National Institute for Occupational Safety and Health National Personal Protective Technology Laboratory 626 Cochrans Mill Road Pittsburgh, PA 15236		
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DETERMINATION OF PARTICULATE FILTER EFFICIENCY LEVEL AGAINST LIQUID PARTICULATES FOR POWERED AIR-PURIFYING RESPIRATORS (PAPRs), SERIES PAPR100-P, STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This procedure establishes the means for ensuring that the particulate filtering efficiency of PAPR100-P series filters meet the requirements set forth in 42 CFR, Part 84, Subpart K, Section 84.180. These filters or filter cartridges may be integral to respirator construction; mounted individually, or in sets of up to three; used in conjunction with filters, cartridges and canisters for half-mask, full facepieces, hoods, and helmets.

2. GENERAL

This STP describes the test method to be used for the Determination of Particulate Filter Efficiency Level Against Liquid Particulates for Powered, Air-purifying Respirators, Series PAPR100-P, test procedure in sufficient detail that a person knowledgeable in the appropriate technical field can 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. TSI Model 8130 Automated Filter Tester or equivalent instrument. Air flow control accuracy is 2% of full scale. Pressure measurement accuracy is 2% of full scale. Penetrations can be measured to 0.001%, efficiencies to 99.999%.

3.1.2. Microbalance accurate to 0.0001 grams (g).

3.1.3. Type A/E glass filters, 102 mm diameter, high efficiency filters with a 1 micrometer pore size.

3.1.4. Timer (accurate to 0.01 percent).

3.1.5. Dioctyl phthalate (DOP, di(2-ethylhexyl)phthalate) min. 98%.

3.1.6. Respirator filter holder supplied for specific manufacturer type which is compatible with TSI filter tester. NIOSH will not be obligated to use these holders for actual certification testing. All manufacturer test fixtures must be correlated with the NIOSH test method.

3.1.7. Thermal printer (supplied with TSI 8130) or optional data acquisition system.

3.1.8. TSI, Green Line paper, part number 813010. Lot number must be included on each box. Each lot number must include the "Penetration vs. Resistance graph".

4. TESTING REQUIREMENTS AND CONDITIONS

4.1. Prior to beginning any testing, confirm that all measuring equipment employed has 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 recognized international standards when available.

4.1.1. Respirator filters and filter cartridges shall be tested as follows. Filters used in conjunction with PAPR100-Ps, and odd or unusually shaped filters may be tested on a test fixture provided by the applicant.

4.1.2. If a test fixture is supplied by the applicant, the test fixture shall have a serial number or other unique, easily referenced identifier permanently etched, engraved, or affixed.

5. PROCEDURE

5.1. Respirator filters will be challenged by a neat cold – nebulized DOP aerosol at 25 ±5 °C that has been neutralized to the Boltzmann equilibrium state. The particle size distribution will be a count median diameter of 0.185 ± 0.020 micrometer and a geometric standard deviation not exceeding 1.6. Each respirator filter unit will be challenged with an aerosol concentration not exceeding 200 mg/m^3.

5.1.1. The DOP aerosol concentration will be determined daily by the following gravimetric method and calculated as milligrams per cubic meter (mg/m^3).

5.1.2. Weigh a 102 mm filter to the nearest 0.1 mg, mount in the gravimetric filter holder, subject it to the generated aerosol at 30 Lpm for 40 minutes, and reweigh the filter. Use a timer to monitor the duration of the test. Record the pre- and post-weights, time, and average flow rate on the data sheet and calculate the aerosol concentration in mg/m^3 by the following formula:

$$\text{Concentration (C) in mg/m}^3 = \frac{(W2 - W1)}{(Q / 1000)\,(T)}$$

Where:

W1 = Initial filter weight in mg
W2 = Final filter weight in mg

Q = Flowrate in liters per minute
T = Test time in minutes

With a flowrate of 30 Lpm for 40 minutes, the above formula simplifies to:

$$C = \frac{W2 - W1}{1.2}$$

5.1.3. Use the following formula to calculate the test duration:

$$T \text{ in minutes} = \frac{(\text{mg load})\ (1000\ L / m^3)}{(C)\ \ (Q)}$$

Where:
C = Concentration in mg/m^3 from 5.1.2.
Q = Flow rate for test in Lpm

5.1.4. The upstream and downstream photometer readings are used for monitoring stability and for calculating a photometer correlation factor (CF). The correlation factor is determined with an empty filter holder and is calculated internally as shown below:

$$CF = \frac{\text{Downstream Photometer Voltage} - \text{Downstream Background Voltage}}{\text{Upstream Photometer Voltage} - \text{Downstream Background Voltage}}$$

The correlation factor is used by the software to express the upstream photometer signal in terms of the downstream photometer signal.

5.1.5. The DOP particle size distribution shall be verified using "green line" filter discs supplied by TSI with a known penetration range. Graphs of penetration vs. resistance for two sheets and five sheets of stacked filter discs are supplied with each lot of the standard filters, with a central line and upper and lower lines representing the expected penetration range at a given resistance. The test data should fall within an acceptance zone having boundaries defined by the upper and lower curves on the graphs. The standard filter test using both 2 sheets and 5 sheets will be run at least once in each 8 hour test period to verify that the aerosol distribution is within the acceptance zone.

5.2. Filters will be mounted and sealed on holders to prevent leakage around the filter holder. Single air purifying respirator filters will be tested at a challenge flow rate of 85 ± 4 Lpm. Filters used as pairs on a respirator are tested using a single filter of the pair at 42.5 ± 2 Lpm challenge flow rate. Filters used in threes are tested using a single filter of the set at 28.3 ± 1 Lpm challenge flow rate.

5.2.1. The challenge flow rate must be checked for stability for at least 30 seconds prior to testing.

5.3. A sample of 20 filter units will be tested against the DOP liquid aerosol. The filters shall be subjected to aerosol mass loading levels as shown in the table below. This is the mass amount of DOP aerosol that has contacted the filter.

Number of Filters In Respirator Configuration	Initial Loading Level	Incremental Loading	Maximum Loading Level
Single	215 ± 5 mg.	30 ± 5 mg.	415 ± 5 mg.
Double	115 ± 5 mg.	30 ± 5 mg.	215 ± 5 mg.
Triple	85 ± 5 mg.	30 ± 5 mg.	155 ± 5 mg.

5.3.1. For PAPR100-P series filters, if the bandwidth (range) in penetration readings is equal to or less than 0.004% for the last 30 ± 5 mg at the initial loading level or within a subsequent incremental loading level, the filter passes the test. If the bandwidth in penetration readings is greater than 0.004% and not clearly decreasing, then the filter penetration is continuing to increase. The test is continued through the next 30 ± 5 mg of loading until the bandwidth in penetration readings is equal to or less than 0.004% for the incremental loading level or the penetration level exceeds the maximum allowable level. The test is concluded and the filter is determined to fail the test if the bandwidth in penetration readings is greater than 0.004% for the last 30 ± 5 mg ending at the maximum loading level indicated in the table above, or the maximum penetration exceeds 0.03%.

5.3.2. If any one of the 20 filters have a penetration greater than 0.03%, further testing of that filter will be terminated. Any filter that exceeds the specified limit shall be remounted and retested to ensure that leakage was not caused by a mounting leak. If retesting eliminates the excessive leakage and testing has gone beyond the initial penetration, that sample will be considered an invalid sample, and another tested in its place.

5.4. Determine and record on the data sheet the maximum filter penetration for each of the 20 filters, and the bandwidth readings over the 30 ± 5 mg on which the “no further decrease in efficiency” determination is made or the initial unacceptable bandwidth readings.

6. PASS/FAIL CRITERIA

6.1. The requirement for passing this test is set forth in 42 CFR, Part 84, Subpart K, Section 84.180.

6.2. The minimum efficiency for each of the 20 filters shall be determined and recorded and shall be equal to or greater than 99.97%.

6.3. In order for the performance of the sample of 20 filters or filter cartridges to be deemed acceptable, each filter tested shall meet or exceed the specified minimum efficiency level at the end point of the test. The bandwidth of the last 30 ± 5 mg for each filter tested shall be less than or equal to 0.004% if not clearly decreasing, before the maximum loading level specified in section 5.3 is reached.

7. RECORDS/TEST SHEETS

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

8. ATTACHMENTS

8.1. Example Data Sheet

8.2. Photograph of TSI 8130 CertiTester with chuck open

8.3. Close-up of respirator test fixture with the chuck closed

8.1. Example Data Sheet

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

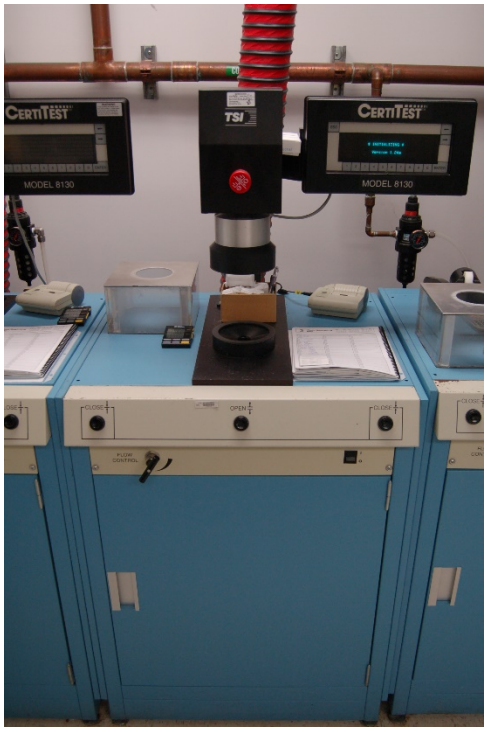
Task Number: TN-XXXXX **Reference No.:** CFR 84.180
Test: Sodium Chloride (NaCl) PAPR100-N **STP No.:**
Manufacturer: Company Name
Item Tested:

Filter	Flow Rate	Initial Filter Resistance	Maximum Allowable Percent Leakage	Initial Percent Leakage	Maximum Percent Leakage	Result
1	85	7.9	0.03	.002	.002	PASS
2	85	8.2	0.03	.002	.002	PASS
3	85	8.1	0.03	.001	.003	PASS
4	85	7.8	0.03	.003	.004	PASS
5	85	7.8	0.03	.001	.003	PASS
6	85	8.3	0.03	.002	.002	PASS
7	85	8.2	0.03	.001	.002	PASS
8	85	8.1	0.03	.002	.003	PASS
9	85	8.2	0.03	.001	.002	PASS
10	85	8.2	0.03	.001	.002	PASS
11	85	8.3	0.03	.002	.003	PASS
12	85	7.8	0.03	.001	.001	PASS
13	85	7.9	0.03	.001	.001	PASS
14	85	8.3	0.03	.002	.002	PASS
15	85	8.2	0.03	.001	.002	PASS
16	85	7.9	0.03	.002	.002	PASS
17	85	8.2	0.03	.002	.003	PASS
18	85	7.9	0.03	.001	.002	PASS
19	85	8.2	0.03	.000	.002	PASS
20	85	7.8	0.03	.002	.003	PASS

Overall Result: PASS

Signature: _____ **Date:**_____
Engineering Technician

8.2. Photograph of TSI 8130 with chuck open



8.3. Close-up of respirator test fixture with the chuck closed

Revision History

Revision	Date	Reason for Revision
0.0	23 March2020	Original release