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ANSI/ASHRAE Standard 52.2

ASHRAE Standard 52.2 was originally released as a standard in 1999. This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC), which has established a documented program for regular publication of addenda or revisions. The most recent publication is ASHRAE Standard 52.2-2017. The title of the standard is:

"Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size"

As the name implies, the standard provides a methodology for determining a filter's efficiency in removing various sizes of particles as the filter becomes loaded. The standard also measures the filter's resistance to airflow when clean. In 2008, the arrestance test and dust holding capacity (DHC) from ASHRAE Standard 52.1 were added to ASHRAE Standard 52.2.

Removal efficiency is calculated by counting the number of particles upstream and downstream of the filter through a range of particle sizes, detailed in the table below. The challenge aerosol is poly-dispersed solid-phase (dry) potassium chloride (KCl) particles generated from an aqueous solution. The removal efficiency is measured when the filter is clean and after each of 5 incremental dust loadings as the filter is loaded to its final resistance. Fractional efficiency curves are developed for the clean filter and after each dust loading. A composite minimum efficiency curve is developed, which reflects the lowest efficiency for each particle size from the 6 curves.

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

The composite minimum efficiency curve has all of the detailed data to make an appropriate filter selection. For example, if filters are being used to clean the air supplied to a paint booth where particles 4 micron and larger can cause a defect in the painted finish, filters that remove 100% of the particles in range 9 through range 12 when tested can be selected. However, to simplify the selection and specification of air filters, the test standard provides an "overall" reporting value of a 52.2 evaluated air filter expressed as the Minimum Efficiency Reporting Value (MERV).

MERV is a single number on a 16 point scale that is determined by placing the efficiencies of the 12 size ranges from the composite minimum efficiency curve into three larger groups as follows:

E1 = Ranges 1 to 4 (0.3 to 1.0 µm)

E2 = Ranges 5 to 8 (1.0 to 3.0 µm)

E3 = Ranges 9 to 12 (3.0 to 10 µm)

The efficiency for each group is arrived at by averaging the composite minimum efficiencies of the 4 ranges.

Range	Size	Group
1	0.30 to 0.40	E1
2	0.40 to 0.55	E1
3	0.55 to 0.70	E1
4	0.70 to 1.00	E1
5	1.00 to 1.30	E2
6	1.30 to 1.60	E2
7	1.60 to 2.20	E2
8	2.20 to 3.00	E2
9	3.00 to 4.00	E3
10	4.00 to 5.50	E3
11	5.50 to 7.00	E3
12	7.00 to 10.00	E3

The average particle-size efficiency (PSE) for each group is referenced against the MERV parameters (see table below). Moving up from the bottom of the table, the MERV rating will be in the left hand column of the first row, where that PSE for each group generates a true statement. For example, if the PSE for Range 3 is 81%, and the PSE for Range 2 is 42%, the filter would be MERV 9 (Range 1 efficiency is not taken into consideration for MERV 9).

Minimum Efficiency Reporting Value (MERV) Parameters Table

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			Average Arrestance, %
	Range 1 0.30-1.0	Range 2 1.0-3.0	Range 3 3.0-10.0	
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \leq A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \leq A_{avg}$
4	N/A	N/A	$E_3 < 20$	$75 \leq A_{avg}$
5	N/A	N/A	$20 \leq E_3$	N/A
6	N/A	N/A	$35 \leq E_3$	N/A
7	N/A	N/A	$50 \leq E_3$	N/A
8	N/A	$20 \leq E_2$	$70 \leq E_3$	N/A
9	N/A	$35 \leq E_2$	$75 \leq E_3$	N/A
10	N/A	$50 \leq E_2$	$80 \leq E_3$	N/A
11	$20 \leq E_1$	$65 \leq E_2$	$85 \leq E_3$	N/A
12	$35 \leq E_1$	$80 \leq E_2$	$90 \leq E_3$	N/A
13	$50 \leq E_1$	$85 \leq E_2$	$90 \leq E_3$	N/A
14	$75 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
15	$85 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
16	$95 \leq E_1$	$95 \leq E_2$	$95 \leq E_3$	N/A

Filters that have a Range 3 value of less than 20% undergo an Arrestance test to establish the MERV.

The arrestance test is also useful for comparing filters, particularly those that are MERV 10 and less. The removal efficiency tests to establish MERV are conducted with a dry aerosol. Some filters show declining efficiency values in Range 3 as the particle size gets larger. This is because the larger dry KCl particles do not adhere as well to dry clean media. A filter's ability to stop and retain the large KCl particles does not necessarily translate into a greater ability to capture dirt. There are MERV 9 and 10 filters that have lower arrestance values (capture less dirt) than MERV 8 filters. It is a good idea to compare the arrestance values and dust holding capacity (DHC) of filters MERV 10 and below to ensure you are getting good filtration value.

Appendix J

There have been many studies globally that have demonstrated a loss in efficiency in some filters as they are exposed to sub-micron particles. Appendix J was added to ASHRAE Standard 52.2 in 2008 as a non-ANSI approved, optional conditioning step to provide a method of identification of the drop in efficiency. The reported value per Appendix J is referred to as MERV 'A'. Filters tested per Standard 52.2 with the Appendix J option have both a MERV and a MERV 'A.'

A motion at the ASHRAE meetings in New York City in 2014 to make appendix J a mandatory part of the standard was subsequently voted down. For the time being, it remains an optional appendix.

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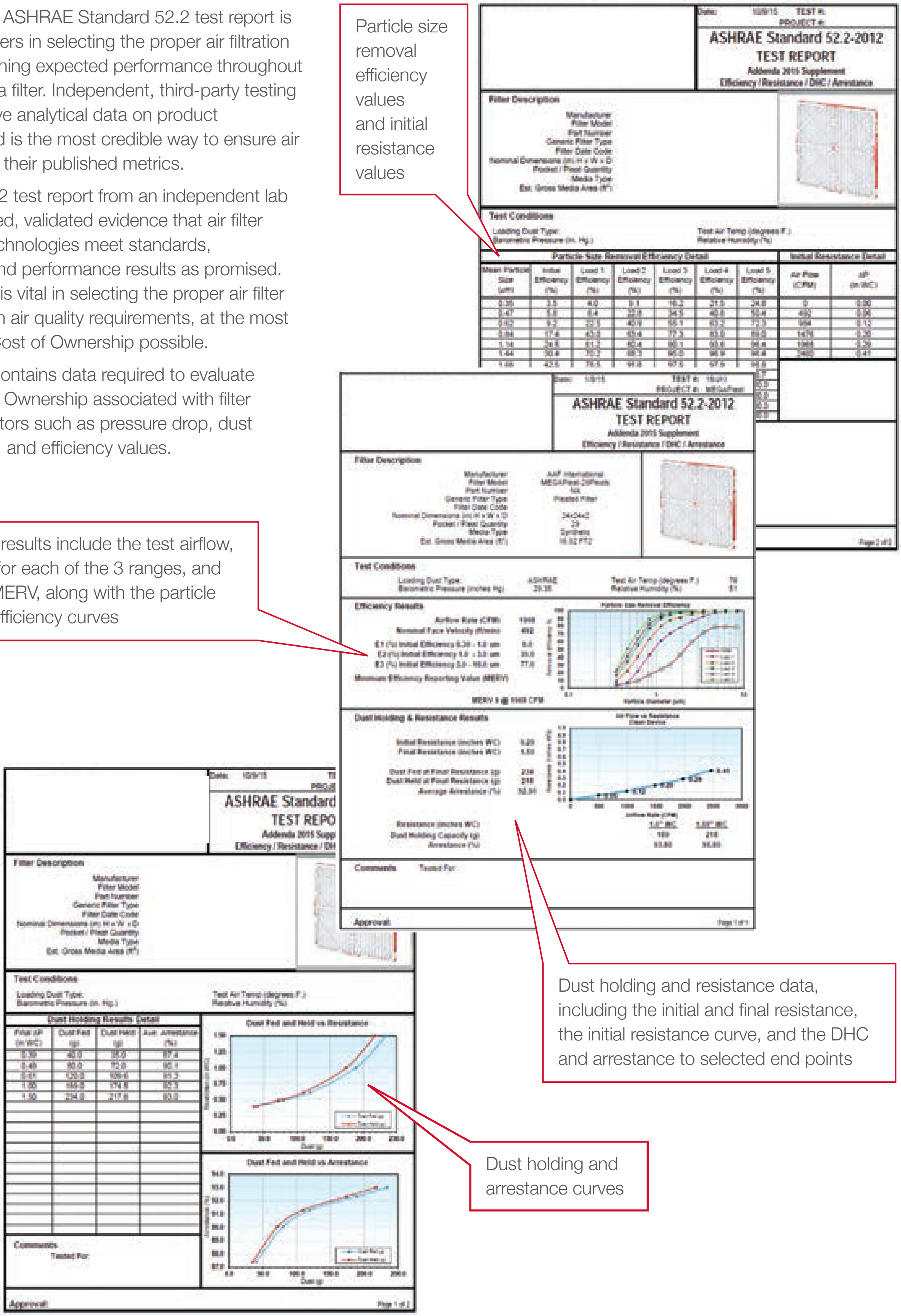
How to Read a Test Report

The intent of the ASHRAE Standard 52.2 test report is to assist customers in selecting the proper air filtration products by defining expected performance throughout the useful life of a filter. Independent, third-party testing provides objective analytical data on product performance and is the most credible way to ensure air filters perform to their published metrics.

An ASHRAE 52.2 test report from an independent lab provides unbiased, validated evidence that air filter products and technologies meet standards, specifications, and performance results as promised. This information is vital in selecting the proper air filter to meet optimum air quality requirements, at the most favorable Total Cost of Ownership possible.

The test report contains data required to evaluate the Total Cost of Ownership associated with filter performance factors such as pressure drop, dust holding capacity, and efficiency values.



Particle size removal efficiency values and initial resistance values

The efficiency results include the test airflow, the efficiency for each of the 3 ranges, and the resulting MERV, along with the particle size removal efficiency curves

Dust holding and resistance data, including the initial and final resistance, the initial resistance curve, and the DHC and arrestance to selected end points

Dust holding and arrestance curves

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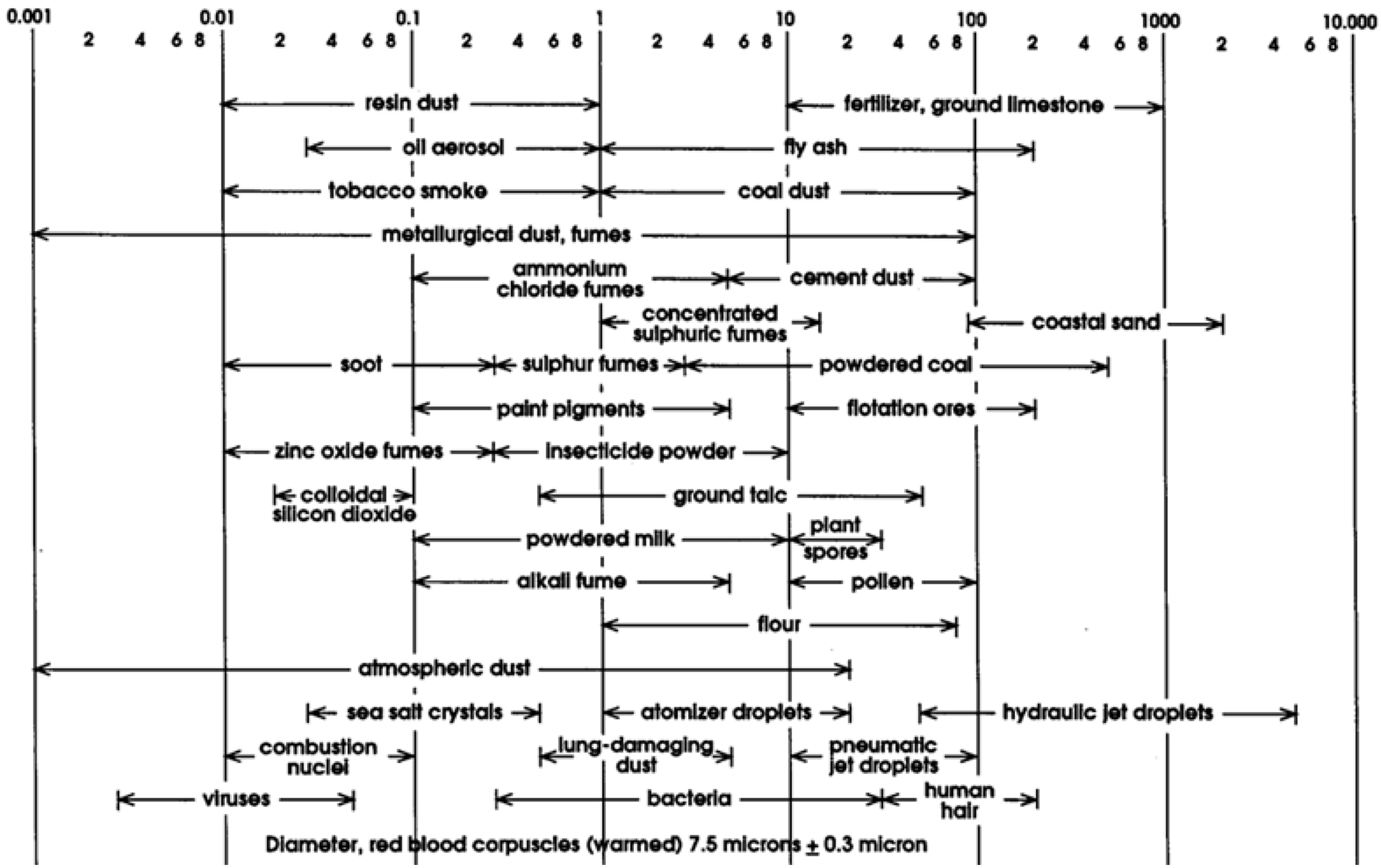

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ENERGY COST PER 24”x24” FILTER

2,000	Flow Rate (cfm)
500	Velocity (fpm)
8,760	Hours of Operation
60%	Fan Efficiency

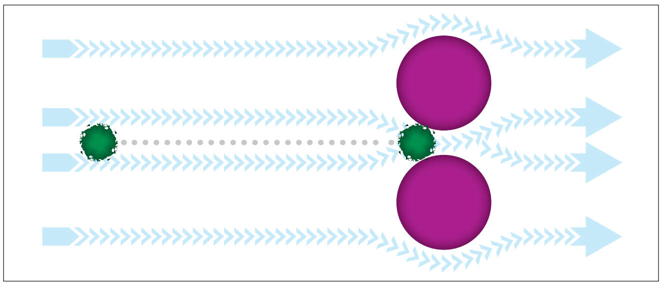
	$0.08	$0.09	$0.10	$0.11	$0.12	$0.13	$0.14	$0.15	$0.16	$0.17
0.10	$27	$31	$34	$38	$41	$45	$48	$51	$55	$58
0.15	$41	$46	$51	$57	$62	$67	$72	$77	$82	$87
0.20	$55	$62	$69	$75	$82	$89	$96	$103	$110	$117
0.25	$69	$77	$86	$94	$103	$111	$120	$129	$137	$146
0.30	$82	$93	$103	$113	$123	$134	$144	$154	$165	$175
0.35	$96	$108	$120	$132	$144	$156	$168	$180	$192	$204
0.40	$110	$123	$137	$151	$165	$178	$192	$206	$219	$233
0.45	$123	$139	$154	$170	$185	$201	$216	$231	$247	$262
0.50	$137	$154	$171	$189	$206	$223	$240	$257	$274	$291
0.55	$151	$170	$189	$207	$226	$245	$264	$283	$302	$321
0.60	$165	$185	$206	$226	$247	$267	$288	$309	$329	$350
0.65	$178	$201	$223	$245	$267	$290	$312	$334	$357	$379
0.70	$192	$216	$240	$264	$288	$312	$336	$360	$384	$408
0.75	$206	$231	$257	$283	$309	$334	$360	$386	$412	$437
0.80	$219	$247	$274	$302	$329	$357	$384	$412	$439	$466
0.85	$233	$262	$291	$321	$350	$379	$408	$437	$466	$496
0.90	$247	$278	$309	$339	$370	$401	$432	$463	$494	$525
0.95	$261	$293	$326	$358	$391	$424	$456	$489	$521	$554
1.00	$274	$309	$343	$377	$412	$446	$480	$514	$549	$583

Y axis = average pressure drop inches water gage
X axis = cost per KwH ($)

Methods of Filtration

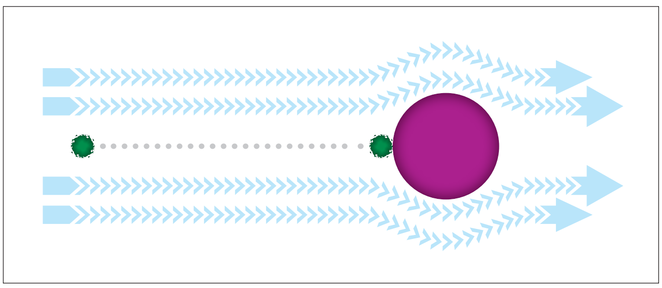
There are several possible methods involved in creating a safe and secure indoor environment. AAF Flanders takes great care in assessing and addressing the individual and specific needs of our customers and choosing the appropriate solution for any IAQ challenge.

Mechanical



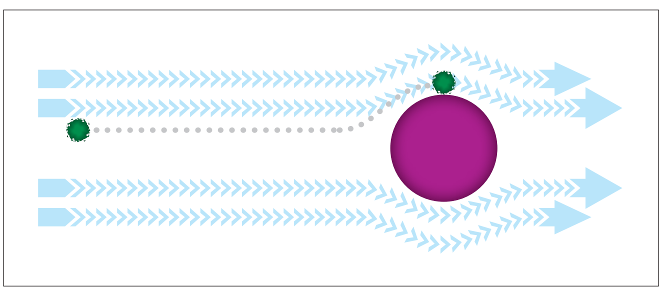
Straining

Straining occurs when a particle is larger than the opening between fibers and cannot pass through. It is a very ineffective method of filtration because the vast majority of particles are far smaller than the spaces between fibers. Straining will remove lint, hair, and other large particles.



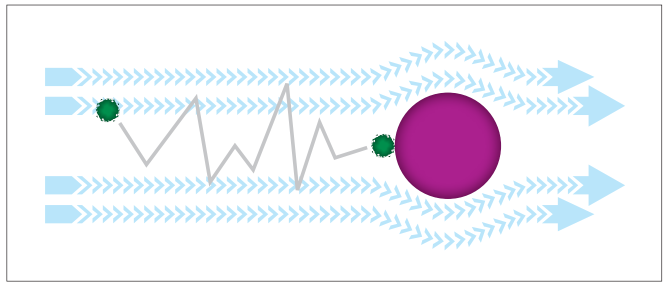
Impingement

As air flows through a filter, it makes repeated changes in direction as it passes around each fiber. Dirt particles, especially larger particles, cannot follow the abrupt changes in direction because of their inertia. As a result, they do not follow the airstream, and they collide with a fiber. Filters using this method are often coated with an adhesive to help retain particles on the fibers.



Interception

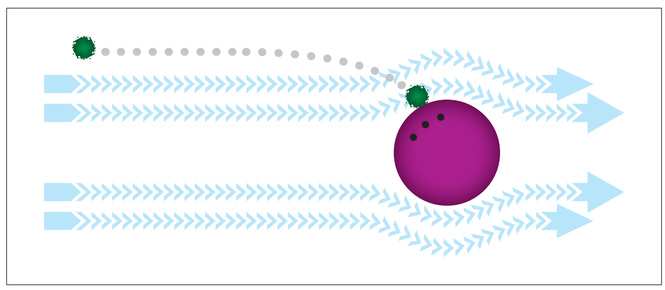
Interception is a special case of Impingement, where a particle follows the airstream, but because of its size in relation to the fiber, it comes in contact with the fiber. Interception is not dependent on the inertia of the particle to bring it into contact with a fiber. The particle is retained by the inherent adhesive forces between the particle and fiber, called "van der Waals" forces.



Diffusion

Diffusion takes place on particles so small that their direction and velocity are influenced by molecular collisions (called "Brownian movement"). They do not follow the airstream, but behave more like gases than particulate. These particles are battered across the direction of flow in a random "helter skelter" fashion. When a particle strikes a fiber, it is retained by the adhesive forces (van der Waals forces) between the particle and fiber.

Electrical



Electrostatic

The electrostatic method of filtration is based on the principle that objects carrying opposite electrical charges are attracted to one another. As particles enter the filter, they pass through the "ionizer" section, where a field with an intense positive charge is imparted to the particles. The particles are then carried by the airstream into the "plate" area, consisting of alternately charged collection plates. Positively charged particles are attracted to the negatively charged plates.

The accumulated dust load is removed from the plates in one of two fashions. Either the plates are periodically washed, or the dust load is left to "agglomerate" on the plates, until the enlarged particles are blown off the plates into the "storage section." The storage section consists of either an automatic roll filter or extended surface filters.

Standards, Regulations, and Recommendations

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ASHRAE – Recommended Minimum Efficiencies by Area

Recommended minimum efficiencies by area as published by the American Society of Heating, Refrigerating, & Air-Conditioning Engineers (2015, 2014 and 2012 Handbooks)

Application	Minimum Filtration Efficiency
Museums, Galleries, Libraries, and Archives	MERV 7 prefilter, plus either activated carbon, treated carbon, or potassium permanganate beds, and MERV 15
Arenas & Stadiums	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Atriums	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Auditoriums	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Convention & Exhibit Centers	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Data Processing & Electronic Office Areas	MERV 8
Hotel/Motel Assembly Rooms	MERV 8 or better
Hotel/Motel Conference/Meeting Rooms	MERV 8 or better
Hotel/Motel Guest Rooms	MERV 6 to MERV 8
Hotel/Motel Lobbies	MERV 8 or better
Houses of Worship	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Laboratories (Biological & Biomedical)	MERV 14 to MERV 15
Laboratories (Chemistry & Physics)	MERV 13
Natatoriums (pool areas)	MERV 8 minimum, up to MERV 13 for facilities with expensive interior décor
Office Buildings	MERV 9 to MERV 12
School Administrative & Office Space	MERV 6 to MERV 8
School Classroom	MERV 6 to MERV 8
Warehouses	MERV 9 to MERV 12

EN 13779:2007 – Recommended Minimum Filter Classes per Filter Section

Outdoor Air Quality	Indoor Air Quality			
	IDA 1 (High)	IDA 2 (Medium)	IDA 3 (Moderate)	IDA 4 (Low)
ODA 1 (pure air)	F9	F8	F7	F5
ODA 2 (dust)	F7+F9	F6+F8	F5+F7	F5+F6
ODA 3 (very high concentrations of dust or gases)	F7+GF+F9[a]	F7+GF+F9[a]	F5+F7	F5+F6

[a] *GF = Gas filter (carbon filter) and/or chemical filter*

ASHRAE Standard 170:2008 Ventilation of Health Care Facilities – Minimum Filter Efficiencies

Space Designation (According to Function)	Filter Bank Number 1 (MERV)	Filter Bank Number 2 (MERV)
Classes B and C surgery; inpatient and ambulatory diagnostic and therapeutic radiology; inpatient delivery and recovery spaces	7	14
Inpatient care, treatment and diagnosis, and those spaces providing direct service or clean supplies and clean processing (except as noted below); All (rooms)	7	14
Protective environment rooms (PE)	7	HEPA
Laboratories; Class A surgery and associated semi-restricted spaces	13[a]	N/R*
Administrative; bulk storage; soiled holding spaces; food preparation spaces; and laundries	7	N/R
All other inpatient spaces	7	N/R
Skilled nursing facilities	7	N/R

**NR = not required*

[a] *Additional prefilters may be used to reduce maintenance for filters with efficiencies higher than MERV 7*

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Standards, Regulations, and Recommendations

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ASHRAE Application Guidelines

Standard 52.2 MERV Range	Dust Spot Efficiency	Arrestance	Range of Contaminants Controlled	Typical Applications	Typical Air Filter/Cleaner Type
16 15 14 13	n/a >95% 90%-95% 80%-90%	n/a n/a >98% >98%	**0.3 to 1.0 µm** **Particle Size** All bacteria Most tobacco smoke Droplet nuclei (sneeze) (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 900mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300mm (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 to 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 900mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300mm (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 to 10 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 125mm (1 to 5 in.) thick with cotton-polyester blend media, cardboard frame **Cartridge Filters** Graded density viscous coated cube or pocket filters, synthetic media
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

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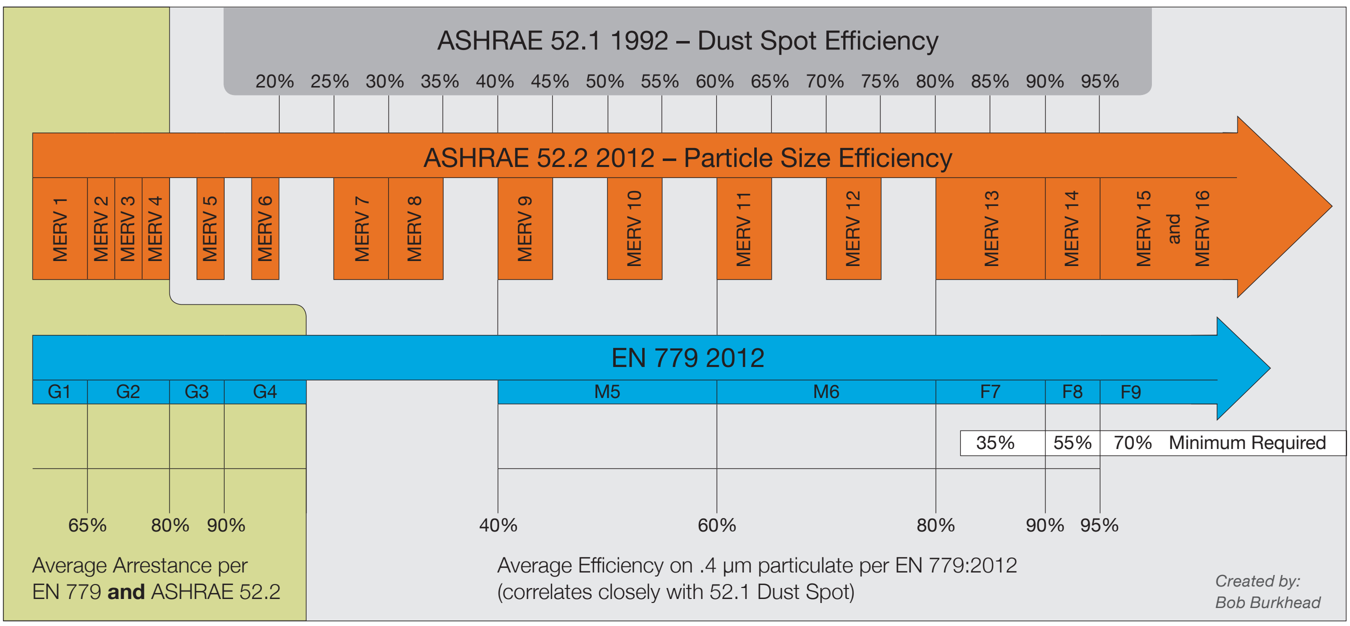
EN 779:2012 Classification

Group	Filter Class	Final Pressure Drop (test) Pa	Average Arrestance (Am) of Synthetic Dust (%)	Average Efficiency (Em) for 0.4 μm Particles (%)	Minimum Efficiency[2] for 0.4 μm Particles (%)
Coarse	G1	250	50 ≤ Am ≤ 65	–	–
	G2	250	65 ≤ Am ≤ 80	–	–
	G3	250	90 ≤ Am	–	–
	G4	250	–	–	–
Medium	M5	450	–	40 ≤ Em ≤ 60	–
	M6	450	–	60 ≤ Em ≤ 80	–
Fine	F7	450	–	80 ≤ Em ≤ 90	35
	F8	450	–	90 ≤ Em ≤ 95	55
	F9	450	–	95 ≤ Em	70

[1]The characteristics of atmospheric dust vary widely in comparison with those of the synthetic loading dust used in the tests. Because of this, the test results do not provide a basis for predicting other operational performance or service life. Loss of media charge or shredding of particles or fibers can also adversely affect efficiency.
[2]Minimum efficiency is the lowest of any of the following three values: initial efficiency, discharged efficiency, or efficiency throughout the test's loading procedure.

Test Standard Correlations



The test standard correlations above are approximations based on results obtained on a sampling of products. Actual results on products may differ somewhat from these correlations, and a product tested to one standard that needs to meet the requirements of another standard should be tested in accordance with the specified standard.

EN 1822:2009 Classification of EPA, HEPA, and ULPA Filters

Filter Group	Integral Value		Local Value	
Filter Class	Efficiency (%)	Penetration (%)	Efficiency (%)	Penetration (%)
E 10	≥ 85	≤ 15	---	---
E 11	≥ 95	≤ 5	---	---
E 12	≥ 99.5	≤ 0.5	---	---
H 13	≥ 99.95	≤ 0.05	≥ 99.75	≤ 0.25
H 14	≥ 99.995	≤ 0.005	≥ 99.975	≤ 0.025
U 15	≥ 99.9995	≤ 0.0005	≥ 99.9975	≤ 0.0025
U 16	≥ 99.99995	≤ 0.00005	≥ 99.99975	≤ 0.00025
U 17	≥ 99.999995	≤ 0.000005	≥ 99.9999	≤ 0.0001

ISO 16890-1:2016(en)

It has been well documented that the quality of air has an effect on human health. Typically, the finer the dust inhaled by the respiratory system, the greater the long-term health risks. Fine particulate matter is of great concern, since fine particles travel deep into the lungs and are absorbed by the body more easily. Long-term exposure to these particles can lead to lung and cardiovascular diseases.

The international standard ISO 16890 was published in December, 2016 and describes a method of testing and classification for general ventilation filters. By the end of June 2018, ISO 16890 will replace EN779 in Europe.

ISO 16890 measures laboratory performance data and efficiency classifications based on measured fractional efficiency converted into a particulate matter efficiency (ePMx) reporting system. In the context of ISO 16890, particulate matter efficiencies are divided into three particle size ranges: ePM1, ePM2.5, and ePM10. These particle matter efficiencies are defined by the size ranges shown in the table below.

Efficiency	Size Range (µm)
ePM10	$0.3 \le x \le 10$
ePM2.5	$0.3 \le x \le 2.5$
ePM1	$0.3 \le x \le 1$

ISO 16890 is comprised of 4 parts:

Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (*e*PM).

Part 2: Measurement of fractional efficiency and airflow resistance.

Part 3: Determination of the gravimetric efficiency and airflow resistance versus the mass of test dust captured.

Part 4: Conditioning method to determine the minimum fractional test efficiency.

Parts 1, 2, and 4 are mandatory. Part 3 is optional and can be used to determine gravimetric efficiency (arrestance) and test duct capacity, using L2 synthetic test dust as described by ISO 15957.

In ISO 16890-2, both a liquid and a solid aerosol are used to calculate fractional efficiency. Liquid DEHS, generated by a Laskin nozzle, is used as the test aerosol for sizes from 0.3 µm up to 1 µm. KCL, generated from a 20% aqueous solution, is generated, dried, and neutralized to form a solid aerosol that is used for particles above 1 µm to 10 µm. A solid aerosol is used for larger size particles, because liquid aerosols do not experience “particle bounce” like solid particles can.
Particle bounce can occur when the kinetic energy of large solid particles bounces off a fiber in the filtration medium, instead of attaching to it. Without considering the potential for particle bounce on filter performance, the efficiency of larger size particles may be over-reported.

The test procedure consists of the following steps with the same filter, with the same conditions at the same airflow.

1. Measure the filter’s resistance to airflow (per Part 2).
2. Measure the initial efficiency curve as a function of particle size on a clean, unloaded, unconditioned filter (per Part 2).
3. Artificially condition the same filter (per Part 4).
4. Measure the initial efficiency curve as a function of particle size on a clean, unloaded conditioned filter (per Part 2).
5. Calculate the *e*PM efficiencies (per Part 1).
6. Load the same filter with synthetic test dust and measure the initial arrestance, the resistance versus mass of dust fed, and the test dust capacity (per Part 3).

Note: *Step 6 is optional for filters of groups ISO ePM10, ePM2.5 and ePM1.*

ISO 16890 uses initial arrestance, the three efficiency values, ePM1, ePM2.5, and ePM10, and the minimum efficiency values ePM1, min and ePM2.5, min to classify filters in one of four groups below.

Group Designation	Requirement			Class Reporting Value
	ePM1, ePM1,min	ePM2.5, ePM2.5, min	ePM10	
ISO Coarse	–	–	<50%	Initial grav. arrestance
ISO ePM10	–	–	≥50%	ePM10
ISO ePM2.5	–	≥50%	–	ePM2.5
ISO ePM1	≥50%	–	–	ePM1

For reporting of the *e*PM classes, the class reporting value is rounded down to the nearest multiple of 5% points. If class reporting values are >95%, then they are reported as >95% and are not rounded down.

Annex B in Part 1 has two examples of how a filter is rated. Below is an example. Filter A generates the following data:

	Value		Value		Value
ePM1, min	45%	ePM2.5, min	56%	ePM10	89%
ePM1	59%	ePM2.5	68%		

In this example, all values are above 50%, except for ePM1, min. Therefore, the lowest group designation that can be reported is ISO ePM2.5. Since an ePM2.5 value of 68% is not an interval of 5, it is rounded down to 65%. Therefore, for reporting purposes, this filter can be rated according to the table above as ISO ePM2.5 65%.

Note: *ISO 16890 is intended for use for general ventilation filters with an ePM1 efficiency ≤99% and an ePM10 efficiency >20% to >50%. Filters measured below ePM10 < 50% are considered as ISO coarse. Filters outside this range (e.g. HEPA filters) should be tested using other procedures. ISO 16890 is also not for rating portable room air cleaners.*

ISO 14644-1 Classification of Air Cleanliness by Particle Concentration

ISO Class Number (N)	Maximum allowable concentrations (particles/m³) for particles equal to and greater than the considered sizes, shown below[a]					
	0.1 µm	0.2 µm	0.3 µm	0.5 µm	1 µm	5 µm
1	10[b]	d	d	d	d	e
2	100	24[b]	10[b]	d	d	e
3	1,000	237	102	35[b]	d	e
4	10,000	2,370	1,020	352	83[b]	e
5	100,000	23,700	10,200	3,520	832	d, e, f
6	1,000,000	237,000	102,000	35,200	8,320	293
7	c	c	c	352,000	83,200	2,930
8	c	c	c	3,520,000	832,000	29,300
9	c	c	c	35,200,000	8,320,000	293,000

[a] *All concentrations in the table are cumulative, e.g. for ISO Class 5, the 10,200 particles shown at 0.3 µm include all particles equal to and greater than this size.*

[b] *These concentrations will lead to large air sample volumes for classification. Sequential sampling procedure may be applied.*

[c] *Concentration limits are not applicable in this region of the table, due to very high particle concentration.*

[d] *Sampling and statistical limitations for particles in low concentrations make classification inappropriate.*

[e] *Sample collection limitations for both particles in low concentrations and sizes greater than 1 µm make classification at this particle size inappropriate, due to potential particle losses in the sampling system.*

[f] *In order to specify this particle size in association with ISO Class 5, the macroparticle descriptor M may be adapted and used in conjunction with at least one other particle size.*

Comparison of International Classification Standards

Number of Part 0.5 µm/m³ (approx.)	U.S. Federal Standard 209 E 1992		EN ISO 14644-1 1996
–	–	–	ISO 1
1	–	–	
4	–	–	ISO 2
10	M 1	–	–
35	M 1.5	1	ISO 3
100	M 2	–	–
353	M 2.5	10	ISO 4
1,000	M 3	–	–
3,530	M 3.5	100	ISO 5
10,000	M 4	–	–
35,300	M 4.5	1,000	ISO 6
100,000	M 5	–	–
353,000	M 5.5	10,000	ISO 7
1,000,000	M 6	–	–
3,530,000	M 6.5	100,000	ISO 8
10,000,000	M 7	–	–
35,000,000	–	–	ISO 9

Standards, Regulations, and Recommendations

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U.S. Federal Standard 209 Class

U.S. Federal Standard 209 Class		0.1 µm	0.2 µm	0.3 µm	0.5 µm	5 µm
SI (E)	English (D)	m^3	m^3	m^3	m^3	m^3
M 1		350	75.7	309	10.0	–
M 1.5	1	1,240	265	106	35.3	–
M 2		3,500	757	309	100	–
M 2.5	10	12,400	2,550	1,060	353	–
M 3		35,000	7,570	3,090	1000	–
M 3.5	100	–	26,500	10,600	3,530	–
M 4		–	75,700	30,900	10,000	–
M 4.5	1,000	–	–	–	35,300	247
M 5		–	–	–	100,000	618
M 5.5	10,000	–	–	–	353,000	2,470
M 6		–	–	–	1,000,000	6,180
M 6.5	100,000	–	–	–	3,530,000	24,700
M 7		–	–	–	10,000,000	61,800

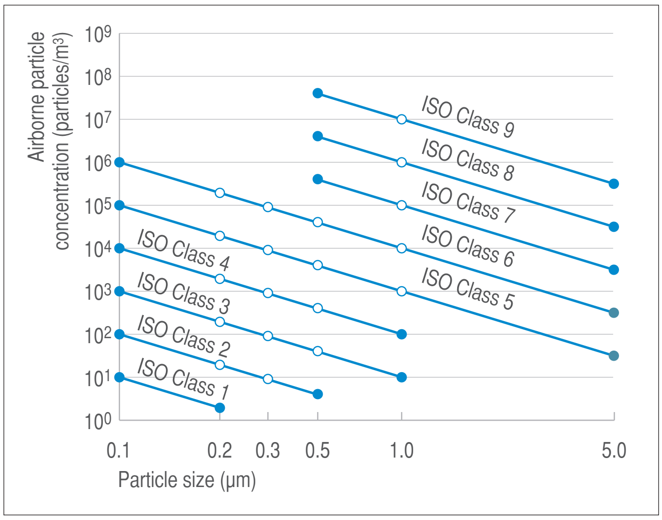
Particles / $m^3 = 10^M (0.5/d)^{2.2}$
Particles / $ft^3 = N_c (0.5/d)^{2.2}$

ISO 29463 Filter Classes and Equivalents

ISO Filter Class	Efficiency	IEST*	EN 1822
ISO 15 E	>95%	–	H 11
ISO 20 E	>99%	–	
ISO 25 E	>99.5%	–	H 12
ISO 30 E	>99.9%	–	
ISO 35 H	>99.95%	–	H 13
–	>99.97%	A,B,E,H,I	–
ISO 40 H	>99.99%	C,J(K)	
ISO 45 H	>99.995%	K	H 14
ISO 50 U	>99.999%	D	
ISO 55 U	>99.9995%	F	U 15
ISO 60 U	>99.9999%	G	
ISO 65 U	>99.99995%	G	U 16
ISO 70 U	>99.99999%	G	
ISO 75 U	>99.999995%	G	U 17

**IEST Type A, B, C, D, and E are classified per test results using photometers (Mil Std 282). Types F, G, H, I, J, and K are classified per test results using particle counters.*

ISO 14644-1 Cleanroom Class Particulate Concentration Limits



The graph shows the minimum and maximum particle size limits acceptable for each of the ISO classes shown. The classification lines do not represent actual particle size distributions found in cleanrooms and clean zones.

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Air Filter Classification According to IEST-RP-CC001

Recommended Test and Minimum Rating for Filters Types A Through K

Filter Type	Penetration Test		Last (Scan) Test[1]			Minimum Efficiency Rating	Designated Leak Penetration
	Method	Aerosol	Method	Aerosol	Comments		
HEPA (type A)	MIL-STD-282	Thermal DOP	None	None		99.97%	None
HEPA (type B)	MIL-STD-282	Thermal DOP	None	None	Two-flow leak test	99.97%	None
HEPA (type C)[1]	MIL-STD-282	Thermal DOP	Photometer	Polydisperse DOP/PAO		99.99%	0.010%
HEPA (type D)[1]	MIL-STD-282	Thermal DOP	Photometer	Polydisperse DOP/PAO		99.999%	0.0050%
HEPA (type E)[1]	MIL-STD-282	Thermal DOP	None	None	Two-flow	99.97%	None
HEPA (type F)[1]	IEST-RP-CC007	TBD[3]	Particle Counter	TBD[3]		99.9995% at 0.1-0.2 or 0.2-0.3 µm	0.00250%
HEPA (type G)[1]	IEST-RP-CC007[2]	TBD[3]	Particle Counter	TBD[3]		99.9999% at 0.1-0.2 or 0.2-0.3 µm	0.0010%
HEPA (type H)[1]	IEST-RP-CC007	TBD[3]	None	None		99.97% at 0.1-0.2 or 0.2-0.3 µm	None
HEPA (type I)[1]	IEST-RP-CC007	TBD[3]	None	TBD[3]	Two-flow leak test	99.97% at 0.1-0.2 or 0.2-0.3 µm	None
HEPA (type J)[1]	IEST-RP-CC007	TBD[3]	Particle Counter or Photometer	Polydisperse DOP/PAO		99.99% at 0.1-0.2 or 0.2-0.3 µm	0.010%
HEPA (type K)[1]	IEST-RP-CC007	TBD[3]	Particle Counter or Photometer	Polydisperse DOP/PAO		99.995% at 0.1-0.2 or 0.2-0.3 µm	0.0080%

[1] *Either of the two scan test methods or an alternative method may be used for filter types C, D, F, and G, if agreed. Designated leak details for these filter types are given in IEST-RP-CC034.*

[2] *Filter medium tested at most-penetrating particle size (MPPS) prior to filter assembly. All filters are leak tested, but in some instances may not be tested for overall penetration. The MPPS for testing this filter type is determined from the media according to IEST-RP-CC021.*

[3] *None specified. To be determined by agreement between customer and supplier, and governing regulations or guidelines.*

Pharmaceutical CGMPs – Air Classifications[a] 2004

Clean Area Classification (0.5 µm particles/ft³)	ISO Designation[b]	≥ 0.5 µm Particles/m³	Microbiological Active Air Action Levels[c] (cfu/m³)	Microbiological Settling Plates Action Levels[c,d] (diam. 90mm; cfu/4 hours)
100	5	3,520	1[e]	1[e]
1000	6	35,200	7	3
10,000	7	352,000	10	5
100,000	8	3,520,000	100	50

[a] *All classifications based on data measured in the vicinity of exposed materials/articles during periods of activity*
[b] *ISO 14644-1 designations provide uniform particle concentration values for cleanrooms in multiple industries. An ISO 5 particle concentration is equal to Class 100 and approximately equals EU Grade A.*
[c] *Values represent recommended levels of environmental quality. You may find it appropriate to establish alternate microbiological action levels due to the nature of the operation or method of analysis.*
[d] *The additional use of settling plates is optional.*
[e] *Samples from Class 100 (ISO 5) environments should normally yield microbiological contaminants.*

Standards, Regulations, and Recommendations

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Cleanroom Classification According to EU GMP Annex 1

Maximum Permitted Number of Particles /m³ Equal to or Greater than the Tabulated Size				
	At-rest		In Operation	
Grade	0.5 μm	5.0 μm	0.5 μm	5.0 μm
A	3,520	20	3,520	20
B	3,520	29	352,000	2,900
C	352,000	2,900	3,520,000	29,000
D	3,520,000	29,000	Not Defined	Not Defined

International Cleanroom Standard Comparison for 'At-rest'		
FED 209E	FED 209D	ISO 14644
M 3.5	Class 100	ISO 5
M 3.5	Class 100	ISO 5
M 5.5	Class 10,000	ISO 7
M 6.5	Class 100,000	ISO 8

Typical Cleanroom Activities for Terminal Sterilization and Aseptic Preparation

GMP Grade	Examples of Typical Activities	
	Terminal Sterilization	Aseptic Preparation
A	Filling of products for sterilization (unusual risk profile)	Handling of sterile starting materials and components Preparation of materials and products (non-sterile filtering) Handling and filling of aseptically prepared products
B	–	Background area for grade A zones
C	Filling of products for sterilization (usual risk profile) Preparation of materials and products (sterile filtering)	Preparation of components (unusual risk profile)
D	Preparation of components (usual risk profile)	Handling of components after washing

ISA 71.04 Classification of Reactive Environments

Severity Level	G1 Mild	G2 Moderate	G3 Harsh	GX Severe
Copper Reactivity Level (in angstroms, Å)	< 300	< 1000	< 2000	> 2000
Silver Reactivity Level (in angstroms, Å)	< 200	< 1000	< 2000	> 2000

The gas concentration levels shown below are provided for reference purposes. For a given gas concentration, the Severity Level can be expected to be increased by one level for each 10% increase in relative humidity above 50% or for a relative humidity rate of change greater than 6% per hour.

	Gas Concentrations (in ppb)					
	Contaminant	Gas	Concentration			
Reactive Species	**Group A**	H_2S	< 3	< 10	< 50	50
		SO_2, SO_3	< 10	< 100	< 300	300
		Cl_2	< 1	< 2	< 10	10
		NO_X	< 50	< 125	< 1250	1250
	Group B	HF	< 1	< 2	< 10	10
		NH_3	< 500	< 10,000	< 25,000	25,000
		O_3	< 2	< 25	< 100	100

ASHRAE TC 9.9 Guideline for RoHS Compliant Corrosion Control

Applications: Data Centers, Tire Manufacture Facilities, Rubber Manufacture Facilities, Paper Mills, Refineries
Protected Equipment: RoHS compliant circuitry in control rooms, motor control centers, or other such areas.

Class	Copper A/30 days	Silver A/30 days	Reliability Statement
G1 (Mild)	< 300	< 200	Acceptable
G2 (Moderate)	< 1000	< 1000	Not acceptable – corrosive attack may occur
G3 (Harsh)	< 2000	< 2000	
GX (Severe)	> 2000	> 2000	

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Filter Engineering Calculations and Conversions

Filter Engineering – Calculations

An air filter's efficiency is expressed in 3 forms:

The Efficiency Percentage: $R = \frac{(I-E)}{I} \times 100$

The Penetration Percentage: $P = \frac{E}{I} \times 100$

The Purification Coefficient (no units): CE $\frac{I}{E}$

Energy Consumed

Energy consumed by an air filter due to its pressure drop:

q = flow rate (m^3/s)

dP = pressure drop (Pa)

h = operating period (hours)

ef = fan efficiency (generally 0.6 to 0.7)

$E = \frac{q \times dP \times h}{e^f \times 1000} = kWh$

Conversions

Speed				
	m/s = 3.6 km/h	1 km/h = 0.278 m/s	1 ft/min = 0.00508 m/s	1 m/s = 196.85 ft/min
Length				
	1 mile = 1.609 km	1 km = 0.621 mile	1 yd = 0.914 m	1 m = 1.09 yd
	1 ft = 0.305 m	1 m = 3.28 ft	1 in = 25.4 mm	1 mm = 0.039 in
	1 mm = 1.000 µm	1 µm = 0.001 mm	1 µm = 1.000 nm	1 nm = 0.001 µm
	1 µm = 10,000 Å	1 Å = 0.0001 µm		
Surface				
	1 ft^2 = 0.0929 m^2	1 m^2 = 10.8 ft^2	1 in^2 = 6.45 cm^2	1 cm^2 = 0.155 in^2
Volume				
	1 ft^3 = 0.0283 m^3	1 m^3 = 35.3 ft^3	1 ft^3 – 28.3 litres	
Flow rate				
	1 cfm =	1 m^3/s -	1 m^3/h =	
	0.472.10 – 3 m^3/s	3 600 m^3/h	0.278.10 – 3 m^3/s	
	1 cfm = 1.699 m^3/h	1 m^3/s = 2 120 cfm		
Weight				
	1 lb = 0.454 kg	1 kg = 2.20 lb	1 oz = 28.3 g	1 g = 0.0352 oz
Force				
	1 kgf = 9.80665 N	1 N = 0.102 kgf	1 lbf = 4.45 N	1 N = 0.225 lbf
Pressure				
	1 mmCE = 9.81 N	1 Pa = 0.102 mmCE	1 kPa = pz	1 kPa = 10.2 g/cm^2
	1 kg/cm^2 =	1 bar = 1.02 kg/cm^2	1 kg/m^2 =	1 kPa = 0.00987 atm
	0.980665 bar		98.0665 kPa	
	1 psi = 6.89 kPa	1 bar = 101325 Pa	1 atm = 101.325 kPa	1 mb = 100 Pa
	1 mmCE = 1 kg/m^2	1 kPa = 0.145 psi	1 Pa = 1 N/m^2	1 in w.g. = 250 Pa
Energy				
	1 kgm = 9.80665 J	1 J = 0.102 kgm	1 cal = 4.184 J	1 J = 0.239 cal
	1 kWh = 3.6 MJ	1 MJ = 0.278 kWh	1 Btu = 1.055 kJ	1 J = 0.945.10-3 Btu
Power				
	1 CV = 0.736	1 kW = 1.36 CV	1 kcal/h = 1.16 W	1 W = 0.860 kcal/h
	1 Btu/h = 0.292 W	1 W = 3.42 Btu/h		

Filter Engineering Calculations and Conversions (cont.)

Temperature: Conversion Formula

0°C = 32°F	0°F = -17.8°C
0°F = (9/5) x °C	+32°C = (5/9) x °F – 17.8

Temperature: Conversion Table

°F	°C	°F	°C	°F	°C	°F	°C
0	-17.8	30	-1.1	50	10.0	80	26.7
10	-12.2	32	0	60	15.6	90	32.2
20	-67.4	0	4.4	70	21.1	100	37.8

Conversion Table (%)

Efficiency	Penetration	Purification Coefficient	Efficiency	Penetration	Purification Coefficient
95	5	20	99.99	0.01	10,000
99	1	100	99.995	0.0005	20,000
99.5	0.5	200	99.999	0.001	100,000
99.9	0.1	1,000	99.9995	0.0005	200,000
99.95	0.05	2,000	99.9999	0.0001	1,000,000
99.97	0.03	3,333	99.99995	0.00005	2,000,000
99.98	0.02	5,000	99.99999	90.00001	10,000,000

Filter Industry Definitions

ABSOLUTE – An arbitrary term once used to describe high efficiency particulate air filters, based on minimal penetration of 0.3 micron particles. In air filtration, there are no absolutes.

ABSOLUTE FILTER – This term has been applied to air filters of high efficiency—greater than 95% against submicron particles—but is now less frequently used. Modern terminology prefers the term HEPA filter (High Efficiency Particulate Air).

ABSORB – To intercept, or drink in, as a sponge sucks in water.

ABSORPTION – A physio-chemical process in which one substance associates with another to form a homogeneous mixture that presents the characteristics of a solution.

ACFM – Actual Cubic Feet Per Minute. Airflow measured at operating temperature and pressure.

ACID – Any of a class of substances whose aqueous solutions are characterized by a sour taste, the ability to turn blue litmus to red, and the ability to react with bases and certain metals to form salts. Acids will yield hydrogen ions when dissolved in water.

ACTIVATED ALUMINA – A highly porous and granular form of aluminum oxide having preferential adsorptive capacity for moisture from gases, vapors, and some liquids.

ACTIVATED CARBON – Any form of carbon characterized by high adsorptive capacity for gases, vapors, or colloidal solids. The carbon or charcoal is produced by destructive distillation of wood, peat, lignite, nut shells, bones, vegetable, or other carbonaceous matter, but must be activated by high temperature steam or carbon dioxide, which creates a porous particle structure.

ACTIVATED CHARCOAL – *See activated carbon.*

ADHESION – Intermolecular forces which hold matter together. Also applied to the sticking together of a particle to a surface, a fiber or another particle. The main factors affecting adhesion of particles are 1) London-van der Waals forces, which are electrical in origin, 2) electrostatic forces, and 3) surface tension, due to films of moisture on particles or on the surface. Other factors influencing adhesion are the nature of the surfaces, surface contaminants, particle size, shape and roughness, and time of contact.

ADSORB – The physio-chemical phenomenon involved to attract and hold a gas, vapor, or liquid on the surface of a solid, particularly on a finely divided material.

ADSORBATE – The material which is adsorbed; i.e., the gas, vapor, or liquid which adheres, or is chemically attracted to, the surface of the solid.

ADSORBENT – The material which adsorbs; i.e., the solid which attracts and holds on its surface the gas, vapor, or liquid. Activated carbon and activated alumina are all adsorbents.

ADSORPTION – The natural phenomenon of a gas, vapor, or liquid being attracted to, and held on, the surface of a solid. To some extent, adsorption takes place on any solid surface, but certain materials have sufficient adsorbent capacity because they are finely divided and are therefore useful in such industrial applications as the purification and separation of gases and liquids.

AEROSOL – Liquid or solid particles suspended in air, gas, or vapor.

AHRI – Air-Conditioning, Heating, and Refrigeration Institute.

ALKALI – A term that applies to the type of compounds which have basic properties and will neutralize acids. Some alkaline materials are hydroxides, carbonates, or caustics.

AMBIENT – Of the surrounding area or environment.

AMBIENT AIR – The air surrounding a building. The source of outdoor air brought into a building.

AMINE – A class of organic compounds of nitrogen that may be considered to be derived from ammonia. It may be a gas, liquid, or solid. All amines are basic in nature and will usually combine readily with hydrochloric or other strong acids to form salts.

AMMONIA – A colorless gas with a characteristic pungent odor. Used for refrigeration, fertilizer, chemical manufacturing, and many other uses.

ANGSTROM – A unit of length, 10^{-10} meter, or one ten thousandth of a micron.

ANSI – American National Standards Institute.

ARRESTANCE – A measure of the ability of an air-cleaning device to remove ASHRAE loading dust from test air. Measurements are made of the weight of loading dust fed and the weight of the dust passing the device during loading. The difference between the weight of dust fed and the weight of dust passing the device is calculated as the dust captured by the device. Arrestance is then calculated as the percentage of the dust fed that was captured by the device.

AROMATIC COMPOUNDS – Compounds related to six-carbon membered rings as benzene or its derivatives.

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers.

ASHRAE LOADING DUST – Loading dust for testing air filtration devices composed, by weight, of 72% SAE Standard J726 test dust (fine), 23% powdered carbon, and 5% milled cotton linters.

ASME – American Society of Mechanical Engineers.

ATMOSPHERIC PRESSURE – The pressure of approximately 14.7 pounds per square inch exerted at sea level in all directions by the atmosphere.

BIOAEROSOL – A suspension of airborne particles that contain living organisms or were released from living organisms.

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Filter Industry Definitions

BLIND SPOTS – Places in a medium where no filtering occurs. These places are also referred to as dead areas and are the opposite of the effective area.

BREAKTHROUGH – When the downstream concentration exceeds the allowable concentration.

BRIDGING – Where particles being removed from the air form an arch over the individual openings/pleats in an extended surface filter, blocking the narrow air passages between pleats and reducing the service life of the filter.

BROWNIAN MOTION – The random movement of microscopic particles suspended in a liquid or gas, caused by collisions with molecules of the surrounding medium. Also called Brownian Movement.

BTU (BRITISH THERMAL UNIT) – A standard measure of heat content in a substance that can be burned to provide energy.

BYPASS – Condition resulting from the fluid stream flowing through a housing without flowing through the filtering medium. In air filtration, unfiltered air going around the filter.

CAPACITY – Volume of air expressed in cubic feet per minute (CFM), or similar units that a filter is rated to handle.

CFM – Cubic feet per minute.

CHEMISORPTION – The combined process of adsorption, absorption, and oxidation, where gases trapped in chemisorbant media (adsorbent with an impregnant) are changed from gases into harmless solids.

CHIMNEY EFFECT – The tendency of heated air to rise due to lower density in comparison with ambient, also called thermal, updrafts. In cleanroom areas, heat generating equipment may cause severe upward air currents, resulting in unwanted turbulence.

CLEAN PRESSURE DROP – Differential pressure (drop) across a clean filter, typically measured in inches of water column (water gauge) or pascals.

CLEANROOM – A specially constructed enclosed area environmentally controlled with respect to airborne particulates, temperature, humidity, air pressure, airflow patterns, air motion, and lighting.

CLEAN SPACE – A term referring to cleanrooms or work stations within a room.

COALESCING – Action of uniting of small droplets of one liquid, preparatory to its being separated from another liquid.

COMPOSITE MEDIA – Media made up of more than one material.

CONTACT TIME – The length of time an absorbent is in contact with a liquid or gas prior to being removed by the filter.

CONTAMINANT – Synthetic or naturally occurring chemical, particle, or microorganism in air that could have adverse effects.

NON-LAMINAR FLOW CLEANROOM – A cleanroom with no requirements for uniform airflow patterns and air velocities.

CORROSION – Conversion of metals into oxides, hydrated oxides, carbonates, or other compounds, due to the action of air or water, or both. Salts and Sulphur are also important sources of corrosion.

CRITICAL SURFACE – The surface in a cleanroom or work station to be protected from particulate contamination.

DEAD AREAS – Places in a medium where no filtering occurs. Also referred to as blind spots. The opposite of the effective area.

DEGRADATION – The wearing down, or reduction in the efficiency of, the medium.

DELTA (Δ) P – A commonly used symbol denoting the difference in pressure between two points, such as the inlet and outlet of a filter. This difference is often referred to as the pressure drop and is typically measured in inches of water column (water gauge) or pascals.

DEPTH FILTRATION – Filtration accomplished by a progressively denser, deep medium, designed to allow finer particles to penetrate further into the medium, while larger particulates are lodged closer to the surface. A progressive density medium has superior dust holding capacity.

DIFFERENTIAL PRESSURE – Difference in pressure between two points, such as the inlet and outlet of a filter. This difference is often referred to as the pressure drop, and is typically measured in inches of water column (water gauge) or pascals.

DIFFERENTIAL PRESSURE INDICATOR – Indicator that signals the difference in pressure at two points.

DIFFERENTIAL PRESSURE SWITCH – Electrical switch operated by the difference between two pressures and often used to give warning of the end of a filtration cycle.

DIFFUSER – An air distribution outlet specifically designed to mix conditioned air with room air by induction. Mixing is accomplished by venture action, as the high velocity airstream leaving the diffuser aspirates ambient air toward the device.

DIFFUSION – A method of filtration that is effective on particles 0.1 micron and smaller, whose direction and velocity are influenced by molecular collisions (called Brownian Motion). Particulates of this size do not follow the airstream, but behave more like gases than particulate. Their dwell time in the media is longer as they are battered across the direction of flow in a random “helter skelter” fashion. When a particle strikes a fiber, it is retained by the inherent adhesive forces between the particle and fiber (van der Waals forces).

DISPOSABLE – Describes an expendable component which is to be discarded after use and replaced with an identical component. This means that the component is replaceable, not reusable.

D.O.P. (DIOCTYL PHTHALATE) – An oil-like plasticizer which is readily atomized to form the test aerosol which was once used in the overall penetration and scan tests of HEPA filters. This test aerosol is now rarely used and has been replaced with PAO (poly-alpha-olefin).

DOWNSTREAM – Portion of the system located after a filter. Also, the leaving air or the clean air side of a filter.

DUAL LAYER MEDIA – Media in a filter element that has a coarse layer followed by a fine layer, to enhance dust holding capacity.

DUST HOLDING CAPACITY (DHC) – The total weight of ASHRAE test dust a filter can hold before reaching a given final resistance. This amount will vary, depending on the size and design of the filter and airflow rate. Typically reported in grams, DHC is used to provide a relative measure of filter service life.

EFFECTIVE AREA – Area of the medium exposed to flow and usable for its intended purpose (filtering). This term means the opposite of blind spots or dead area.

EFFICIENCY – Degree to which a filter will perform in removing solids, in accordance with the chosen test method.

EFFICIENCY CURVE – Graph showing the performance of a filter when challenged by specified contaminants under controlled conditions. Usually will be plotted against particle size at a given face velocity.

ELECTRET MEDIA – Filter media containing an electrostatic charge.

ELECTROSTATIC PRECIPITATION – A method of filtration that imparts a positive charge to airborne particulate matter and collects the particles on negatively charged collection plates.

EXFILTRATION – Outward air leakage from a space through openings, caused by pressure differences across these openings.

EXTENDED SURFACE FILTER – A category of filter that is designed with pleats or pockets to increase the amount of media exposed to the airstream within a given face dimension. Greater filter surface area reduces media velocity and increases efficiency and dust holding capacity.

FACE AREA – The area of a filter perpendicular to the flow direction.

FACE LOADING – The phenomenon by which contaminants in the air load up on the surface of the filter, causing an abnormal rise in resistance.

FDA – U.S. Food and Drug Administration, which is responsible for protecting and promoting public health through the regulation and supervision of food safety, tobacco products, dietary supplements, prescription and over-the-counter pharmaceutical drugs, vaccines, biopharmaceuticals, blood transfusions, medical devices, electromagnetic radiation emitting devices, cosmetics, animal food and feed, and veterinary products. The FDA enforces Current Good Manufacturing Practices (CGMPs).

FIBER – Fundamental unit comprising a textile raw material such as cotton or wool.

FIBERGLASS – A term used to describe a variety of filter media made with glass fibers.

FILTER – A term generally applied to a device used to remove contaminates from the air. A filter may be one of a number of types, such as panel, automatic self-renewable, extended surface, HEPA, electrostatic, or gas phase. The term filter is sometimes erroneously used to describe the media used inside the device.

FILTER MEDIUM – The porous material mounted in the filter through which air is passed to remove the contaminants.

FILTRATION – The process of removing contaminants from liquid or gas by forcing them through a porous medium.

FINAL FILTER – The last and usually most efficient filter in a multi-stage filtration system.

FPM – Feet Per Minute. This term refers to the speed at which air moves through an area.

FRESH AIR – Term used for outdoor air.

GAS – The state of matter in which molecules move freely, causing matter to expand indefinitely, occupying the total volume available.

GAS-PHASE FILTER – Air cleaning device that uses the adsorption and/or chemisorption removal process. Typical filter mediums are activated carbon, alumina, and zeolite, with and without chemical impregnants.

GASKET – Material inserted between contact surfaces of a joint to ensure a seal.

HEPA FILTER – High Efficiency Particulate Air filter, which is capable of removing a minimum of 99.97% of 0.3 micron particles (typically PAO) of other gases from air.

HYDROCARBON – Any one of a large number of compounds composed primarily of the elements carbon and hydrogen. As they increase in molecular weight and boiling point, these compounds may be respectively gases, liquids, or solids.

HYDROPHILIC – Water accepting, or water wetting. Having an affinity for water, the opposite of hydrophobic.

HYDROPHOBIC – Non-water wetting. Having an antagonism for water, the opposite of hydrophilic.

IEST – Institute of Environmental Sciences and Technology, whose mission is “To globally expand and communicate the knowledge of contamination control, nanotechnology facilities, and test reliability. This is accomplished through the development of Recommended Practices and Standards by a community dedicated to professional collaboration, training, and education.”

Filter Industry Definitions

Servicing Southern California Since 2013

IMPINGEMENT – A method of filtration that is effective on particles with sufficient inertia to cause them to leave the airstream and collide with a fiber. Often referred to as "viscous impingement," when the fibers are coated with an adhesive.

INCHES W.G. – Abbreviation for "inches water column gauge." This is a method of reporting filter resistance (or pressure drop) across a filter.

INFILTRATION – Inward air leakage from a space through openings, caused by pressure differences across these openings.

INITIAL RESISTANCE – Differential pressure (drop) across a clean filter, typically measured in inches of water column (water gauge) or pascals. Synonymous with initial pressure drop, or clean pressure drop.

INTERCEPTION – A special case of the impingement method of filtration that does not depend on the inertia of the particles to bring them in contact with a fiber. Interception occurs when a particle follows the airstream but touches a fiber as it attempts to flow around it. The particle is held by the inherent adhesive forces between the particle and fiber (van der Waals force).

INTERSTICES – Spaces or openings in a medium, such as the spaces between intersecting fibers. Also referred to as pores or voids.

KNIFE-EDGE SEAL – A narrow, pointed ridge on the peripheral sealing surface of a filter or filter frame, which provides a seal by the impression of a sharp edge into a gasket or gel.

LAMINAR AIRFLOW – Airflow in parallel flow lines with uniform velocity and minimum eddies.

LAMINAR FLOW CLEANROOM – A cleanroom with a requirement for laminar airflow. Airflow velocities are usually not greater than 90 FPM.

LIFE EXPECTANCY – The service life or change-out interval of a filter cartridge. Even with known dust holding capacity, the useful life will vary according to the type and size of contaminants entering the filter, particularly on makeup air or 100% outside air systems.

LIFE CYCLE COSTS (FILTER) – Sum of all costs associated with operating a filter system, including product, energy, labor, transportation, and disposal costs.

MAKEUP AIR – Outside air introduced to the HVAC system for ventilation, pressurization, or to replace exhausted air quantities.

MASS TRANSFER ZONE – Area of the adsorbent bed where contaminants are removed from the airstream. The mass transfer zone will move away from the inlet of the bed to the discharge until breakthrough occurs (end of useful life of the medium).

MAXIMUM DIFFERENTIAL PRESSURE – The highest pressure differential which a filter is required to withstand without structural failure or collapse.

MAXIMUM RECOMMENDED PRESSURE DROP – Published final pressure drop by manufacturer.

MEDIA – Plural of medium. This is the material that performs the actual separation of contaminants from the air stream.

MEDIA VELOCITY – Speed of the air flowing perpendicular to the media, calculated by dividing the total airflow through a filter by the effective media area.

MEDIUM – The porous material through which air is passed to remove contaminants (particulates or gases). It is usually confined within a frame or cell sides and is generally referred to as a filter or filter cartridge.

MERV – Minimum Efficiency Reporting Value is a single number that is used, along with the air velocity at which the test was performed, to simplify the extensive data generated by the ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. MERV is expressed on a 16 point scale (MERV 1 through MERV 16) and is derived from the particle size removal efficiency measured in the test.

MICRON OR MICROMETER – A unit of length in the metric system. This term means one millionth of a meter, 10^{-4} centimeter, 10^{-3} millimeter, or 0.000039 of one inch. It is commonly used as a measure of particle size or fiber size in filter media. The naked eye can see a particle approximately 10 microns or larger without magnification.

MICROORGANISMS – Living bodies that can be seen only through a microscope.

MIGRATION – Contaminant captured and subsequently released downstream of a filter.

MILLILITER – One thousandth of a liter, equal to one cubic centimeter.

NET EFFECTIVE MEDIA AREA – The amount of media area in a filter that is exposed to airflow and usable for collecting airborne contaminants. The opposite of blind spots or dead area, this term is synonymous with net effective filtering area.

NEGATIVE PRESSURE – Vacuum or suction.

NON-LAMINAR – As applied to cleanroom airflow, this is less desirable than laminar flow because the air supply is introduced at random, causing turbulence and induction that stir the airborne dust particles and keep them in suspension.

NONWOVEN – A filter cloth or paper that is formed of synthetic fibers that are randomly oriented in the media. It is usually held together with a binder or binder fibers.

NON-SUPPORTED FILTERS – Extended-area filters which rely on the airflow to support the media in the airstream. Filters will generally sag or collapse under low or no airflow conditions.

OFFGASSING – Term used to express the release of a gas from a material that was previously captured by an adsorbent. Preferential off-gassing occurs when an adsorbent releases a lighter molecular weight gas in order to adsorb a heavier molecular weight gas.

ORGANIC – Describes the vast number of chemical substances containing carbon, hydrogen, and oxygen.

OUTDOOR AIR – Ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

OXIDE – Combination of oxygen with another element.

OXIDATION – Any chemical reaction in which a material gives up electrons, as when the material combines with oxygen. Burning is an example of rapid oxidation, while rusting is an example of slow oxidation.

PANEL FILTER – A low efficiency filter, consisting of a flat sheet of media that is usually contained within a cardboard frame. An alternative design has an internal wire frame. Panel filters are typically made with fiberglass or synthetic media and are often referred to as throw-away filters.

PARTICLE COUNT – In a cleanroom, the particulate concentration expressed as particles per cubic foot or particles per cubic meter, by particle size, is used to express the Airborne Particulate Cleanliness Class in accordance with Federal Standard 209E or ISO Standard 14644-1. Depending on the cleanliness class, particles are simultaneously measured from 0.1 micron to 5 microns in size.

PARTICULATE MATTER (PM) – Also known as particle pollution, PM is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

PENETRATION – The leak rate through the filter, penetration is expressed as a percentage based upon a specific particle size. The percentage of penetration is the reciprocal of the percentage of the efficiency. HEPA filters, for example, have a 0.03% maximum penetration on 0.3 micron (μ) particles.

PLEATED FILTER – A type of extended surface filter where the media is folded back and forth to increase the amount of media exposed to the airstream within a given face dimension. Greater filter surface area reduces media velocity and increases the efficiency and dust holding capacity.

PLEATING – In filters with a paper medium or other sheet material, pleating means the folding processes which provide a large surface area within a given volume of filter.

PREFILTER – A filter placed in front of another filter to remove larger, heavier particles. The primary purpose of this is to extend the life of the final filters. Prefilters are highly recommended in systems requiring high efficiency filtration, especially where a high concentration of lint and larger particles are present.

PRESSURE DIFFERENTIAL – Difference in pressure between two points.

PRESSURE DROP – Difference in pressure between two points, generally at the inlet and outlet of a filter. Pressure drop is typically measured in inches of water column (water gauge) or pascals.

PRESSURE, STATIC – The fan-induced pressure that tends to burst or collapse a duct, which is required to move air through a system. Fans must push or pull air to deliver against resistance from duct friction, filters, coils, and other airflow obstructions.

PRESSURE, TOTAL – The combination of static pressure and velocity pressure within a duct.

PRESSURE, VELOCITY – The pressure required to maintain movement of air through a duct.

RESIDENCE TIME – The theoretical time that a contaminant is within the confines of a media bed.

RETENTIVITY – The ability of an adsorbent to resist the desorption of an adsorbate.

SCAN TEST – Technique for disclosing leaks in HEPA and ULPA filters. Tests are performed by introducing a challenge aerosol upstream of the filters and passing the inlet of a sampling probe of an aerosol photometer or discrete particle in a series of parallel, slightly overlapping strokes across the downstream face of the filter (scanning), to detect any leaks.

SCFM – Standard Cubic Feet per Minute. This term refers to airflow that has been corrected to “standardized” conditions of temperature and pressure.

SKIN LOADING – The condition that occurs when collected particles build up on the surface of the media, plugging the spaces between the fibers. This is also known as blocking or surface loading. As a rule, the finer the media, the more susceptible it is to skin loading by “coarse” particles.

SORBENT – A substance that has the property of collecting molecules of another substance by adsorption or absorption.

STATIC TIP – Device used to measure static pressures in ducts or rooms. These devices are frequently installed upstream and downstream of a filter bank and connected to a pressure gauge to measure the pressure differential across the filter bank.

STOKES’ LAW – A physical law which approximates the velocity of a particle falling under the action of gravity through a fluid. The particle accelerates until the frictional drag of the fluid just balances the gravitational acceleration, after which it will continue to fall at a constant velocity known as the terminal or free-settling velocity.

STRAINING – A method of filtration that removes larger particles. Straining occurs when a particle is larger than the space between fibers and cannot pass through them.

SULPA FILTER – Super Low Penetrating Air filter with a minimum efficiency of 99.9999% on 0.12 micron (μ) particles.

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Filter Industry Definitions

SoCal Filters Sales & Service

Servicing Southern California Since 2013

SURFACE AREA – The surface area of an adsorbent is determined by the BET method and is usually expressed in square meters per gram of adsorbent.

TERMINAL HEPA MODULE – A HEPA filter module that is connected to the end of a duct, most often mounted in the ceiling of a cleanroom.

TERMINAL VELOCITY – Steady velocity achieved by a falling particle when gravitational forces are balanced by viscous forces. *See Stokes' Law.*

UL 586 – Standard for High Efficiency, Particulate Air (HEPA) Filter Units. For this standard, filters are tested for efficiency and penetration and undergo a moisture test, heated air test, a low temperature test, and a spot flame test. A UL 586 label can only be applied to HEPA filters whose designs have been proven to meet the requirements of UL 586 test standard and must be tested for efficiency and resistance.

UL 900 – Standard for Air Filter Units. Filters that are classified to this standard and bear the UL mark meet the requirements of the test for the amount of smoke generated and the combustibility of the air filter unit. Filters meeting the standard are classified as follows: "Air filter units covered by this standard are classified as those that, when clean, burn moderately when attacked by flame or emit moderate amounts of smoke, or both."

ULPA FILTER – Ultra Low Penetrating Air filter with a minimum efficiency of 99.9995% on 0.12 micron (µm) particles.

UNLOADING – Release downstream of trapped contaminate. This can be due to a change in flow rate, mechanical shock, vibration, excessive pressure build-up, or medium failure.

VAPOR – A substance diffused or suspended in the air, especially one that is normally liquid or solid.

VENTILATION – The movement of air to and from a space by mechanical or natural means, including both the exchange of air to the outside, as well as the circulation of air within a building or space.

VOLATILE ORGANIC COMPOUNDS (VOCs) – Organic chemicals that have a high vapor pressure/low boiling point at ordinary room temperature, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air. The health effects of VOCs in indoor environments vary, depending on the type and concentration of VOCs, along with the length of time a person is exposed.

Indoor Air Quality (IAQ)

refers to the air quality within and around buildings and structures, especially as it relates to the **health and comfort** of building occupants.

Understanding and controlling common pollutants indoors can **help reduce your risk of indoor health concerns**.

Indoor Air Quality Research

focuses on **improving the techniques** used to measure and model emissions of indoor air chemical contaminants present in free-standing structures.

Research is dedicated to investigating various approaches to **eliminating mold problems** in residence and office buildings.

Source: Environmental Protection Agency (EPA)

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