The Committee for Conformity Assessment of Accreditation and Certification on Functional and Technical Textiles

Specified Requirements of General Ventilation Air－Cleaning Devices for Removal Efficiency by Particle Size

Document No. FTTS-FP-104e

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1.Scope：

1.1 This specified requirements covers any type of general ventilation air-cleaning filters, including bag filter、panel filter、pleated filter and V type filter, and the same performance of air filters。

1.2 This specified requirements only apply to a method of laboratory testing to measure the performance of general ventilation air-cleaning devices .

1.3The specified requirements provides a method for counting airborne particles of 0.3 ～10 µm.The loading dust for testing the filtration device shall be composed, by weight, of 72 ％SAE（The society of Automotive Engineers, Appendix 1）J726, ，23 ％carbon black, and 5 ％milled cotton linters. or ISO 12103-1 A2 standardised air cleaner test dust（Appendix 2） ，or JIS Z8901 air cleaner test dust 15type（Appendix 3）.

2.Terminology：

2.1 Dust holding capacity－amount of loading dust retained by the filter up to final pressure drop（expressed in grams）.

2.2 Final pressure drop－pressure drop up to which the filtration performance is measured for classification purposes（expressed in Pa）.

2.3 Initial arrestance－arrestance of the first 30 g loading dust increment（expresses in ％）.

2.4 Initial efficiency－pressure drop of the clean filter operating at the test air flow rate（expressed in ％ for each size range of selected particles）.

2.5 Initial pressure drop－efficiency of the clean filter operating at the test air flow rate（expressed in Pa）.

2.6 Isokinetic sampling－sampling of the air within a duct such the probe inlet air velocity is the same as the velocity in the duct at the sampling point.

2.7 Loading dust－synthetic test dust specifically formulated for determining the dust holding capacity and arrestance of the filter.

2.8 Neutralisation－bring the aerosol tp a Boltzmann charge distribution（same amount of positive as negative ions in the aerosol）.

3.Performance specification：

The filters are classified 19 class according to their minimum efficiency reporting value（MERV） in the specified requirement。The MERV be based on three composite average particle size efficiency point developed from tests at manufacturer's specified air-flow rate。

TABLE 1 minimum efficiency reporting value parameters

MERV	composite average particle size efficiency % in size range（μm）			Average Arrestance,(%) (ASHRAE 52.1)	Minimum Final Resistance (Pa)
	Range 1（0.3~1.0）	Range 2（1.0~3.0）	Range 3（3.0~10.0）		
1	n/a	n/a	E3<20	Aavg<65	75
2	n/a	n/a	E3<20	65≦Aavg<70	75
3	n/a	n/a	E3<20	70≦Aavg<75	75
4	n/a	n/a	E3<20	Aavg≦75	75
5	n/a	n/a	20≦E3<35	n/a	150
6	n/a	n/a	35≦E3<50	n/a	150
7	n/a	n/a	50≦E3<70	n/a	150
8	n/a	n/a	70≦E3	n/a	150
9	n/a	E2<50	85≦E3	n/a	250
10	n/a	50≦E2<65	85≦E3	n/a	250
11	n/a	65≦E2<80	85≦E3	n/a	250
12	n/a	80≦E2	85≦E3	n/a	250
13	E1<75	90≦E2	90≦E3	n/a	350
14	75≦E1<85	90≦E2	90≦E3	n/a	350
15	85≦E1<95	90≦E2	90≦E3	n/a	350
16	95≦E1	95≦E2	95≦E3	n/a	350
17	≧99.97（0.3 μm）			n/a	n/a
18	≧99.99（0.3 μm）			n/a	n/a
19	≧99.999（0.3 μm）			n/a	n/a

4.Test method（Summary）：

4.1 Specimen preparation：

4.1.1 Test rig：nominal face dimension of 610 ㎜ ×610 ㎜。

4.1.2 Test condition：Temperature 10～38 ℃、Relative humidity 20～65 ％。

4.2 Test equipment：

4.2.1 Test duct：

(1)Air filter testing equipment are shown in the figures 1.The design of equipment not specified, including but not limited to blowers, valves, and external piping, is discretionary, but the equipment must have adequate capacity to meet this requirements .。

(2)The test duct is defined in figure 2、figure3,and is primarily of square cross section,610 ㎜ ×610 ㎜（24in. × 24 in.）.The duct material must be electrically grounded, have a smooth interior finish, and be sufficiently rigid to maintain its shape at the operating pressures. The inlet filter bank must contain high efficiency particulate air filters. Increasing the cross section of the duct at the inlet filter bank to accommodate more than 610 ㎜ ×610 ㎜（24in. × 24 in.）HEPA filter to minimize pressure drop is allowed. The inlet filter bank must discharge along the centerline of the upstream mixing orifice. The duct must be operated at positive pressure, the blower discharges into the duct upstream of the device。

(3)The bend in the duct is optional, thereby allowing both a straight duct and a U-shaped duct configuration. Except for the bend itself, all dimensions and components(including the downstream mixing orifice and baffle) are the same for the straight and U-shaped configurations。

(4)Room air or recirculated air shall be used as the test air source. The temperature of the air at the test device shall be between 10～38 ℃ with a relative humidity of20％ and 65 ％ Exhaust flow shall be discharged outdoors ,indoors ,or recirculated。

(5)An orifice plate and a mixing baffle shall be located downstream of the aerosol injection point. An identical orifice plate/mixing baffle shall be located downstream of the test device。

(6)The test aerosol shall be injected into the duct between the inlet filter bank and the upstream mixing orifice .the aerosol injection system shall product an upstream challenge that meet the qualification criteria of 5.3.The injection system design is discretionary so long as it fulfills this requirement。

(7) The test duct shall be isolated from vibration caused by the blower or other sources of vibration.。

(8) The test apparatus shown in Figure 1 is designed for test devices with nominal face dimensions of 610 ㎜ ×610 ㎜（24 in. × 24 in.） Transitions in accordance with Figures 3-a and 3-b shall be used for test devices with face areas from 60% to 150% of the normal test duct cross section area of 0.37 m^2 (4 ft^2). It is permitted to test a bank of several devices if the face area or an individual device is less than 60% of the duct area. It is also permitted to test specially sized air cleaners duplicating the structure of standard units if the size requirement cannot otherwise be met。

4.2.6 Test apparatus for test loading：

(1) The test apparatus and materials required by the dust loading procedure shall include：

(a) Dust feeder
(b) Dust injection tube
(c) Backup filter
(d) Backup filter duct section
(e)Loading test
(f) Seals for the particle counter sampling probes
(g)Dust feeder venturi calibrator.

(2) The dust-feed tube leading from the dust feeder to the center of the dust mixing orifice shall discharge along the centerline of the mixing orifice that is located on the centerline of the test duct.

(3) The general design of the dust feeder and its critical dimensions shall conform to Figures 5 and 6.Backflow through the pickup tube from the positive-pressure duct shall be prevented when the feeder is not in use.

(4) The aspirator venturi dimensions shall be monitored periodically in accordance with Table 4 to ensure that the tolerances shown in Figure 6 are met.

(5) The gauge pressure on the air line to the venturi corresponding to an airflow rate out of the dust-feeder pipe of 6.8±0.2 dm^3/s（14.5±0.5 cfm） shall be measured periodically in accordance with Table 3 The required gauge pressure on the ejector tube supply line necessary to provide this airflow at discharge duct pressures of 0. 500, 1000, 1500.2000, and 2500 Pa (0, 2, 4, 6, 8, and 10 in. of water) above ambient pressure shall be determined using the test device shown in Figure 7 The compressed air supply shall be fitted with a filter-dryer system to provide clean, oil-free air with a dew point no higher than 1.7 ℃（35 ℉）

4.3 Apparatus qualification testing：

4.3.1Apparatus qualification tests shall verify quantitatively that the test rig and sampling procedures are capable of providing reliable particle size efficiency measurements. The tests shall be performed in accordance with Table 3.

4.3.2 Qualification tests shall be performed for:

(1). Air velocity uniformity in the test duct
(2) Aerosol uniformity in the test duct
(3) Downstream mixing of aerosol
(4)Overload tests of the particle counter
(5)100% efficiency test
(6)Correlation ratio test
(7)Aerosol generator response time
(8)Duct leakage test
(9)Particle counter zero
(10)Particle counter sizing accuracy
(11)Radioactivity of the aerosol neutralizer
(12)Dust feeder airflow rate
(13)Final filter efficiency

4.3.3 Velocity Uniformity in the Test Duct：

(1) The uniformity of the challenge air velocity across the duct cross section shall be determined by a nine-point traverse (Figure 8- 1) in the 610㎜ x6l0㎜(24 in. x 24

in.)duct immediately upstream of the device section. The velocity measurements shall be made with an instrument having an accuracy of 10% with 0.05 m/s (approximately 10 fpm) resolution. The uniformity test shall be performed at airflow rates of 0.22, 0.93, and 1.4 m^3/s (472, 1970, and 2990 cfm).

(2) A one-minute average velocity shall be recorded at each grid point. The average must be based on at least ten readings taken at equal intervals during the one-minute period. The traverse shall then be repeated two more times to provide triplicate one-minute averages at each point for the given airflow rate. The average of the triplicate readings at each point shall be computed.

(3) The CV (where CV is the coefficient of variation computed as the standard deviation/mean) of the nine corresponding grid point air velocity values shall be less than 10％ at each airflow rate.

4.3.4 Aerosol Concentration Uniformity in the Test Duct：

(1) The uniformity of the challenge aerosol concentration across the duct cross section shall be determined by a nine-point traverse in the 610 ㎜ x 610 ㎜(24 in . **x** 24 in.) duct immediately upstream of the device section (at the location of the upstream sample probe), using the grid points as shown in Figure 8- 2.The traverse shall be made by either (a) installing nine sample probes of identical curvature, diameter, and inlet nozzle diameter but of variable vertical length or (b) repositioning a single probe. The inlet nozzle of the sample probe(s) shall be sharp edged and of appropriate entrance diameter to maintain isokinetic sampling within 10% at 0.93 m^3/s (1970 cfm). The same inlet nozzle diameter shall be used at all airflow rates.

(2) The aerosol concentration measurements shall be made with the particle counter meeting the specifications of 4.2.5. A one-minute sample shall be taken at each grid point with the aerosol generator operating. After sampling all nine points, the traverse shall be repeated four more times to provide a tota1 of five samples from each point. The five values for each point shall then be averaged for each of the 12 particle counter size ranges. The traverse measurements shall be performed at airflow rates of 0.22, 0.93, and 1.4 m^3/s (472.1970, and 2990 cfm).

(3) The CV of the corresponding nine grid point particle concentration shall be less than 15% for each airflow rates of in each of the 12 particle counter size ranges.

4.3.5 Downstream Mixing of Aerosol：

(1) A mixing test shall be performed to ensure that all aerosol that penetrates the air cleaner (media or flame) is detectable by the downstream sampler. The mixing test shall be performed at airflow rates of 0.22,0.93, and 1.4 m^3/s (472.1970, and 2990 cfm). The point of aerosol injection immediately downstream of the device section shall be traversed and the downstream sampling probe shall remain stationary in its normal center-of-duct sampling location.

(2) A HEP filter with face dimensions of 610 ㎜ x610 ㎜ (24 in. x 24 in.) shall be installed to obtain smooth airflow at the outlet of the device section. An aerosol nebulizer shall nebulize a KCl/water solution (prepared using a ratio of 300 g of KCl to 1000 mL water) into an aerosol of primarily submicrometer sizes A rigid extension tube with a length sufficient to reach each of the injection points shall be affixed to the nebulizer outlet. A 90° bend shall be placed at the outlet of' the tube to allow injection of the aerosol in the direction of the airflow. 'The injection probe shall point downstream. The aerosol shall be injected immediately downstream of

the HEPA filter at preselected points located around the perimeter of the test duct ;and at the center o f the duct as indicated in Fig 9. The flow rate through the nebulizer and the diameter of the injection tube outlet shall be adjusted to provide an injection air- velocity within ±50 ％ of the mean duct velocity.

(3) Sampling sequence: A one-minute sample from the downstream probe shall be acquired with the nebulizer operating 'and the injection tube positioned at the first injection grid point. The injection point shall to the next grid point location. A new one-minute sample shall be obtained after waiting at least 30 seconds. The procedure shall be repeated until all nine grid points have been sampled.

(4) The aerosol injection traverse shall be repeated two more times to provide triplicate measurement at each grid point.

(5) The downstream aerosol concentration shall be measured as total aerosol concentration >0.30 μm. The CV of the corresponding nine downstream grid point particle concentrations shall be less than 10% for each airflow rate

4.3.6Aerosol Generator Response Time

(1) Measure the time interval for the aerosol concentration to go from background level to steady test level. The test shall be performed at an airflow rate of 0.93 m^3/s (1970 cfm) with the particle counter sampling from the upstream probe. Similarly, measure the interval for the aerosol to return to background level after turning off the generator.

(2) Measure the time interval for the aerosol concentration to return to the background level after turning off the generator. These time intervals shall be used as the minimum waiting time between activating the aerosol generator and beginning the particle counter sampling sequence and deactivating the aerosol generator and beginning the particle counter sampling sequence for determination of background aerosol concentration.

4.3.7 Concentration Limit of the Particle Counter：

(1) A series of initial efficiency tests shall be performed over a range of challenge aerosol concentrations to determine a total concentration level for the PSE tests that does not over-load the particle counter(s). The lowest total concentration level shall be less than 1% of the instrument's stated total concentration limit. The tests shall be performed following the procedures of 4.4.1 through 4.4.3on a media-type air cleaner using a range of upstream aerosol concentration. The tests shall be performed at 0.93 m^3/s (1970 cfm). The filters selected for this test shall have an initial efficiency in the range of 30% Id 70% as measured by the 0.30 to 0.40 μm diameter size range and >90% efficiency for the 7.0μm to 10μm diameter size range.

(2) The aerosol for these tests shall be generated using the same system and procedures as specified in Section 4.4 for PSE tests.

(3) The tests shall be performed over a sufficient range of total challenge concentrations to demonstrate that the particle counter(s) is not overloaded at the intended test concentration.

4.3.8 100% Efficiency Test and Development of Purge Time：

(1) An initial efficiency test shall be performed using a HEPA or ULPA filter as the test device to ensure that the test duct and sampling system are capable of providing a >99% efficiency measurement. The test procedures for determination of PSE shall be performed following the procedures of 4.4.1 through 4.4.3, and

the test shall be performed at an airflow rate 0.93 m^3/s (1 970 cfm).

(2) The computed PSE values shall be greater than 99% for all particle sizes.

(3) One parameter affecting the efficiency during the 100% efficiency test is the purge time. The purge time is too short if, after switching form the upstream to the downstream line, residual particles from the upstream sample are counted during the downstream sampling and yield an efficiency of <99%. In this case, the purge time shall be increased and the 100% efficiency test repeated.

4.3.9 Correlation Test：

(1) A test shall be performed without a test device in place to check the adequacy of the overall duct, sampling, measurement, and aerosol generator.

(2) The test procedures for determination of the correlation ratio given in 4.4.2 shall be followed.

(3) The correlation ratio/or each particle size shall the requirements specified in Table 4

4.3.10 Test Duct Air Leakage Test

(1) Air leakage from the test duct shall not exceed 1% of the total airflow rate.

(2) The leak rate of the test duct shall be evaluated by a method similar to that delineated in ANSI/ASME Standard N510. The test duct shall be sealed immediately upstream of The aerosol injection location and immediately upstream of the exhaust filter bank by bolting a gasketed solid plate to the duct opening or other appropriate means. Carefully meter air into tile test duct until the lowest test pressure is achieved. The airflow rate required to maintain the pressure constant shall be measured and recorded as the leak rate, and the test shall then be repeated for the other two test pressures. The measured leak rates shall not exceed 1.0% of the corresponding test airflow rate.

(3) To establish the pressure for the leak test, the pressure at the aerosol injection location shall be measured with the duct operating at airflow rates of 0.22,0.93, and 1.4 m^3/s (472, 1970, and 2990 cfm) without a test device installed. To determine the test pressures, add 250 Pa (1 in. of water) to the measured pressures to account for the added resistance of an air cleaner.

(4) The highest pressure anticipated by this standard is 3200 Pa (13 in. of water). The user shall exercise caution and shall not pressurize the duct beyond its design limit for personal safety.

4.3.11 Particle Counter(s) Zero：

The zero count of the particle counter(s) shall be verified to be <10 total counts per sample time used during testing in the 0.30 μm to 10 μm size range when operating with a HEPA filter attached directly to the instrument's inlet.

4.3.12 Particle Counter(s) Sizing Accuracy：

The sizing accuracy of the particle counter(s) shall be checked by sampling an aerosol containing monodispersed polystyrene spheres of known size. A relative maximum particle count shall appear in the particle counter sizing channel that encompasses the PSL diameter.

4.3.13 Confirmation of the Activity of the Aerosol Neutralizer：

(1) The activity of the radiation source within the aerosol neutralizer shall be confirmed by use of an appropriate radiation detection device. The measurement may be relative (as opposed to absolute) but shall be adequate to indicate the presence of an active source and shall be capable of being performance in a

repeatable manner.

(2) The measurement shall be repeated annually and compared to prior measurements to determine if a substantial decrease in activity has occurred Replace neutralizers showing a lack of activity in accordance with the manufacturer's recommendations.

(3) The corona discharge level must be high enough to meet the same neutralizing level as from the radioactive source .

4.3.14 Dust feeder airflow rate：

Determine and record the gauge pressure on the compressed air line to the venturi necessary to provide an airflow rate of 6.8±0.2 dm^3/s (14.5±0.5 cfm) for discharge pressures of 0,500, 1000, 1500,2000, and 2500 Pa (0 , 2 , 4 , 6 , 8, and 10 in of water) above ambient pressure:

4.3.15 Final filter efficiency：

Weigh the final filter to the nearest 0.1 g and install it in the test duct without the test device installed. The method specified In 4.4.4 shall be used to challenge the filter with100 g of loading dust. Remove and weigh the filter. Its weight increase shall be within 2 g of 100 g.

4.3.16 Summary of Qualification Test Requirements：

Qualification test criteria shall conform to Table 4

4.3.17 Apparatus Maintenance：

Maintenance items and schedules shall conform to Table 5.

4.3.18 Reference Filter Check：

(1) For each test duct, a minimum of three identical reference filters shall be maintained by the testing facility solely for initial efficiency testing on a bi-weekly basis and shall not be exposed to dust loading. The three filters shall be labeled as "primary," "secondary," and "reserve." The "primary" filter shall be checked every two weeks. If the filtration efficiency curve shows a shift along the particle sizing axis of >l0% for any of the 12 particle sizing channels, the "secondary filter" shall be tested. If both the primary and secondary filters show shifts > 10% along the particle sizing axis for any of the 12 particle sizing channels, the particle counter shall be recalibrated or other system maintenance performed as needed (e.g., clean sample lines) to restore the reference filter efficiency test to <10% shift along the particle sizing axis. The "reserve" filter shall be used should either the primary or secondary filters become unusable (e.g., damaged).

(2) The measured pressure drop across the reference filter shall be within 10% 'of the reference value. If the pressure drop deviates by more than 10％, system maintenance shall be performed to restore the pressure drop to within10% of the reference value:.

(3) The reference filter test shall be performed at 0.93 m^3/s（1970 cfm）.

(4) The filtration efficiency of the reference filters shall pass through 50% efficiency in the particle diameter range of 1.0 to 3.0 μm and be <20% efficiency at 0.30 to 0.40 μm and >80%efficiency at the 0.30 to 0.40 μm range:

(5)Immediately after .calibration of the particle counter(s), retest each of the reference filters (or a new set of reference filters) to establish new filtration efficiency and pressure drop reference values.

(6) When either the primary or secondary filter shows shifts > 10% along the particle sizing axis for any of the 12 particle size ranges and the secondary or reserve filter does not, the primary and/or secondary filter shall be replaced with an identical filter or filters. if available, or a new set of identical reference filters shall be obtained

4.3.19 Pressure Drop Across Empty Test Section.：

The pressure drop across the empty test section shall be measured as part of each correlation test performed in accordance with Table 4. The measured pressure drop across the empty test section shall be less than 8 Pa (0.03 in. water)system maintenance shall be performed until the pressure drop is below 8Pa (0.03 in. water).

4.4 Test Procedures：

4.4.1Measurement of Resistance vs. Airflow ：

(1)The airflow rates and final resistances for test shall be selected by client If the client has not been specified .As a general rule, airflow rates for test shall be set 1971 cfm, and test to a final resistance of 350Pa，the other airflow rates shall be selected in accordance with Table 2。

(2) Measure and record the resistance of the device at a minimum of four airflow rates: 50%, 75%, 100%, and 125% of test airflow rate. Resistance shall be measured between the static taps.

Table 2、610 ㎜ × 610 ㎜ filter airflow rate

610 ㎜×610 ㎜ filter airflow rate	
meters^3/sec（m^3/s）	ft^3/min（cfm）
0.223	472
0.465	985
0.557	1180
0.706	1496
0.929	1971
1.189	2519
1.412	2992

4.4.2 Initial Efficiency Test：

(1)Test Sampling：

The sampling pattern in Figure 2 illustrates one iteration of a sequential upstream-downstream sampling sequence.

(2)Correlation Ratio：

(a) The correlation ratio *R* shall be used to correct for any bias between the upstream and downstream sampling systems. The correlation ratio shall be established from the ratio of downstream to upstream particle counts without the test device installed in the test duct and before testing an air cleaner and shall be performed at the airflow rate of the air cleaner PSE test. The general equation for the correlation ratio as used in this standard is

R＝（downstream particle concentration / upstream particle concentration）

(b) Background counts shall be made before generating test aerosols. Upstream and downstream sampling shall be done sequentially, The total number of samples and sampling times shall be determined by the data quality requirements

(c) Start generating aerosol when background counts are complete. Begin sampling after stabilization of the test aerosol, The total number of samples and sampling times shall be determined by the data quality requirements

(3)Penetration：The device shall be installed in the test section for determination of air cleaner penetration. For the purposes or this standard, penetration P shall be the fraction of particles that pass through the air cleaner, and the general equation for penetration shall be：

P ＝（downstream particle concentration / upstream particle concentration）

(4)Efficiency：The general equation for PSE(particle size removal efficiency)：

PSE（％）＝〔1－（downstream particle concentration / upstream particle concentration）〕×100

4.4.3 Data Reduction：

(1)Symbol and Subscripts：

(a)Symbol：

U＝upstream counts of each size range

D＝downstream counts of each size range R＝correlation ratio

P＝penetration

T＝sampling time

δ_g ＝standard deviation of sample

n＝number of sample sets

t＝t distribution variable

(b) Subscripts：

i＝sample number   o＝observed

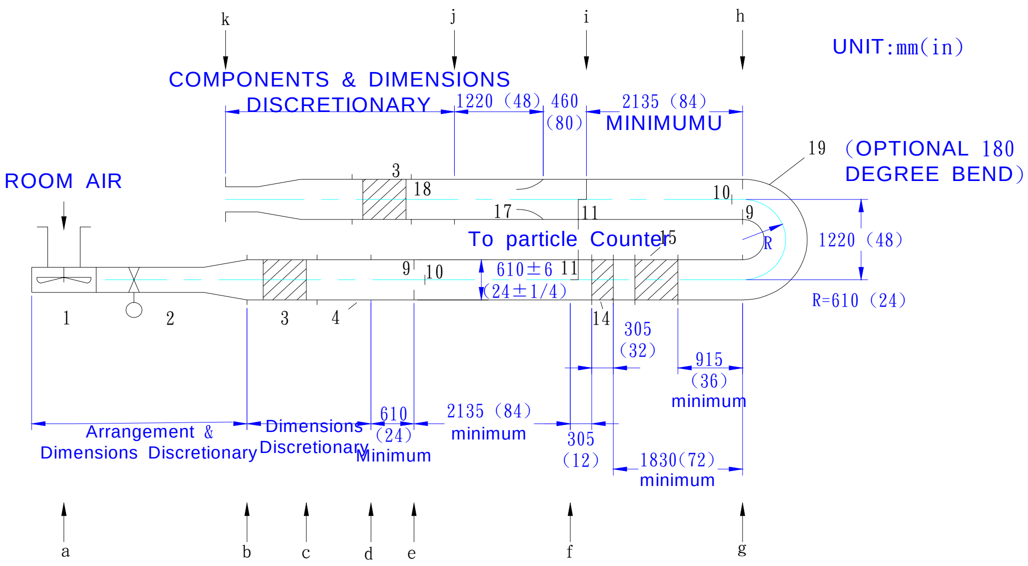
c＝correlation   b＝background

t＝testing an air cleaner   u＝upstream

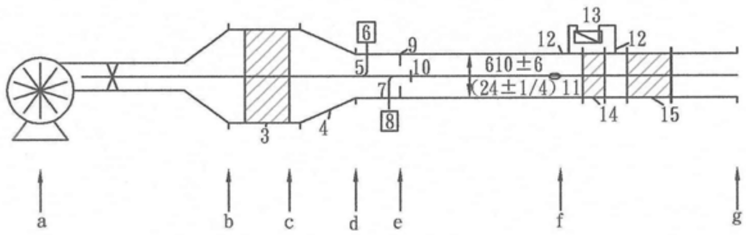
d＝downstream   e＝estimated

lcl＝lower confidence limit   ucl＝upper confidence limit

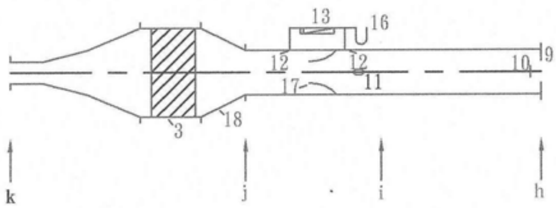
n＝number of sample sets



（a）Overall View of Test Duct



（b）Upstream Duct Detail



（c）Downstream Duct Detail

Figure 1 Schematic diagram of the test duct

1.Blower 2.Flow control valve 3.HEPA filter bank 4.Transition（From filter bank to 610 ㎜×610 ㎜） 5.Aerosol injection tube 6.Aerosol generator 7.Dust feed pipe 8.Dust feeder 9.Mixing orifice 10.Perforated diffusion plate 11Location of sample probe 12.Static tap 13.Manometer 14.Air cleaner device and transitions 15.Final filter 16.Vertical manometer 17.Main flow measurement nozzle 18.Trasition 19.Bend（optional）

Notes：

1.Duct segments「d」through「j」shall have a cross section of 610 ㎜ ×610 ㎜（24 in. × 24 in.），excluding the device section that has transitions as shown in Figure （a）、（b）and （c）。

2.「b」through「g」shall be in centerline alignment

3.「h」through「j」shall be in centerline alignment

4.Upstream airflow and aerosol traverse measurements in accordance with Section 4.3

shall be performanced at「f」

5.Aerosol injection shall occur between 「c」and「e」；design discretionary in accordance with 4.2.1

6.Side-by-side or over and under arrangements of the upstream and downstream sections of the test duct are allowed.

Dimensions：mm（in）

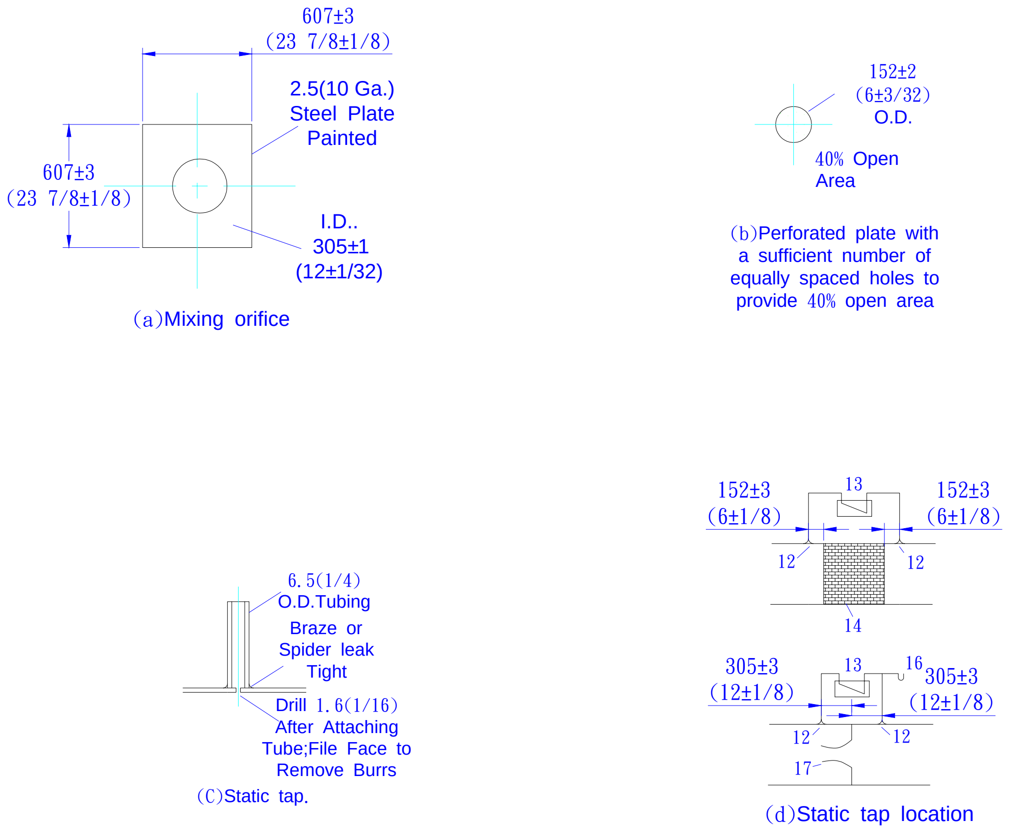
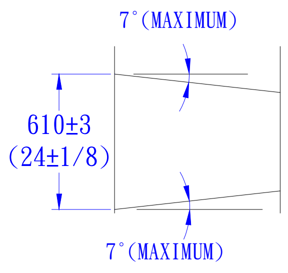
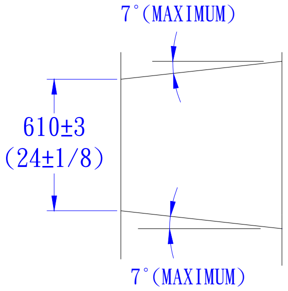


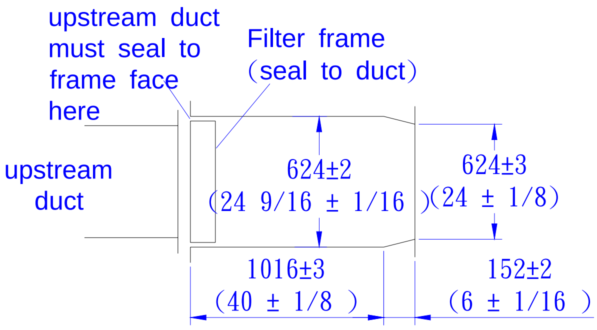
Figure 2 Details of test duct components



（a）Transition：test air cleaner dimensions smaller than test duct



（b）Transition：test air cleaner dimensions larger than test duct



（c）Allowable special duct section for non-rigid air cleaners

Figure 3. Details of transition duct and special duct components

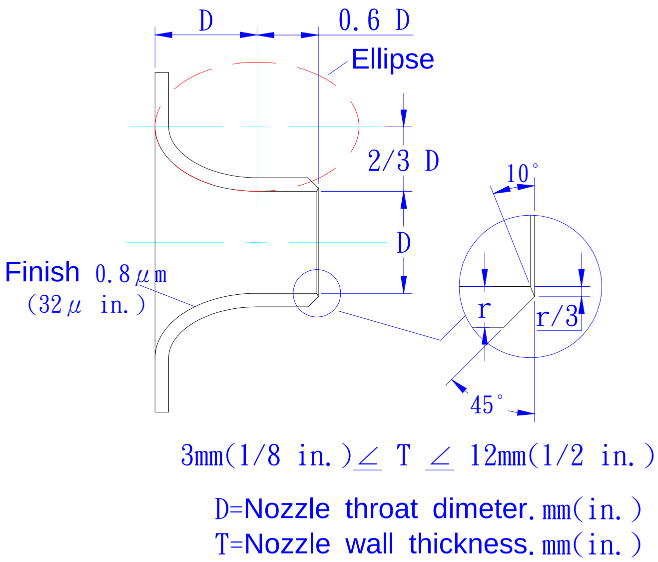


Figure 4 ASME long-radius flow nozzle dimensions

Unit：mm

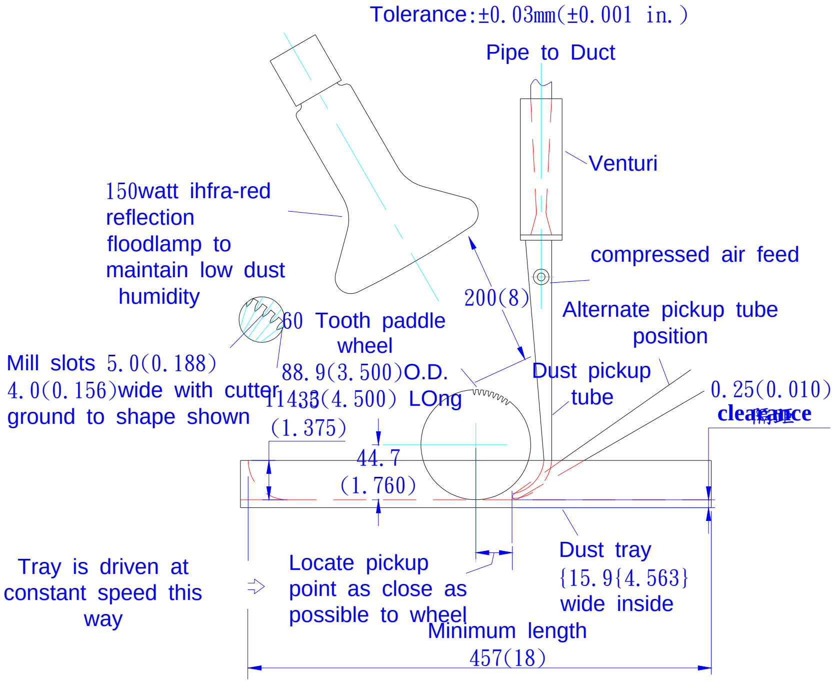


Figure 5 Critical dimensions of dust feeder assembly

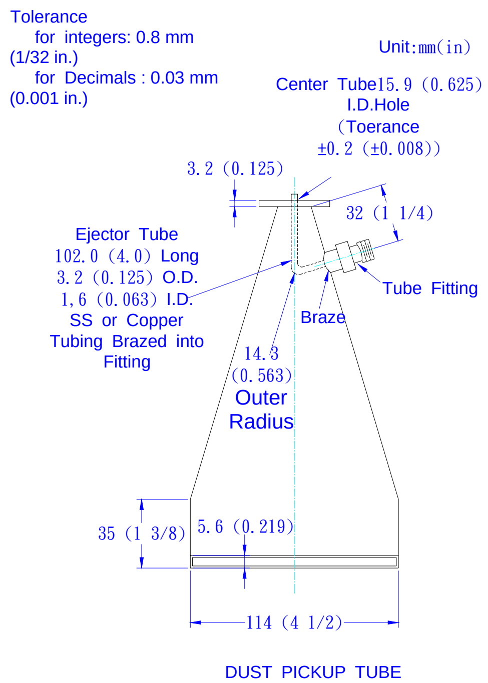


Figure 6（a）Dust Pickup Tube

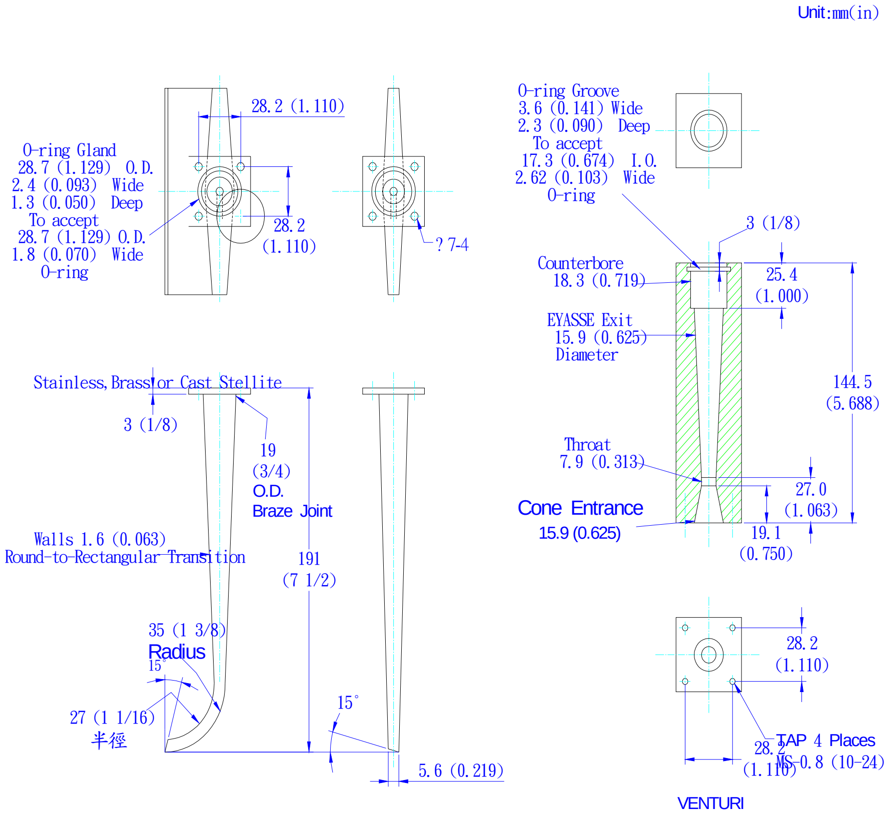


Figure 6（b）Dust feeder ejector/venture and pickup tube details

Table 3 Particle Counter Size Range Boundaries

Range	Size Range		Geometric Mean Particle Size （μm）
	Lower Limit（μm）	Upper Limit（μm）	
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

Table 4 System Qualification Measurement Requirements

Parameter	Requirement
Air Velocity Uniformity：Based on traverse measurements made over a 9-point equal-area grid at each test airflow rate	CV＜10 ％
Aerosol Uniformity：Based on traverse measurements made over a 9-point equal-area grid at each test airflow rate	CV％＜15 ％
Downstream Mixing：Based a 9 perimeter injection grid and center-of-duct downstream sampling	CV％＜10 ％
100 ％ Efficiency Test：Based on HEPA filter test	＞99 ％
Correlation Ratio Test	0.3～1.0 μm：0.9-1.10 ％ 1.0 ～3.0 μm：0.8-1.2 ％ 3.0～10.0 μm：0.7-1.3 ％
Upper Concentration Limit：Based on Limiting the concentration to below the level corresponding to the onset of coincidence error	No predetermined level
Aerosol Generator Response Time	No predetermined level
Duct Leakage: Ratio of leak rate to test airflow rate	＜1.0 ％
Particle Counter Zero Count Check：Based on HEPA filter attached to the instrument's inlet	＜10 counts per minute over the 0.3 μm-10.0 μm range
Particle Counter Sizing Accuracy Check：Based on sampling of aerosolized monodispersed PSL, spheres of known size	Relative maximum must appear in the appropriate sizing channel
Aerosol Neutralizer Activity：Based on detection of radioactive source within neutralizer	Radioactivity must be detected
Dust Feeder Airflow Rate As A Function Of Discharge Pressure：Based on determination of gauge pressures on ejector tube supply line to provide 6.8±0.2 dm^3/s（14.5±0.5 cfm）for discharge pressures of 0,500,1000,1500,2000 and 2500 Pa（0,2,4,6,8and10 in .water ）above ambient pressure	No predetermined gauge pressures .Gauge pressures are recorded in order to set the proper flow rate during the dust feeder operation
Final Filter Efficiency：Based on the difference between the quantity of dust injected and the quantity captured on the final filter with no test device in place	100±2 g captured for 100 g injected

Table 5 Apparatus Maintenance Schedule

Maintenance Item	Incorporated Into Each Test	Monthly	Bi-annually	After a change That May Alter Performance	Comment
Correlation ratio measurement	×				
Pressure drop across empty test section	×				
Background particle count	×				
Particle counter zero count	×				
Particle counter accuracy check	×				
Reference filter check					Every two weeks
100 ％Efficiency measurement		×			
Particle counter primary calibration using PSL					Note 1
Air velocity uniformity			×	×	
Aerosol uniformity			×	×	
Downstream mixing			×	×	
Generator response time			×	×	
Overloading test of particle counter			×	×	
Duct leak test			×	×	
Confirmation of neutralizer radioactivity			×		Note 5
Dust feeder airflow rate as a function of discharge pressure			×	×	
Measurement of venture dimensions for compliance with Figure 6				×	Every 500 hours of operation
Flow rate、pressure drop、temperature、relative humidity		Note 3			Note 2
Cleaning of test duct and components					Note 4

Note：

1. Calibration performed annually。
2. In accordance with manufacturer’s recommendations but at least annually。
3. Monthly visually inspection for proper installation and operation。
4. Cleaning intervals of the test duct, aerosol generator system ,aerosol sampling line, and other test component is discretionary。
5. Wash the inside of radioactive neutralizer every 100 hours of use .Check balance of the corona discharge ionizer monthly, per manufacturer’s instructions。

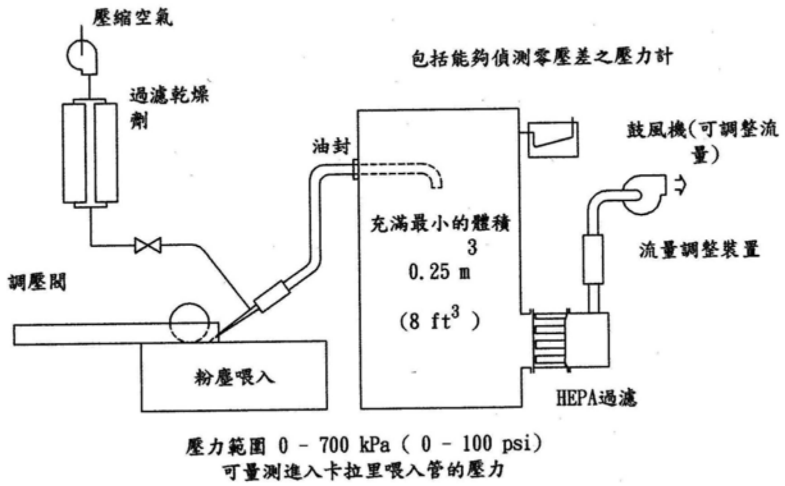


Figure 7 Dust feeder venture calibrator

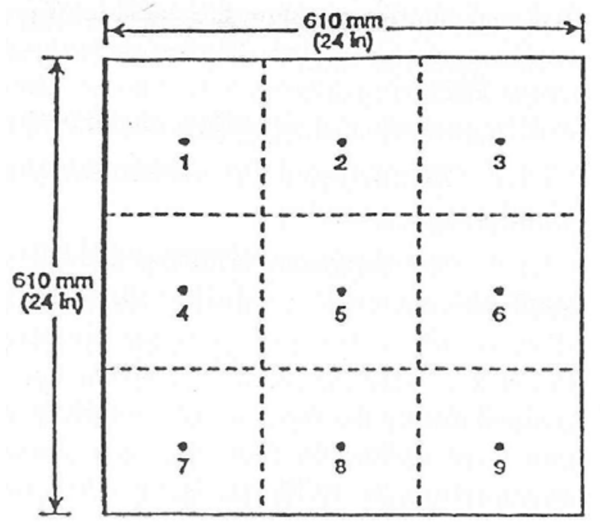


Figure 8-（a）Sampling grid with nine equal-area point for measuring the uniformity of air velocity and aerosol dispersion

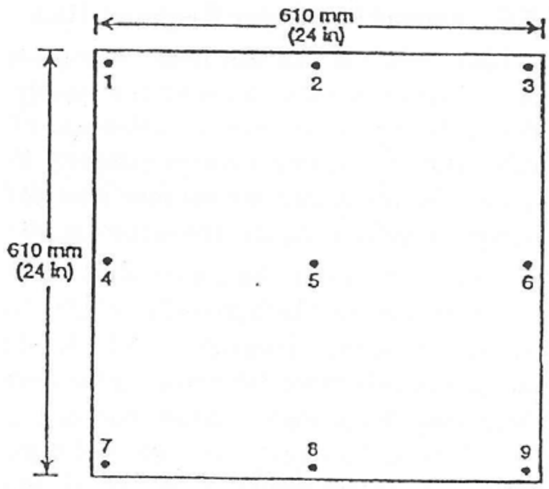


Figure 8-（b）Injection grid with nine equal-area point to assess downstream mixing .Perimeter point are 25 ㎜ from duct wall

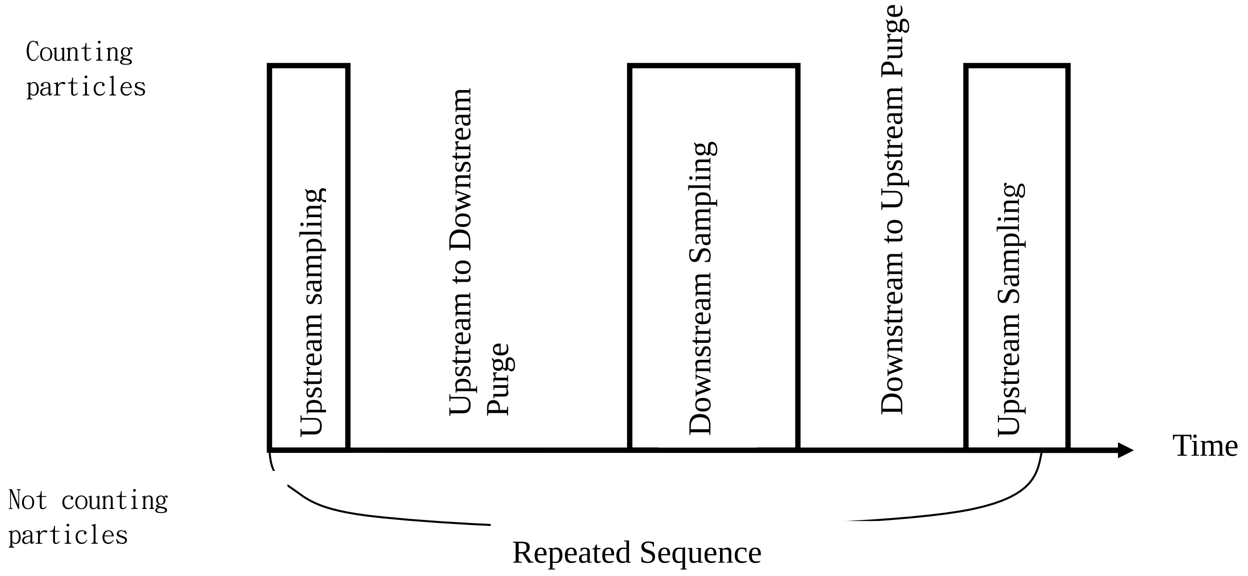


Figure 9 Sampling sequence

(2)Correlation Ratio Data Reduction

(a) The upstream counts from two samples shall be averaged to obtain an estimate of the upstream counts that would have occurred at the same time as the downstream counts where taken：

$$U_{i,o,c} = \frac{U_{i,o,c} + U_{(i+1),o,c}}{2} \qquad (4\text{-}1)$$

(b) The background counts before and after the correlation aerosol test generation shall be simply averaged：

$$\overline{U} = \frac{\sum_{i=1 \to n} U_{i,o,b}}{n} \qquad \overline{D} = \frac{\sum_{i=1 \to n} D_{i,o,b}}{n} \qquad (4\text{-}2)$$

(c) The correlation ratio shall be calculated for each upstream and downstream sample set using the observed downstream count, the estimated upstream count, the average downstream background count, and the average upstream：

$$R_i = \frac{D_{i,o,c} - \overline{D}_b}{U_{i,o,c} - \overline{U}_b} \qquad (4\text{-}3)$$

(d) These correlation ratios shall be averaged to determine a final correlation ratio value：

$$\overline{R} = \frac{\sum_{i=1 \to n} R_i}{n} \qquad (4\text{-}4)$$

(e)The standard deviation of the correlation ratio shall be determined by：

$$\delta_c = \sqrt{\sum_{i=1\to n}(R_i - \overline{R}) \Big/ n-1} \qquad (4\text{-}5)$$

(f)The standard deviation of the background counts shall be determined by：

$$\delta_{u,b} = \sqrt{\sum_{i=1\to n}(U_{,o,bi} - \overline{U_b})^2 \Big/ n-1} \qquad \delta_{d,b} = \sqrt{\sum_{i=1\to n}(D_{,o,bi} - \overline{D_b})^2 \Big/ n-1} \qquad (4\text{-}6)$$

(g)The 95% confidence limits of the correlation value shall be determined by：

$$\overline{R}_{lcl} = \overline{R} - \delta_c \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}7) \qquad \overline{R}_{ucl} = \overline{R} + \delta_c \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}8)$$

(h) The 95% upper confidence limits of the background counts shall be determined by：

$$\overline{U}_{b,ucl} = \overline{U_b} - \delta_{u,b} \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}9) \qquad \overline{D}_{b,ucl} = \overline{D_b} + \delta_{u,b} \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}10)$$

(3) Correlation Ratio Data Acceptance Criteria：

(a)Correlation Ratio Error Limit：

The number of correlation sample runs ***n*** shall be at least three and sufficient to satisfy the following conditions：

$\delta_c \cdot \frac{t}{\sqrt{n}} \leq 0.05$ for particle size range 1-8 （4-11）

$\delta_c \cdot \frac{t}{\sqrt{n}} \leq 0.10$ for particle size range 9 and 10 （4-12）

$\delta_c \cdot \frac{t}{\sqrt{n}} \leq 0.15$ for particle size range 11 and 12 （4-13）

This requirement shall be satisfied by calculating this expression after each sample set and halting the testing sequence when the requirement is reached for each size range, or by an acceptance criterion for a predetermined number of sample sets.。

(b)Limits on Magnitude of Correlation Ratio：

The correlation ratio shall meet the requirements specified in Table 4：

(c)Correlation Ratio Maximum Background Counts：

The 95% upper confidence limit of the upstream and downstream background counts shall be less than ***5%*** of the average estimated upstream count when the particle generation is on:

$$\overline{D}_{b,ucl}, \overline{U}_{b,ucl} < \frac{\sum_{i=1\to n} U_{i,e,c}}{n \cdot 20} \qquad (4\text{-}14)$$

(d) Correlation Ratio Minimum Average Counts：

The sum of the estimated upstream counts shall be greater than or equal to 500. If a sufficient number of counts is not obtained, the sample time or aerosol concentration shall be increased. The aerosol concentration shall not exceed the concentration limit of the particle counter, as determined by

$$\sum_{i=1\to n} U_{i.,e,c} \geq 500 \qquad (4\text{-}15)$$

(4) Penetration Data Reduction：

(a) The upstream counts from the first two samples shall be averaged to obtain an estimate of the upstream counts that would have occurred at the same time as the downstream counts where taken：

$$U_{i,e,l} = \frac{U_{i,o,t} + U_{(i+1),o,t}}{2} \qquad (4\text{-}16)$$

(b)The background counts before and after the penetration test shall be simply averaged：

$$\overline{U}_b = \frac{\sum_{i=1\to n} U_{i,o,b}}{n} \qquad \overline{D}_b = \frac{\sum_{i=1\to n} D_{i,o,b}}{n} \qquad (4\text{-}17)$$

(c)The observed penetration shall be calculated for each upstream and downstream set using the observed downstream count, the upstream count, the average downstream background count, the average upstream background count, the upstream sampling time, and the downstream sampling time：

$$P_{i,o} = \frac{D_{i,o,t} - \overline{D}_b}{U_{i,e,t} - \overline{U}_b} \cdot \frac{T_u}{T_d} \quad \text{if } \overline{D}_{b,ucl} \le 0.05 \frac{\sum_{i=1\to n} U_{i,o,u}}{n} \left[\frac{T_d}{T_u} \right] \qquad (4\text{-}18)$$

$$P_{i,o} = \frac{D_{i,o,t}}{U_{i,e,t}} \cdot \frac{T_u}{T_d} \quad \text{if } \overline{D}_{b,ucl} > 0.05 \frac{\sum_{i=1\to n} U_{i,o,u}}{n} \left[\frac{T_d}{T_u} \right] \qquad (4\text{-}19)$$

(d)These observed penetration shall be averaged to determine an average observed penetration value：

$$\overline{P_o} = \frac{\sum_{i=1\to n} P_{i,o}}{n}$$

(e)The standard deviation of the observed penetration shall be determined by：

$$\delta_t = \sqrt{\sum_{i=1\to n} (p_{i,o} - \overline{P_o}) \Big/ n-1} \qquad (4\text{-}20)$$

(f)The observed penetration shall be corrected by the correlation ratio to yield the final penetration：

$$\overline{P} = \frac{\overline{P_o}}{\overline{\overline{R}}} \qquad (4\text{-}21)$$

(g) The standard deviation of the correlation ratio shall be combined with the standard deviation of the observed penetration to determine the total error by：

$$\delta = \overline{P} \cdot \sqrt{\left(\frac{\delta_c}{\overline{\overline{R}}}\right)^2 + \left(\frac{\delta_t}{\overline{\overline{P_o}}}\right)^2} \qquad (4\text{-}22)$$

(h)The 95％ confidence limits of the penetration shall be determined by：

$$\overline{P}_{lcl} = \overline{P} - \delta \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}23) \qquad \overline{P}_{ucl} = \overline{P} + \delta \cdot \frac{t}{\sqrt{n}} \quad (4\text{-}24)$$

(i)The standard deviation and 95％ upper confidence limits for the background counts shall be determined using Equations（4-6）、（4-9）and（4-10）。

(5)Penetration Data Acceptance Criteria：

(a)Penetration Error Limit：

① The number of sample runs ***n*** shall be at least three and sufficient to satisfy the following conditions：

$$\delta \cdot \frac{t}{\sqrt{n}} \le 0.07 \cdot \overline{P} \text{ or} \le 0.05 \text{ whichever is greater, for particle size ranges 1-8} \quad (4\text{-}25)$$

$$\delta \cdot \frac{t}{\sqrt{n}} \le 0.15 \cdot \overline{P} \text{ or} \le 0.05 \text{ whichever is greater, for particle size ranges 9 and 10} \quad (4\text{-}26)$$

$$\delta \cdot \frac{t}{\sqrt{n}} \le 0.20 \cdot \overline{P} \text{ or} \le 0.05 \text{ whichever is greater, for particle size ranges 11 and 12} \quad (4\text{-}27)$$

This requirement shall be satisfied by calculating this expression after each sample set and halting the testing sequence when the requirement is reached for each size range, or by an acceptance criterion for a predetermined number of sample sets.。

②Penetration Maximum Background Counts：

For correlation tests and tests before dust loading, the 95% upper confidence limits of the upstream and downstream background counts shall be less than 5% of the average estimated upstream count when the particle generation is on:

$$\overline{D}_{b,ucl}, \overline{U}_{b,ucl} < \frac{\sum_{i=1 \to n} U_{i,e,c}}{n \cdot 20} \quad (4\text{-}28)$$

③Penetration Minimum Upstream Counts：

The sum of the estimated upstream counts shall be greater than or equal to 500。

$$\sum_{i=1 \to n} U_{i.,e,c} \ge 500 \quad (4\text{-}29)$$

(6) Efficiency：

Particle size removal efficiency PSE is determined by：

PSE＝（1-$\overline{P}$）×100　　（4-30）

4.4.4Dust Loading and Efficiency Test：

(1)Test Procedure：

(a) The test airflow rate shall be selected in accordance with 4.4.1. The final resistance shall be chosen using the Table 1 values as minimum, except that the final resistance shall be equal to or greater than twice the initial resistance。

(b) Particle size efficiency measurements shall be performed at intervals during the dust-loading procedure to establish a curve of efficiency as a function of dust loading. Efficiency curves shall be drawn for any or all of the particle size ranges of the test protocol. Efficiency measurements shall be made at the following points during the dust-loading procedure：

① before any dust is fed to the device;

② after an initial conditioning step with a dust loading of 30 g or an increase of 10 Pa (0.04 in. of water) pressure drop across the device, whichever comes first

③ after the dust-loading increments have achieved an airflow resistance increase of one-quarter, one-half, and three-quarters of the difference between the beginning and the prescribed end point limit of air flow resistance

④ after the dust increment that loads the device to its prescribed end point resistance limit

(2)Dust-Loading Procedure：

(a) The test duct shall be in the dust-loading configuration with the final filter installed. The dust feeder shall be positioned so that the feeder nozzle is centered in the inlet mixing orifice and the nozzle tip is in the same plane as the orifice. All airflow in the particle sampling lines shall be turned off and their inlets scaled to prevent the entry of loading dust.

(b) Weigh the quantity of dust to ±0.1 g for one increment of loading.

(c) Distribute the dust uniformly in the dust feeder tray. Dust shall be distributed with a depth that will provide a dust concentration in the test of 70±7 mg/m^3 （2.0±0.2 g/1000ft^3）

(d) Start the test duct blower and adjust to the test airflow rate for the test device

(e) Turn on the dust feeder heater lamp. Adjust the air pressure regulator on the dust feeder to give the required dust feeder- venturi airflow rate, 0.0068±0.0002 m^3/s（14.5±0.5 cfm）. This condition shall be maintained throughout the feed period. Start the dust feeder tray drive

(f) Maintain the test duct airflow rate at the test flow 52%. Vibrate or rap the dust feeder tube for 30 seconds

(g) Turn off the feeder tray drive and the airflow to the aspirator venturi. With the test duct airflow on, re-entrain any test dust in the duct upstream of the test device by use of a compressed air jet directed obliquely away from the device. Record the airflow resistance of the test device.

(h) If several dust increments are required to achieve one quarter of the required flow resistance increase of the device repeat the steps of (b) through (g). A complete dust increment shall be fed before running the next PSE test.

(i) Stop the test duct airflow and remove the final filter from the test duct. Remove any test dust deposited in the test duct between the test filler device and the final filter.

(3)Adjusting for Dust Migration：

(a) Air-flow shall be maintained through the device for 20 minutes. A duration of less than 20 minutes is allowable if a release rate of no more than *5%* is obtained in each of the particle size ranges.

(b) For the purposes of this standard, the release rate is the ratio of the number of released test dust particles from the filter after a dust-loading increment to the average number of upstream aerosol particles challenging the test device during the determination of the efficiency for a specific size range：

$$\text{Release rate（\%）} = \frac{D_{b,ucl}}{\frac{\sum_{i=1\rightarrow n} U_{i,o,u}}{n}} \left(\frac{T_u}{Td}\right) \times 100 \qquad (4\text{-}31)$$

(c) The efficiency of the air cleaner in a specific size range shall be reported as 0% if during a test run for PSE in that range the PSE is negative.

4.4.5 Reporting Results of Loading Tests：

(1)Results of loading tests shall be reported in the form of PSE curve for the test device：

(a)clean。

(b)after each incremental dust loading, a total of four curves

(c)at its final loading point。

(2) Develop a composite minimum efficiency curve by plotting the minimum PSE in each of the 12 size ranges shown on the plots of each of the six curves from 4.4.5(1)

(3) 'The four data points from the 4.4.5(2) composite curve in each of the three size

range groups from Table 6 shall be averaged and the resultant three average minimum PSEs (El, E2, and E3***)*** shall be reported.

(4)Test results shall be reported in accordance with 4.5 and the air cleaner's MERV shall be determined in accordance with 4.5(12)。

Table 6 Size Range Groups

Average minimum PSE Designator	Corresponding Size Range Group，μm
E_1	0.30 ～ 1.0
E_2	1.0 ～ 3.0
E_3	3.0 ～ 10

4.5 Testing Results：

4.5.1 The summary section of the performance report shall include the following information：

(1)Name and location of the test laboratory。

(2)Date of the test。

(3)Test operator's name(s)。

(4)Brand and model number of the particle counting and sizing device。

(5)Air cleaner manufacturer's name。

(6)How the sample was obtained。

(7)Description of the test air cleaner, including：

(a) Brand and model number。

(b)Physical description of construction。

(c)Face dimensions and depth。

(d)For fiber media air cleaners（Type、Color、Effective media area、Type and amount of dust adhesive、Electrostatic charge）。

(8)Operating data as stated by the manufacturer：

(a)Test condition：airflow rate and final pressure。

(b)initial and final resistances。

(c)any other operating data furnished。

(9)Test data：

(a)Test air temperature and relative humidity。

(b)Airflow rate。

(c)Loading dust weight。

(d)Type of test aerosol。

(10Results of resistance testing：

(a)Initial resistance 。

(b)Final resistance。

(11)Performance curves（Including Figure 11. Airflow vs. resistance of clean device、Figure 12.Particle size vs. efficiency、Figure 13. PSE after incremental dust loading、Figure 14. Composite minimum efficiency curve）。

(12)Minimum Efficiency Reporting Value：

(a)The average of the minimum PSE of the four size range from 0.30 μm to 1.0 μm（E_1）。

(b) The average of the minimum PSE of the four size range from 1.0 μm to 3.0 μm （E_2） 。

(c) The average of the minimum PSE of the four size range from 3.0 μm to 10.0 μm（E_3） 。

(d)MERV for the device。

Airflow rate in ％ of test airflow rate

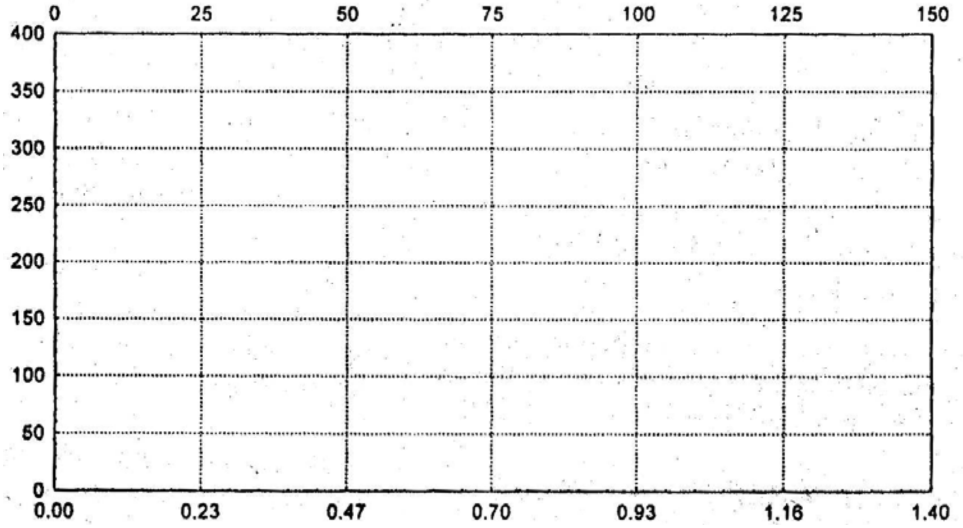
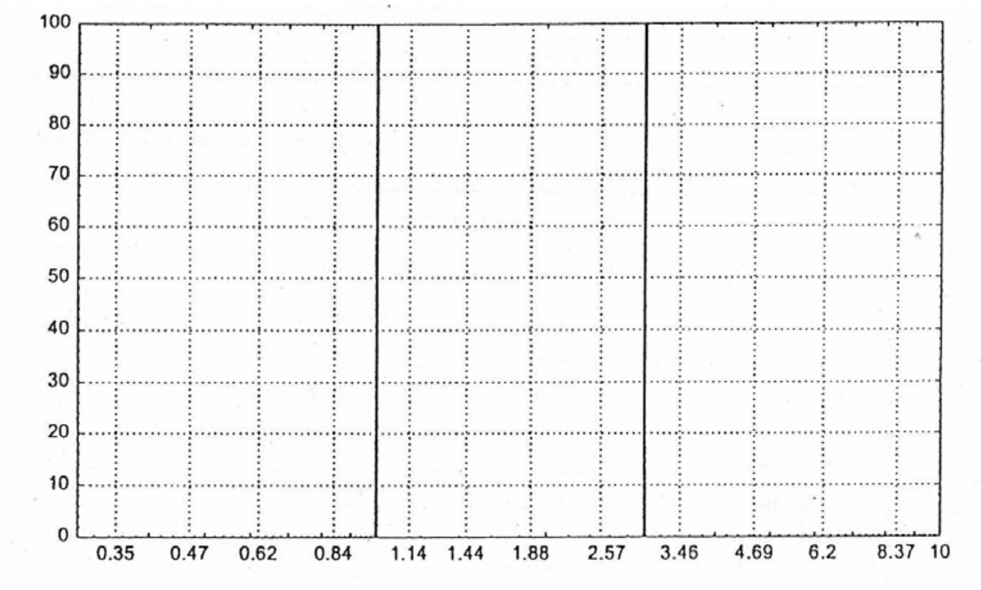


Figure 11 Airflow vs. resistance of clean device



Particle size, μm

Figure 12 Particle size vs. efficiency

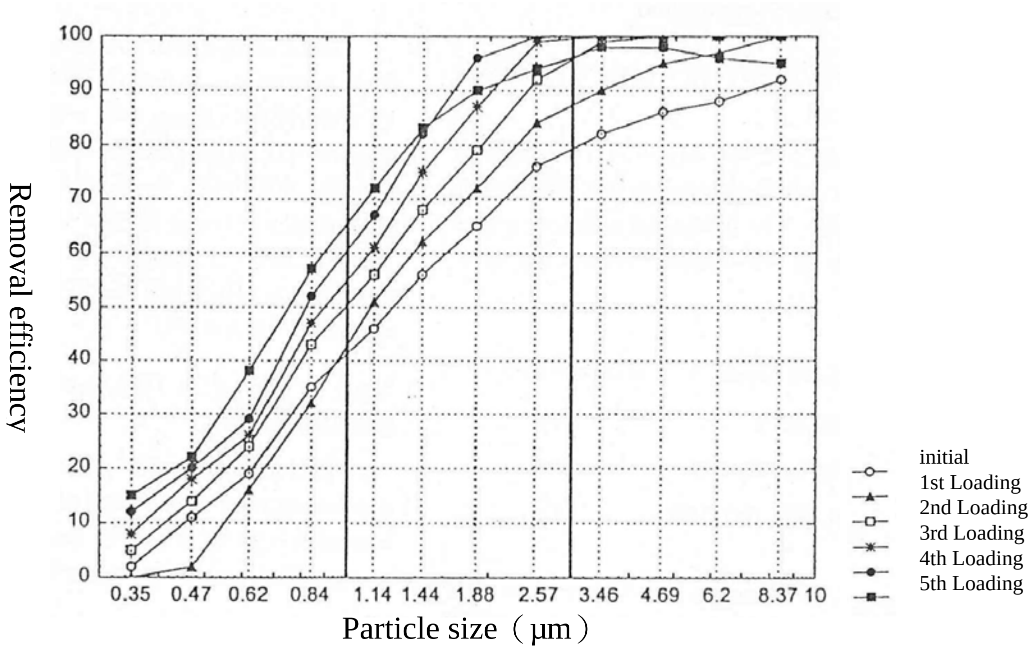


Fig 13.PSE after incremental dust loading

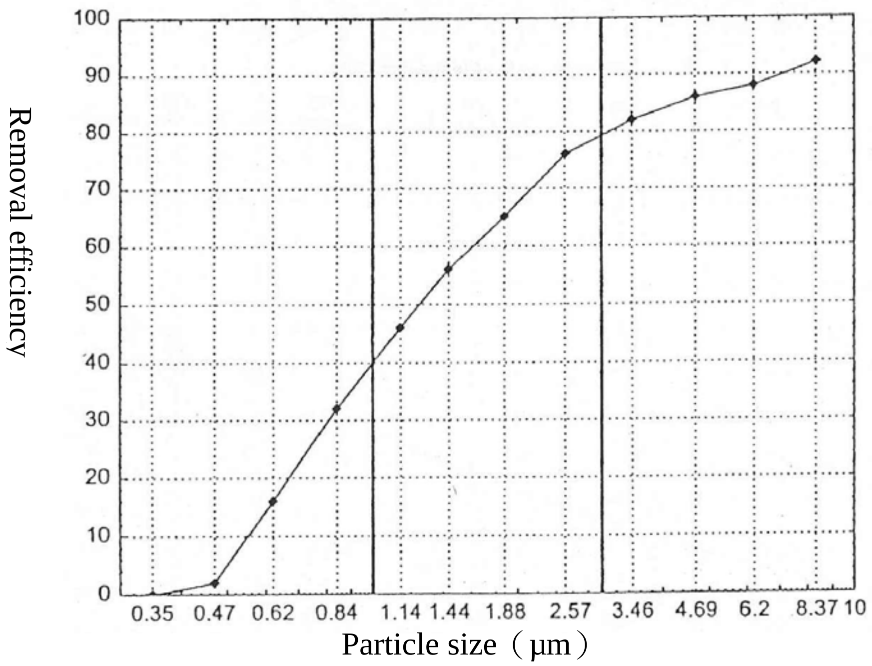


Figure 14.Compsiteminimumefficiency curve

5.Reference standard：

ANSI/ASHRAE Standard 52.2-1999 Method of Testing General Ventilation Air-cleaning Devices for Removal Efficiency by Particle Size

ANNEX 1： According to the Society of Automotive Engineers, SAE J726,the test dust contaminant shall be standardized and shall be of two grades labeled FINE and COASE. The following chemical analysis（Table 7、Table 8）is typical：

Table 7 Chemical analysis of dust

Chemical	%，of Weight
SiO_2	65-76
Al_2O_3	11-17
Fe_2O_3	2.5-5.0
Na_2O	2-4
CaO	3-6
MgO	0.5-1.5
TiO_2	0.5-1.0
$V2O_3$	0.10
ZrO	0.10
BaO	0.10
Loss on ignition	2-4

Table 8 Particle Size Distribution by Volume，%

Size,Microns	Fine Grade（%、less than）	Coase Grade（%、less than）
5.5	38±3	13±3
11	24±3	24±3
22	71±3	37±3
44	89±3	56±3
88	97±3	84±3
176	100	100

ANNEX 2： Test dust according to ISO 12103-1 A2 are manufactured from Arizona desert sand，The following particle size distribution（Table 9）is typical：

Table 9 Particle size distribution

Size（μm）	Maximum volume fraction（%）
	A2
	fine
1	2.5 to 3.5
2	10.5 to 12.5
3	18.5 to 22.0
4	25.5 to 29.5
5	31 to 36
7	41 to 46
10	50 to 54
20	70 to 74
40	88 to 91
80	99.5 to 100
120	100
180	------
200	------

ANNEX 3：The 15 type test dust are composed of 8 type test dust and 12 type test dust. according to of JIS Z8901. The following chemical content（Table 10）is typical：

Table 10 The chemical content of the15 type test dust according to JIS Z8901

Test dust	8 type test dust	12 type test dust	Cotton Linter
Mass fraction（%）	72	23	5
Composition	0-5μm 39%	0.03～0.20μm	Diameter 1.5μm Length 1mm 以下
	5-10μm 18%		
	10-20μm 16%		
	20-30μm 12%		
	30-40μm 6%		
	40-75μm 9%		
	Total 100%		
Note	The same as Arizona test dust	The same as Carbon black	