DETERMINATION OF CBRN ACID GASES (HYDROGEN CYANIDE) SERVICE LIFE TEST, TIGHT-FITTING POWERED AIR-PURIFYING RESPIRATORS (PAPR) STANDARD TEST PROCEDURE (STP)

1. PURPOSE

This test establishes the procedure for ensuring that the level of protection provided by the *CBRN Acid Gases (Hydrogen Cyanide) Service Life Test, Tight-fitting Powered Air Purifying Respirators (PAPR) Standard Test Procedure* 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, 84.63(a)(c)(d); Volume 60, Number 110, June 8, 1995 and the *Statement of Standard for Chemical, Biological, Radiological, and Nuclear (CBRN) Powered Air Purifying Respirator(PAPR).*

2. GENERAL

This STP describes the *Determination of CBRN Acid Gases (Hydrogen Cyanide) Service Life Test, Tight-fitting Powered Air-Purifying Respirators (PAPR) Standard Test Procedure* 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 AND 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. This system is an automated system to control the airflow, temperature, and humidity of an air supply for an operating system. Laboratory air and distilled water are supplied to the unit. The unit output is air of the variable volume/flow dependant on the size of unit (10% of max flow to max flow in liters per minute (Lpm) ± 2%), and relative humidity (10%–98% ± 3%) and temperature (20ºC–30º ^{0}C ± 0.3%).

3.1.2. EdgeTech Dew Prime II Hygrometer, Model 2000 or equivalent. A micro-processor based programmable chilled mirror dew point hygrometer . The hygrometer uses the dew point and ambient temperature to calculate the relative

humidity. Ambient temperature range is: -50ºC to 130ºC ± 0.2ºC; relative humidity is 1% to 95% ± 0.5%.

3.1.3. Labview software developed for NIOSH Service Life Testing.

3.1.4. California Analytical Instruments, Model 1314 Photoacoustic Multigas Monitor with UA0980 optical filter or equivalent. This monitor uses photoacoustic infrared detection to measure gases that absorb infrared light. A filter is used to select the wavelength specific for the gas being detected. Range for hydrogen cyanide is 8000 to 0.8 ppm ± 0.08 ppm.

3.1.5. Gas Chromatograph, Shimadzu, Model 14A with Flame Ionization Detectors or equivalent.

3.1.6. Mass Flow Controller, Brooks Instruments, Model 5851. Variable flow rate depending on use.

3.1.7. Read out and Control Electronics, Brooks Instruments, Model 0154, Power supply and controller for the Brooks Mass Flow Controller or equivalent. The flow controllers are an integrally mounted control valve module with which stable gas flows can be achieved. Various flow rates are used with an accuracy of ± 0.7 % of rate and ± 0.2 % full scale.

3.1.8. Dry Test Meter, American Meter Company, Model and size depending on air flow to be measured. Must have NIST traceable calibration certificate.

3.1.9 Certified cylinders of 5 ppm and 1000 ppm hydrogen cyanide, balance gas nitrogen or hydrogen cyanide permeation tubes that are certified to NIST standard

3.1.10 Kin-Tek 491MB Basic Gas Standards Generator with cyanogen permeation tubes that are certified to NIST standard.

3.1.11 Hydrogen Cyanide cylinders, 2% hydrogen cyanide, balance gas of nitrogen.

3.2 Test fixture for mounting canisters.

3.3 The test chamber consisting of an air tight box with door opening lined with gasket material. Two fittings located on the test chamber for the introduction of the test concentration and for the exit of the test fixture. This fixture is not commercially available

3.4 Resistance tester equipment as described in standard test procedures RCT-APR-0007.

3.5 Airflow measurement equipment as described in standard test procedure RCT-APR-00025.

4. TESTING REQUIREMENTS AND CONDITIONS

4.1 For tight-fitting respirators, this test procedure is only valid if the respirator system has first completed NIOSH Standard Test Procedure entitled *Durability Conditions Process For Environmental, Transportation And Rough Handling Conditions On Chemical Biological, Radiological and Nuclear (CBRN) Respiratory Protective Devices (RPD) Standard Conditioning Procedure (SCP)*.

4.2 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).

4.3 Any laboratory using this procedure to supply certification test data 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.

4.4 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.

4.5 Compressed gas cylinders must meet all applicable Department of Transportation requirements for cylinder approval as well as retesting / requalification.

4.6 Normal laboratory safety practices must be observed. This includes safety precautions described in the current NIOSH Pittsburgh Health and Safety Program.

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

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

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

4.7 **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 photoacoustic monitor for hydrogen cyanide using a certified hydrogen cyanide gas cylinder at a concentration of approximately 1000 ppm.

5.3 After the manufacturer's specified warm-up period, calibrate the Gas Chromatograph using the Kin-Tek gas generator with the hydrogen cyanide and cyanogen permeation tube or a certified gas cylinder of hydrogen cyanide.

5.4 Start automatic sampling mode on the gas chromatograph. Monitor and record the upstream and downstream concentrations.

5.5 Set up test equipment as shown in Figure 1. The humidity reading controlled by the Miller Nelson system and monitored the Dew Point Hygrometer. The sample pickup for the hygrometer is place into the air stream via a tee after the Miller Nelson and before the introduction point of challenge agent. The thermocouple for the hygrometer is placed in the challenge gas stream immediately before the test chamber.

5.6 Verify the following equipment is on:

5.6.1 Miller Nelson Unit.

5.6.2 Air and water supplies.

5.6.3 Gas Chromatograph

5.6.4 NIOSH Service Life Apparatus Controller software program.

5.7 Establish the correct humidity and temperature using chilled mirror dew point hygrometer per the test standard in paragraph 6.3.

5.8 Set the required airflow for the system. Individual canisters will be tested by dividing 115 Lpm by the number of air-purifying elements on the system. See worksheet 3 in appendix 8.2. Verify the airflow from the test fixture using the appropriate dry test meter.

5.9 Weigh and record initial weight of the test canister on Test Data Sheet.

5.10 Take and record initial airflow measurements in accordance with RCT-APR-012. See section 84.1152 (b) Title 42, Code of Federal Regulations, Part 84 for minimum airflow requirements.

5.11 Take and record initial inhalation resistances for tight-fitting PAPR in accordance with RCT-APR-007. See Sections 84.122, 84.203, 84.1157 Title 42, Code of Federal Regulations, Part 84 for breathing resistance requirements.

5.12 Ensure that the diverter valve in the system is diverting the challenge concentration airflow to the discharge and not into the test chamber.

5.13 Mount canister onto test fixture in testing chamber.

5.14 Turn on the hydrogen cyanide cylinder.

5.15 Establish the test concentration of 940 ppm ± 94 ppm hydrogen cyanide.

5.16 Once the hydrogen cyanide concentration has been established, testing may begin.

5.17 Direct challenge concentration airflow into test chamber.

5.18 Start timer. Airflow out of the fixture is directed into the breakthrough detector. Monitor and record the upstream and downstream temperatures of the air stream throughout testing. Record breakthrough values and times.

5.19 Run test until breakthrough of 4.7 ppm hydrogen cyanide and cyanogen is observed or selected service life time is surpassed. Record this data on the test data sheet.

5.20 Direct challenge concentration airflow out of the test chamber.

5.21 Weigh and record final weight of the test canister on Test Data Sheet.

5.22 Take and record final airflow measurements in accordance with RCT-APR-012. See section 84.1152 (b) Title 42, Code of Federal Regulations, Part 84 for minimum airflow requirements.

5.23 Take and record final inhalation resistances for tight-fitting PAPR in accordance with RCT-APR-007. See Sections 84.122, 84.203, 84.1157 Title 42, Code of Federal Regulations, Part 84 for breathing resistance requirements

5.24 Allow clean air to purge through the test chamber for 5 minutes.

5.25 Repeat steps 5.7 through 5.22 for each test described in section 6.3.

5.26 End sampling mode program in the gas chromatograph.

5.27 When all tests are complete turn off hydrogen cyanide cylinder, clean regulator by purging with air, set temperature and humidity to zero and allow air to pass through the system for 30 minutes.

6. PASS OR 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 I, Section 84.110(c); 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.

6.3 Acid Gas (Hydrogen Cyanide) Test for Canisters.

6.3.1 Inhalation resistance to airflow of system will be taken before and after each test

6.3.2 Airflow measurements of system must be taken before and after each test.

6.3.3 Three canisters will be tested at the determined, continuous airflow, 25 $\pm$ 5% RH, 25 $\pm 5^{o}$ C, containing 940 ppm hydrogen cyanide.

6.3.4 Three canisters will be tested at the determined, continuous airflow, 80 $\pm$ 5 % RH, 25 $\pm 5^{o}$ C, containing 940 ppm hydrogen cyanide.

6.3.5 Minimum service life will be 15, 30, 45, 60, 90 or 120 minutes as per manufacturer request. End of service life concentration is 4.7 ppm, which is the sum of the breakthrough products of hydrogen cyanide and cyanogen.

7. RECORD AND TEST SHEETS

7.1. All test data will be recorded on the CBRN HYDROGEN CYANIDE 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 TEB Team 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 TEB Team 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 Branch Chief, or the Branch Chief's designee, following the standard operating procedures outlined in *Procedure for Scheduling, and Processing Post-Certification Product Audits,*
RB-SOP-0005-00.

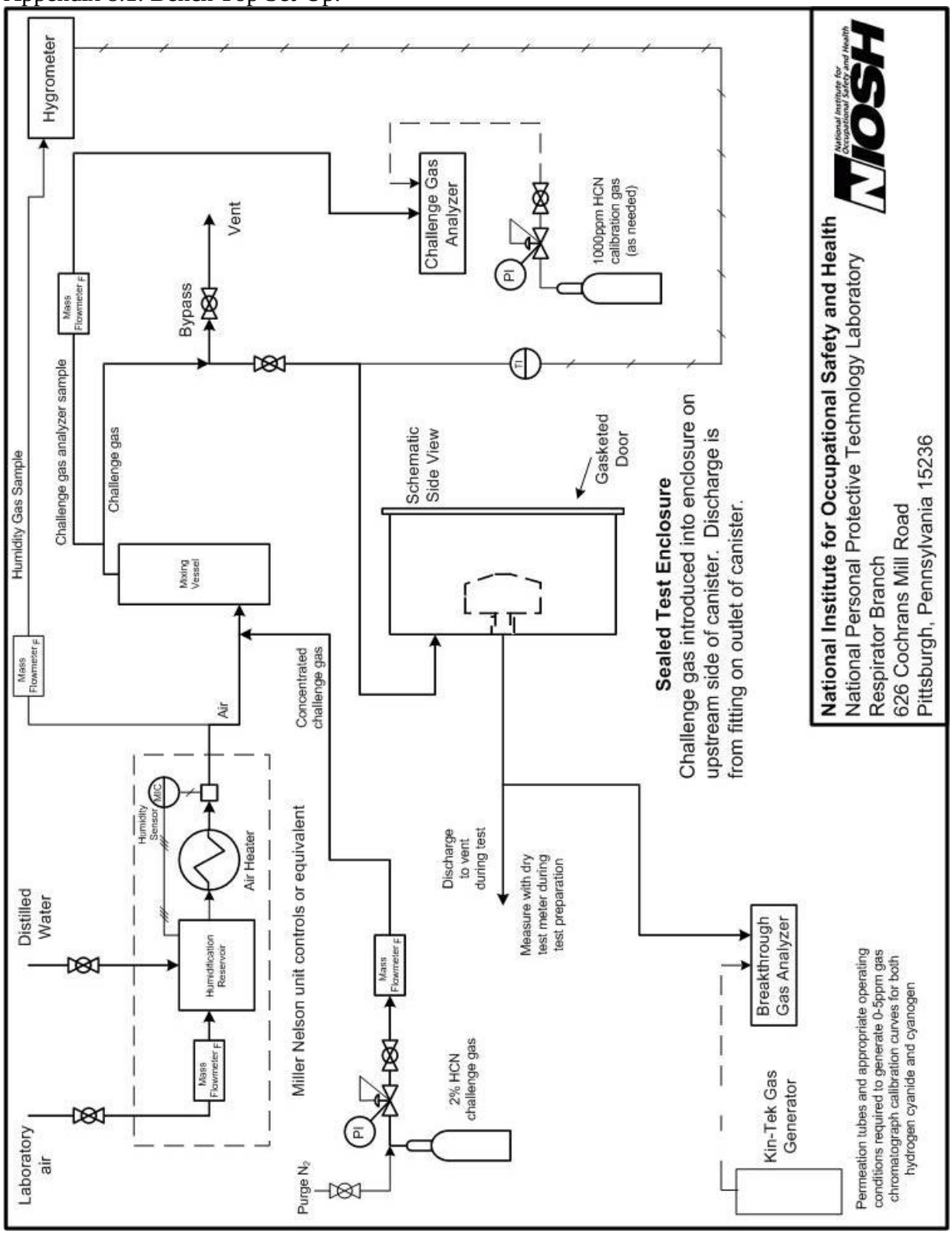
8. APPENDIXES

8.1 Bench Top Set-Up.

8.2 Data Sheet.

8.3 Airflow calculations

Appendix 8.1: Bench Top Set-Up.



Appendix 8.2 - Data Sheet.

Data Type: HCN

Task Number: _____ Company: _____

Description: _____

Test Date: _____ #: _____ Test Time: _____

Canister Initial	Canister Final	Inhalation Resistance Canister only		Inhalation Resistance System		Exhalation Resistance System		Flow	Conc	
grams	grams	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Lpm	ppm	%Rh

Time	HCN Leakage	Cyanogen Leakage	Temperature Downstream	Temperature Upstream	Remarks:

Test Date: _____ #: _____ Test Time: _____

Canister Initial	Canister Final	Inhalation Resistance Canister only		Inhalation Resistance System		Exhalation Resistance System		Flow	Conc	
grams	grams	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Lpm	ppm	%Rh

Time	HCN Leakage	Cyanogen Leakage	Temperature Downstream	Temperature Upstream	Remarks:

Test Date: _____ #: _____ Test Time: _____

Canister Initial	Canister Final	Inhalation Resistance Canister only		Inhalation Resistance System		Exhalation Resistance System		Flow	Conc	
grams	grams	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Initial in H2O	Final in H2O	Lpm	ppm	%Rh

Time	HCN Leakage	Cyanogen Leakage	Temperature Downstream	Temperature Upstream	Remarks:

Test Operator _____

Page ____ of ____

Appendix 8.3 - Service life testing airflow calculations.

Tight-fitting PAPR

_____ Number of filtering elements on a tight-fitting PAPR System.

115 Lpm airflow

Airflow for service life test = 115 Lpm / number of filtering elements

Test Flow			
4 Canisters	3 Canisters	2 Canisters	1 Canister
28.8 Lpm	38.3 Lpm	57.5 Lpm	115 Lpm

Revision History

Revision	Date	Reason for Revision
0.0	21 November 2006	Original Issue