"To promote and advance the common interest of those engaged in the air filtration industry"

NAFA User's Guide for Application of ASHRAE Standard 52.2

Method of Test

Final Draft

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National Air Filtration Association

The mission of NAFA is to conduct education and certification programs for members and end-user personnel; to provide forums for the exchange of information about technical standards, government regulations, and product information; to educate end-users about the importance of air filtration and NAFA's certifications; to certify air filtration products; to set field performance standards for products; and to explore ways to increase business for NAFA members.

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Forward

This pamphlet is designed to give the air filter specifier and user a primer on the use of ASHRAE Test Standard 52.2.

This guide has been assembled by the National Air Filtration Association, (NAFA) a group of over 200 air filter distributors, manufacturers and engineers. It is hoped that this guide will encourage the use and application of particle-based contaminant removal with filters so that building owners, managers and occupants can benefit from cleaner indoor air.

Special thanks for their contribution and help in assembling this document goes to:

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I. Why 52.2?

It has been more than a half century (the creation of the HEPA in 1943) since really good air filtration technology has been available. High-end filtration is well established in selected markets, such as health care, electronics, and pharmaceuticals, yet, it has not attained wide acceptance in general commercial buildings. One of the factors is the lack of meaningful test methods.

When Standard 52 was last revised in the late 1980's, there was a strong effort by the committee to bring about resolution to (52.1) weaknesses. However, at that time, there were too many unresolved issues to enable the development of a consensus standard. Thus, ASHRAE sponsored a Research Project to determine and resolve these questions so that a new SPS Committee could be formed to finalize the new Standard MOT (method of test). The outcome is Standard 52.2-1999, which resolved many of the weaknesses of the previous standard because of the following features:

- The standard was developed using mandatory language – this enables it to be referenced by other documents that are to be codified such as Standard 62-1999.
- The MOT employs a controlled laboratory generated aerosol (potassium chloride salt) – this enables accuracy and reproducibility from test to test and laboratory to laboratory.
- The MOT provides the minimum efficiency curves of filters over a particle size range of 12 size bands, from 0.3 to 10 micrometers in size – this allows the selection of the desired filtration efficiency against a known particle size.
- The MOT documents the minimum efficiency curves of filters through six stages of loading – this avoids the fiction of "averaging" and provides the "worst case" experience over the entire loading cycle.
- The MOT summarizes the above data into a single combined curve as the primary data product that typifies the minimum efficiency of a filter – this enables the simple reporting of the efficiency performance.

To simplify the general screening and selection process for users, the committee derived a shortcut "handle" to communicate the general category of efficiency performance. This is the Minimum Efficiency Reporting Value (MERV) that is derived by averaging the minimum particle size efficiencies in each of three size ranges. The MERV value is not intended to replace the minimum efficiency curve as the primary data product of the MOT. However, it provides marketers and specifiers an easy handle to specify the general range of efficiency required for specific tasks. Compliance to specifications and final selection or comparison should be based on the actual minimum efficiency performance curve.

II. Overview of Procedure and How Data Is Obtained

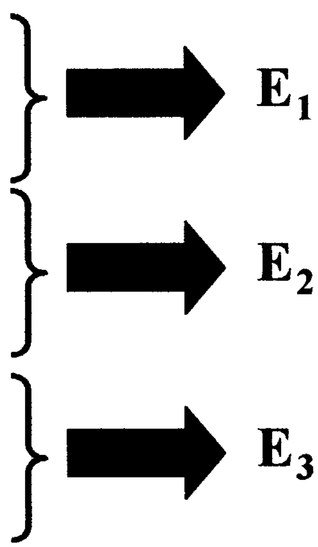
An air cleaner's filtration efficiency is computed from particle concentrations measured upstream and downstream of the air cleaner. The particle concentrations are measured with one or more laboratory instruments commonly known as aerosol particle counters. These instruments count and measure the size of individual microscopic airborne particles and typically operate by passing the particles through a high intensity light beam (often a laser) and use the amount of light scattered by each particle to determine its size.

For ASHRAE 52.2 tests, the aerosol particle counter covers the size range from 0.3 to 10 μm in a series of 12 sizing channels (see Figure 1). Each sizing channel covers a narrow range of particle size. For example, Channel 1 covers particles from 0.3 to 0.4 μm in diameter, Channel 2 from 0.4 to 0.55 μm, ... up to Channel 12 which covers particle sizes from 7 - 10 μm in diameter. These sizes are further classified into 3 efficiency ranges; E_1, E_2 and E_3.

Figure 1

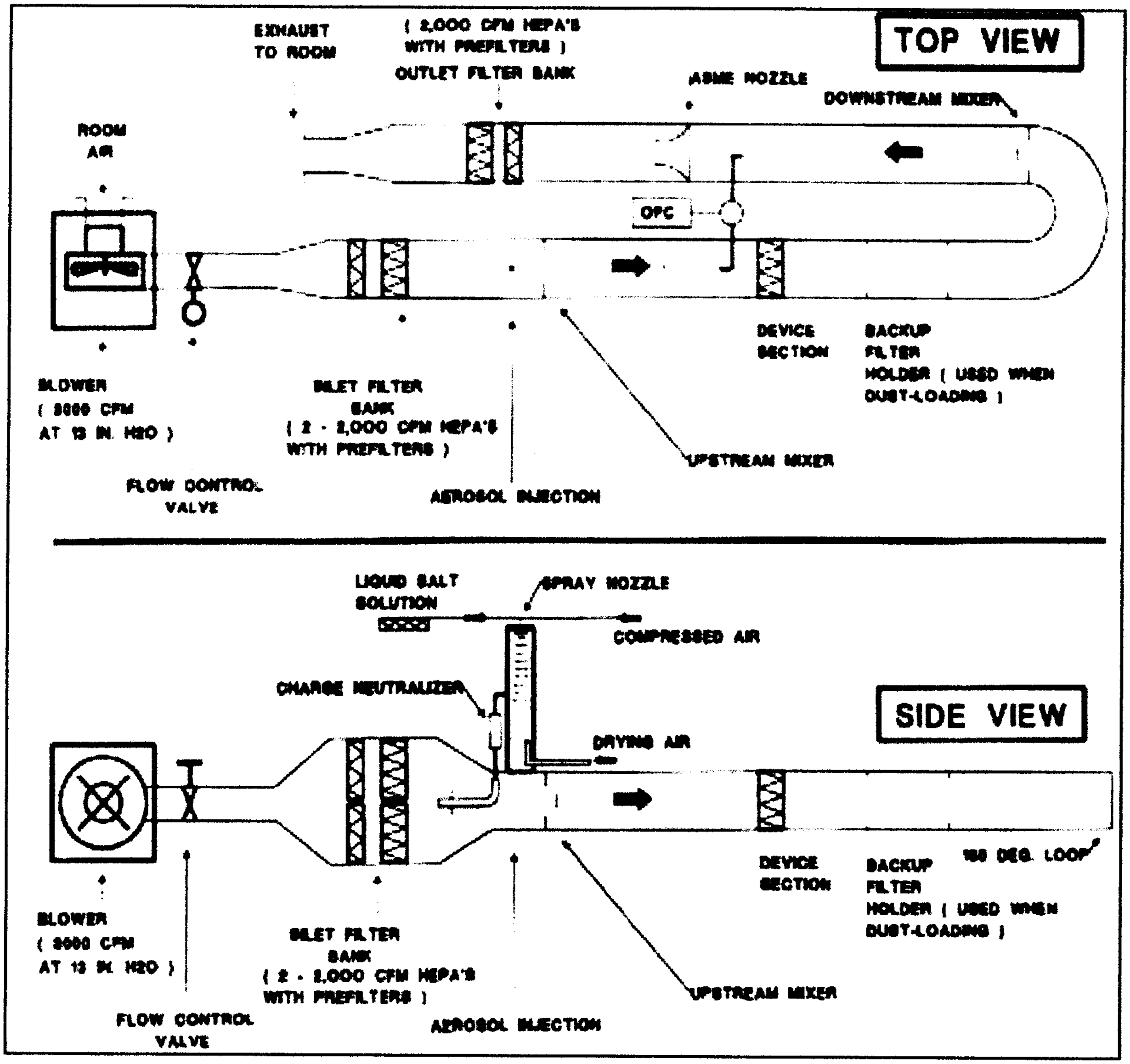
ASHRAE 52.2 Particle Size Range

Range	Size Range		Geometric Mean (microns)
	Lower Limit (microns)	Upper Limit (microns)	
1	0.30	0.40	0.35
2	0.40	0.55	0.47
3	0.55	0.70	0.62
4	0.70	1.00	0.84
5	1.00	1.30	1.14
6	1.30	1.60	1.44
7	1.60	2.20	1.88
8	2.20	3.00	2.57
9	3.00	4.00	3.46
10	4.00	5.50	4.69
11	5.50	7.00	6.20
12	7.00	10.00	8.37



After installing the air cleaner in the test duct (see Figure 2 - Test Duct Configuration), the test duct's blower is turned on and adjusted to provide the desired airflow rate through the air cleaner.

Figure 2



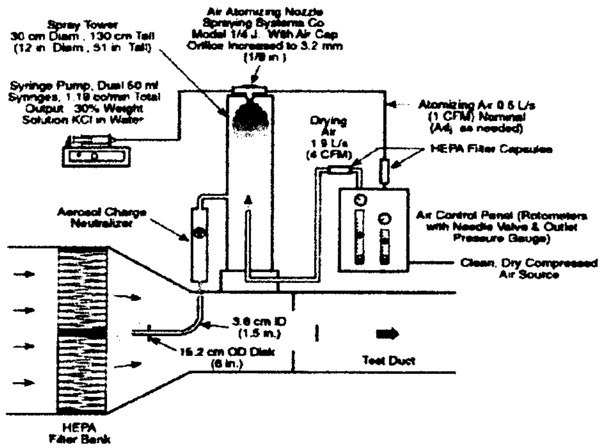


Figure 3 Particle Generator

The inlet air to the rig contains HEPA filters to remove the ambient aerosol from the air stream. A short distance downstream of the HEPA filters, a laboratory aerosol generator is used to produce the challenge aerosol. The generator (see Figure 3-Particle Generator) operates much like a small paint spray gun but instead of spraying paint, it atomizes a salt water solution (potassium chloride) to produce a very fine salt water spray.

The saltwater particles are dried in a low humidity air stream and then injected into the test duct where they mix with the air stream. This test aerosol spans the particle size range from 0.3 to 10 µm and provides a sufficient upstream concentration in each of the sizing channels to allow accurate calculation of filtration efficiencies up to 99%.

The test operator then uses the aerosol particle counter to sample the air upstream and downstream of the air cleaner. This can be done by using one aerosol particle counter that is switched back and forth between the upstream and downstream ducts (see Figure 4—Upstream/Downstream Switcher) or by using two aerosol particle counters with one sampling upstream and one sampling downstream

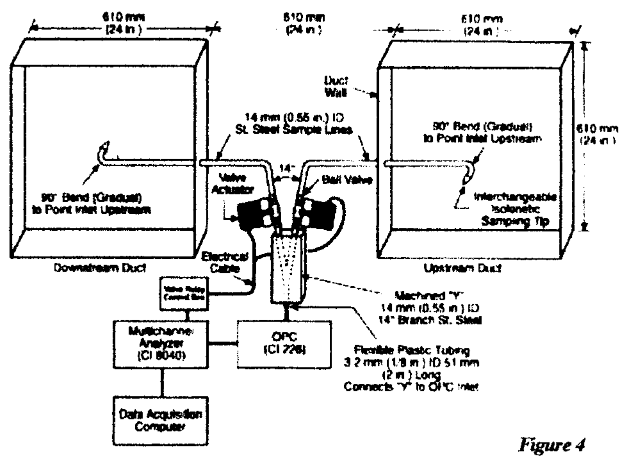


Figure 4

A minimum of three upstream and three downstream samples must be taken; additional samples are often needed to meet the statistical requirements in the standard.

Filtration efficiency is computed by taking the ratio of the downstream to upstream particle concentrations on a channel-by-channel basis: This calculation is performed for the clean air cleaner and after each of the five dust loading steps.

$$\text{Filtration Efficiency @ } 0.35\,\mu m = \left(1 - \frac{\text{Channel 1 downstream concentration}}{\text{Channel 1 upstream concentration}}\right)$$

$$\text{Filtration Efficiency @ } 0.47\,\mu m = \left(1 - \frac{\text{Channel 2 downstream concentration}}{\text{Channel 2 upstream concentration}}\right)$$

$$\text{Filtration Efficiency @ } 8.37\,\mu m = \left(1 - \frac{\text{Channel 12 downstream concentration}}{\text{Channel 12 upstream concentration}}\right)$$

Figure 5 is an example of a MERV 11 filter showing the 12 data points in each range of E1, E2 and E3 along with the average of the points. The computed efficiency values are then tabulated, presented graphically, and are used to compute the E1, E2, and E3 (see Figure 5) values needed to determine the MERV.

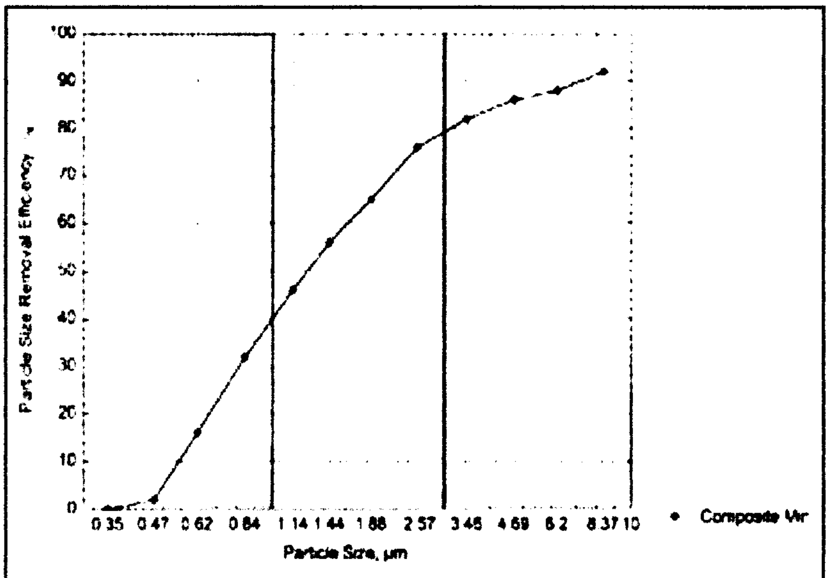
24 X 24 X 2 Pleat Filter @ 492 fpm

Dust Load	Initial	1st Load	2nd Load	3rd Load	4th Load	5th Load
Size Range (microns)	Fractional Efficiency (%)					
0.3-0.4	25.4	26.1	31.2	36.2	39.3	40.1
0.4-0.55	29.9	29.8	36.9	42.1	43.9	45.8
0.55-0.7	38.6	38.6	44.1	55.1	57.7	60.9
0.7-1.0	48.1	48.8	58.1	66.7	70.3	73.9
1.0-1.3	56.2	60.7	66.4	75.5	79.3	82.4
1.3-1.6	61.0	66.4	73.3	80.1	82.1	85.3
1.6-2.2	68.6	74.1	80.9	87.3	89.3	90.7
2.2-3.0	79.5	87.6	92.2	94.4	96.0	95.0
3.0-4.0	84.4	95.6	96.9	97.6	98.4	98.2
4.0-5.5	86.2	97.3	98.2	98.5	99.2	98.9
5.5-7.0	87.8	98.4	98.4	99.2	99.2	99.0
7.0-10.0	88.7	98.3	98.9	99.3	98.3	99.3

Composite Minimum Efficiency	
25.4	$E_1 = 35.5\%$
29.8	
38.6	
48.1	
56.2	$E_2 = 66.3\%$
61.0	
68.6	
79.5	
84.4	$E_3 = 86.8\%$
86.2	
87.8	
88.7	

Figure 5

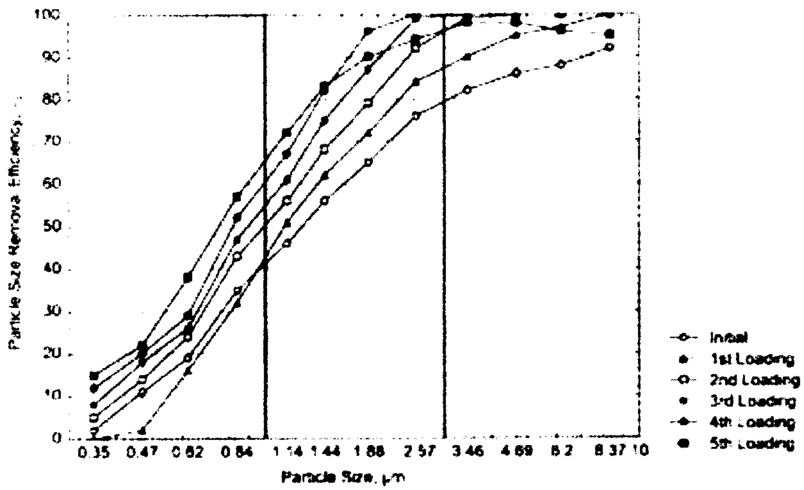
The first step is the use of the E1, E2 and E3 particle efficiency graphs that are part of the 52.2 test. (see Figure 6) These charts show the 12 data points of particle size efficiency removal of the filter at each of the stages of testing.



Composite minimum efficiency curve. (15)

Figure 6

The graph (see Figure 7) also shows all 5 efficiency curves through the initial loading and 5 test dust loadings to final pressure drop. The user can use this data to select the percent of removal of what size particle they need.



(b) PSE after incremental dust loading. (14)

Figure 7

III. How to Interpret and Apply 52.2 Data

Understanding how the 52.2 test is run provides you with the data needed to determine your filter MERV value. You must determine the size particle you wish to remove from the air stream and at what efficiency you wish it removed and then look on the 52.2 test data report to obtain it.

NOTE: You may wish to contact your local NAFA Certified Air Filter Specialist to obtain recommendations on the correct filter for your application. If this is not possible, you may retain the services of a company that performs particle counts to determine the size and number of particles in a space. If neither of the above are options, you may refer to the particle chart (Figure 9) to estimate the particle size and the filter that would remove it.

Figure 8

Minimum Efficiency Reporting Value (MERV) Parameters

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			Average Arrestance, %, by Standard 52.1 Method	Minimum Final Resistance	
	Range 1 0.30 - 1.0	Range 2 1.0 - 3.0	Range 3 3.0 - 10.0		Pa	in. of water
1	n/a	n/a	$E_3 < 20$	$A_{avg} < 65$	75	0.3
2	n/a	n/a	$E_3 < 20$	$65 \le A_{avg} < 70$	75	0.3
3	n/a	n/a	$E_3 < 20$	$70 \le A_{avg} < 75$	75	0.3
4	n/a	n/a	$E_3 < 20$	$75 \le A_{avg}$	75	0.3
5	n/a	n/a	$20 \le E_3 < 35$	n/a	150	0.6
6	n/a	n/a	$35 \le E_3 < 50$	n/a	150	0.6
7	n/a	n/a	$50 \le E_3 < 70$	n/a	150	0.6
8	n/a	n/a	$70 \le E_3$	n/a	150	0.6
9	n/a	$E_2 < 50$	$85 \le E_3$	n/a	250	1.0
10	n/a	$50 < E_2 < 65$	$85 < E_3$	n/a	250	1.0
11	n/a	$65 \le E_2 < 80$	$85 \le E_3$	n/a	250	1.0
12	n/a	$80 \le E_2$	$90 \le E_3$	n/a	250	1.0
13	$E_1 < 75$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
14	$75 \le E_1 < 85$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
15	$85 \le E_1 < 95$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	n/a	350	1.4

NOTE: The minimum final resistance shall be at least twice the initial resistance, or as specified above, whichever is greater. Refer to 10.7.1.1.[45]

Your filter manufacture's representative should furnish you with a test report on the filter performed by an independent testing laboratory (see note on NAFA Product Certification at the end of this text).

The final step is to find, on the Minimum Efficiency Reporting Value (MERV) chart (see Figure 6 – ASHRAE MERV Parameters) the percentage removal efficiency to determine the number assigned for this removal efficiency. The MERV number allows the user to immediately identify a filter's relative minimum efficiency by large or small particles. For example;

MERV 1-8 – removal efficiency of particles between 3.0 to 10.0 micrometers.
MERV 9-12 - removal efficiency of particles between 1.0 to 3.0 micrometers and between 3.0 to 10.0 micrometers.
MERV 13-16- removal efficiency of particles between 0.3 to 1.0 micrometers, 1.0 to 3.0 micrometers and 3.0 to 10.0 micrometers.

Dust loading graphs (Figure 7) provide the complete picture of filter efficiency on particle size at different steps in the dust loading procedure. We would recommend requesting a complete set of test data from your local NAFA filter distributor or filter manufacturer in order to understand the loading characteristics of the filter to final pressure drop.

As an example, let us assume that there is a problem in our building with dust. On the particle chart (Figure 9) dust falls in the range of between 0.5 and 100 micrometers and we refer to the testing data for 80% removal of this size particle and the filter that will accomplish this task. In this case, we would select a MERV 14 or better to accomplish this removal requirement.

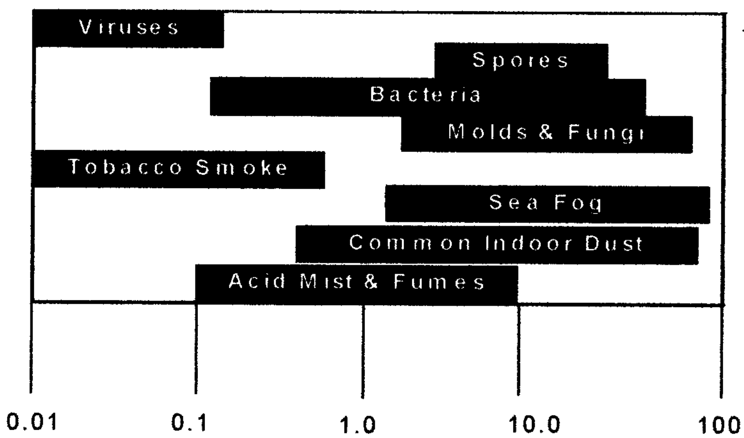


Figure 9

Relative particle Size of Airborne Contaminants

*For a more detailed description of particle sizes, see NAFA Guide to Air Filtration, Third Edition, Page 1.3 .

Addendum 1

Addendum 1 provides an approximate cross-reference of ANSI/ASHRAE Standard 52.1-1992 reporting methods (arrestance and atmospheric dust-spot efficiency) to the air cleaner MERV.

Application Guidelines

Std. 52.2 Minimum Efficiency Reporting Value (MERV)	Approx. Std. 52.1 Results		Application Guidelines		
	Duct Spot Efficiency	Arrestance	Typical Controlled Contaminant	Typical Applications and Limitations	Typical Air Filter/Cleaner Type
20 19 18 17	n/a n/a n/a n/a	n/a n/a n/a n/a	**≤0.30 µm Particle Size** Virus (unattached) Carbon dust Sea salt All combustion smoke Radon progeny	Cleanrooms Radioactive materials Pharmaceutical manufacturing Carcinogenic materials Orthopedic surgery	**HEPA/ULPA Filters** ≥99.999% efficiency on 0.10–0.20 µm particles, IEST Type F ≥99.999% efficiency on 0.30 µm particles, IEST Type D ≥99.99% efficiency on 0.30 µm particles, IEST Type C ≥99.97% efficiency on 0.30 µm particles, IEST Type A
16 15 14 13	n/a >95% 90–95% 80–90%	n/a n/a >98% >98%	**0.30–1.0 µm Particle Size** All bacteria Most tobacco smoke Droplet nuclei (sneeze) Cooking oil Most smoke Insecticide dust Copier toner Most face powder Most paint pigments	Hospital inpatient care General surgery Smoking lounges Superior commercial buildings	**Bag Filters** Nonsupported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300 mm (6 to 12 in.) deep may use lofted (air laid) or paper (wet laid) media.
12 11 10 9	70–75% 60–65% 50–55% 40–45%	>95% >95% >95% >90%	**1.0–3.0 µm Particle Size** Legionella Humidifier dust Lead dust Milled flour Coal dust Auto emissions Nebulizer drops Welding fumes	Superior residential Better commercial buildings Hospital laboratories	**Bag Filters** Nonsupported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300 mm (6 to 12 in.) deep may use lofted (air laid) or paper (wet laid) media.
8 7 6 5	30-35% 25-30% <20% <20%	>90% >90% 85–90% 80–85%	**3.0–10.0 µm Particle Size** Mold Spores Hair spray Fabric protector Dusting aids Cement dust Pudding mix Snuff Powdered milk	Commercial buildings Better residential Industrial workplaces Paint booth inlet air	**Pleated Filters** Disposable, extended surface, 25 to 125 mm (1 to 5 in.) thick with cotton-polyester blend media, cardboard frame. **Cartridge Filters** Graded density viscous coated cube or pocket filters, synthetic media **Throwaway** Disposable synthetic media panel filters
4 3 2 1	<20% <20% <20% <20%	75–80% 70–75% 65–70% <65%	**>10.0 µm Particle Size** Pollen Spanish moss Dust mites Sanding dust Spray paint dust Textile fibers Carpet fibers	Minimum filtration Residential Window air conditioners	**Throwaway** Disposable fiberglass or synthetic panel filters **Washable** Aluminum mesh, latex coated animal hair, or foam rubber panel filters **Electrostatic** Self charging (passive) woven polycarbonate panel filter

Note: A MERV for other than HEPA/ULPA filters also includes a test airflow rate, but it is not shown here because it has no significance for the purposes of this table.

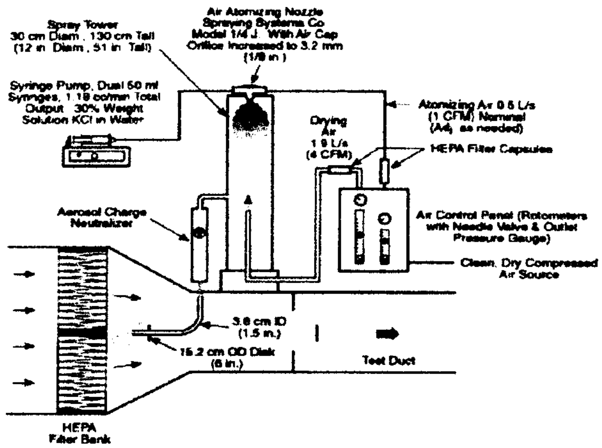


Figure 3 Particle Generator

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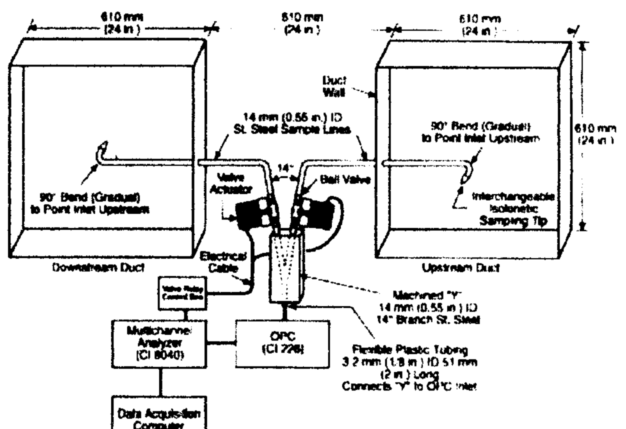

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