury Vapor Service Life Test, Air-Purifying Respirators 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

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

3.1.1. Miller Nelson Research Model 401 Flow-Temperature-Humidity Control System or equivalent.

3.1.2. Mercury Vapor Model 431X Analyzer or equivalent.

3.1.3. Mercury, 99.9%.

3.1.4. Three-necked round bottom flask (250ml), 1 each.

3.1.5. Two-necked round bottom flasks (250ml), 2 each.

3.1.6. Heating mantle with controller for 3 necked 250ml flask.

3.1.7. Temperature controlled water bath, 2 each, to hold and regulate the temperature of the two-necked round bottom flasks.

3.1.8. Glass wool.

Approvals:	1st Level	2nd Level	3rd Level

3.1.9. Electronic Balance with an accuracy of 0.001 grams (g).

3.1.10. Vaisala model HMI 31 humidity indicator.

3.2. Test fixture for mounting cartridges. The test fixture used is specific to each manufacturer depending on how the cartridge is mounted to the facepiece. The T-end has a 29/42 ground glass joint glued in place. In most cases the cartridge cups of the respirator are affixed by hot melt glue to PVC pipe tee of appropriate size.

3.3. The test chamber consisting of a 12" x 11½" x 7" air tight box, made of ½" plexiglass with 2 hinge type locks on the door opening lined with gasket material. A ½" hole is located on the back of the test chamber for the introduction of the test concentration and a 1½" hole on the top for the exit of the test fixture and to detect the breakthrough concentration. This fixture is not commercially available.

3.4. Resistance tester consisting of a vacuum source capable of delivering 85 liters per minute (lpm), a 6-inch slant manometer, and a 29/42 female ground glass joint. The resistance testers currently being used are located on the silica dust chamber.

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 manufacturer's calibration procedure and schedule. At a minimum, all measuring equipment utilized for this testing must have been calibrated within the preceding 12 months using a method traceable to the National Institute of Standards and Technology (NIST).

4.2. Normal laboratory safety practices must be observed. This includes safety precautions described in the current ALOSH Facility Laboratory Safety Manual.

4.2.1. Safety glasses, lab coats, and hard-toe shoes must be worn at all times.

4.2.2. Work benches must be maintained free of clutter and non-essential test equipment.

4.2.3. When handling any glass laboratory equipment, lab technicians and personnel must wear special gloves which protect against lacerations or punctures.

4.3. MERCURY VAPOR BENCH TEST FOR CARTRIDGES

4.3.1. Resistance to air flow will be taken before and after each test, 84.203.

4.3.2. Three "as received" cartridges (or pairs of cartridges) will be tested at 64 lpm, continuous air flow, 50 $\pm$ 5 percent relative humidity (RH), approximately 25 degrees Celsius (^{O}C), and 21.5 mg/m^3 mercury vapor.

4.3.3. Two cartridges or pairs of cartridges will be equilibrated at room temperature by passing 25 percent RH air through them at 25 lpm for 6 hours and then testing them at 25 percent RH, approximately 25^{o}C, and 64 lpm continuous air flow containing 21.5 mg/m^{3} mercury vapor.

4.3.4. Two cartridges or pairs of cartridges will be equilibrated at room temperature by passing 85 percent RH air through them at 25 lpm for 6 hours and then testing them at 85 percent RH, approximately 25^{o}C, and 64 lpm continuous air flow containing 21.5 mg/m^{3} mercury vapor.

4.4. PASSIVE END OF SERVICE LIFE INDICATOR

4.4.1. The passive end of service life indicator (ESLI) must clearly indicate that it is a reliable indicator of sorbent depletion at 90% or less of the service life of the cartridge or canister.

4.5 **Please refer to Material Safety Data Sheets and the NIOSH Health and Safety Manual for the proper protection and care in handling, storing, and disposing of the chemicals and gases used in this procedure.**

5. PROCEDURE

Note: Reference Section 3 for equipment, model numbers and manufacturers. For calibration purposes use those described in the manufacturer's operation and maintenance manuals.

5.1. Follow individual instruction manuals for set up and maintenance of equipment used in this procedure prior to beginning testing. Malfunctioning equipment must be repaired or replaced and properly set up and calibrated before starting all tests.

5.2. Calibrate the Model 431X Analyzer following the instruction manual.

5.3. Set up test equipment as shown in Figure 1. In addition to the humidity reading controlled by the Miller Nelson system, the Vaisala HMI 31 humidity indicator sensor is inserted into the air stream via a tee set-up directly prior to the introduction of the gas. This set up is not shown on Figure 1. The humidity reading obtained at this point takes into account tubing length and outside hood air temperature.

5.4. Set up test equipment as shown in Figure 1.

5.5. Turn on:

5.5.1. Miller Nelson Unit.

5.5.2. Air and water supplies.

5.5.3. Heating mantles and water baths.

5.6. Add 500-800 g mercury to the first 3-necked round bottom flask and place flask on heating mantle.

5.7. Add the same amount of mercury to the second flask and secure the flask with laboratory clamps in the water bath. The necked portion of the flasks should be above the water level of the water baths.

5.8. Using forceps add a palm size amount of glass wool to the third flask.

5.9. The mercury concentration is achieved by allowing clean air at 64 lpm to pass through the first 3-necked round bottom flask containing the 500-800 g mercury heated to 65-70^{o}C (Vapor Pressure = 0.03514/0.04925; concentration = 334/452 mg/m3). This air, containing a high mercury concentration, is then passed through a second flask containing mercury at room temperature, 24 to 26^{o} C, (VP = 1.691 x 10^{-3} ; conc. = 3/21.5 mg/m^{3}) to obtain an air stream saturated with mercury vapor at 24 to 26^{o}C. The mercury laden air is next passed through a third flask containing glass wool to remove any droplets which may have formed due to condensation. The second and third flasks are contained in thermostatically controlled water baths. After passing through the third flask, the mercury laden air enters the test chamber containing the cartridges.

5.10. Allow 30-40 minutes for the mercury concentration to stabilize.

5.11. Establish the mercury vapor concentration. Using the syringe draw 0.5 cc of the challenge concentration and inject the sample into the analyzer. Allow the analyzer to read the challenge sample and multiply by the factor of 250. Adjust the temperature to control the concentration.

5.12. Weigh the cartridge and record the weight.

5.13. Take inhalation and exhalation resistances of the cartridge mounted on the respirator at 85 lpm. See Section 84.203 Title 42, Code of Federal Regulations, Part 84 for breathing resistance requirements.

5.14. Mount cartridge onto test fixture and place in testing chamber.

5.15. Direct challenge concentration airflow into test chamber. Start timer. Mount small piece of tygon tubing onto the outlet of the test fixture. Insert intake tubing of the analyzer into a slit cut into the side wall of the tubing to allow the analyzer to sample at the flow rate of the analyzer without interference from airflow back pressure. Monitor and record upstream and downstream temperatures throughout testing. Record breakthrough values and times.

5.16. Monitor ESLI (end of service life indicator) for change as described in the user instruction manual or cartridge insert. Record time and degree of ESLI change.

5.17. Run test until breakthrough of 0.05 mg/m is observed or minimum service life is surpassed.

5.18. Dismount cartridge and weigh and record final weight, and take final inhalation and exhalation resistances.

5.19. Shut off heater and water baths.

5.20. Turn off air and water supply to Miller Nelson system.

6. PASS/FAIL CRITERIA

6.1. The criterion for passing this test is set forth in 42 CFR Part 84, Subpart G, Section 84.63(a)(c)(d) and Subpart L, Section 84.190(b); Volume 60, Number 110, June 8, 1995.

6.2. This test establishes the standard procedure for ensuring that:

84.63 Test requirements; general.

(a) Each respirator and respirator component shall when tested by the applicant and by the Institute, meet the applicable requirements set forth in subparts H through L of this part.

(c) In addition to the minimum requirements set forth in subparts H through L of this part, the Institute reserves the right to require, as a further condition of approval, any additional requirements deemed necessary to establish the quality, effectiveness, and safety of any respirator used as protection against hazardous atmospheres.

(d) Where it is determined after receipt of an application that additional requirements will be required for approval, the Institute will notify the applicant in writing of these additional requirements, and necessary examinations, inspections, or tests, stating generally the reasons for such requirements, examinations, inspections, or tests.

84.190 Chemical cartridge respirators: description.

(b) Chemical cartridge respirators for respiratory protection against gases or vapors, which are not specifically listed with their maximum use concentration, may be approved if the applicant submits a request for such approval, in writing, to the Institute. The Institute shall consider each such application and accept or reject the application after a review of the effects on the wearer's health and safety and in the light of any field experience in use of chemical cartridge respirators as protection against such hazards.

7. RECORDS/TEST SHEETS

7.1. All test data will be recorded on the MERCURY VAPOR SERVICE LIFE test data sheet.

7.2. All videotapes and photographs of the actual test being performed, or of the tested equipment shall be maintained in the task file as part of the permanent record.

7.3. All equipment failing any portion of this test will be handled as follows:

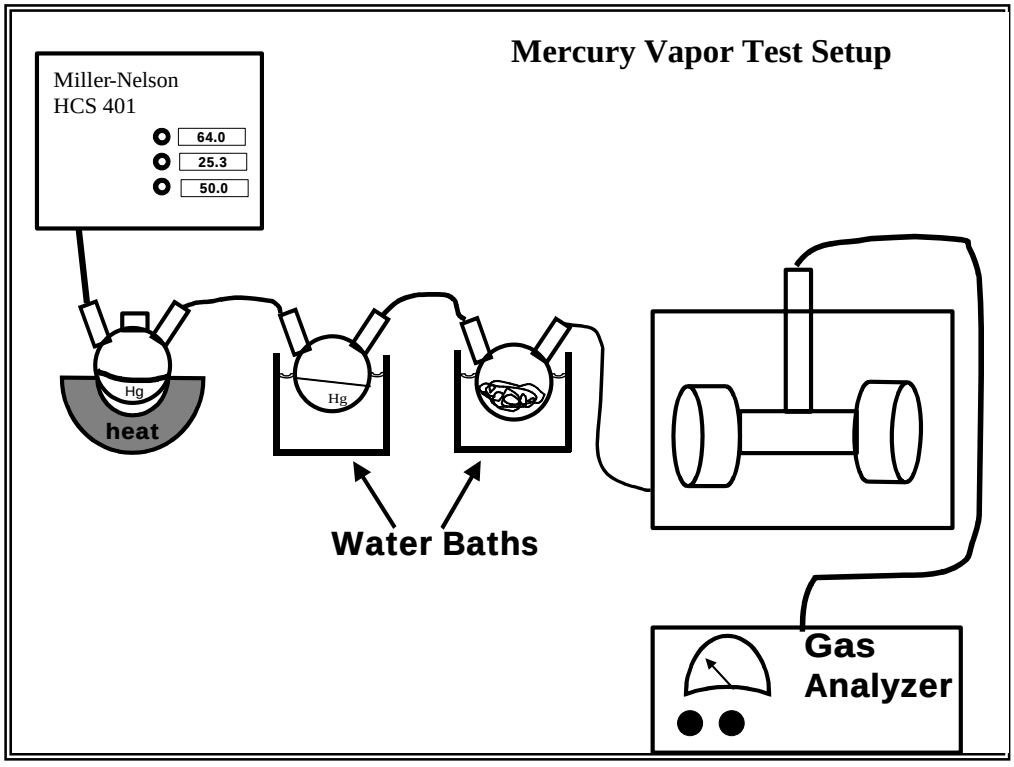
7.3.1. If the failure occurs on a new certification application, or extension of approval application, send a test report to the RCT Leader and prepare the hardware for return to the manufacturer.

7.3.2. If the failure occurs on hardware examined under an Off-the-Shelf Audit the hardware will be examined by a technician and the RCT Leader for cause. All equipment failing any portion of this test may be sent to the manufacturer for examination and then returned to NIOSH. However, the hardware tested shall be held at the testing laboratory until authorized for release by the RCT Leader, or his designee, following the standard operating procedures outlined in Procedure for Scheduling, and Processing Post-Certification Product Audits, RB-SOP-0005-00.

8. ATTACHMENTS

8.1 Bench Top Set-Up.

8.2 Data Sheet.


Mercury Vapor Test Setup
Miller-Nelson
HCS 401
64.0
25.3
50.0
Hg
heat
Hg
Water Baths
Gas
Analyzer

NIOSH *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					**(ppm)**	RH%	lpm	Initial	Final
1									
2									
3									
4									
5									
6									
7									

Overall Results: Pass ___ Fail ___ Comment:

DATA TABLE	**Test Cond.**	**Final Time (min)**	**Leakage (ppm)**	**Temperature (°C)**		**Corrected Time (min)**
Test				**Dnstream**	**Upstream**	
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	15 March 2002	Historic document
1.1	25 July 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method