National Institute for Occupational Safety and Health
National Personal Protective Technology Laboratory
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Procedure No. TEB-APR-STP-0003	Revision: 2.3	Date: 25 March 2014

DETERMINATION OF EXHALATION RESISTANCE TEST, AIR-PURIFYING RESPIRATORS STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedure for ensuring that the level of protection provided by chemical cartridge respirators, particulate respirators, gas masks, and tight fitting powered air-purifying respirators submitted for Approval, Extension of Approval, or examined during Certified Product Audits, meet the minimum exhalation resistance requirements set forth in 42 CFR, Part 84, Subpart I, Section 84.122, Subpart K, Section 84.180, Subpart L, Section 84.203 Subpart KK, Section 84.1149, Section 84.1156(a)(1)(2), the Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Full-Facepiece Air-Purifying Respirator (APR) Revision 2 dated 4-4-2003, and the Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Air-Purifying Escape Respirator (APER) dated 9-30-2003.

2. GENERAL

This STP describes the Determination of Exhalation Resistance 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. An anthropometric headform or fixture on which to mount the complete respirator assembly in the configuration as worn by the user. In addition, fixtures are required for mounting a canister only when testing full facepiece APR for CBRN, and for testing mouthpiece respirators.

3.1.2. A means of connecting the headform or test fixture to the resistance tester. The respirator must be fitted to the headform / fixture with no leaks.

3.1.3. Resistance tester consisting of a compressed air source capable of delivering 85 liters per minute (lpm), a 6-inch slant manometer in inches of water increments, with a connection port for the test fixture with mounted respirator. The resistance tester currently being used is located on the front panel of the silica dust chamber.

Approvals: First Level	Second Level	Third Level	Fourth Level

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

3.1.5. Rope caulk, glue gun with hot melt glue and beeswax if needed.

3.1.6. Heating plate, beaker, and small brush if needed.

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 measuring the exhalation resistance of 3 samples of the same make and model respirator. Each sample was tested 6 times. The entire procedure was repeated from beginning to end for each reading. The results are shown in the table below.

Sample	1	2	3
Mean	8.17 mm H_2O	8.09 mm H_2O	8.81 mm H_2O
Std. Dev.	0.34	0.30	0.47

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

4.6. There are no unusual or special safety precautions necessary for this test procedure.

5. PROCEDURE

Note: Reference Section 3 for equipment, model numbers and manufacturers. For calibration purposes use the procedures 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 any testing. Malfunctioning equipment must be repaired or replaced and properly set up and calibrated before starting all tests.

5.2. Turn on resistance tester and adjust air pressure to 14 ± 0.5 psi. Spiral airflow should be set at 2 cfm.

5.3. Adjust airflow to 85 lpm to calibrated mark on the vertical exhalation resistance airflow manometer. This airflow shall be calibrated at least monthly using the dry test meter.

5.4. Insert the connection of the headform or test fixture without the respirator mounted to the connection of the resistance tester.

5.5. Set the exhalation resistance scale to read zero on the slant manometer with the headform or fixture connected without the respirator.

5.6. Disconnect the headform or test fixture from the resistance tester, and mount the respirator facepiece on the headform or fixture. Filtering facepiece respirators are sealed using hot melt glue and beeswax on a flat plate with a glass tube attached that has a ground glass joint for connection to the resistance apparatus. For air purifying escape respirators for CBRN, spread the elastomeric neck dam, and pull the hood over the headform. The neck dam should seal tightly around the neck of the headform. Mouthpiece type respirators require a special adapter. Elatomeric half mask and full face respirators are carefully mounted on the headform to ensure good contact around the entire sealing flange. Rope caulk can be used to help seal the critical area around the nose and / or chin for half masks. Be careful not to block the mouth of the headform with the chin cup of full facepieces. For each particular model, the size that fits the standard headform best should be used. Other headforms from different manufacturers are available in the lab to obtain a better seal on a particular facepiece if problems are encountered in obtaining a good seal.

5.7. Insert the connection of the headform or test fixture to the connection of the resistance tester.

5.8. Read resistance in inches of water, estimating the last digit to the nearest hundredth of an inch, on the positive resistance slant tube manometer. Convert inches to millimeters by multiplying by 25.4.

5.9. Record the measurement.

ALTERNATE PROCEDURE USING ELECTRONIC DIGITAL MANOMETER AND MASS FLOW CONTROLLER

3A. EQUIPMENT/MATERIAL

3A.1. The list of necessary test equipment and materials follows:

3A1.1. An anthropometric headform or fixture on which to mount the complete respirator assembly in the configuration as worn by the user. In addition, fixtures are required for mounting a canister only when testing full facepiece APR for CBRN and for mounting mouthpiece respirators.

3A1.2. A means of connecting the headform or test fixture to the flow controller. The respirator must be fitted to the fixture with no leaks.

3A1.3. Compressed air source capable of delivering a minimum of 85 liters per minute (lpm).

3A1.4. Setra Datum 2000 Model 239 digital manometer with an accuracy of ± 0.01%R ± 1 digit. Connect manometer to a pressure tap on the line between the flow controller and headform or test fixture with mounted respirator.

3A1.5. Brooks Instrument Co. model 5853S Mass Flow Controller with Brooks Control and Read-out Unit model 0154. Accuracy +/- 0.70%R +/- 0.20% f.s.

3A1.6. American Meter Co. Dry Test Meter Model DTM-325.

3A1.7. Rope caulk, glue gun with hot-melt glue and beeswax if needed.

3A1.8. Heating plate, beaker, and small brush if needed.

4A. TESTING REQUIREMENTS AND CONDITIONS

4A.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.

4A.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.

4A.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.

4A.4. The precision and accuracy of this method was determined by measuring the exhalation resistance of 3 samples of the same make and model respirator. Each sample was tested 6 times. The entire procedure was repeated from beginning to end for each reading. The results are shown in the table below.

Sample	1	2	3
Mean	8.72 mm H_2O	8.89 mm H_2O	9.40 mm H_2O
Std. Dev.	0.21	0.16	0.16

4A.5. Normal laboratory safety practices must be observed. This includes safety precautions described in the current NIOSH Pittsburgh Health and Safety Program.

4A.6. There are no unusual or special safety precautions necessary for this test procedure.

5A. 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.

5A.1. Follow individual instruction manuals for set up and maintenance of equipment used in this procedure prior to beginning any testing. Malfunctioning equipment must be repaired or replaced and properly set up and calibrated before starting all tests.

5A.2. Turn on airflow and set flow controller to 85 lpm. This airflow shall be calibrated at least monthly using the dry test meter.

5A.3. Insert the connection of the headform or test fixture to the connection of the resistance tester without the respirator mounted. Set the digital manometer to read zero.

5A.4. Disconnect the headform or test fixture from the resistance tester, and mount the respirator facepiece on the headform or fixture. Filtering facepiece respirators are sealed using hot melt glue and beeswax on a flat plate with a joint for connection to the resistance apparatus. For air purifying escape respirators for CBRN, spread the elastomeric neck dam, and pull the hood over the headform. The neck dam should seal tightly around the neck of the headform. Mouthpiece type respirators require a special adapter. Elatomeric half mask and full face respirators are carefully mounted on the headform to ensure good contact around the entire sealing flange. Rope caulk can be used to help seal the critical area around the nose and / or chin for half masks. Be careful not to block the mouth of the headform with the chin cup of full facepieces. For each particular model, the size that fits the standard headform best should be used. Other headforms from different manufacturers are available in the lab to obtain a better seal on a particular facepiece if problems are encountered in obtaining a good seal.

5A.5. Insert the connection of the headform or test fixture to the connection of the resistance tester.

5A.6. Read resistance in inches of water to the nearest hundredth of an inch on the digital manometer. Convert inches to millimeters by multiplying by 25.4.

5A.7. Record the measurement.

6. PASS/FAIL CRITERIA

6.1. The requirement for passing this test is set forth in 42 CFR, Part 84, Subpart I, Section 84.122, Subpart K, Section 84.180, Subpart L, Section 84.203 Subpart KK, Section 84.1149, Section 84.1156(a)(1)(2), the Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Full-Facepiece, Air-Purifying Respirator (APR) Revision 2 dated 4-4-2003, and the Statement of Standard for Chemical, Biological, Radiological and Nuclear (CBRN) Air-Purifying Escape Respirator (APER) dated 9-30-2003.

6.2. The maximum allowable resistance requirements for gas masks are as follows:

Maximum Resistance
[mm. water-column height]

Type of gas mask	Exhalation	
	Initial	Final[1]
Front-mounted or back-mounted (without particulate filter)	20	20
Front-mounted or back-mounted (with approved particulate filter)	20	20
Chin-style (without particulate filter)	20	20
Chin-style (with approved particulate filter)	20	20
Escape (without particulate filter)	20	20
Escape (with approved particulate filter)	20	20

[1]Measured at end of the service life specified in Tables 5, 6, and 7 of this subpart.

6.3. The resistance for non-powered air-purifying particulate respirators upon initial exhalation shall not exceed 25 mm water column height pressure.

6.4. The maximum allowable resistance requirements for chemical cartridge respirators are as follows:

Maximum Resistance
[Millimeter water column height]

Type of chemical-cartridge respirator	Exhalation	
	Initial	Final[1]
Other than single-use vinyl chloride respirators:		
For gases, vapors, or gases and vapors	20	20
For gases, vapors, or gases and vapors, and particulates	20	20
Single-use respirator with valves:		
For vinyl chloride	20	20
For vinyl chloride and particulates	20	20
Single-use respirator without valves:		
For vinyl chloride	15	20
For vinyl chloride and particulates	25	40

[1] Measured at end of service life specified in Table 11 of this subpart.

6.5. The maximum allowable resistance requirements for tight fitting powered air-purifying respirators (PAPR) are as follows:

Maximum Resistance
[Millimeter water column height]

Type of tight fitting PAPR	Exhalation	
	Initial	Final [1]
With HE particulate filter(s) only	20	20
With chemical cartridge(s) and HE particulate filter(s)	20	20
With chin-style canister and HE particulate filter	20	20
With front or back mounted canister and HE particulate filter	20	20

[1] Measured at end of silica dust test specified in section 84.1152 (b) of this subpart.

6.6. The maximum allowable resistance requirements for CBRN Full Facepiece Air Purifying Respirators are as follows:

	Chin Style	Non Facepiece Mounted	Canister Only
Initial Exhalation	20 mm H_2O	20 mm H_2O	NA
Final Exhalation[1]	20 mm H_2O	20 mm H_2O	NA

[1] Measured at end of service life

6.7. For CBRN Air Purifying Escape Respirators, the exhalation resistance prior to environmental conditioning shall not exceed 20 mm H_2O.

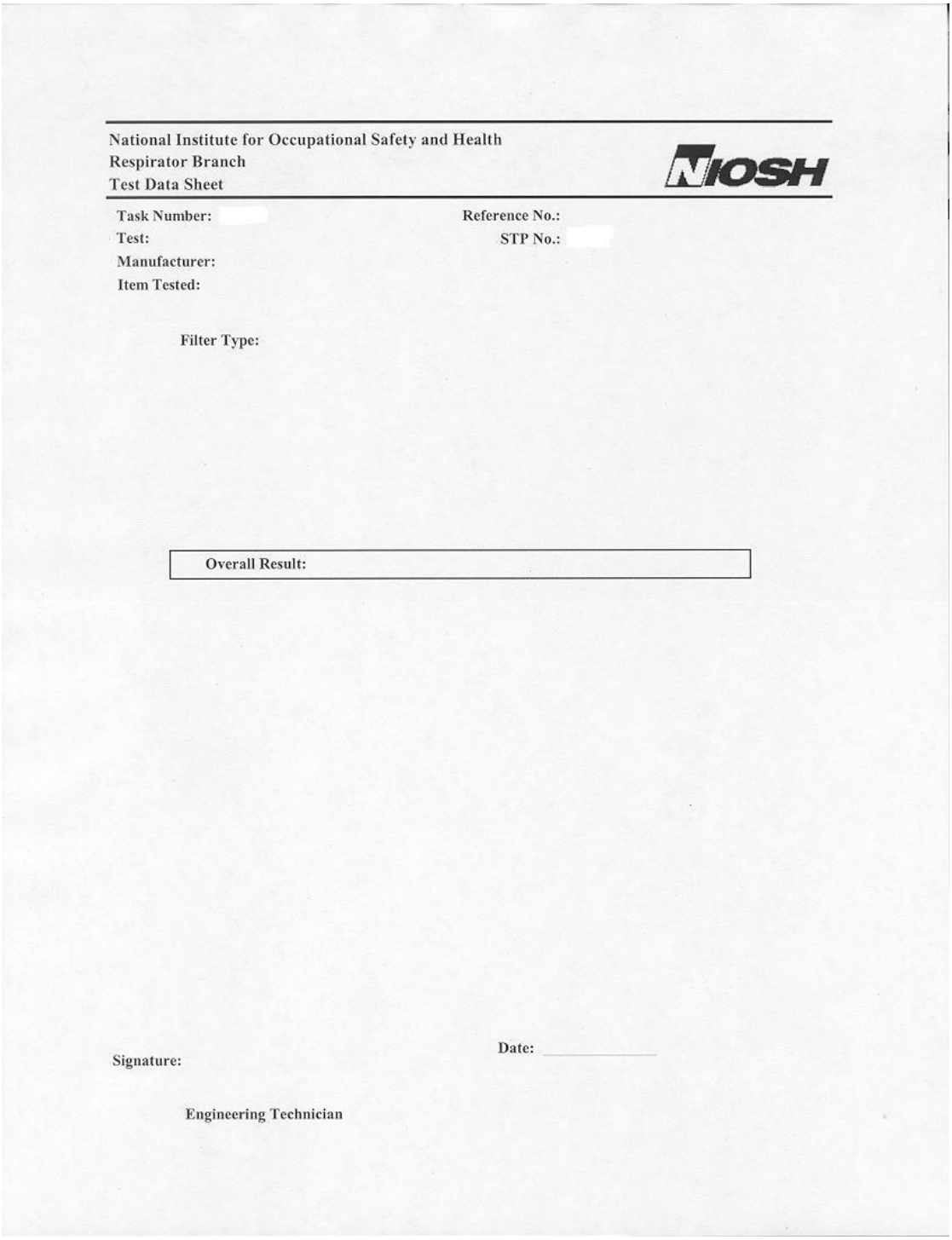
7. RECORDS/TEST SHEETS

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

8. ATTACHMENTS

8.1. Sample Data Sheet

Attachment 8.1. Sample Data Sheet



National Institute for Occupational Safety and Health
Respirator Branch
Test Data Sheet

NIOSH

Task Number:
Reference No.:
Test:
STP No.:
Manufacturer:
Item Tested:

Filter Type:

Overall Result:

Signature:

Date:

Engineering Technician

Revision History

Revision	Date	Reason for Revision
1.0	7 March 2004	Historic document
1.1	3 June 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method
2.0	30 March 2009	Significant rewrite of RCT-APR-STP-0003. Document name changed to TEB-APR-STP-0003. Changes affect form and provide clarification of technical content. -Addition of alternate method using digital manometer and mass flowmeter -Addition of precision and accuracy data for standard and alternate methods -New tables added for clarification, removal of obsolete respirator types and incorporation of CBRN APR, APER and industrial PAPR types -New instructions on fitting respirators to headforms and fixtures -Specifications added to equipment list
2.1	27 September 2011	Update description of mass flow controller called out in 3A1.5. Formatting check for web accessibility
2.2	19 September 2012	Review and editing for accuracy, no technical changes
2.3	25 March 2014	Modified specification in sections 5.6 and 5.A.4 from “flat aluminum plate” to “flat plate”. Editorial change to section 6.1.