



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

Procedure No. RCT-APR-STP-0065	Revision: 1.1	Date: 12 September 2005
--------------------------------	---------------	-------------------------

DETERMINATION OF AIR FLOW RESISTANCE OF
BREATH RESPONSIVE, POWERED AIR-PURIFYING RESPIRATORS (PAPR's)
STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedures for ensuring that the level of protection provided by breath responsive powered air-purifying respirators (PAPR's) meets the requirements deemed as appropriate under 42 CFR 84.157 for air flow and breathing resistance. Breath responsive powered air-purifying respirators (PAPR's) are designed to maintain a positive pressure in the facepiece in order to match the respiratory requirements of the user. The requirements for the evaluation of a PAPR under Part 84 do not address these design features. Therefore, in accordance with the applicable sections of 42 CFR § 84.60 and § 84.63, these types of PAPR's will be evaluated under the requirements for PAPRs in 42 CFR Part 84 which are applicable to its design and under those additional requirements which NIOSH determines are necessary to ensure the quality, effectiveness and safety of the respirator. Since, there is no applicable test or requirements for a breath responsive respirator in the PAPR requirements, the airflow resistance of this device will be evaluated under the requirements of §84.157 for pressure-demand supplied air respirators which can adequately test the quality, effectiveness and safety of this type of design feature. These are as follows:

84.157. Airflow resistance test; Type C supplied-air respirator, pressure-demand class; minimum requirements.

- (a) The static pressure in the facepiece shall not exceed 38 mm. (1.5 inches) of water-column height.
- (b) The pressure in the facepiece shall not fall below atmospheric at inhalation airflows less than 115 liters (4 cubic feet) per minute.
- (c) The exhalation resistance to a flow of air at a rate of 85 liters (3 cubic feet) per minute shall not exceed the static pressure in the facepiece by more than 51mm (2 inches) of water-column height.

Approvals:	1 st Level	2 nd Level	3 rd Level
------------	-----------------------	-----------------------	-----------------------

2. GENERAL

- 2.1. This STP describes the Determination of Breathing Resistance of Breath Responsive Powered Air-Purifying Respirators (PAPR's) 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/MATERIALS

- 3.1. The list of necessary test equipment and materials follows:
- 3.1.1. Two channel thermal tip recording system (Model Number 1102B Hewlett Packard) with Carrier Preamplified (Number 8805A) or equivalent.
 - 3.1.2. Mechanical breather with 622 kg-m/min. cam as per U.S. BOM Drawings C-1748 (3/17/69) Breathing Machine and B-1198 (3/6/69) Breathing Cam.
 - 3.1.3. Anthropometric test head with probe at upper lip for measuring breathing resistance (Sierra Engineering Company Model 428) or equivalent.
 - 3.1.4. Temperature compensated strain sensitive resistance wire type transducer (Stratham Instruments). Pressure rate ± 0.5 psig or equivalent.

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. The compressed-air cylinder must meet all applicable Department of Transportation Requirements for cylinder approval as well as for retesting/requalification.
- 4.3. Normal laboratory safety practices must be observed. This includes all safety precautions described in the current ALOSH Facility Laboratory Safety Manual.
- 4.3.1. Safety glasses, lab coats, and hard-toe-shoes must be worn at all times.
 - 4.3.2. Work benches must be maintained free of clutter and non-essential test equipment.
 - 4.3.3. When handling any glass laboratory equipment, lab technicians and personnel must wear special gloves which protect against lacerations or punctures.
- 4.3. 42 CFR, Part 84, Subpart J, Section 84.156 and 84.157, Volume 60, Number 110, June 8, 1995.

84.156 Air Flow resistance test; Type C supplied-air respirator, demand class; minimum requirement.

- (a) Inhalation resistance shall not exceed 50 millimeters (2 inches) of water at an air flow of 115 liters (4 cubic feet) per minute.
- (b) The exhalation resistance to a flow of air at a rate of 85 liters (3 cubic feet) per minute shall not exceed 25 millimeters (1 inch) of water.

84.157 Air Flow resistance test; Type C supplied-air respirator, pressure-demand class; minimum requirements.

- (a) The static pressure in the facepiece shall not exceed 38 mm (1.5 inches) of water-column height.
- (b) The pressure in the facepiece shall not fall below atmospheric at inhalation airflows of 115 liters (4 cubic feet) per minute.

5. PROCEDURE

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

5.1.1. Turn on recorder and allow at least 30-minute warmup.

5.1.2. Assemble the apparatus as shown in Figure 1. Mount the pressure transducer where shock and vibration are minimal.

5.1.3. Assemble respirator and mount facepiece on anthropometric head, taking care not to block resistance port below and left of nose, particularly if a nosecup is used. Make sure that the face seal is leak tight by blocking off the inhalation port of the facepiece and inhaling through the breathing tube port exiting the back of head. After building up several inches of negative pressure hold breathing several seconds, which will enable you to determine if a leak is present. If there is a leak, readjust headstraps and facepiece position and repeat leak test until a seal is obtained.

5.1.4. Connect the breathing tube to facepiece. Do not connect head to breathing machine. Turn on breathing machine and use a timer to determine that the cam is operating at 24 rpm. (This will give a 40 lpm volume). When calibrated, turn breathing machine off.

5.1.5. Zero the recorder base-lines to mid-point of chart paper. Calibrate the pressure transducer and balance the carrier preamplifier as instructed in the manual.

5.1.6. Connect the anthropometric head to the breathing machine.

- 5.1.7. Turn on the blower unit with fully charged batteries.
- 5.1.8. Turn on breathing machine for three complete cycles to obtain inhalation resistance. (See data Analysis, Appendix C.) Then turn off breathing machine leaving blower turned on.
- 5.1.9. With the blower unit still turned on connect transducer port from head form to a slant manometer to obtain static pressure in facepiece.
- 5.1.10. When tracings are complete shut off breathing machine and blower unit, disconnect transducer from head (make sure recorder speed and attenuator switch are both off).
- 5.1.12. Retrieve the tracings on chart paper for data analysis.

NOTE: This test should be done on a minimum of three respirators, or more if additional testing is required.

5.2. Data Analysis. Reference Appendix B.

- 5.2.1. Take the peak values of the inhalation tracings and read resistances in inches of water column height.
- 5.2.2. All values read in paragraph 1 may not exceed 50 mm (2 inches) of water column height in order to meet Part 84 performance requirements.
- 5.2.3. For pressure-demand units the inhalation resistance cannot fall below the zero pressure base line. A negative spike is allowed as long as there is no area between the point where the spike goes negative and the point where it returns to positive.
- 5.2.4. All values obtained in paragraph 5.1.9. of test procedure may not exceed 38 mm (1.5 inches) of water column height in order to meet Part 84 performance requirements.

6. PASS\FAIL CRITERIA

- 6.1. The criterion for passing this test is set forth in Subpart J, Sections 84-157.

7. RECORDS\TEST SHEETS

- 7.1. All test data will be recorded on the Determination of Air Flow Resistance of Breath Responsive Powered Air-Purifying Respirators 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 new certification application hardware, send a test report to the Team Leader and prepare the hardware for return to the manufacturer.
 - 7.3.2. If the failure occurs to hardware examined under an Extension of Approval or Off-the-Shelf Audit; the hardware will be examined by a technician and the Team Leader for cause. All equipment failing any portion of this test may be returned to the manufacturer applicant for examination. However, the hardware tested shall be held at the testing laboratory until authorized for release by the Team Leader, or his designee, following the standard operating procedures outlined in Procedure for Scheduling, and Processing Post-Certification Product Audits, RB-SOP-0005-00.

Appendix A

Equipment Required

1. Two channel thermal tip recording system (Model Number 1102B Hewlett Packard) with Carrier Preamplifier (Number 8805A) or equivalent.
2. Mechanical breather with 622 Kg m/min. cam as per U.S. BOM Drawings C-1748 (3/17/69) Breathing Machine and B-1198 (3/6/69) Breathing Cam.
3. Anthropometric test head with probe at upper lip for measuring breathing resistance (Sierra Engineering Company Model 428) or equivalent.
4. Temperature compensated strain sensitive resistance wire type transducer (Stratham Instruments). Pressure range ± 0.5 psig or equivalent.
5. Dwyer slant manometer with a range of 1 to 3 inches of water or equivalent.

Appendix B

Test/Data Sheets

1. Determination of Air Flow Resistance of Breath Responsive Powered Air-Purifying Respirators Test Data Sheet.

AIR FLOW RESISTANCE
BREATH RESPONSIVE POWERED AIR-PURIFYING RESPIRATORS (PAPR's)

Date: _____

Project No.:

Company:

Respirator Type:

42 CFR Part 84 Reference: 42 CFR 84.60 & 84.63, Subpart J 84.157
Pressure- Demand Class SAR.

Requirement: (a) Inhalation resistance shall not exceed 50 mm
(2 inches) of H₂O column height at an airflow
of 115 lpm. (4 cfm).

(b) The exhalation resistance to a flow of air at a
rate of 85 lpm. (3 cfm.) shall not exceed
25 mm (1 inch) of H₂O column height.

Results:

(a) Air Flow 115 lpm. (4 cfm.)
Inhalation Resistance:

(b) Air Flow 85 lpm. (3 cfm.)
Exhalation Resistance:

Comments:

Test Engineer:

Pass_____ Fail

Appendix C

Figures:

1. Set up for Measuring Breathing Resistance.

SILICA DUST CHAMBER

Revision History

Revision	Date	Reason for Revision
1.0	13 March 2001	Historic document
1.1	12 September 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method