Quick Selection Guide

	Filter Grade				Air Filter Selection	
Primary Filtration	Medium Efficiency	Primary Filters	ASHRAE 52.2	MERV 2 - 4 MERV 5 - 6 MERV 7 - 9	EN 779: 2002	**Primary Filters** G2 ≥ 65% G3 ≥ 80% G4 ≥ 90% EN 779:2002 Average Arrestance
Filtration for Air Conditioning Systems. Pre-filtration for HEPA/ULPA Filters	High Efficiency	Fine Filters (EUROVENT AIR FILTERS CLASS F5-F9)	ASHRAE 52.2	MERV 10 MERV 11-12 MERV 13 MERV 14 MERV 15	EN 779: 2002	**Fine Filters** F5 ≥ 40% F6 ≥ 60% F7 ≥ 80% F8 ≥ 90% F9 ≥ 95% EN 779:2002 efficiency
Final Filters / Clean Room Filters	Very High Efficiency	HEPA / ULPA — DOP 0.3um		≥ 95% ≥ ≥ 99,9% ≥ ≥ 99,97% ≥ 99,99% ≥ 99,999%	EN 1822	**MPPS (Most Penetrating Particle Size)** H10 ≥ 85% H11 ≥ 95% H12 ≥ 99,5% H13 ≥ 99,95% H14 ≥ 99,995% U15 ≥ 99,9995% U16 ≥ 99,99995% U17 ≥ 99,999995%
Molecular						CityFlo, CitySorb, CityCarb, Camcarb
Frames, housings & speciality filters						Filter Housings, Camseal FC Casings, Type 8 Frames

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Standards, Regulations and Recommendations

Ventilation filters

Standards

Year	Reference	Type of test	Classification
1968	ASHRAE 52.2	ARRESTANCE EFFICIENCY	MERV 1 - 20
1980	EUROVENT 4/5	ARRESTANCE EFFICIENCY	EU1 to EU4 - EU5 to EU9
1982	AFNOR NF X 44.012	ARRESTANCE EFFICIENCY	
1993	CEN EN 779	ARRESTANCE EFFICIENCY	G1 to G4 - F5 to F9
2003	CEN EN 779:2002	ARRESTANCE EFFICIENCY	G1 to G4 - F5 to F9

The new standard for general ventilation filters EN 779:2002

1. Measurement of filter efficiency using modern particle counting technique
2. The aerosol challenge is DEHS (the same as used with HEPA filters)
3. Classification based on a particle size of 0.4 µm
4. The test includes initiatives to determine the discharged efficiency of filters to better represent their performance in use. These are shown in Annexe A.

Why a new standard?

Certain types of filter media rely on an electrostatic effect to achieve a high level of efficiency whilst promising a low pressure drop for a given air volume.

It is important that users are aware of filters that rely on this electrostatic effect and are also informed about the degradation in efficiency once the electrostatic effect dissipates.

This new test procedure describes in Annexe 'A' a mechanism that removes the electrostatic effect by treating the filter material with Isopropanol. This discharges the filter and enables the real efficiency to be determined. The average efficiency of the filters after discharge is recorded on the certificate.

Filters are classified based on their performance against particles of 0.4 µm. Filters in Group F must achieve an average efficiency greater than 40%; below this they are included in Group G.

EN 779:2002 Classification

EN 779:2002 standard		Average arrestance Am (%)	Average efficiency Em (%)	EUROVENT 4/5 equivalent
Filter group	Filter class	Filter class limits		Filter class
Coarse (G)*	G2	65 ≤Am < 80	-	EU 2
	G3	80 ≤Am < 90	-	EU 3
	G4	90 ≤Am	-	EU 4
Fine (F) **	F5	-	40 ≤Em < 60	EU 5
	F6	-	60 ≤Em < 80	EU 6
	F7	-	80 ≤Em < 90	EU 7
	F8	-	90 ≤Em < 95	EU 8
	F9	-	95 ≤Em	EU 9

Initial efficiency (Ea) : * Ea < 20% ; ** Ea ≥20%

Final pressure drop: * 250 Pa ; ** 450 Pa

Very high efficiency filters

Standards

Year	Reference	Type of test		Classification
1956	MIL STD 282	DOP	0.3 µm	-
1972	AFNOR NF X 44.011	Uranine	0.15 µm	-
1976	EUROVENT 4/4	NaCl	0.65 µm	EU10 to EU14
1995	CEN EN 1822	MPPS	0.1 to 0.2 µm	HEPA: H10 to H14 ULPA: U15 to U17

EN 1822 Classification

		MPPS integral values			MPPS local values		
Filter group	Filter class	Min. efficiency (%)	Max. penetration (%)	Min. P.C.	Min. efficiency (%)	Max. penetration (%)	Min. P.C.
HEPA (H)	H10	85	15	6.7	-	-	-
	H11	95	5	20	-	-	-
	H12	99.5	0.5	200	-	-	-
	H13	99.95	0.05	2.000	99.75	0.25	400
	H14	99.995	0.005	20,000	99.975	0.025	4.000
ULPA (U)	U15	99.9995	0.0005	200,000	99.9975	0.0025	40,000
	U16	99.99995	0.00005	2.000,000	99.99975	0.00025	400,000
	U17	99.999995	0.000005	20,000,000	99.9999	0.0001	1.000,000

HEPA : High Efficiency Particulate Air (filter)

ULPA : Ultra Low Penetration Air (filter)

P.C. : Purification Coefficient

ASHRAE 52.2 / EN779 / EN1822 Cross reference Table

ASHRAE 52.2	EN779 / EN1822
MERV 1	EN779 : G1
MERV 2	EN779 : G2
MERV 3	EN779 : G2
MERV 4	EN779 : G2
MERV 5	EN779 : G3
MERV 6	EN779 : G3
MERV 7	EN779 : G4
MERV 8	EN779 : G4
MERV 9	EN779 : G4
MERV 10	EN779 : F5
MERV 11	EN779 : F6
MERV 12	EN779 : F6
MERV 13	EN779 : F7
MERV 14	EN779 : F8
MERV 15	EN779 : F9
MERV 16	EN1822 : H10
MERV 17	EN1822 : H13
MERV 18	EN1822 : H13
MERV 19	EN1822 : H14
MERV 20	EN1822 : H14

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Standards, Regulations and Recommendations

Classification as per Eurovent 4/4 recommendation, NaCl method

EUROVENT 4/4 Filter class	Initial efficiency Ei (%) Limits of filter classes	Penetration Pi (%) Limits of filter classes
EU 10	95 ≤ Ei < 99.9	5 ≥ Pi > 0.1
EU 11	99.9 ≤ Ei < 99.97	0.1 ≥ Pi > 0.03
EU 12	99.97 ≤ Ei < 99.99	0.03 ≥ Pi > 0.01
EU 13	99.99 ≤ Ei < 99.999	0.01 ≥ Pi > 0.001
EU 14	99.999 ≤ Ei	0.001 ≥ Pi

Clean rooms

Classification of different air qualities required for manufacture of sterile products

	Maximum number of particles per m^3 of a size greater than or equal to 0.5 µm inactive (b)	5 µm inactive (b)	0.5 µm active	5 µm active	Max. nbr: of µorganisms per m^3 (active)
A	3.500	0	3.500	0	< 1
B	3.500	0	350,000	2.000	10
C	350,000	2.000	3.500,000	20,000	100
D	3.500,000	20,000	not defined (c)	not defined (c)	200

Pharmaceutical industry

Pharmaceutical industry
Guide to good Manufacturing Practice (2002)
(b) Corresponds approximately to the US Federal Standard 209 E and ISO as follows: classes A and B to class 100. M 3.5. ISO 5; class C to class 10,000. M 5.5. ISO 7; class D to class 100.000. M 6.5 ISO 8.

Comparison of international classification standards

Nbr of part 0.5 µm/ m^3 (approx.)	US Fed. Std 209 E 1992		EN ISO 14644 -1 1996	France AFNOR NF X 44.101 1981	European Union Pharma industry Guide GMP 1989	Nbr of part 0.1 µm/ m^3 (approx.)
-	-	-	ISO 1	-	-	10
1	-	-	-	-	-	35
4	-	-	ISO 2	-	-	100
10	M 1	-	-	-	-	350
35	M1.5	1	ISO 3	-	-	1,000
100	M 2	-	-	-	-	3,500
353	M2.5	10	ISO 4	-	-	10,000
1,000	M 3	-	-	-	-	35,000
3,530	M3.5	100	ISO 5	4,000	A and B	100,000
10,000	M 4	-	-	-	-	350,000
35,300	M4.5	1.000	ISO 6	-	-	1.000,000
100,000	M 5	-	-	-	-	-
353,000	M5.5	10,000	ISO 7	400,000	C	-
1.000,000	M 6	-	-	-	-	-
3.530,000	M6.5	100,000	ISO 8	4.000,000	D	-
10,000,000	M 7	-	-	-	-	-
35.000,000	-	-	ISO 9	-	-	-

Permissible particle levels in different classes of clean rooms and clean zones

ISO classification CD 14644-1 (1996)	Maximum permissible concentrations (particles/m^3 of air) of particles of a size greater than or equal to the size shown below: 0.1 µm	0.2 µm	0.3 µm	0.5 µm	1 µm	5 µm
ISO 1	10	2	-	-	-	-
ISO 2	100	24	10	4	x	-
ISO 3	1,000	237	102	35	8	-
ISO 4	10,000	2,370	1,020	352	83	-
ISO 5	100,000	23,700	10,200	3,520	832	29
ISO 6	1.000,000	237,000	102,000	35,200	8,320	293
ISO 7	-	-	-	352,000	83,200	2,930
ISO 8	-	-	-	3.520,000	832,000	29,300
ISO 9	-	-	-	35.200,000	8.320,000	293,000

$C = 10N(0.1/D)2.08$ part / m^3

US Fed Std 209 E (1992)

Class Name S1	English	Class Limits 0.1 µm Volume Units m3	0.2 µm Volume Units m3	0.3 µm Volume Units m3	0.5 µm Volume Units m^3	5 µm Volume Units m^3
M 1	-	350	75.7	30.9	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	2,650	1,060	353	-
M 3	-	35,000	7,570	3,090	1,000	-
M 3.5	100	-	26,500	10,600	3,530	-
M 4	-	-	75,700	30,900	10,000	-
M 4.5	1000	-	-	-	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 / $m^3 = 10M(0.5/d)2 . 2$

particles / $ft^3 = Nc(0.5/d)2 . 2$

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Standards, Regulations and Recommendations

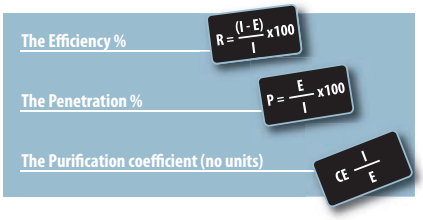
Air-conditioning / Comfort

Air quality of premises with non specific pollution

	Regulatory aspect Labour code / Circular of application of decrees 84/1093-1094 dated 7/12/1984	Recommendations UNICLIMA Air-conditioning & Health guide (1993)
Fresh air	Labour code Art. R235.2.6 Minimum arrestance efficiency 90% (G4 according to EN 779:2002)	Air-conditioning system inlet: 85% opacimetric (F7 according to EN 779:2002) Air-conditioning system outlet: 90% opacimetric (F8 according to EN 779:2002)
Recycled air	Labour code Art. R232.5.4 Minimum opacimetric efficiency 50% (F5 according to EN 779:2002)	85% opacimetric (F7 according to EN 779:2002)

FILTER ENGINEERING - Calculations

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



Clearly the purification

Clearly the purification coefficient is the most representative expression for high levels of filtration. E.g.:
Efficiency 99.995 % : CE of 20,000
Efficiency 99.9998% : CE of 500 000
The second filter is 25 times more efficient than the first.
Nota : I = particle concentration upstream E = particle concentration downstream

Conversion table (%)

Efficiency	Penetration	Purification Coefficient	Efficiency	Penetration	Purification Coefficient
95	5	20	99.99	0.01	10,000
99	1	100	99.995	0.005	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	0.00001	10,000,000

Comperative efficiencies

		on 1 µm			on 0.5 µm		
		E	P	PC	E	P	PC
90%	ARRESTANCE	10%	90%	1.1	5%	95%	1.05
50%	EFFICIENCY	30%	70%	1.4	10%	90%	1.1
65%	EFFICIENCY	45%	55%	1.8	25%	75%	1.3
85%	EFFICIENCY	85%	15%	6.6	70%	30%	3.3
95%	EFFICIENCY	95%	5%	20	90%	10%	10
95%	0.3 µm	≥ 98%	< 2%	≥100	≥98%	<2%	≥ 50

E = Efficiency, P = Penetration, PC = Purification Coefficient

Operating life

An air filter's operating life is not directly proportional to its useful filtering surface. It is much better to opt for a model comprising 50% additional surface. This increases its operating life by 100%, not 50%!

Actual case study

Filter model	Effective filtering surface	Initial pressure drop at 3 600m³/ h	Operating life*
Hi-Flo 3P 85	6.5 m²	120 Pa	3.500 hours
Hi-Flo 3M 85	9.4 m²	100 Pa	6.500 hours
Gain	3 m²	20 Pa	3.000 hours
Conclusion	+ 46% in surface (x 1.5)**	- 17% in energy	+ 86% in operating life (x 1.9)**

* Determined using the Camfil Farr calculation charts in the Hi-Flo brochure, for an average town environment

** factor of increase

Energy costs

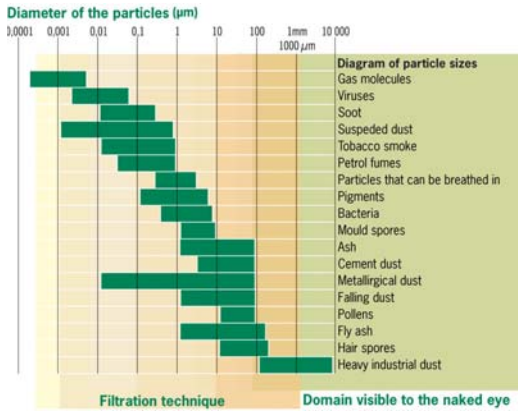
Energy consumed by an air filter due to its pressure drop:

$$E = \frac{q \times dP \times h}{e_f \times 1000} = kWh$$

q = flow rate (m3/s)
dP = pressure drop (Pa)
h = operating period (hours)
e_f = fan efficiency (generally 0.6 to 0.7)

Diagram of particle sizes

particle sizes



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Standards, Regulations and Recommendations

Conversions

Speed			
1 m/s = 3.6 km/h	1 km/h = 0.278 m/s	1 ft/min = 0.00508m/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 ft² = 0.0929 m²	1 m² = 10.8 ft²	1 in² = 6.45 cm²	1 cm² = 0.155 in²
Volume			
1 ft³ = 0.0283 m³	1 m³ = 35.3 ft³	1 ft³ = 28.3 litres	
Flow rate			
1 cfm = 0.472.10 -3 m³/s		1 m³/s = 3 600 m³/h	1 m³/h = 0.278.10 -3 m³/s
1 cfm = 1.699 m³/h		1 m³/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 Pa	1 Pa = 0.102 mmCE	1 kPa = pz	1 kPa = 10.2 g/cm²
1 kg/cm² = 0.980665 bar	1 bar = 1.02 kg/cm²	1 kg/m² = 98.0665 kPa	1 kPa = 0.00987 atm
1 psi = 6.89 kPa	1 bar = 101325 Pa	1 atm = 101.325 kPa	1 mb = 100 Pa
1 mmCE = 1kg/m²	1 kPa = 0.145 psi	1 Pa = 1 N/m²	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		

Temperature: conversion formulae

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	-6,7	40	4,4	70	21,1	100	37,8

Energy

Energy

1 kcal/kg = 4.19.103 J/kg

1 J/kg = 0.239.10^{-3} kcal/kg

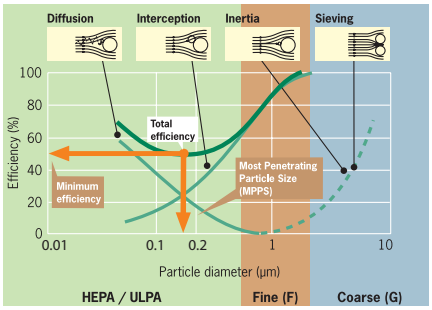
Heat transmission

1 kcal/h.m².°C = 1.16 W/(m².°C)	1 W/(m².°C) = 0.86 kcal/h.m².°C
1 Btu/(h.ft².°F) = 5.64 W/(m².°C)	1 W/(m².°C) = 0.177 Btu/(h.ft².°F)

FILTER ENGINEERING - Theory

MPPS

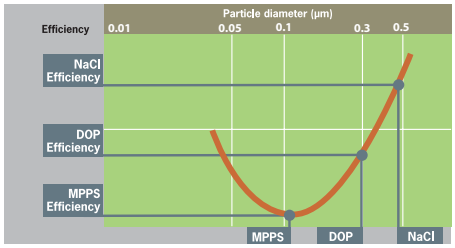
Minimum efficiency of air filters



The overall efficiency of an air filter is the result of a combination of 4 basic filtration mechanisms (sieving, inertia, interception and diffusion), so that the efficiency curve of an air filter adopts a characteristic V shape showing a minimum level of efficiency. This minimum efficiency corresponds to a particle size called MPPS (Most Penetrating Particle Size). In other words, the MPPS is the particle size that is the most difficult to stop. The MPPS is situated between 0.1 and 0.2 µm depending on the filter type, and the speed of air flow through the filtering media

EFFICIENCY TESTS (Not all the tests are equivalent)

MPPS (Most Penetrating Particle Size)



The NaCl test (EUROVENT 4/4)

The NaCl test (EUROVENT 4/4) is less demanding than the DOP test, which in turn is less demanding than the MPPS test

Whitby diagram

Distribution of particles in atmospheric air

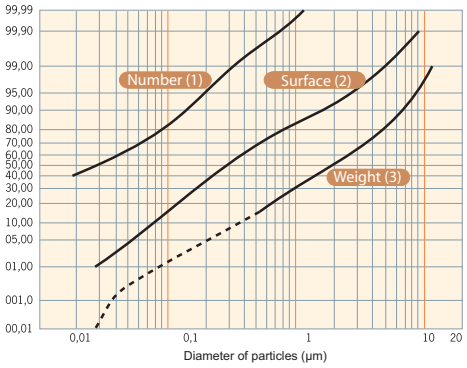


Diagram of Whitby: This diagram shows that more than 99.90% of airborne particles are less than or equal to 1 µm in size.
Therefore, the essential part of air filtration's activity takes place in the invisible domain (human ocular partition power: 30 µm).

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