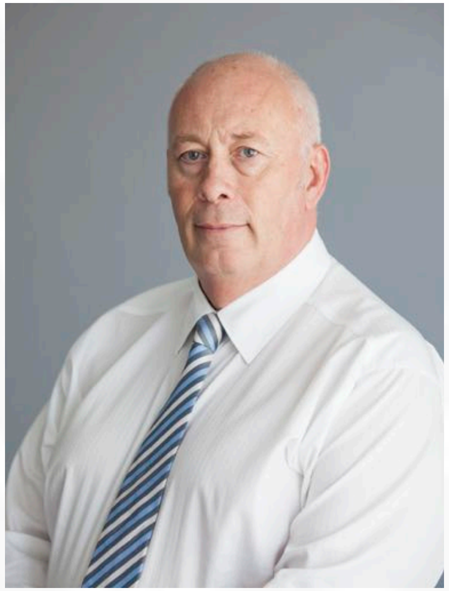
EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Event Introduction:
Air Filtration and IAQ



Brian Suggitt
Chairman
Eurovent Middle East

Members

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camfil
CLIMA UNO
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DAIKIN
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RELATED ORGANISATIONS

ceis
REHVA
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Agenda

1. Air filters for general ventilation
2. Keynote: ISO16890
3. Indoor Air Quality improvement in operating theaters
4. Eurovent Certified Performance program for air filters
5. Open discussion
6. Networking and dinner

Air filters for General Ventilation

Prasad Natraj
General Manager
AAF International LLC

Agenda

1. Air Filters for General Ventilation
2. Benefits & Fundamentals of Air Filtration
3. Standards & Maintenance
4. Filter Design of Key Applications
5. Practical Issues
6. Question and Answers

Reasons for Cleaning Air

- Human health
- Human comfort
- Creating a sustainable environment
- Preservation of mechanical equipment
- Improving the quality of production processes e.g. microelectronics, pharmaceutical and food processing

Principles of Air Filtration

Before we proceed with the principles, let us understand the following:

- Sources of contamination
- Physics of filtration technology

Types of Airborne Contaminants 1/2

Basically, there are three major types of contaminants:

- Solid particles
- Liquid particles
- Gaseous particles

Types of Airborne Contaminants 2/2

Solid Particles	Liquid Particles	Gaseous particles
Natural and man-made dust, fumes and smoke	**Includes contaminated and suspended liquids**	**Gaseous and condensed gaseous contaminants from outside air, building materials and processes**
Includes viable and inert particles, such as: • Synthetic and natural lint • Fungal spores and pollen • Bacteria and viruses • Silicates (sand) • Fly ash • Carbon dust • Oil and tobacco smoke	• Aerosols • Mist and fogs	• CO, CO2 • Ozone • Sox and Nox • NH3 and amines • Mineral acids • Condensable hydrocarbons and silicones • Organo-phosphates, arsenates, solvents

Sources of Airborne Contaminants

Man-made

- Combustion processes
- Industrial processes
- Bodily detritus in the form of dead skin and hair
- Abrasion products from rail, road and air traffic
- Macromolecules and metal ions

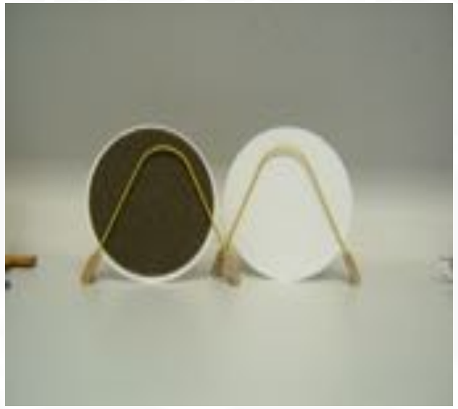
Naturally occurring

- Volcanic eruptions, forest fires
- Smog, fog and free carbon
- Bacteria, viruses and endotoxins
- Organic carbon originating from decaying animal and vegetable waste

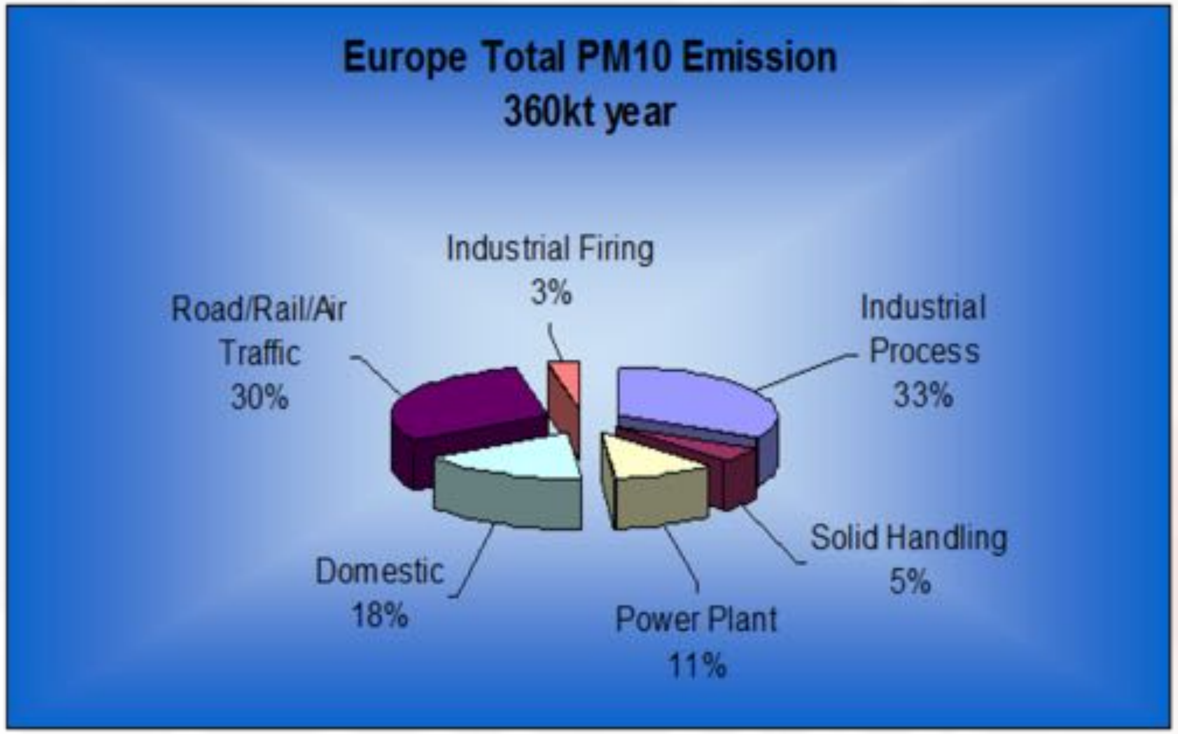
Outdoor Air Pollutants

SO2

PM10



Ozone



NO2

CO

Indoor Air Pollutants

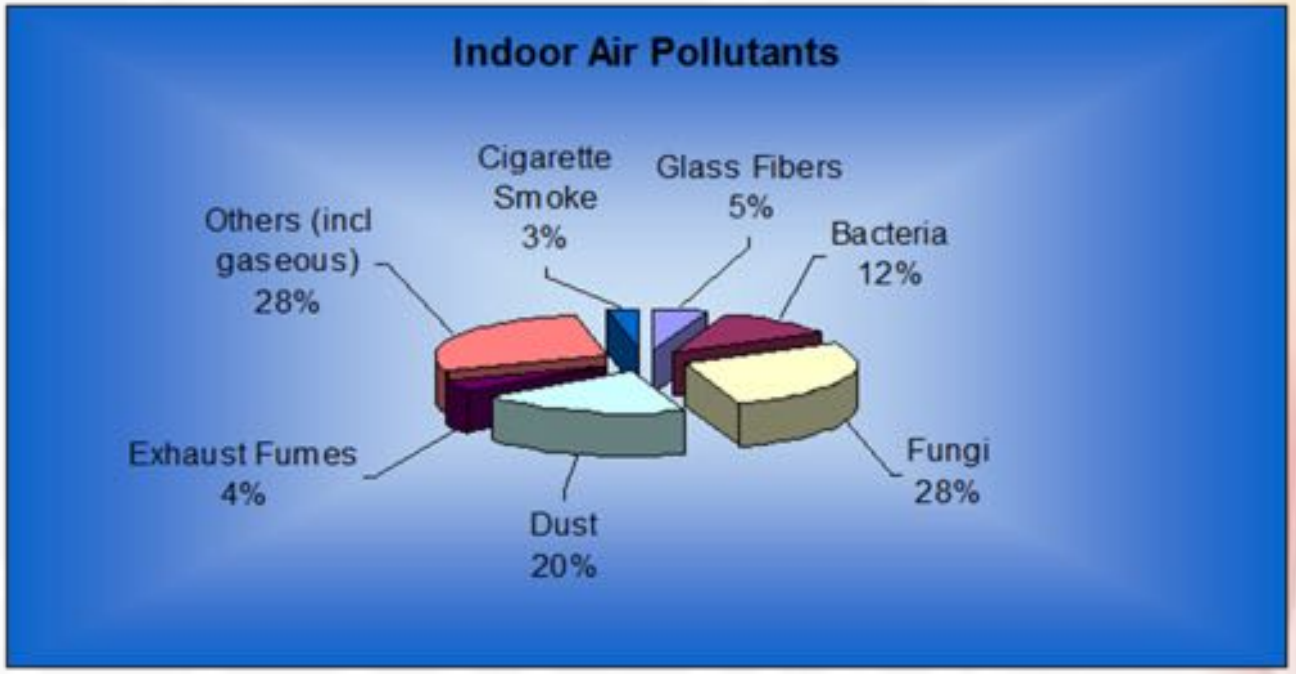
Outgassing from carpets, paint, wood (formaldehyde), office machinery (ozone)

Paint

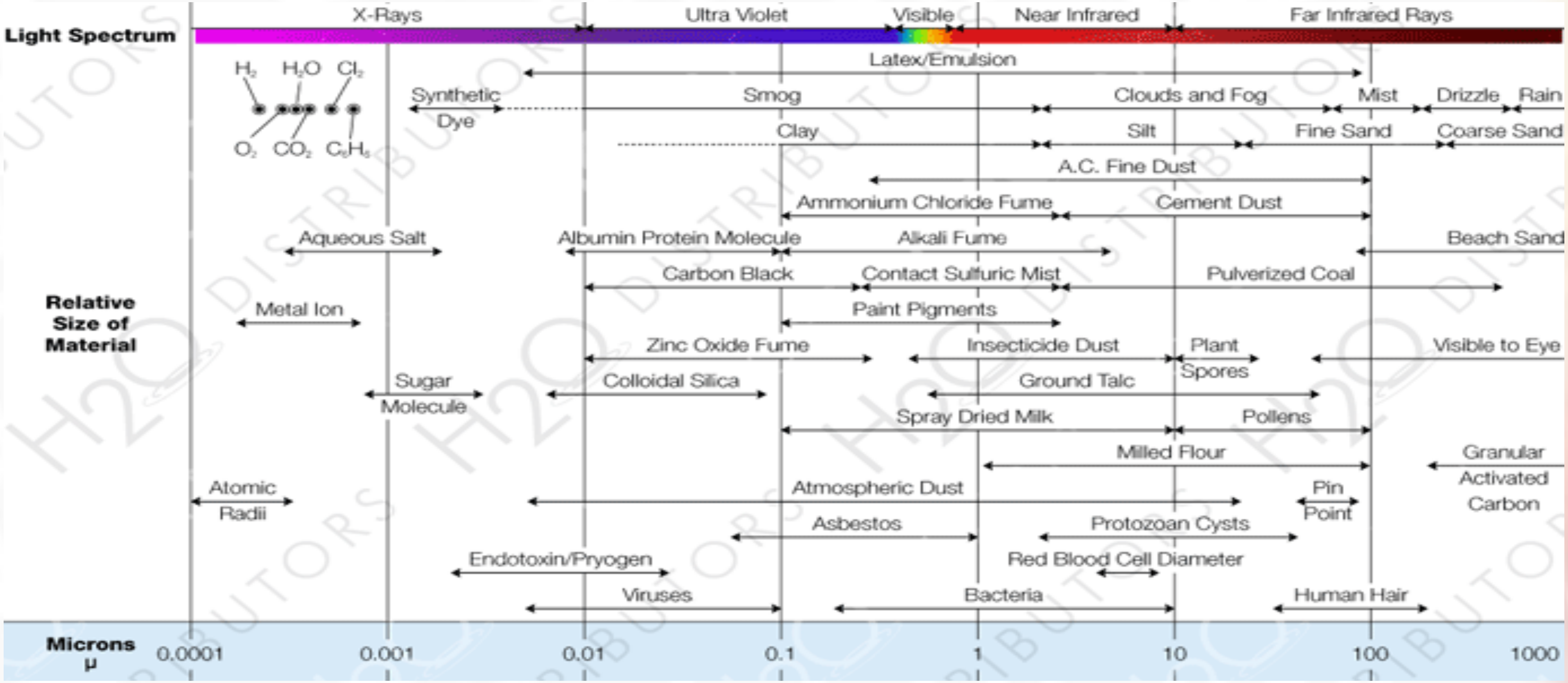
Waste

Copier

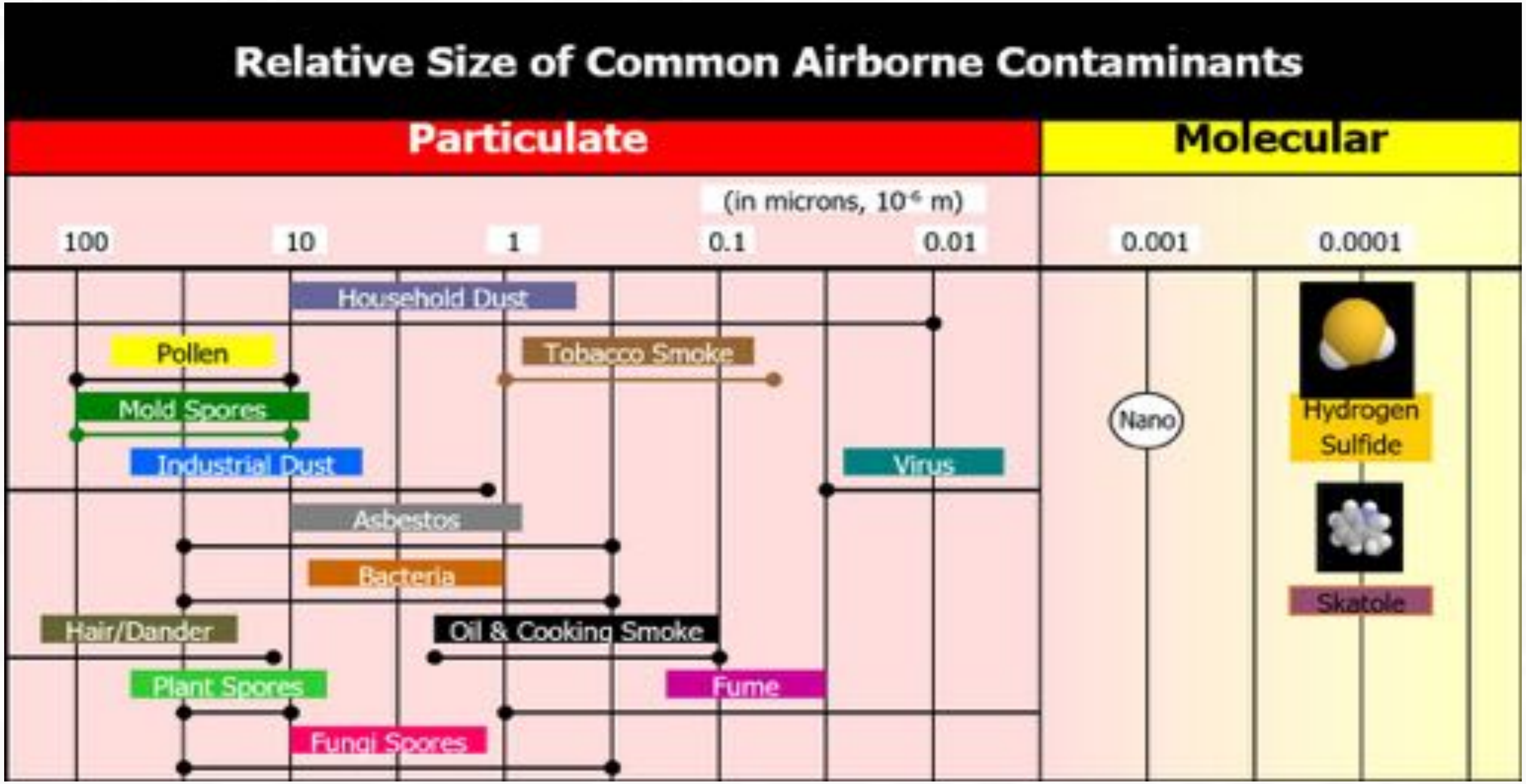
Smoke



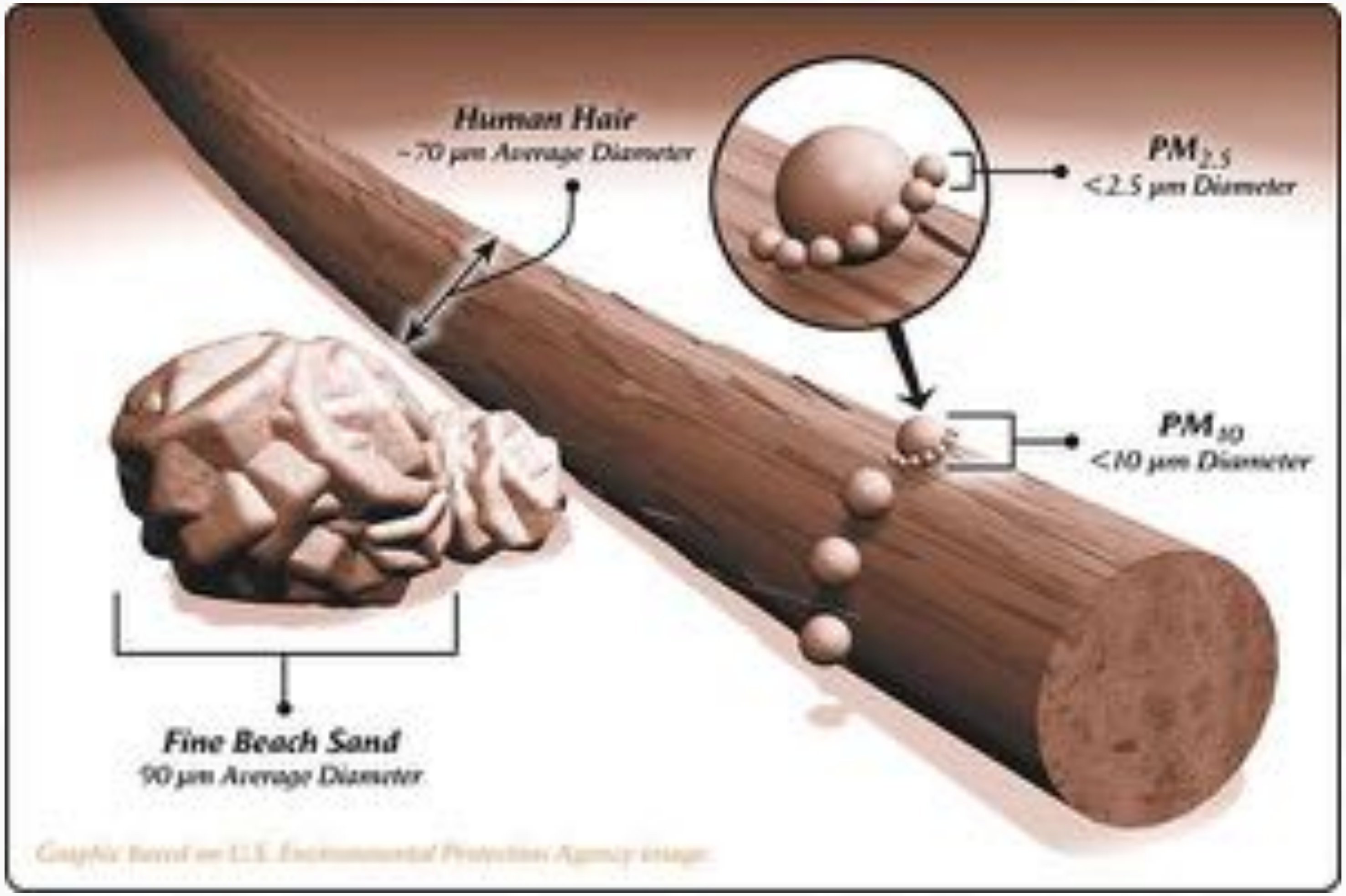
Particle Size Distribution



Particle Sizes and Size Distribution



Particle Sizes Human Hair



Particle Size Distribution-
Size vs. Weight

Basic rules of thumb are:

- There are always much more small particles in the air than large particles
- Large particles have a much higher mass than smaller particles, thus contribute much more to the total weight
- Only particles larger than 10 micrometre can be seen with the naked eye
- Only 50 particles out of every million are visible to the naked eye
- Typically:
  <1% of the number of particles represent 90% of the total weight
  >95% of particles have a diameter of less than 0.5 µm

Viable Microorganisms

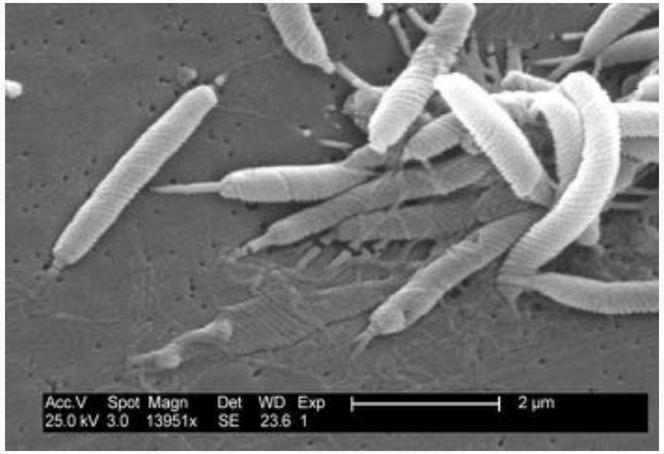
Molded Bread (wikipedia.org)

Molded Ceiling (wikipedia.org)

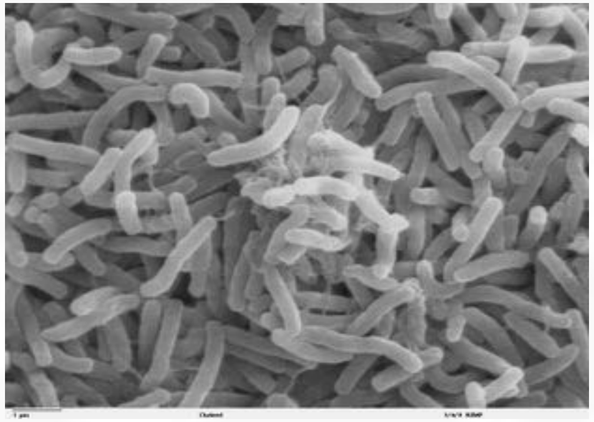
Molded Nectarine (wikipedia.org)

Viable Microorganisms
Bacteria

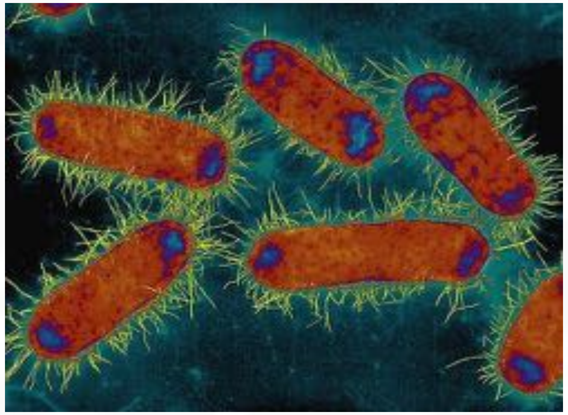
- Under ideal conditions, bacteria duplicate every 20 minutes
- On the skin surface of a human being (≈ $2m^2$) around 7 billion microorganisms can be found – nearly as much as people living on earth



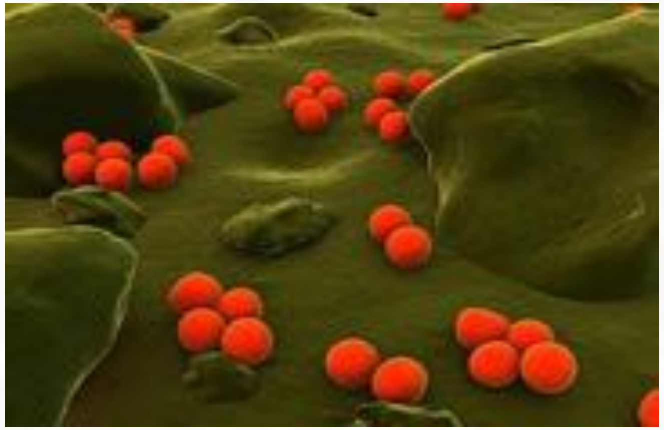
Heliobacter Pylori (wikipedia.org)



Neisseria Gonorrhoeae (onmeda.de)

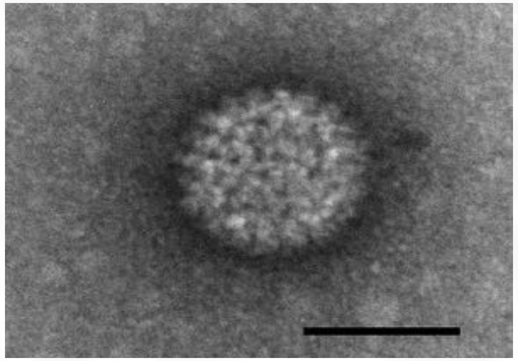


Neisseria Gonorrhoeae (onmeda.de)



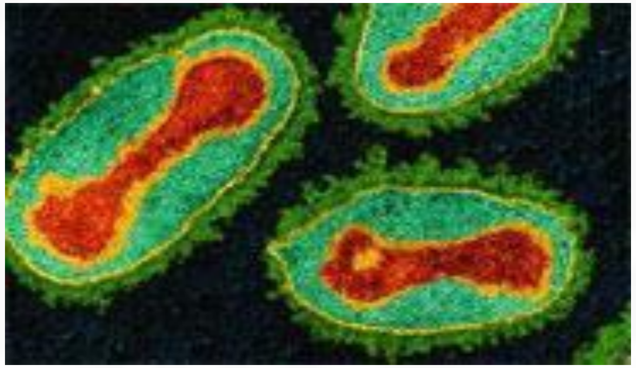
Neisseria Gonorrhoeae (onmeda.de)

Viable Microorganisms



Bluetongue Virus (wikipedia.org)

Pox Virus (biokurs.de)



Ebola Virus (biokurs.de)

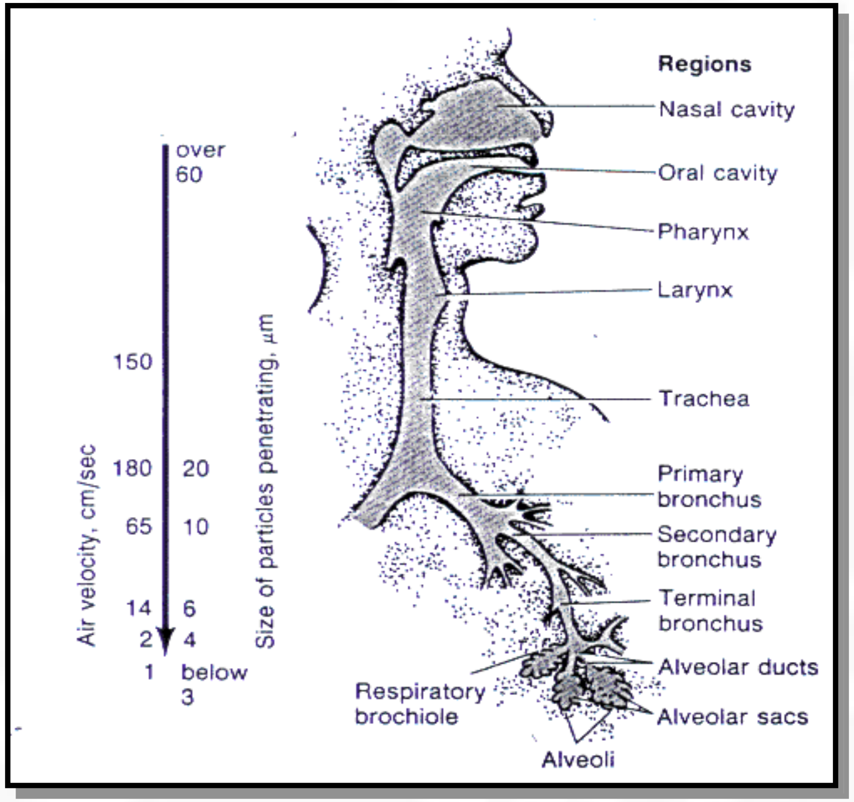
Indoor Air Pollutants 1/2

- A survey by Healthy Buildings International showed that fungi and bacteria are major contributors to poor IAQ
- In approximately 70% of the buildings with poor IAQ, this was caused by airborne particulate and could be solved by proper air filtration
- In approximately 40% of the buildings with poor IAQ, the main contributor were biological particulate (bacteria, fungal spores and their byproducts)

Source: Healthy Buildings International

Fine particles penetrate deep into the lungs, while gaseous contaminations even get adsorbed into the blood stream

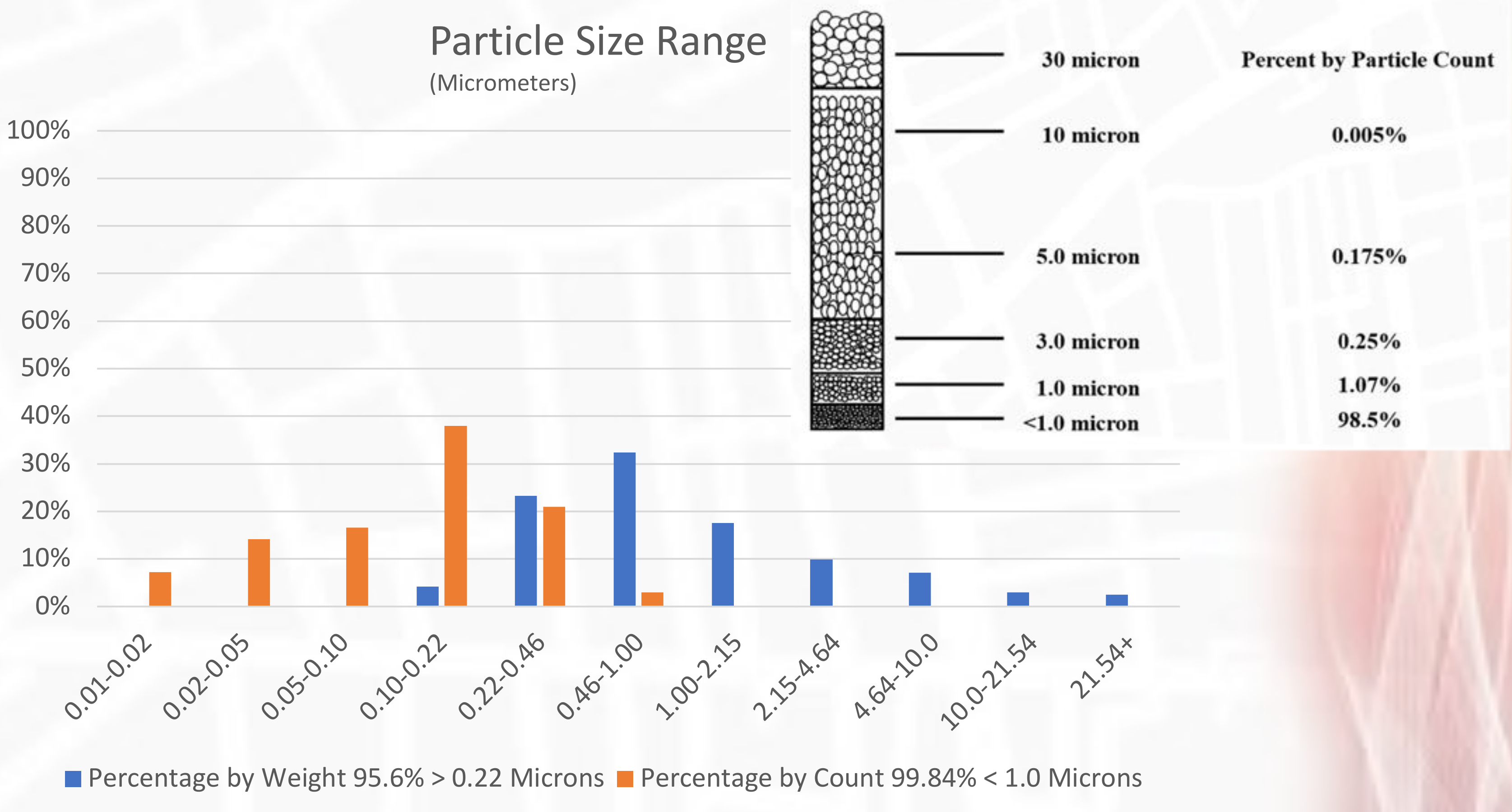
Indoor Air Pollutants 2/2



Aerodynamic Diameter (µm)	Likely Region of Deposit
>9.0	Filtered out by nose
6.0 – 9.0	Deposited in pharynx
4.6 – 6.0	Deposited in tranche and primary bronchi
3.3 – 4.6	Deposited in secondary bronchi
2.15 – 3.3	Deposited in terminal bronchi
0.41 – 2.15	Deposited in the alveoli

Suspended Atmospheric Dust

- 2.4 Billion particles/Cu. Ft.
- 99% Smaller than 1.0μ
- Lung damaging 0.5 to 5.0μ
- Smallest visible 10.0μ
- Fungal spores 1.0 to 60.0μ
- Bacteria 0.3 to 10.0μ 90% 1.0μ and larger



The Importance of IAQ

Energy conservation measures of the 70's:

- Reduced outside air
- Tighter buildings

Reduced air filtration

- Heat pumps
- Lower resistance/ lower efficiency

Reduced preventive maintenance

- Mechanical
- Housekeeping

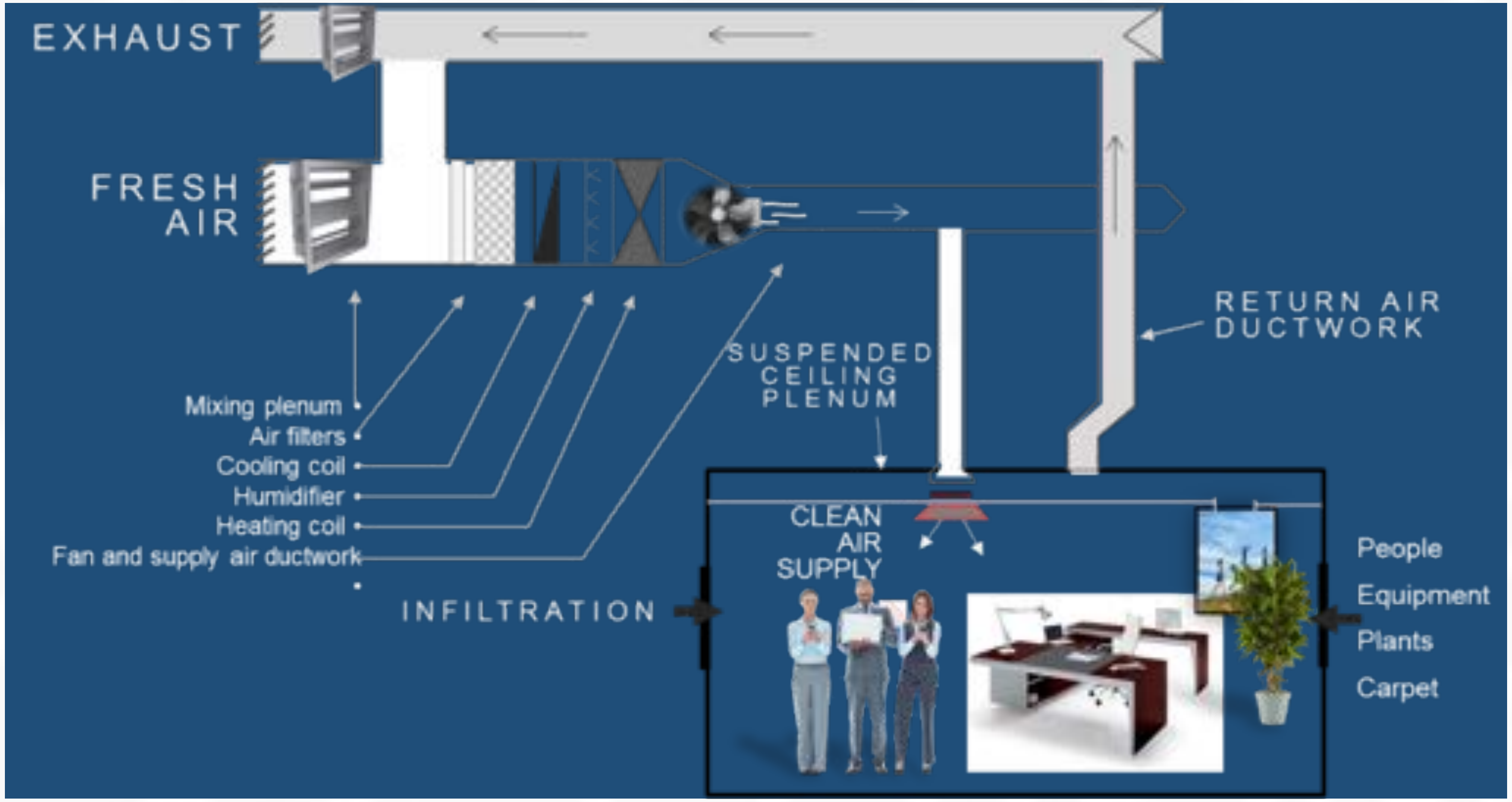
Increased density of occupants

New building materials

- Increase in VOCs

Improved Indoor Air Quality

High Efficiency Air Filtration

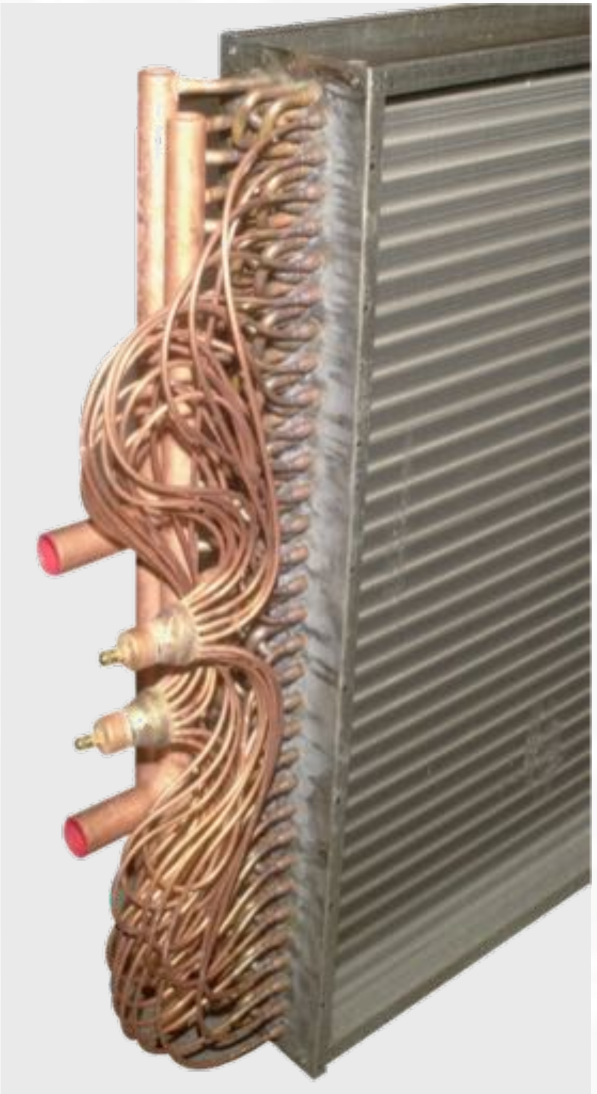


Impact of “Dirty” Coils

From the Trane Company: they cite a reduction in Heat Transfer Efficiency (R-22 Coil) due to “scaling effects” as follows:

Amount of Scale	% Reduction
.006”	16%
.012”	20%
.024”	27%
.036”	33%

From Air Conditioning, Heating & Refrigeration News --“Equipment operating with dirty coils may use a much as 37% more energy than equipment with clean coils



Volume/Capacity Calculation

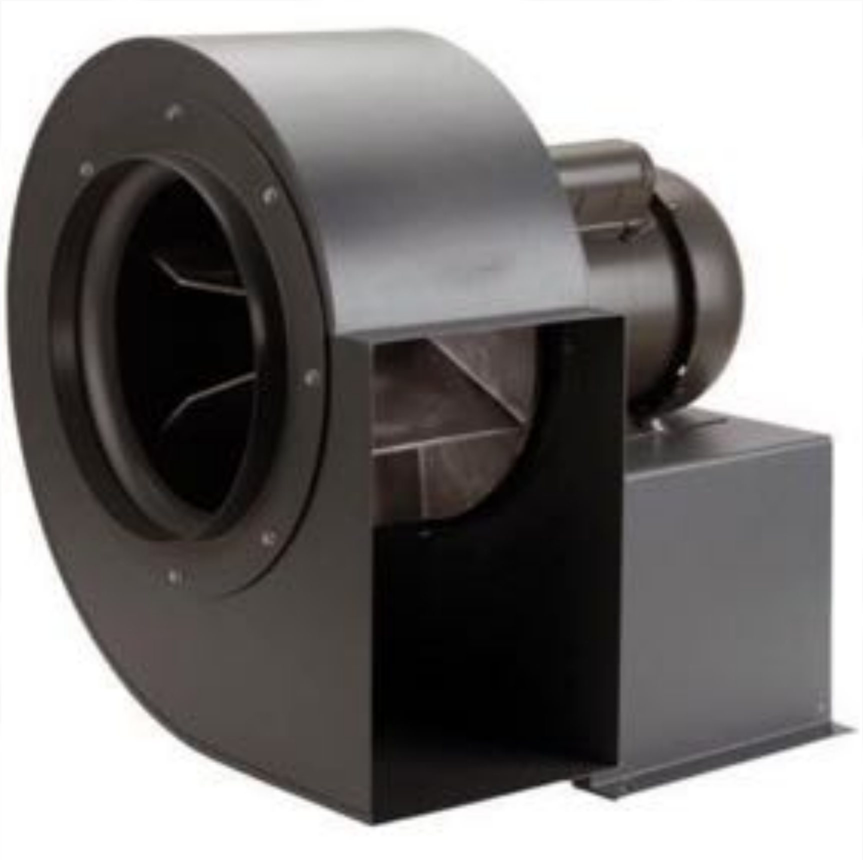
Area (SF)

X

Velocity (FPM)

=

Volume (CFM)



Resistance or Pressure Drop

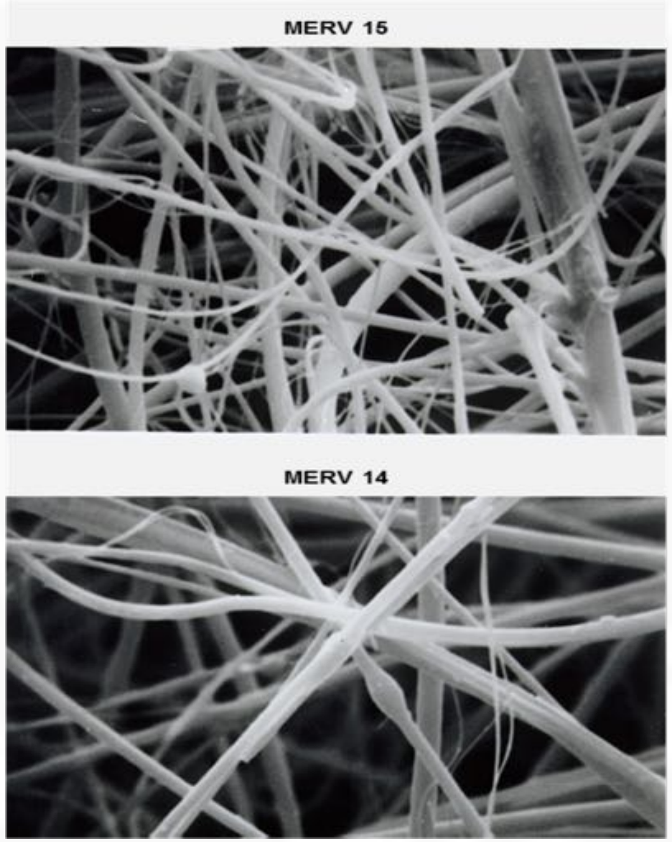
.20” W.G.

.28” W.G.

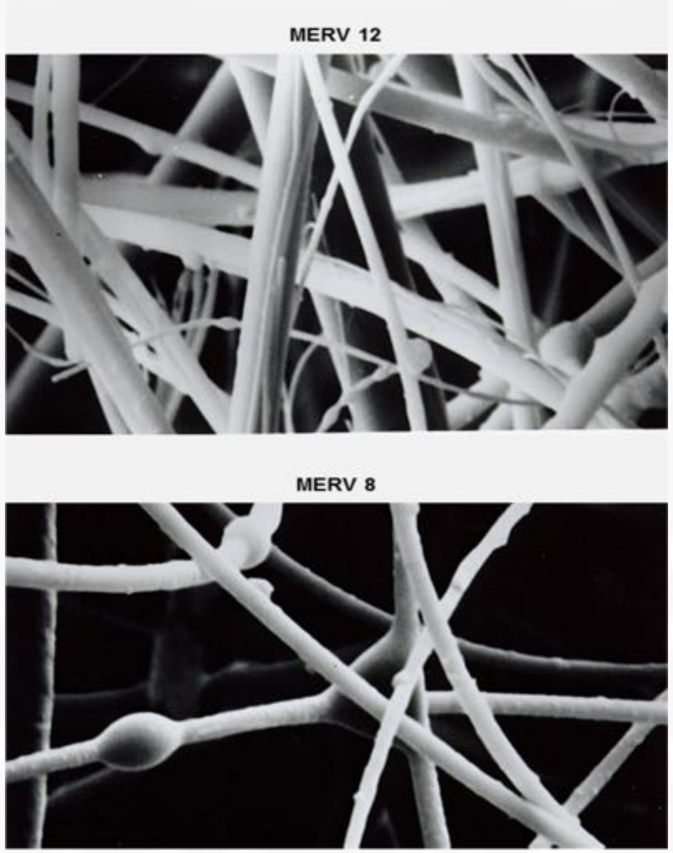
.45” W.G.

Fiber Size and Density

DriPak 2000 MEDIA (Magnified 2000 times)



DriPak 2000 MEDIA (Magnified 2000 times)



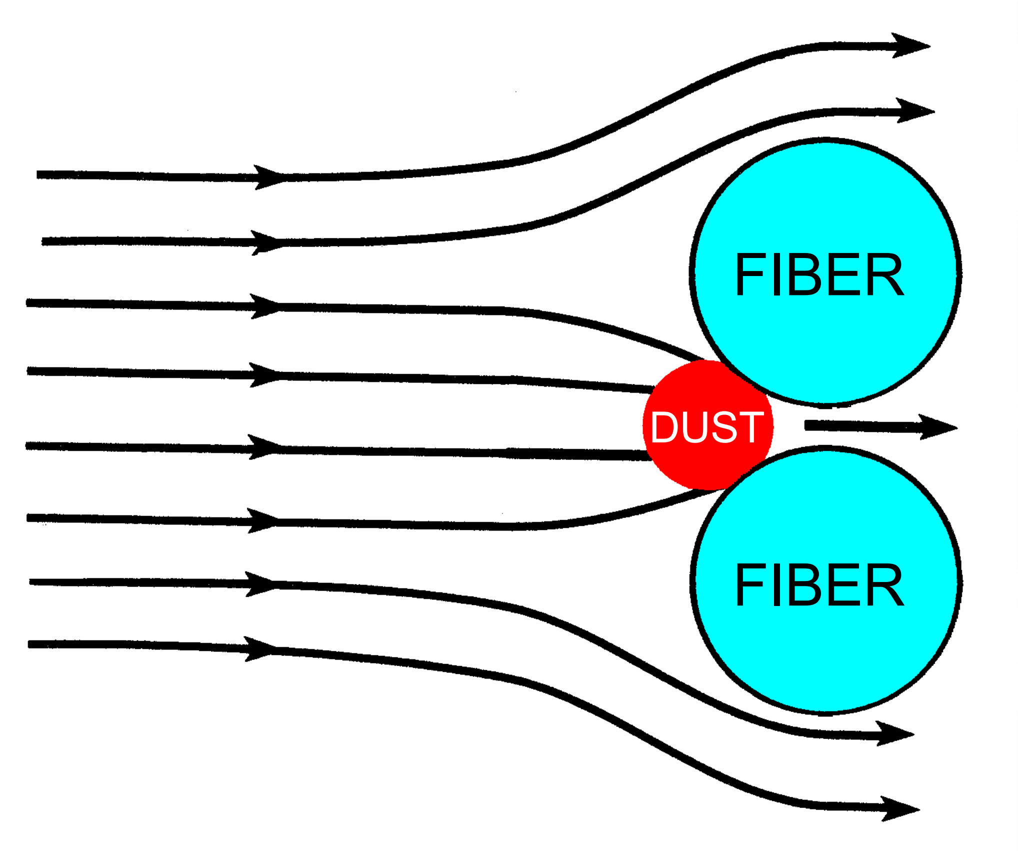
Physics of Filtration Technology

There are six basic physical phenomena:

- Straining
- Inertial separation
- **(Viscous) Impingement**
- **Interception**
- **Diffusion**
- Electrostatic charged filtration (active and passive)

Physics of Filtration Technology

Straining



Physics of Filtration Technology

(Viscous) Impingement

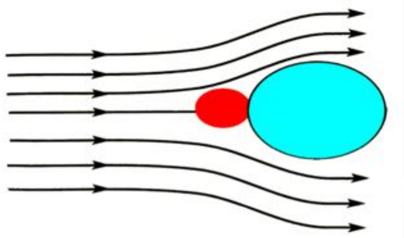
- Principle is based on as many particles as possible colliding (impinging) and sticking to filter media.

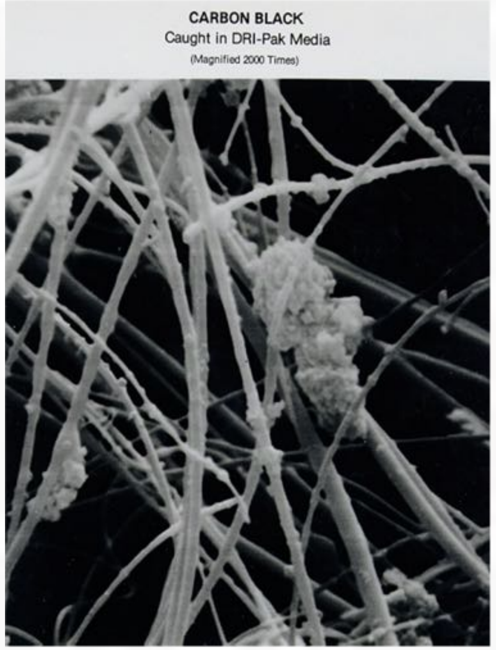
- An efficient adhesive is required to retain heavy particles (viscous adhesive).

- Principle is used in pre-filters and is effective for large, heavy particles only.

- Filter media should have as many large fibers as possible to increase particle impingement.

- A high air velocity, typically 1.5 to 3.0 m/s, to increase collision/ impingement ratio.

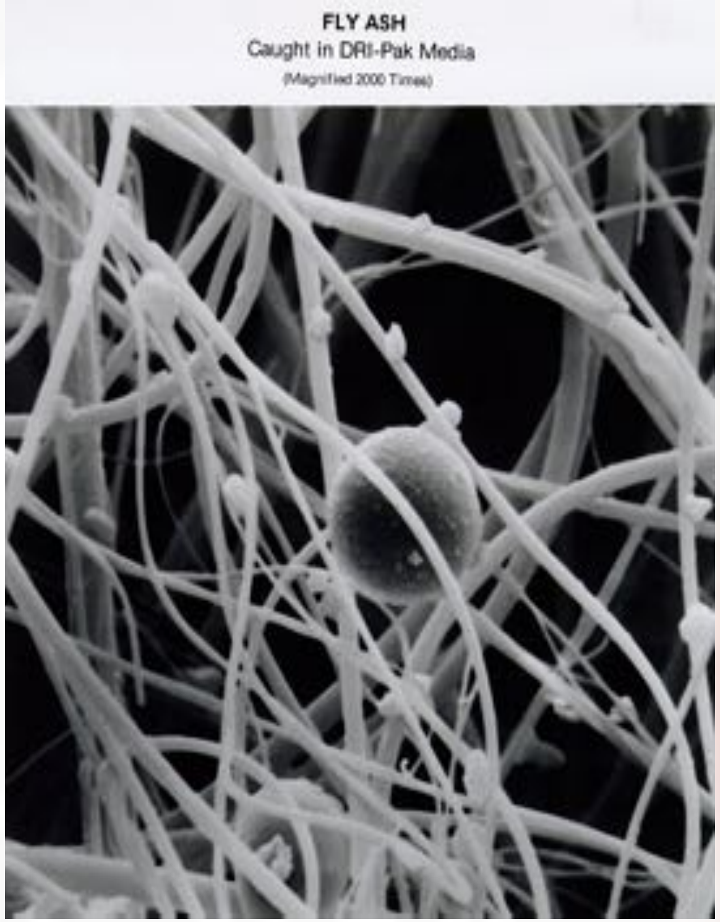




Physics of Filtration Technology

Interception

- Principle is based on intercepting as many particles as possible in fine packed fleece of filtration media.
- The incidence of interception is increasing with particle size and air velocity until a point is reached where the particle will be re-entrained into the air stream.
- A low media velocity, typically 0,1 m/s, is required to achieve effective air filtration and to avoid blow-off.
- Principle is used in medium efficiency filters

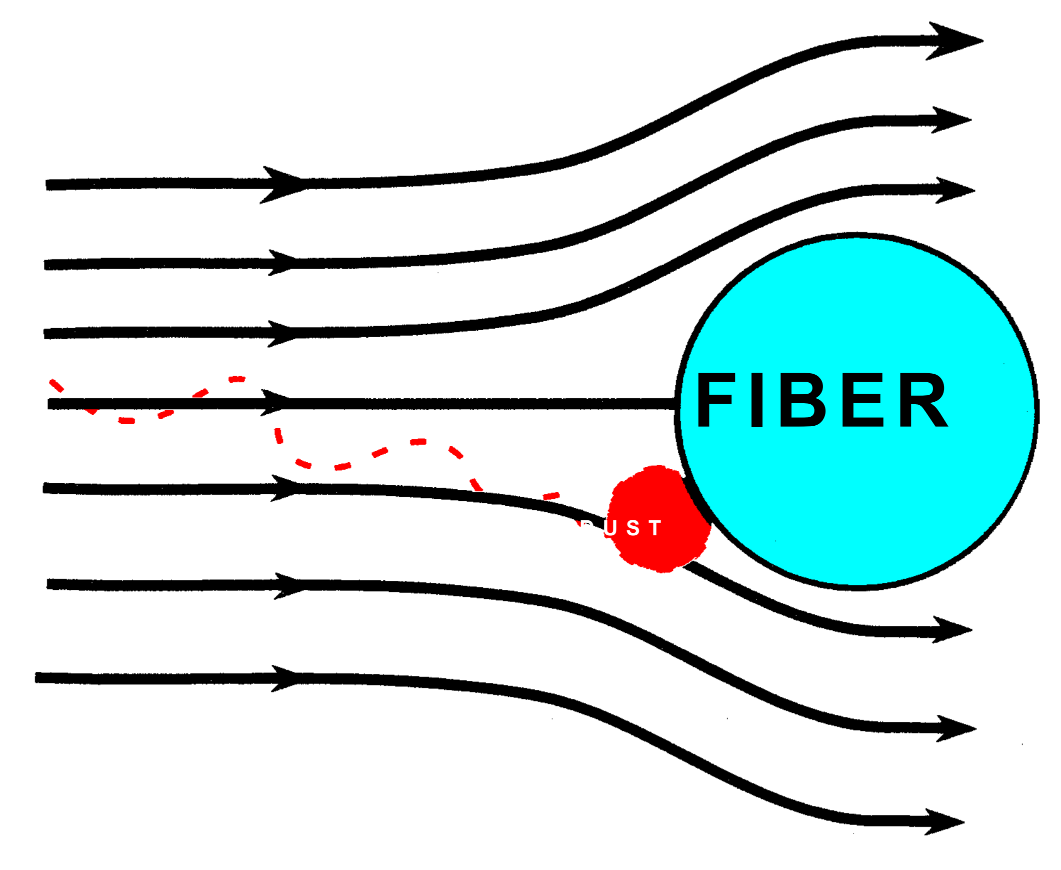


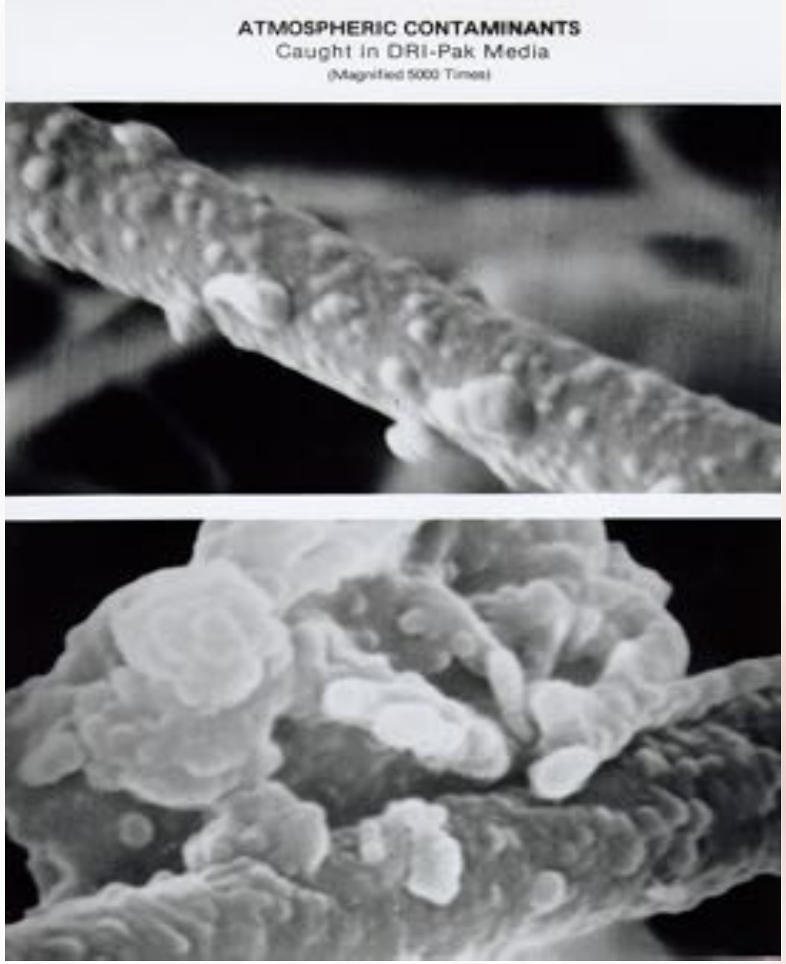
Physics of Filtration Technology
Diffusion 1/2

- Principle is based on very small particles having very little mass and therefore behaving comparable to gas molecules.
- Collision with gas molecules results in randomly moving particles and is known as Brownian movement.
- Intercepting as many particles and thus achieving affective air filtration, requires a very low media velocity of typically 0.02 m/s.
- The molecular forces of attraction, known as Van der Waal's force, that exist between particles and media, retain the particle on the filter media.
- Principle is therefore getting more effective, the smaller and lighter the particle is.
- The principle is used in medium and high efficiency filters

Physics of Filtration Technology

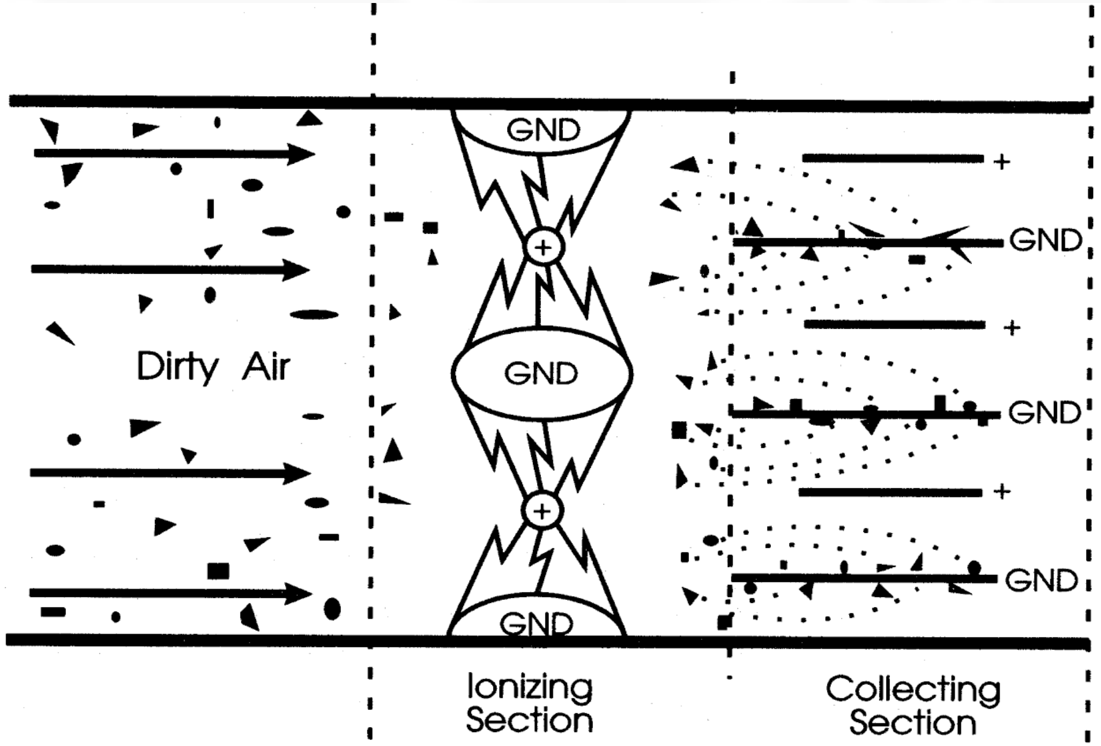
Diffusion 2/2





Physics of Filtration Technology

Electrostatic



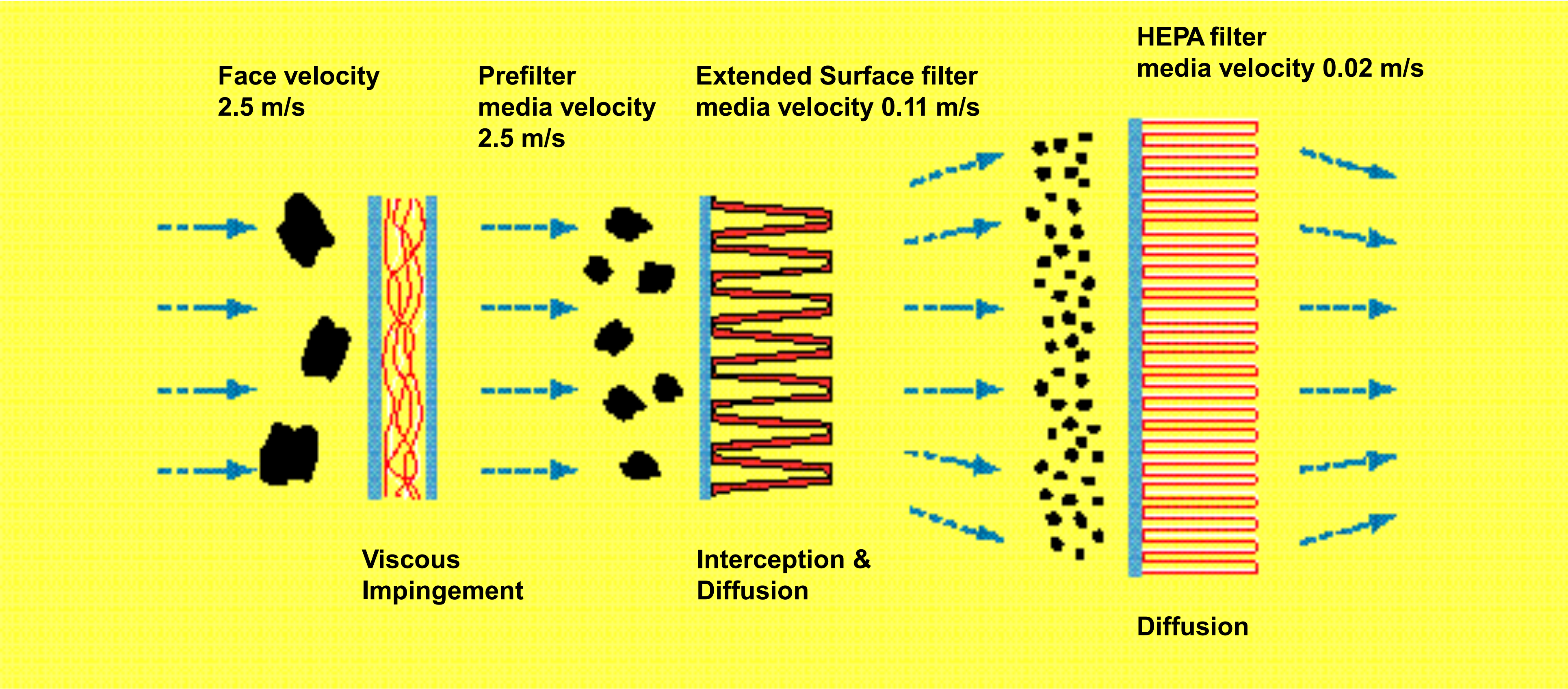
Many years ago electrostatic precipitators were pieces of equipment using this method. The idea was to impart an electrostatic charge to a particle, then collect the particle on a metal plate with an opposite charge to it. While this was very effective on small particles, such as cigarette smoke and exhaust, these pieces of equipment were expensive and difficult to maintain. Today, a similar effect is used in a passive matter to varying degrees of success. Electrostatically charged media is a synthetic media that has an electrostatic charge imparted on it at its time of manufacture. This charge stays with the media as it is manufactured into a disposable filter and used like any other HVAC type filter. The charge on the media increases the efficiency of the filter, without increasing the resistance by adding mass to the media. This provides a filter with a lower resistance than other filters of the same efficiency rating. The controversial part of this method, is that the charge on the media can dissipate over time, depending on several parameters, such as humidity, fine particle concentrations, time and chemical composition of the particulate. As a worse case scenario, the end user would be using a filter purchased as a high level of filtration, but the charge dissipates and is seeing an efficiency that is lower than expected. Because of this, before choosing to use an electrostatically charged filter you should seriously consider the ramifications of the filter performing at an efficiency lower than advertised.

Physics of Filtration Technology
Effective all-round Particle Removal 1/2

Involves use of different types of filters:

- Coarse Filter → Viscous Impingement
- Medium Efficiency Filter → Interception and Diffusion
- **H**igh **E**fficiency **P**article **A**ir Filter → Diffusion

Physics of Filtration Technology
Effective all-round Particle Removal 2/2



Filter Testing: Why?

Three major concerns in regards to air filters:

- What will be the efficiency of the filter in removing the airborne contamination (usually dust and in a specific size)?
- How much of this dust will it remove before maintenance is required?
- What resistance will the filter offer to airflow?

Filter Testing Standards

The standards have evolved to address:

- Indoor air quality and air cleanliness in occupied spaces: Health of occupants versus air cleanliness
- Protection of products during process manufacture
- Protection of HVAC equipment

Standards make it possible to compare the filters with each other

Applications
Interior Air

Typical applications:

- Office Buildings
- Museums
- Archives
- Libraries
- Shopping Malls
- Schools
- Airports
- Hotels and Restaurants



Air filtration products:

Particulate pre-filtration (G1-F7)


Panel filters


Pocket filters

Particulate final filtration in 2-stage HVAC systems (F5-F9)


Pocket filters


Compact filters

Gas-phase (combination) filters


Panel filters


Compact filters


Cassettes with media

Applications
Process Air

Typical applications:

Automotive	**Healthcare Facilities**
Pharmaceutical	**Laboratories**
(Micro)electronics	**Aviation**
Food & Beverage	**Manufacturing**



Air filtration products:

Particulate pre-filtration or final filtration 1-stage HVAC system (G1-F7)


Pads & Rolls


Panel filters


Pocket filters

Particulate final filtration in 3-stage2-/ HVAC/cleanroom systems (E10-U17)


Compact filters


HEPA/ULPA filters


HT filters

Gas-phase (combination) filters


Panel filters


Compact filters

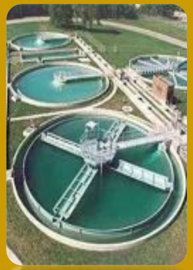

Cassettes with media


Equipment systems

Applications
Environmental Air

Typical applications:

Pulp & Paper
Waste water treatment
Gas turbine
Diesel engines
Nuclear plants
Mining
Steel mills
Laboratories



Air filtration products:

Particulate pre-filtration

Pads & Rolls

Pocket filters

Particulate final filtration in 2-stage HVAC systems (F5-F9)

Rotary machinery filters

Nuclear grade filters

Gas-phase (combination) filters

Chemical media

Cassettes with media

Equipment systems

Q&A

ISO 16890

Tobias Zimmer

Global Product Manager Comfort

Camfil

Agenda

- ISO 16890 – the new global air filtration standard
  - What are the benefits of this new standard?
  - Comparison to standards EN779 & ASHRAE 52.2
  - Overview of ISO 16890 filter classification

- Eurovent 4/23 – how to select air filters based on ISO 16890
  - In relation to local outdoor air quality (ODA)
  - In relation to required supply air quality (SUP)
  - Cumulated filter efficiency of multi-stage filtration

ISO 16890

Air Filters for General Ventilation

EUROVENT MIDDLE EAST

HVACR Leadership Workshops

Introduction

- Global situation

USA	Europe	Middle East / Asia
ASHRAE 52.2	EN 779:2012	ASHRAE 52.2, EN779 and local standards

- A significant harmonisation for the air filtration industry has been recently adopted.

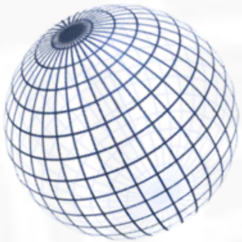
- A new standard for filter testing and classification with global coverage.

ISO16890 “Air Filters for General Ventilation”

Why a new global standard?
What are the customer benefits?

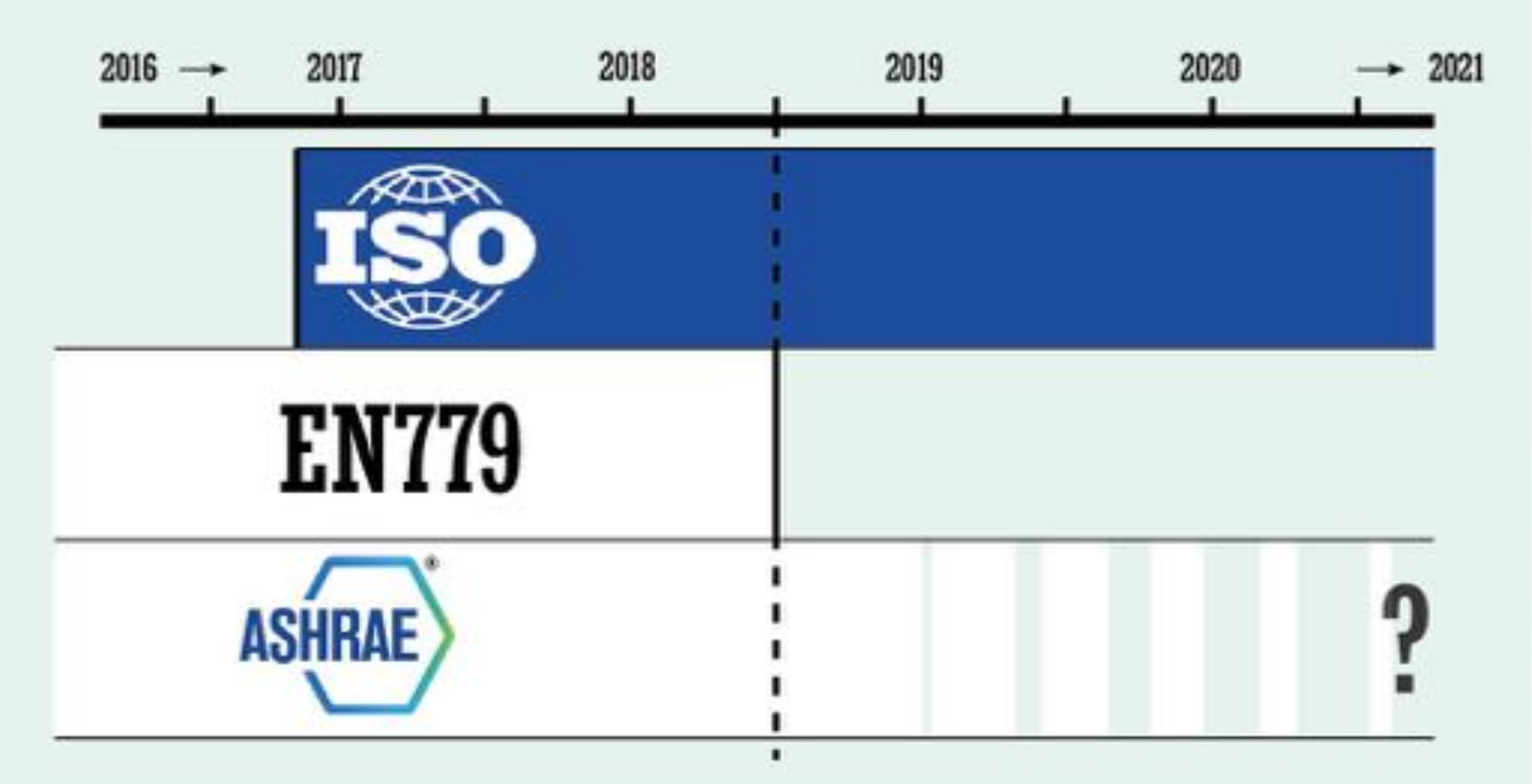
Recognition
–
Air filters positively influence air quality and human health

More intuitive
–
Filter efficiency and classification aligned with real world air pollution



Global applicability
–
Eliminate confusion

ISO 16890: Timeline



Comparison of Test Standards

	EN779:2012	ASHRAE 52.2	ISO16890
Filter test method	Testing efficiency with **0,4µm particles**	Testing efficiency with 0,3-10 µm particles. Classifications relate to results for **E1, E2 & E3 efficiency classes – MERV rating**	Testing efficiency with 0,3-10 µm particles. Classifications relate to result for **PM1, PM2.5 & PM10**
Discharging method	Discharges filter media only, using IPA soak **Tough discharging** method	Discharges entire filter Using KCL salt **Soft discharging** method (not mandatory – App. J)	Discharges entire filter using IPA vapor **Tough discharging** method
Filter loading method	Dustloading with ASHRAE dust **Coarse & sticky dust**	Dustloading with ASHRAE dust **Coarse & sticky dust**	Dustloading with ISO fine dust **Finer & less sticky dust**
Classification system	**9 Classes**	**16 Classes**	**49 classes** in **4 Filter Groups**

ISO16890: How Does it Work?

The standard is written in four parts:

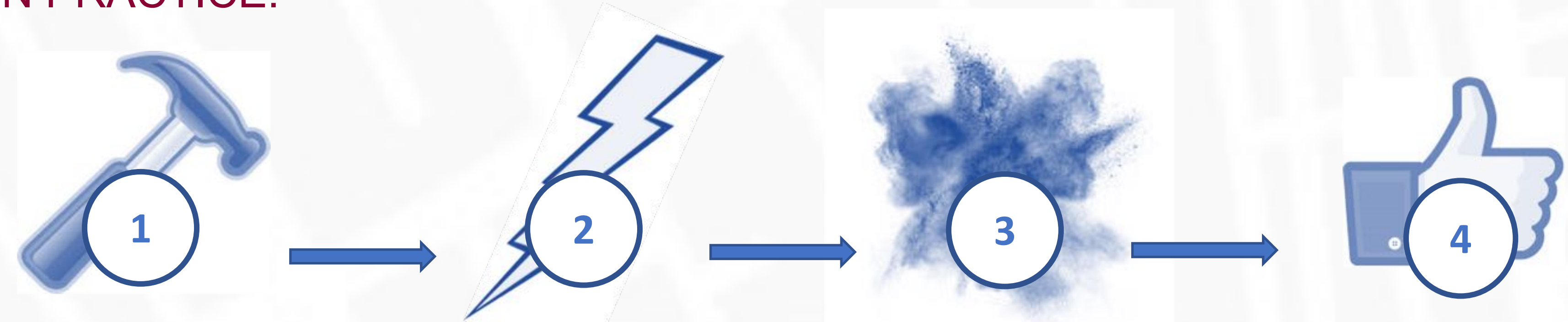
Part 1: *Technical specifications, requirements and classification system.*

Part 2: *Measurement of fractional efficiency.*

Part 3: *Determination of the arrestance and the air flow resistance versus the mass of test dust.*

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

IN PRACTICE:



1. Measurement of fractional efficiency
2. Discharging method
3. Gravimetric test method (optional)
4. Classification system

Filter Classification

4 filter groups

ePM 1	ePM 2.5	ePM 10	ISO Coarse
0,3 – 1 µm	0,3 – 2,5 µm	0,3 – 10 µm	ISO Fine Dust Initial arrestance
Corresponding to **E1** ASHRAE 52.2	Corresponding to **E2** ASHRAE 52.2	Corresponding to **E3** ASHRAE 52.2	Filters with **ePM10 < 50%**

ISO16890: Classification System

Table 4 – Filter groups

Group designation	Requirement			Class reporting value
	$ePM_{1,\ min}$	$ePM_{2,5,\ min}$	ePM_{10}	
ISO Coarse	—	—	< 50%	Initial grav. arrestance
ISO ePM10	—	—	≥ 50%	ePM_{10}
ISO ePM2,5	—	≥ 50%	—	$ePM_{2,5}$
ISO ePM1	≥ 50%	—	—	ePM_{1}

Filter Classification
3 Simple Rules:

Reported efficiency – is an average between the initial and the discharged efficiency.

To be able to report – initial new efficiency needs to be over 50%.

AND

To be able to report – discharged efficiency needs to be over 50% (ePM1 and ePM2.5)

ISO 16890 Test Report

ISO 16890-1:2016 - Air Filter Test Results	**Testing Organization:** RISE Research Institute of Sweden Brinellgatan 4, 501 15 Borås, Sweden +46010516000

GENERAL

Report no.: 6P07577-25-rev1	Date of tests: 2017-02-16 - 2017-02-23		Date of report: 2017-03-02
Supervisor: CM		Device obtained (when and how obtained):	
Test(s) requested by: Camfil AB		The device was sent and obtained on 2017-02-14	

DEVICE TESTED

Model: Hi Flo II XLT 7/640 50+ (HFGX-F7-592/592/640-10-25)		Manufacturer: Camfil AB	Construction: Pocket filter, 10 Pockets
Article number: 610165	Type of medium: Glass	Net effective filtering area: 7.3 m^2	Filter dimensions (width x height x depth) 592x592x640 mm

TEST DATA AND ATTACHED TEST REPORTS

Test air flow rate: 0.944 m^3/s	Test aerosole: KCl (1-10 µm) DEHS (0.3-1 µm)	Test report to ISO 16890-2	Report no. 6P07577-25-rev1 Appendix 2
		Test report to ISO 16890-3 (optional)	Report no. 6P07577-25-rev1 Appendix 3
		Test report to ISO 16890-4	Report no. 6P07577-25-rev1 Appendix 4

RESULTS

Initial pressure differential: 72 Pa	Initial grav. arrestance: 97 %	$ePM_{1,min}$ 63 %		$ePM_{2.5,min}$ 73 %	ISO rating
Final test pressure differential: 300 Pa	Test dust capacity: 1160 g	ePM_1 64 %	$ePM_{2.5}$ 73 %	ePM_{10} 91 %	**ISO ePM $_1$ 60 %**

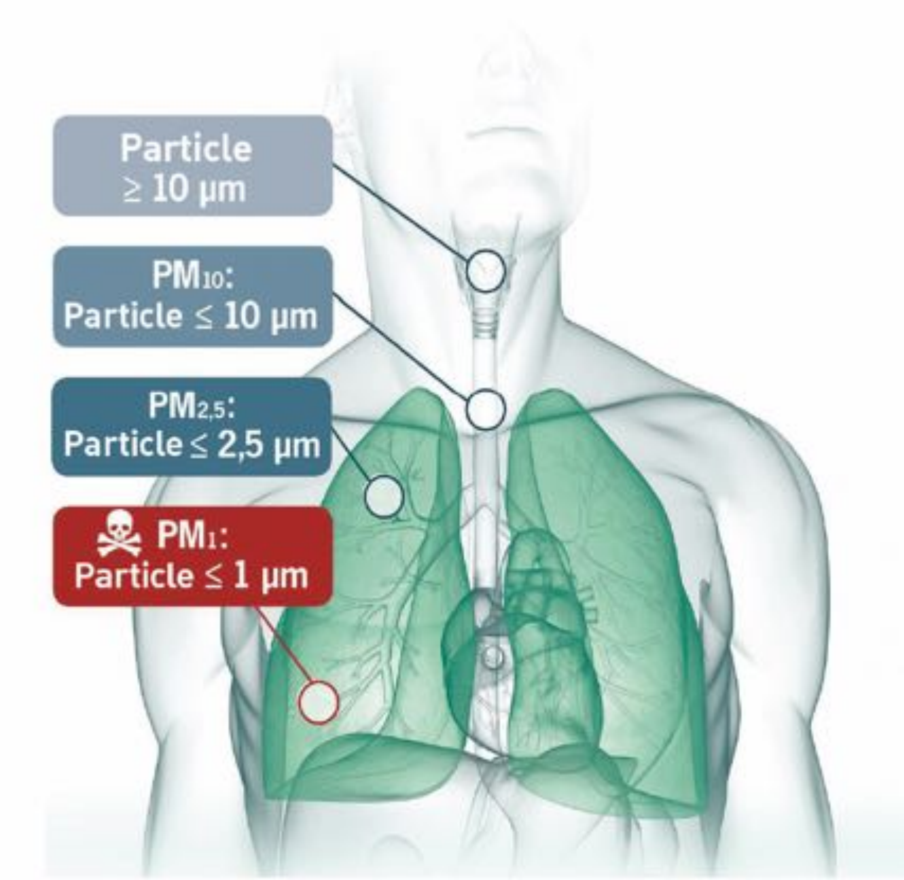
Eurovent 4/23

Selection of ISO 16890 rated Air Filters for General Ventilation Applications

Eurovent 4/23

- Recommendation for the selection of ISO 16890 rated air filters for general ventilation applications
- Developed in a joint effort by the participants of the Eurovent Product Group ‘Air Filters’
- Published on 09 January 2018

Introduction
Impact on Health



PM10	PM2.5	PM1
Particles 10 µm in diameter or smaller can reach the respiratory ducts and potentially cause decreased lung function.	**Particles 2.5 µm** in diameter or smaller can penetrate the lungs and cause decreased lung function, skin and eye problems.	**Particles 1 µm** in diameter or smaller are most dangerous. They are tiny enough to enter the bloodstream and lead to cancer, cardiovascular diseases and dementia.

Outdoor Air (ODA)
How clean is my Outdoor Air?

- 3 Outdoor Air Classes (ODA 1-3)
- Based on WHO Tresholds:
- Annual mean for PM2.5 < 10 µg/m3
- Annual mean for PM10 < 20 µg/m3

Category	Description	Typical environment
ODA 1	**OUTDOOR AIR, WHICH MAY BE ONLY TEMPORARILY DUSTY** Applies where the World Health Organisation WHO (2005) guidelines are fulfilled (annual mean for PM2.5 ≤ 10 µg/m³ and PM10 ≤ 20 µg/m³).	
ODA 2	**OUTDOOR AIR WITH HIGH CONCENTRATIONS OF PARTICULATE MATTER** Applies where PM concentrations exceed the WHO guidelines by a factor of up to 1,5 (annual mean for PM2.5 ≤ 15 µg/m³ and PM10 ≤ 30 µg/m³).	
ODA 3	**OUTDOOR AIR WITH VERY HIGH CONCENTRATIONS OF PARTICULATE MATTER** Applies where PM concentrations exceed the WHO guidelines by a factor of greater than 1,5 (annual mean for PM2.5 > 15 µg/m³ and PM10 > 30 µg/m³).	

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Supply Air Classes (SUP)

SUP 1	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,25 (annual mean for PM2.5 ≤ 2.5 µg/m³ and PM10 ≤ 5 µg/m³).
SUP 2	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,5 (annual mean for PM2.5 ≤ 5 µg/m³ and PM10 ≤ 10 µg/m³).
SUP 3	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0,75 (annual mean for PM2.5 ≤ 7.5 µg/m³ and PM10 ≤ 15 µg/m³).
SUP 4	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values (annual mean for PM2.5 ≤ 10 µg/m³ and PM10 ≤ 20 µg/m³).
SUP 5	refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by factor x 1,5 (annual mean for PM2.5 ≤ 15 µg/m³ and PM10 ≤ 30 µg/m³).

Examples for Supply Air Classes (SUP)

CATEGORY	GENERAL VENTILATION			CATEGORY	INDUSTRIAL VENTILATION	
SUP 1	-	-		SUP 1	**Applications with high hygienic demands.** Examples: Hospitals, pharmaceutics, electronic and optical industry, supply air to clean rooms.	
SUP 2	**Rooms for permanent occupation.** Example: Kindergardens, offices, hotels, residential buildings, meeting rooms, exhibition halls, conference halls, theaters, cinemas, concert halls.			SUP 2	**Applications with medium hygienic demands.** Example: Food and beverage production.	
SUP 3	**Rooms with temporary occupation.** Examples: Storage, shopping centers, washing rooms, server rooms, copier rooms.			SUP 3	**Applications with basic hygienic demands.** Example: Food and beverages production with a basic hygienic demand.	
SUP 4	**Rooms with short-term occupation.** Examples restrooms, storage rooms stairways.			SUP 4	**Applications without hygienic demands.** Example: General production areas in the automotive industry.	
SUP 5	**Rooms without occupation.** Examples: Garbage room, data centers, underground car parks.			SUP 5	**Production areas of the heavy industry.** Examples: Steel mill, smelters, welding plants.	

Recommended Minimum Efficiency

			SUPPLY AIR				
OUTDOOR AIR			SUP 1* PM2.5 ≤ 2.5 PM10 ≤ 5	SUP2* PM2.5 ≤ 5 PM10 ≤ 10	SUP3** PM2.5 ≤ 7.5 PM10 ≤ 15	SUP4 PM2.5 ≤ 10 PM10 ≤ 20	SUP5 PM2.5 ≤ 15 PM10 ≤ 30
Category	PM2.5	PM10	ePM_1	ePM_1	$ePM_{2.5}$	ePM_{10}	ePM_{10}
ODA 1	≤ 10	≤ 20	60%	50%	60%	60%	50%
ODA 2	≤ 15	≤ 30	80%	70%	70%	80%	60%
ODA 3	> 15	> 30	90%	80%	80%	90%	80%

Table 3: Recommended min. ePMx filtration efficiencies depending on ODA and SUP category. Annual mean PMx values in $\mu g/m^3$

* Minimum filtration requirements ISO ePM_1 50% refer to a final filter stage

** Minimum filtration requirements ISO $ePM_{2.5}$ 50% refer to a final filter stage

Presented efficiency values concern both single filter and multi-stage filtration systems with a cumulated efficiency.

Multi-Stage Filtration
Estimation of cumulated efficiency

To facilitate rough estimations, it is recommended to use the following formula to determine the combined filtration efficiency for respective particle size fractions:

$$ePM_{x,\,cum} = 100 \cdot \left(1 - \left(\left(1 - \frac{ePM_{x,\,s1}}{100}\right) \cdot \left(1 - \frac{ePM_{x,\,s2}}{100}\right) \cdot\cdot\cdot\cdot\cdot \left(1 - \frac{ePM_{x,\,sn+1}}{100}\right)\right)\right)$$

Where

$ePM_{x,cum}$ is the total cumulated efficiency for x fraction
$ePM_{x,sn+1}$ is the fractional efficiency for each filter stage

Multi-Stage Filtration
Estimation of cumulated efficiency

Office in Dubai: ODA 3 & SUP 2 = min. ePM1 80%

Stage 1
ePM1 60%

Stage 2
ePM1 60%

$$ePM1_{\ cum} = 100 \times (1 - (1 - \frac{60}{100}) \times (1 - \frac{60}{100})) = 84\%$$

Summary

- ISO16890 is a new global standard for testing and classification of air filters
- It brings clear benefits for specifiers, purchasers and users of air filters
- Selecting ePM1 filters will result in improved air quality and lower health risk
- Eurovent 4/23 merges theoretical and practical aspects of designing Indoor Air Quality in terms of air filtration
- Eurovent 4/23 provides hands on and effective advice for HVAC planners and manufactures of ventilation equipment to correctly design filtration

Indoor Air Quality in Critical Environments

Dr. Jason Shilliday

Sales Director

TROX Middle East

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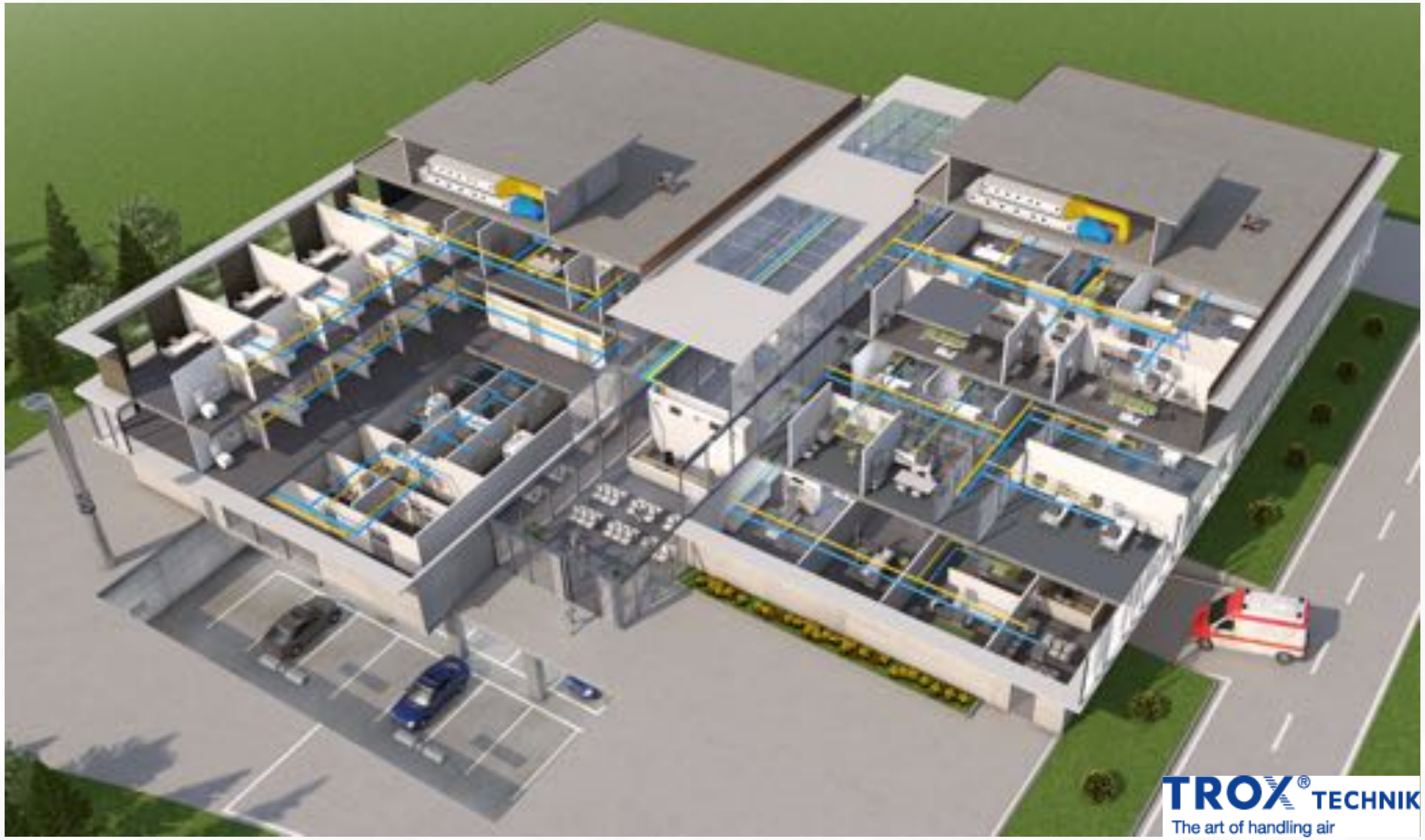
Contents

Introduction
IAQ Design Brief

1. Minimize levels of micro-organisms in the air
2. Ensure necessary air change and maintain stringent room conditions
3. Limit the concentration of various substances in occupied zone
4. Ensure a safe and hygienic environment

Hospitals



Operating rooms

Recovery rooms

Intensive Care Units

Isolation rooms

Laboratories

Clean room

Laminar flow rooms

Mixed flow rooms

Air Locks

ISO 1 to 8 Classes

Standards and Regulations
Clean rooms and Hospitals

- ISO EN 14644
- Federal Standard 209E
- JIS – B 9920
- IES – RP – CC – 006
- DIN 1946-6
- VDI – 6022
- DIN - 13080
- GMP EU
- HAAD
- JCI – HOSPITALS
- JCI - LABORATORIES
- DHA
- WHO STANDARDS

Classification
Clean rooms

Table 1 — Selected airborne particulate cleanliness classes for cleanrooms and clean zones

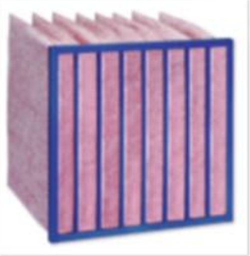
ISO classification number (N)	Maximum concentration limits (particles/m³ of air) for particles equal to and larger than the considered sizes shown below [concentration limits are calculated in accordance with equation (1) in 3.2]					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000

NOTE Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level

BS EN ISO 14644

Classification
Filtration

Medium efficiency filters (EN779:2012)	High efficiency filters (EN 779:2012)	Very high efficiency filters (EN 1822:2009)	Ultra high efficiency filters (EN 1822)
		HEPA	ULPA
G1	M5	E10	U15
G2	M6	E11	U16
G3	F7	E12	U17
G4	F8	H13	
	F9	H14	



Classification
Filtration

Pocket filters (bag filter)

- Air intake filters (AHU)
- M6, F7, F9, E11
- Many material options
  - ➢ Non-woven fibres
  - ➢ Synthetic fibres
  - ➢ Glass fibres
  - ➢ Nano wave medium

Initial pressure: 50 – 150pa
Final pressure: 250 - 350pa

Classification
Filtration

Mini-pleat filters

- Final filters
- M5-M6, F7-F9, E10-E12, H13-H14, U15-U17
- High quality moisture resistant glass fibres or other fibre options

Initial pressure: 90 – 150pa
Final pressure: 250 - 600pa

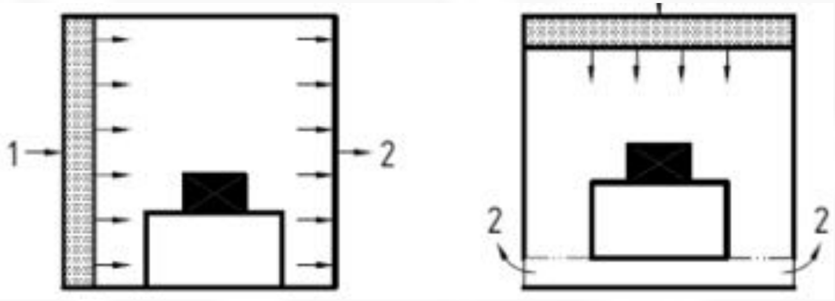
Classification
Clean rooms – Filtration

Types of ventilation and filters (ISO 14644)

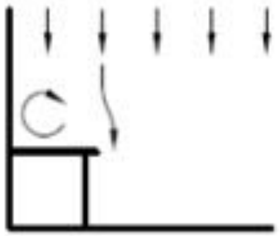
ISO classification [a]	8	7	6	5	4	3
Typical type of ventilation	Turbulent flow TF or mixed flow M (combination of low-turbulence laminar flow LF and turbulent flow TF)			Low-turbulence laminar flow LF		
Typical prefilters, 1st stage	M5	M5	M5	M5 / F7	M5 / F9	M5 / F9
Typical secondary filters, 2nd stage	F7	F9	F9	E11	H13	H13
Typical final filters	E11 / H13	H13	H13	H14	U15	U16
Max. number of months allowed between tests to prove continued compliance with the allowable particle concentration	12	12	12	6	6	6
Recommended max. number of months between standard tests to carry out optional tests – leakage of installed filters	24	24	24	24	24	24

Classification
Clean rooms – Airflow

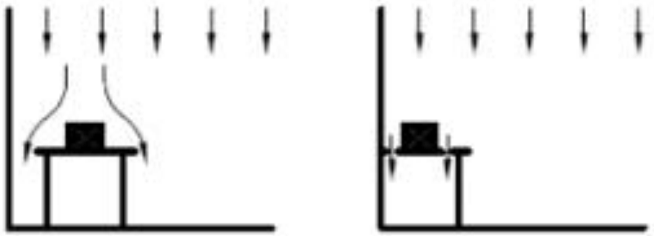
Uni-directional flow
Laminar flow



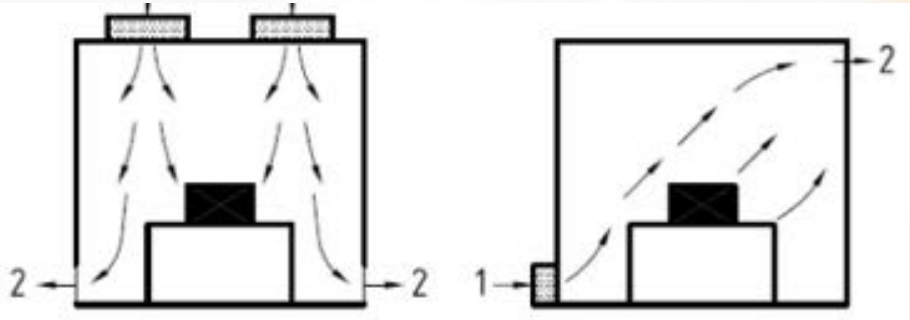
Flow obstacles causing
a flow disturbance

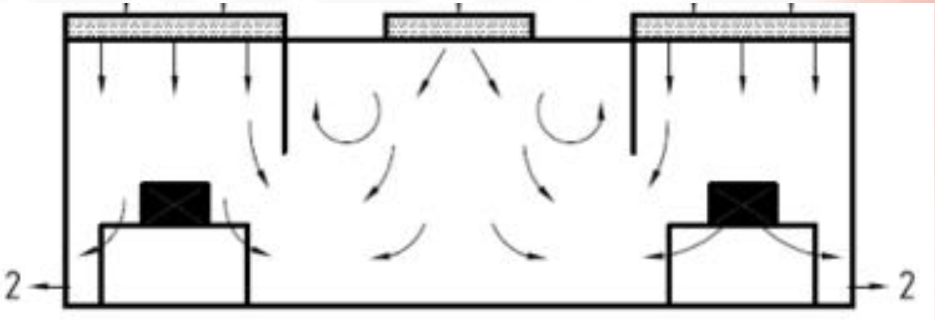


Adjustments to equipment and behaviour
to improve airflow



Mixed flow
Turbulent flow





Classification
Clean rooms – Airflow

Examples of clean rooms in microelectronics (ISO 14644-4)

TROX TECHNIK

ISO classification b)	8	7	6	5	4	3
Type of ventilation	TF or M	TF or M	TF or M e)	LF	LF	LF
Average airflow velocity d)	not given	not given	not given	0.2 to 0.5	0.3 to 0.5	0.3 to 0.5
Air changes per hour e)	10 to 20	30 to 70	10 to 160	not given	not given	not given

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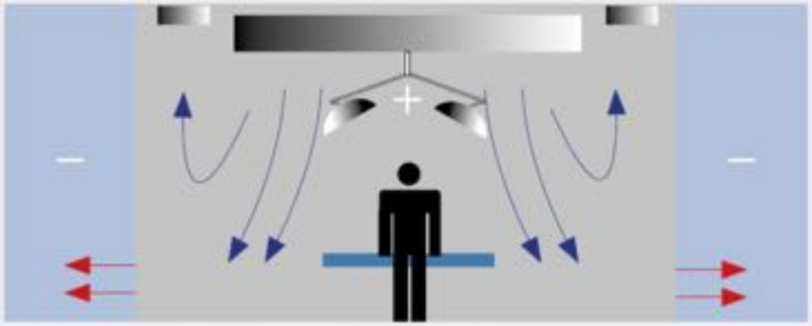
Classification

Hospitals – Airflow

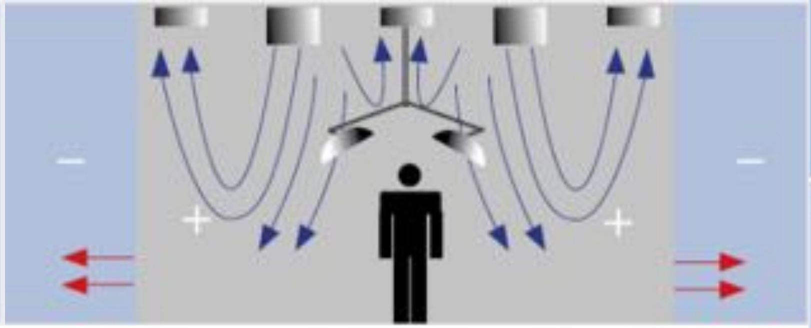
TROX® TECHNIK
The art of handling air

Classification
Hospitals – Airflow

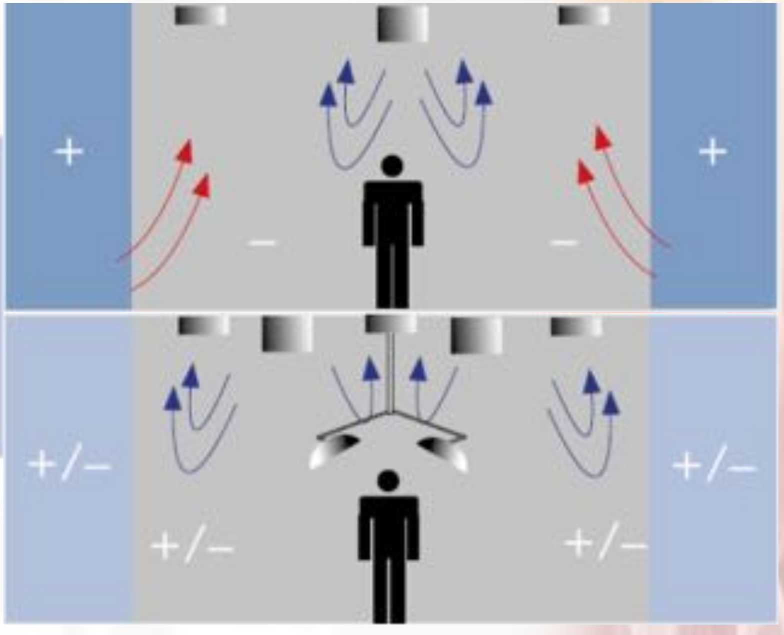
Room Class Ia
Very high requirement on hygiene
Operating theatres
3 stage filtration F5/F9/H13



Room Class Ib
Increased Hygiene Requirements
Recovery rooms, ICU
3 stage filtration F5/F9/H13



Room Class II
General Hygiene Requirements
Other treatment rooms, ENT



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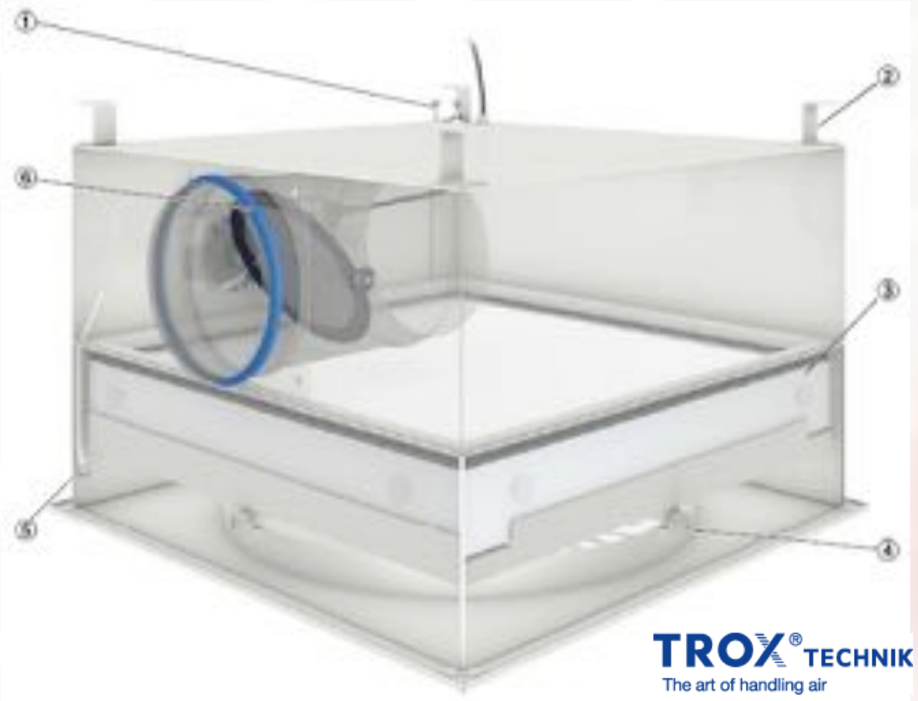
Airflow
Diffusers

Terminal Units

Ceiling mounted particulate filters as final stage filters with mini pleat filter panels for the separation of suspended particles

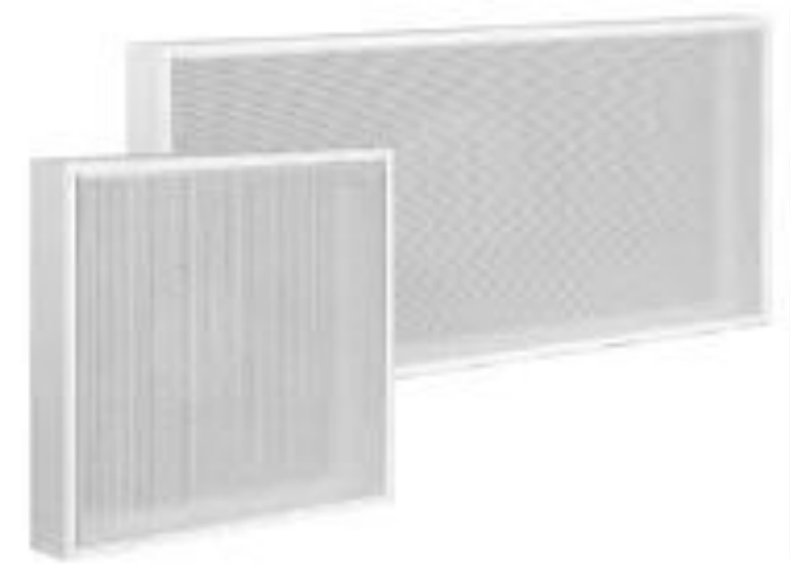
1. Top pressure measurement points
2. Top suspension
3. Filter element with seal
4. Clamping mechanism for filter
5. Internal measuring tube
6. Spigot with lip seal

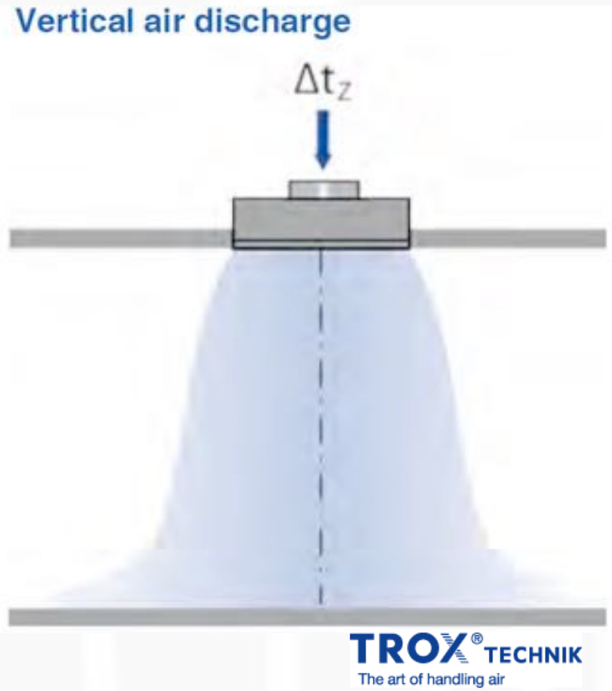


Airflow
Diffusers

Laminar Flow Panels

The Laminar Flow Panel has been developed for specialist applications where the mixing of supply air with room air must be avoided. The diffuser provided stable, low turbulence vertical discharge into the occupied zone





Pressure Control

1. A pressure differential exists across the barrier between the cleaner zone towards the less clean zone.
2. The pressure differential should be of sufficient magnitude and stable to prevent reversal of airflow direction from that intended.
3. The pressure differential between adjacent cleanrooms or clean zones of different cleanliness level should lie typically in the range of 5 Pa to 20 Pa, to allow doors to be opened and to avoid unintended cross-flows due to turbulence.

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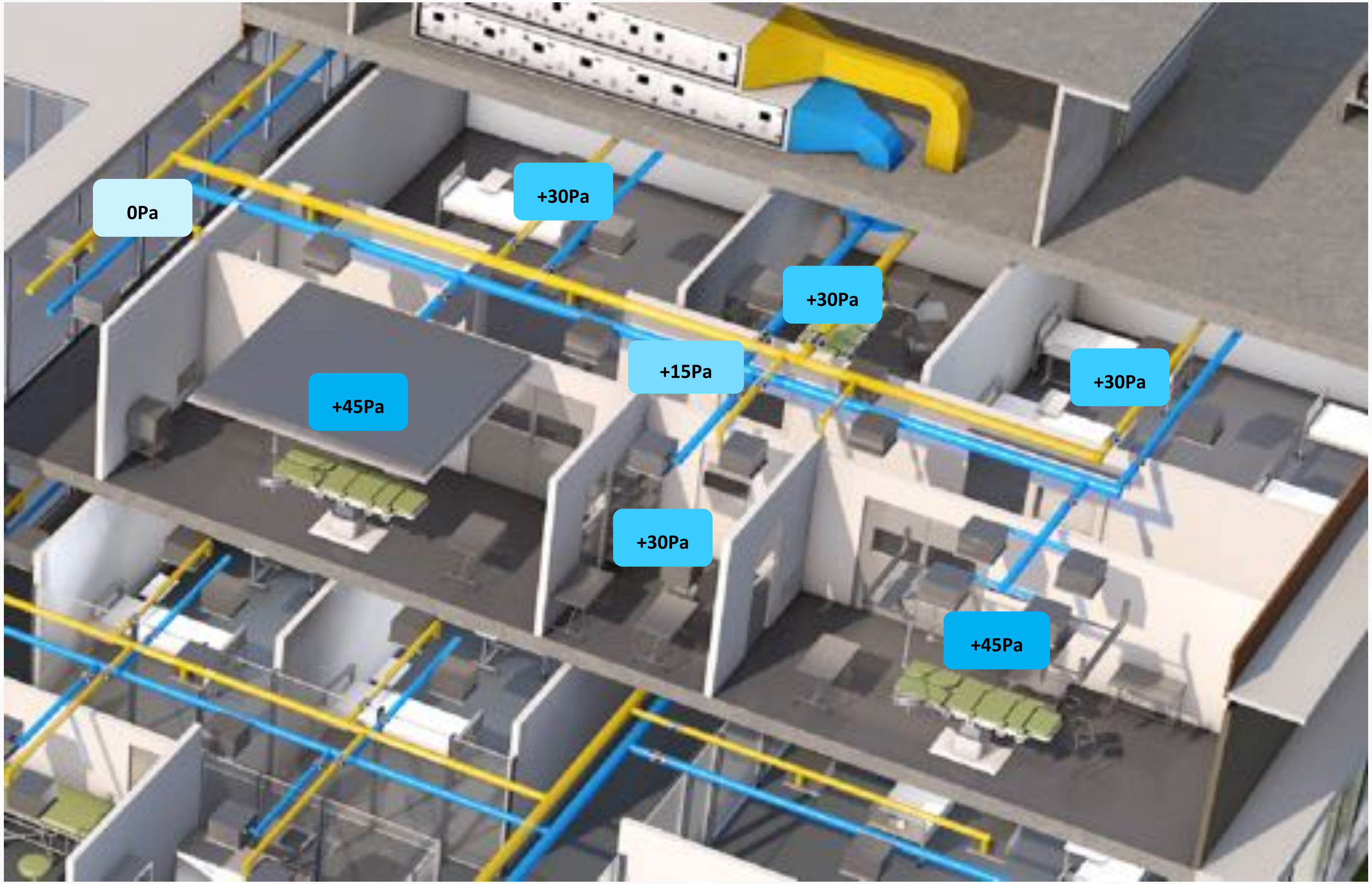
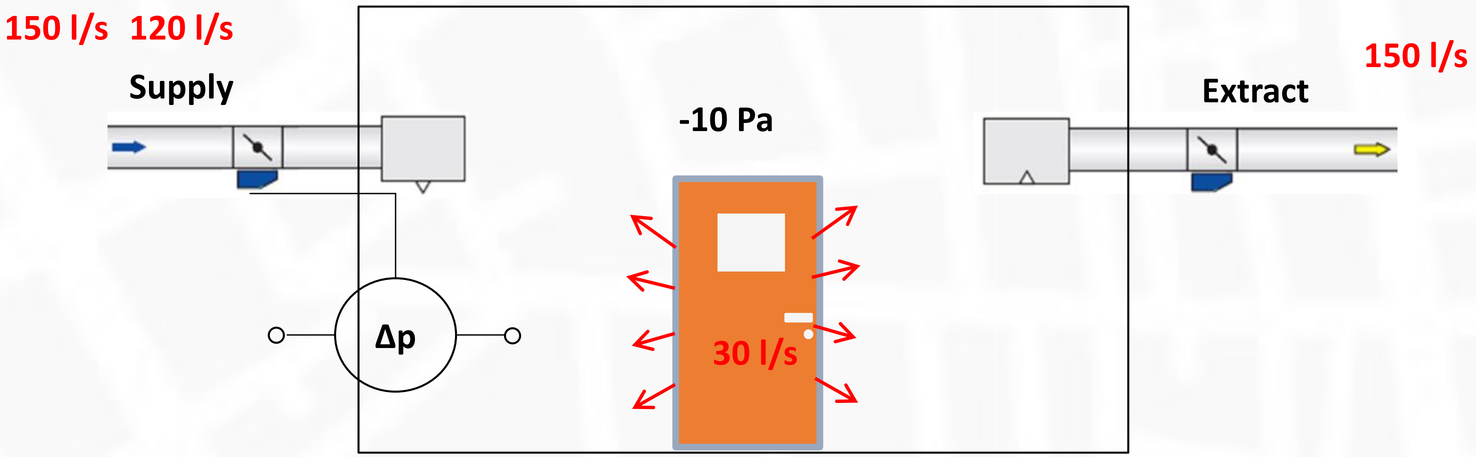
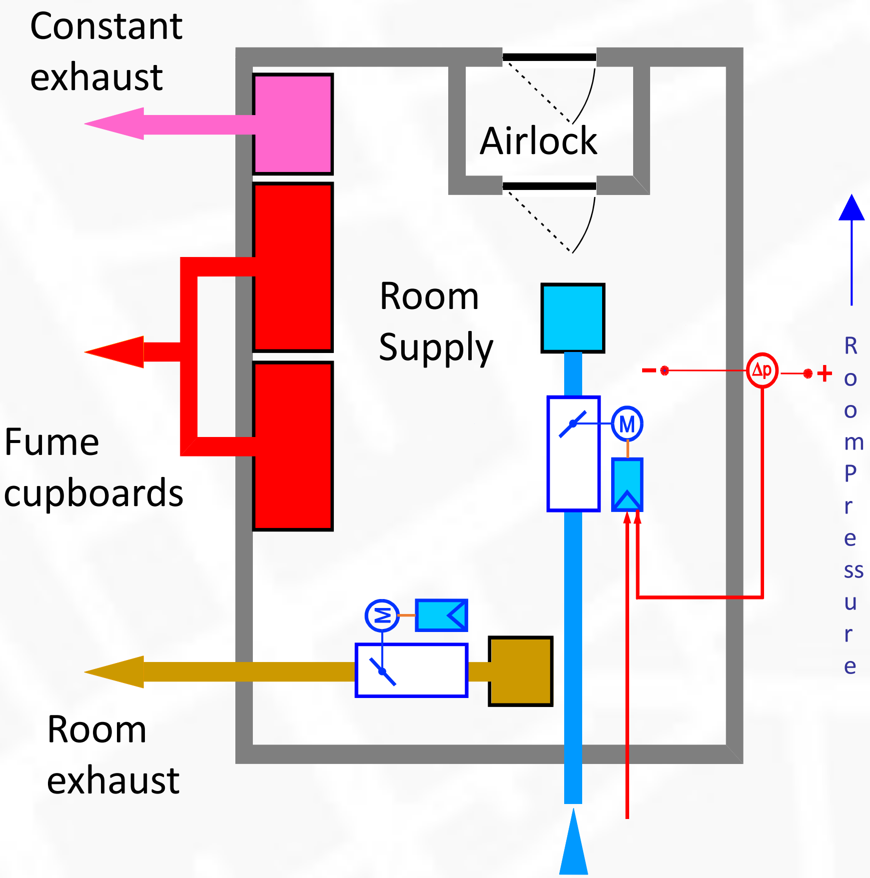


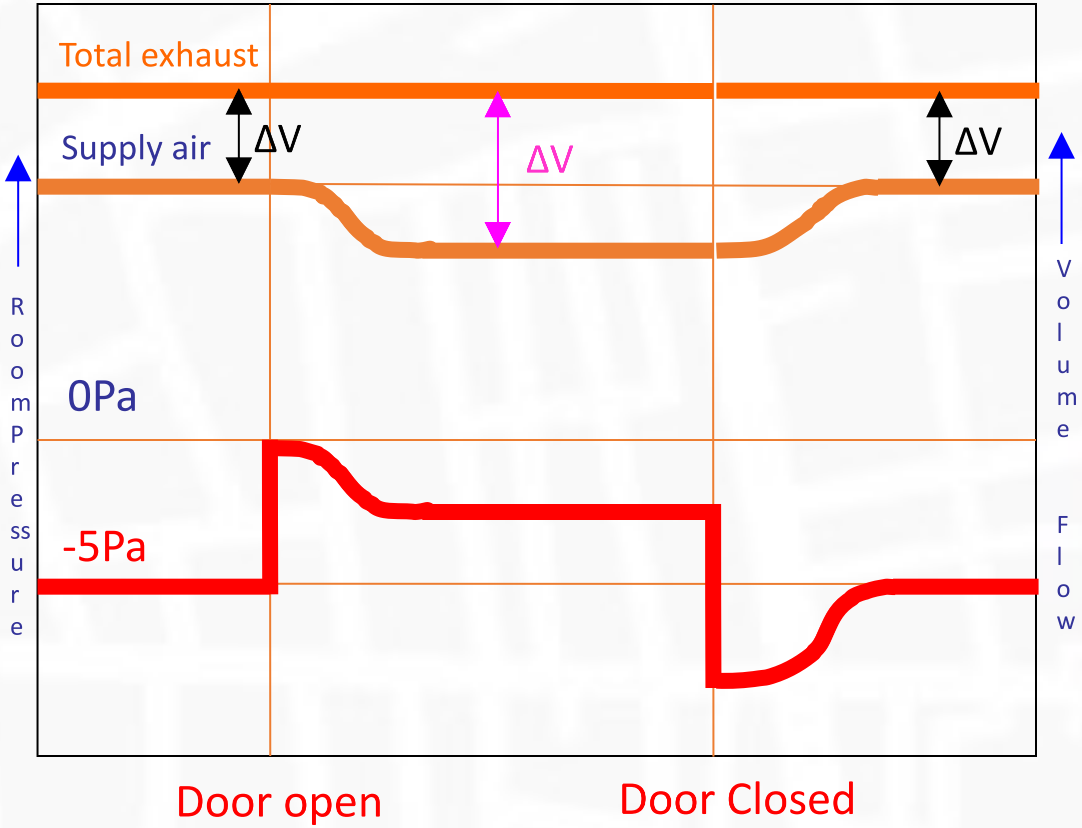
Pressure Control

- Negative pressure – extract more air than is being supplied
- Positive pressure – extract less air than is being supplied
- Pressure Controlled – Supply unit responds to a room pressure transducer and adjusts to maintain room pressure

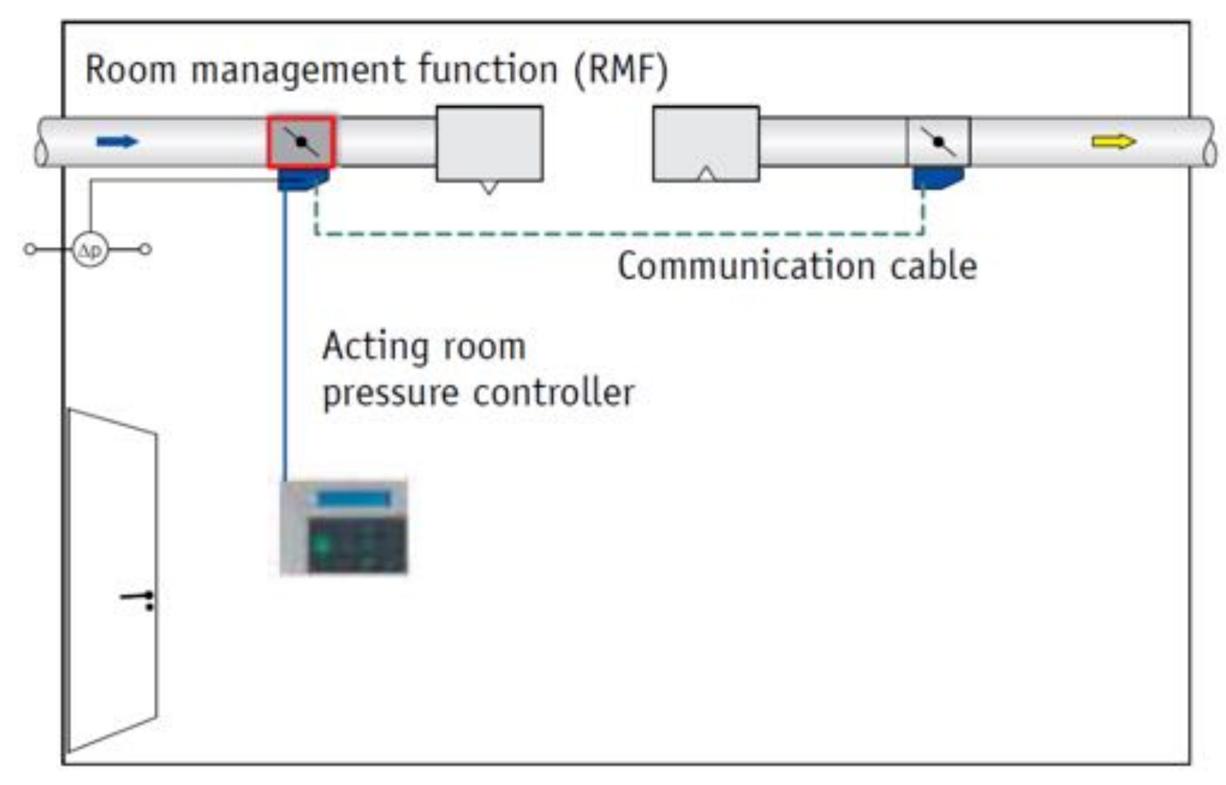


Pressure Control





Pressure Control



VAV or Venturi system with on board controls system and fast acting actuator

Pressure Transducer

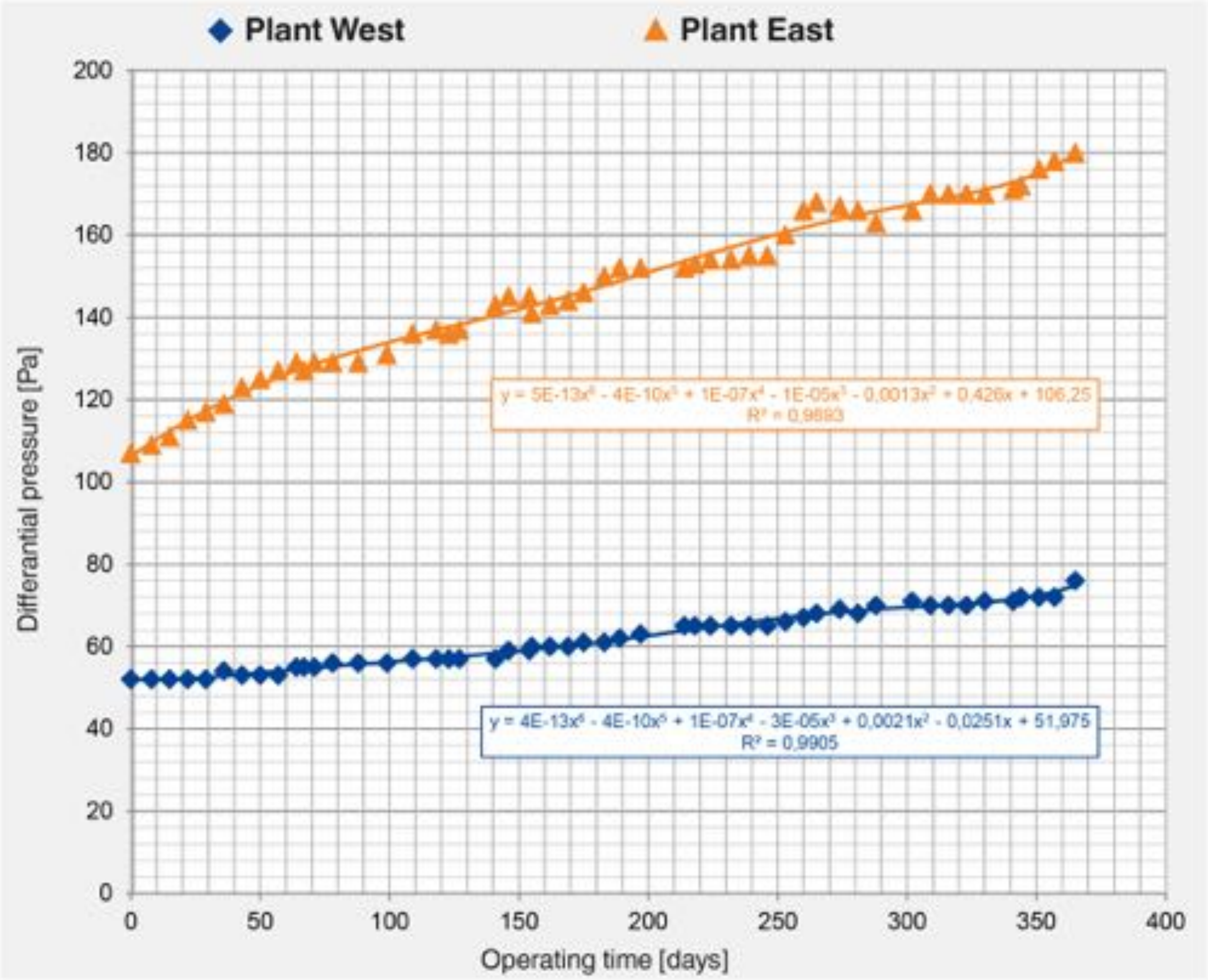
Room control panel

Energy
Considerations for filtration

Yearlong test of two different F7 bag filters
Initial resistance of Nanowave – 52 pa
Initial resistance of Synthetic - 107 pa


TROX Nanowave filter


TROX Synthetic filter

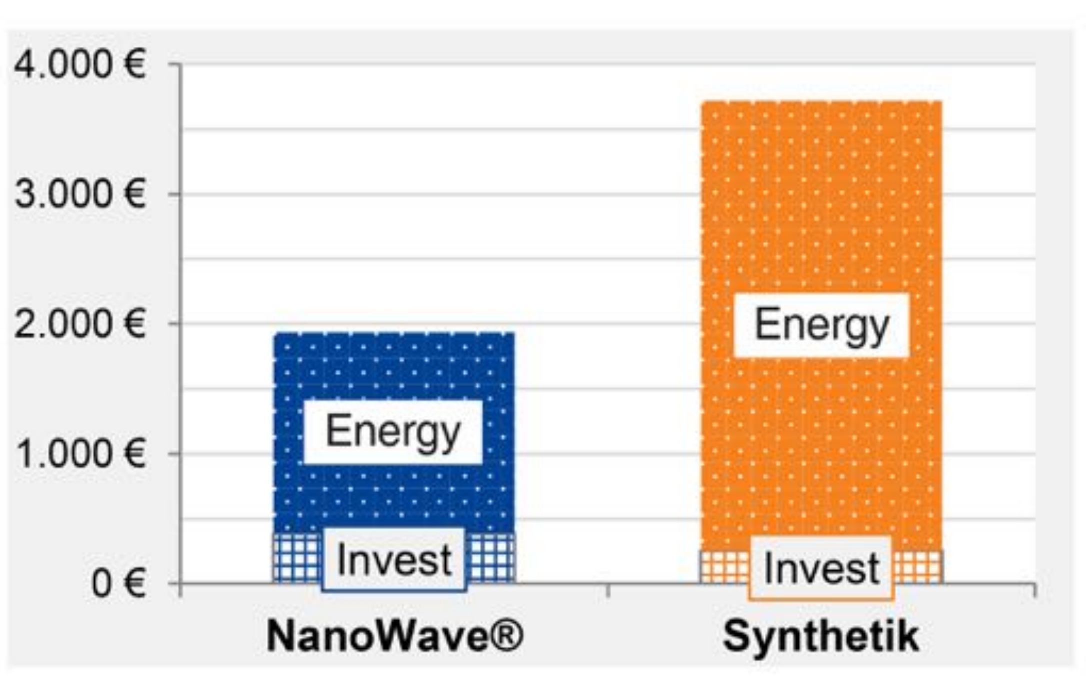

Plant West
Plant East
Differantial pressure [Pa]
Operating time [days]
200
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
y = 5E-13x⁶ - 4E-10x⁵ + 1E-07x⁴ - 1E-05x³ - 0,0013x² + 0,426x + 106,25
R² = 0,9893
y = 4E-13x⁶ - 4E-10x⁵ + 1E-07x⁴ - 3E-05x³ + 0,0021x² - 0,0251x + 51,975
R² = 0,9905

Energy
Considerations for filtration

Final resistance of Nanowave – 180 pa
Final resistance of Synthetic - 76 pa

Energy costs for Nanowave – 51% lower

Less energy consumed by fan motor



Summary

When designing HVAC system for critical areas its very important to know how the environment is to be classified. This will enable the correct design and selection of:

- Filters type and class
- Airflow volume flow rate
- Air diffusers
- Pressure requirement

Correct selection of products will enable the room to maintain the correct level of Indoor air quality specified

Eurovent 4/23 Rating Standard

Dany Elamana
Technical Manager
Camfil Middle East

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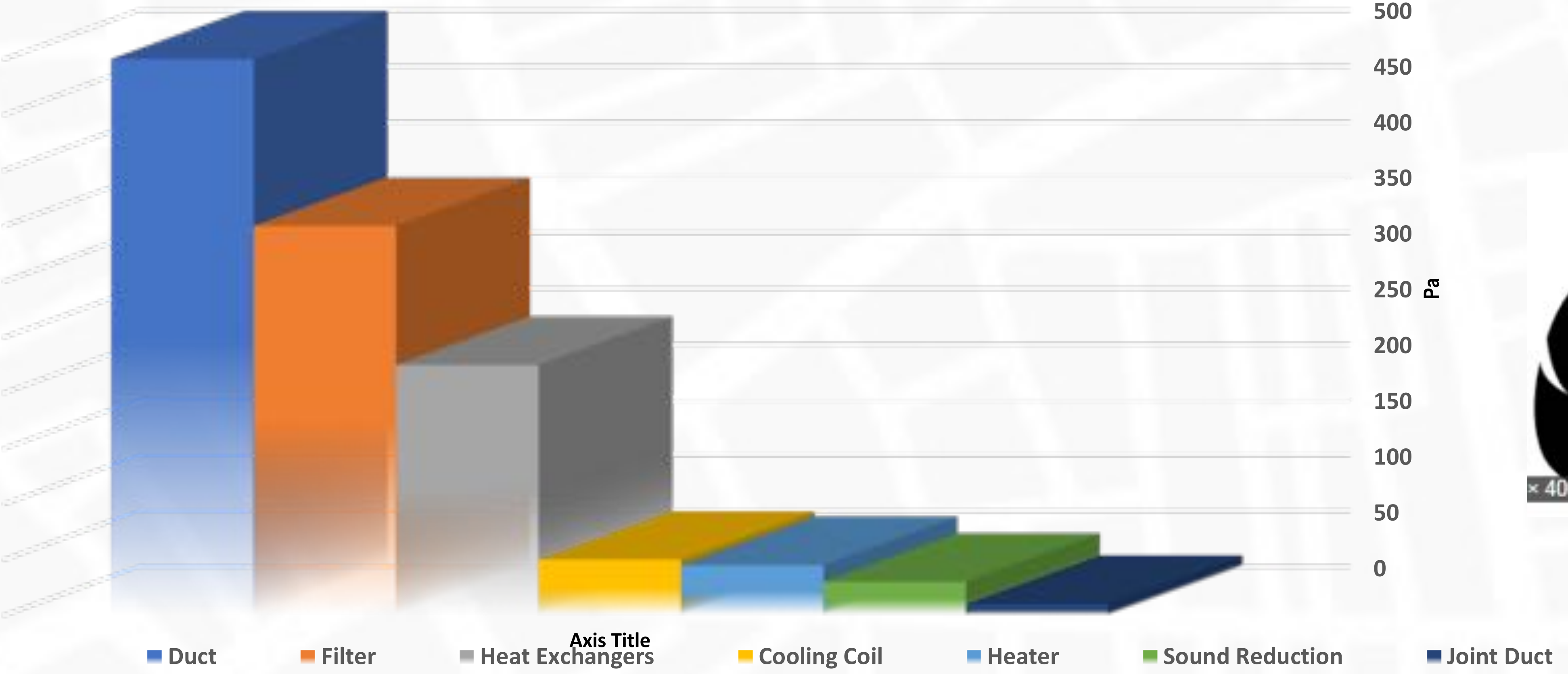
Overview

- Objective
- What’s costing you money
- Eurovent RS 4/C/001-2015
- Filter Classification - EN 779:2012
- Calculation to classify Eurovent 4/21
- Filter Classification –Eurovent
- Conclusion
- Discussion

The Objective…

To familiarize Eurovent filter classification and thus making it easier to find the right filter based on both energy efficiency and Indoor Air Quality.

What's costing you MONEY…?



Eurovent RS 4/C/001-2015

- Certifying Fine Air filters based on Energy consumption
- Filters graded from A+ to E
- Classification based on EN 779:2012

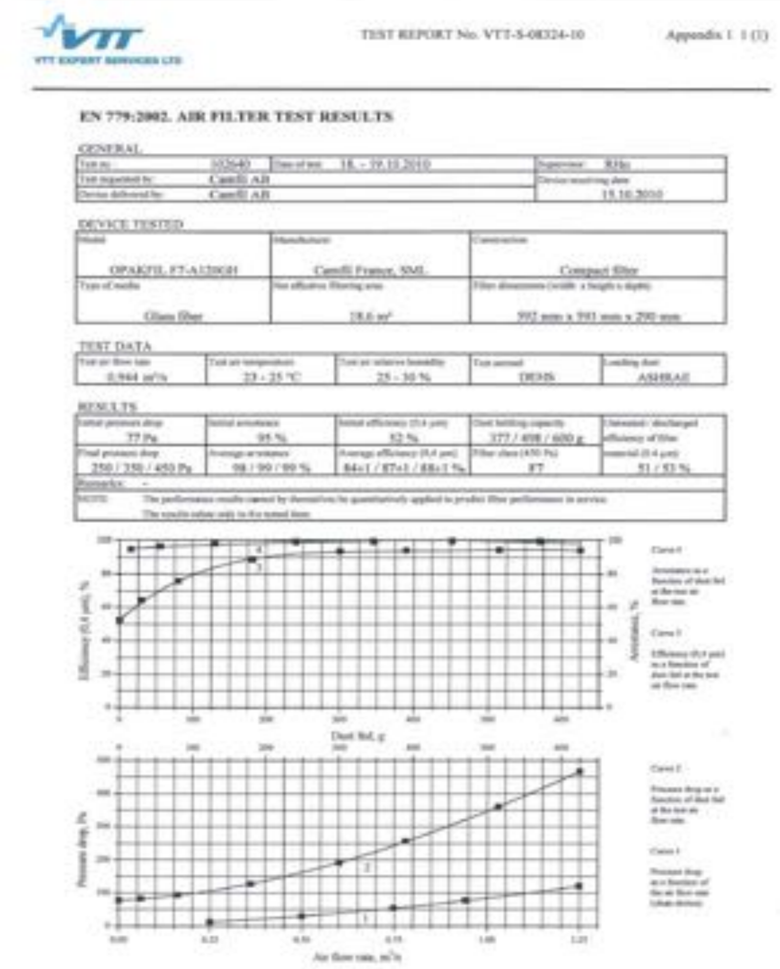
Filter classification – EN 779:2012

Classification of air filters[1]					
Group	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	80≤Am<90	-	-
	G4	250	90≤Am	-	-
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**

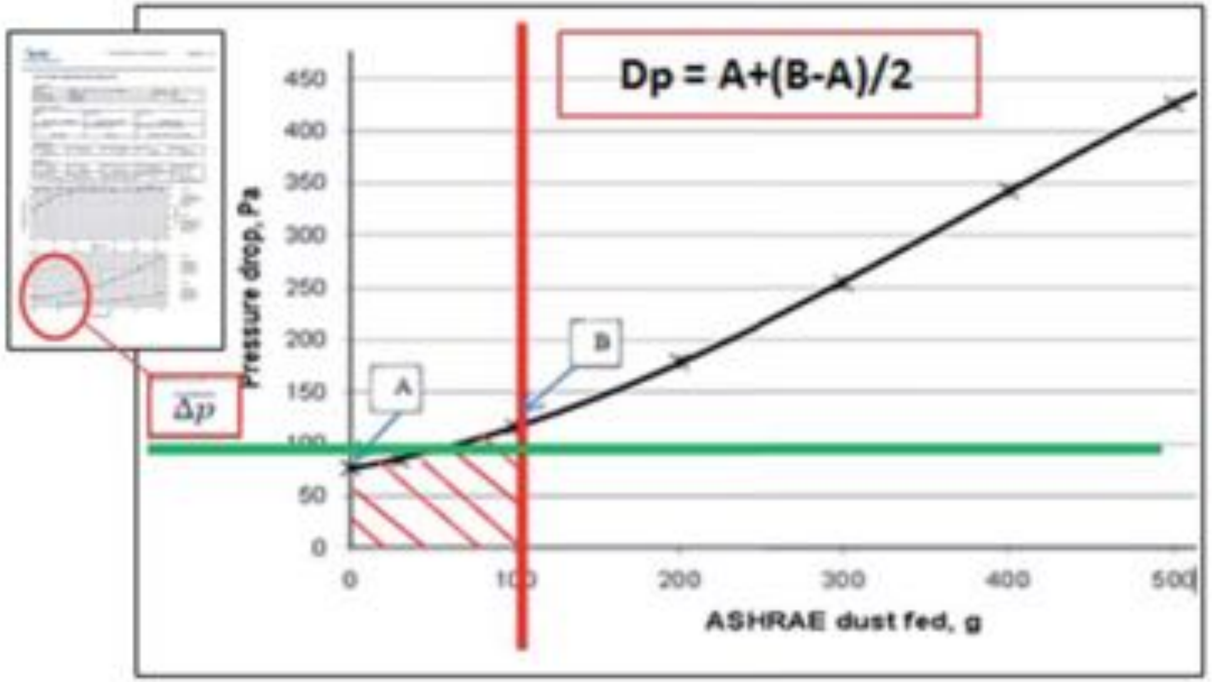
Calculation to classify
Eurovent 4/21

- Find the avg. pd. as in EN 779:2012
- Find the pressure drop as a function of dust curve
- Estimate the avg. pd. at the defined amount of dust

G4	350g
M5-M6	250g
F7-F9	100g


VTT
TEST REPORT No. VTT-S-08324-10
EN 779:2002. AIR FILTER TEST RESULTS
GENERAL
DEVICE TESTED
TEST DATA
RESULTS

Calculation to classify
Eurovent 4/21



Calculation to classify
Eurovent 4/21

$$W = \frac{q_V \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000}$$

W= Energy (Kwh)
qv – Flow rate (m3/s)
Δp- Mean Pressure drop averaged over the course of dust loading
t- time in hour
n- Efficiency of the fan

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Eurovent classification 4/21

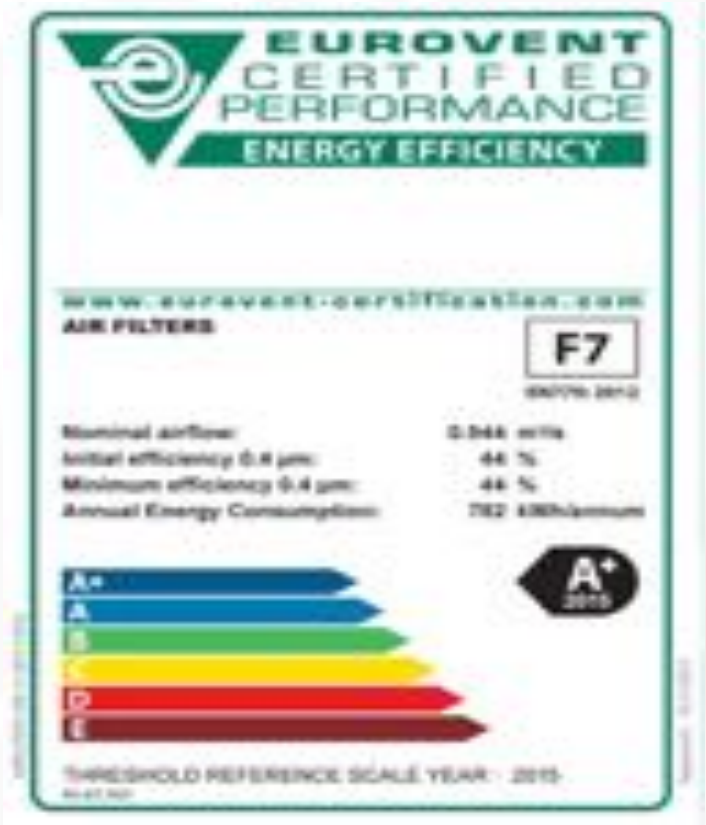
Filter class 2015	M5	M6	F7	F8	F9
ME	-	-	ME ≥ 35%	ME ≥ 55%	ME ≥ 70%
	MM=250 g ASHRAE			MF=100 g ASHRAE	
A+	0 – 450 kWh	0 – 550 kWh	0 – 800 kWh	0 – 1000 kWh	0 – 1250 kWh
A	>450 kWh – 600 kWh >	550 kWh – 650 kWh	>800 kWh – 950 kWh	>1000 kWh – 1200 kWh	>1250 kWh – 1450 kWh
B	>600 kWh – 700 kWh	>650 kWh – 800 kWh	>950 kWh – 1200 kWh	>1200 kWh – 1500 kWh	>1450 kWh – 1900 kWh
C	>700 kWh – 950 kWh	>800 kWh – 1100 kWh	>1200 kWh – 1700 kWh	>1500 kWh -2000 kWh	>1900 kWh – 2600 kWh
D	> 950 – 1200 kWh	> 1100 kWh – 1400 kWh	> 1700 kWh – 2200 kWh	> 2000 kWh – 3000 kWh	> 2600 kWh – 4000 kWh
E	>1200 kWh	>1400 kWh	>2200 kWh	>3000 kWh	>4000 kWh

Energy class: according to Eurovent RS-4/C/001-2015

Save energy, money and your health

- Choose a filter that saves both energy, money and keeps a good indoor air quality
- Look for Eurovent

- Q&A



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