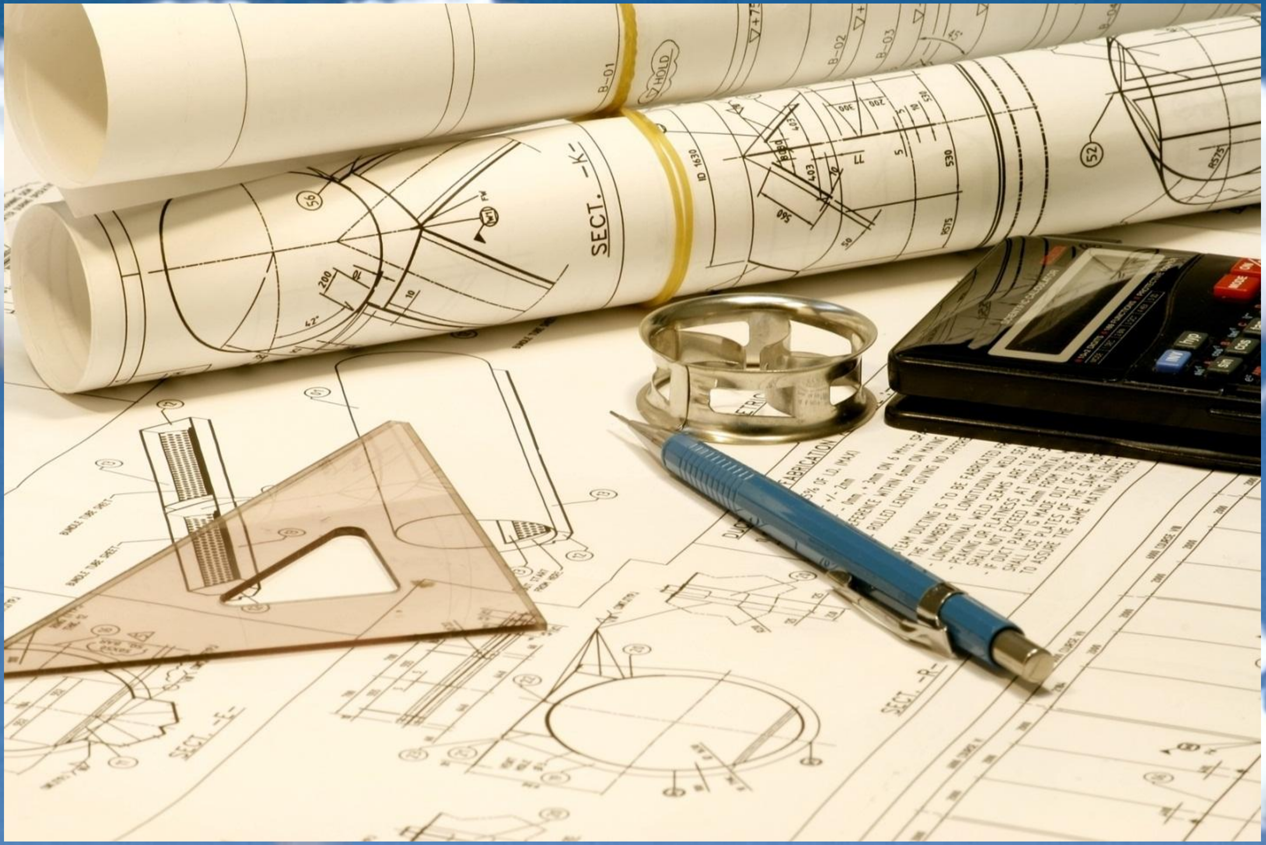
Industry Terminology and Filter Engineering



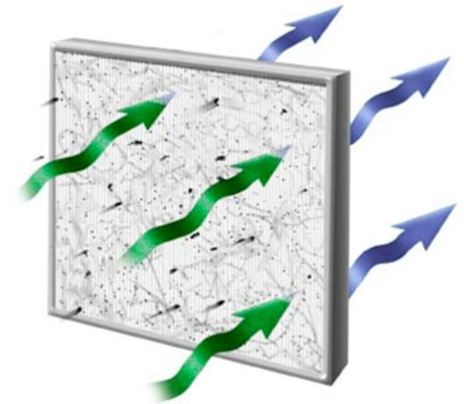
Camfil College 2013

Basic Industry Terminology:

By the end of this class you will know the most commonly used terms in the air filter industry.

Pay attention – these will help you understand later

Filtration efficiency



Measurements of air filter's ability to remove dust and particles.

Listed alternatively,
- Particulate Efficiency:%
- Weight Efficiency,%

The term covers :

Coarse filter
= weight efficiency (arrestance)

Fine filter
= particulate efficiency

HEPA/ULPA filter
= particulate efficiency

Dust holding capacity

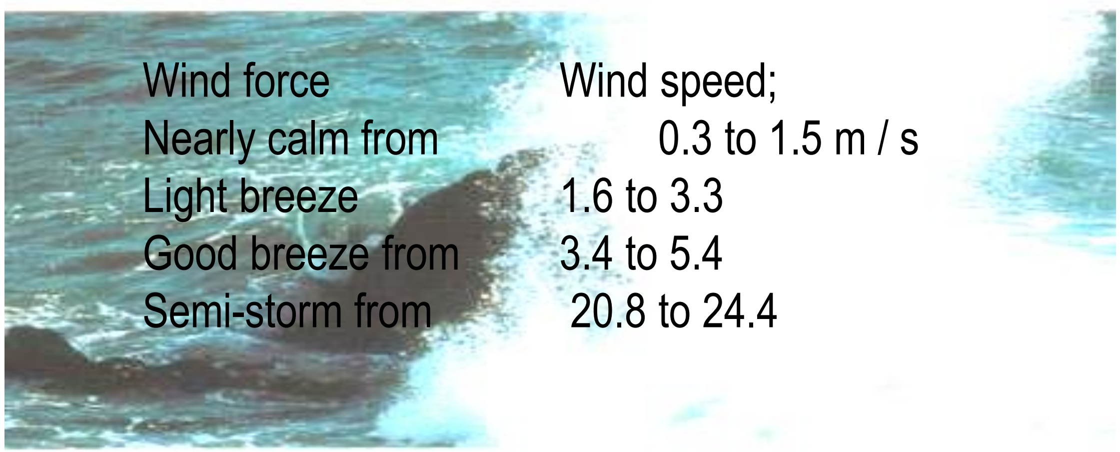
Specifies the amount of dust that collects in a filter during the operation period until the final pressure drop. Expressed in grams.

Rule of thumb:
The higher the filter class the less dust holding capacity,
and vice versa.

Air velocity

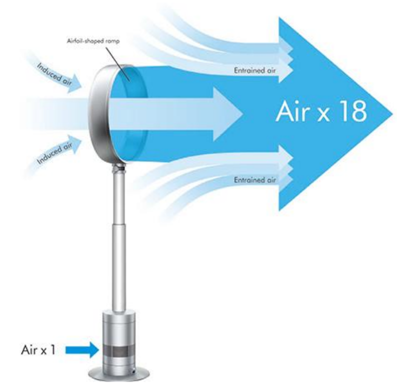
The air velocity through a filter or
channel cross-section of a ventilation system.
Expressed in m / s.

Common front velocities over the filter is 1.5 - 3.5 m / s



Wind force	Wind speed;
Nearly calm from	0.3 to 1.5 m / s
Light breeze	1.6 to 3.3
Good breeze from	3.4 to 5.4
Semi-storm from	20.8 to 24.4

Airflow



The amount of air passing through a filter or through a ventilation per unit time. Expressed in m³/s.
Other name is m³/h (m³/s x 3600) or l / s (m³/s x 1000)

Common air flow for a full module filter (592x592mm) is about
0.75 to 1.2 m³/s

Simple rule of thumb! A full module filter ~ 1 m³/s

Pressure (force per unit area)

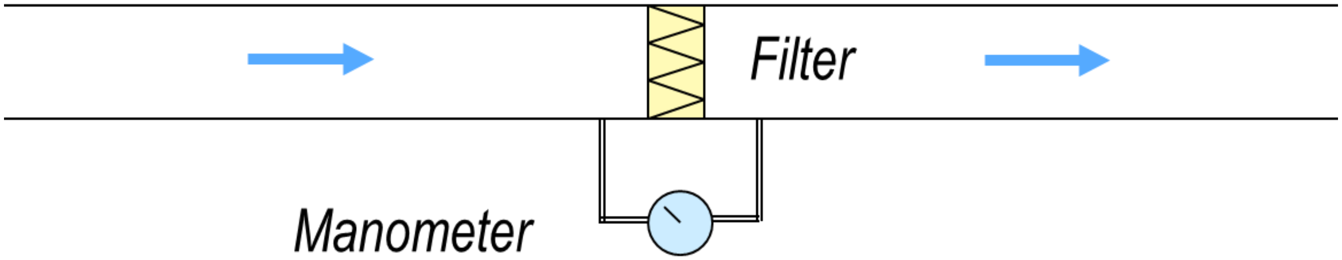
For air in a ventilation system, the following terms:

- Pressure unit in SI system is a pascal (Pa).
- Pressure unit in US system is Inch Water Gauge (" W.G.)
- Conversion 1" W.G = 250 Pa.

- Static pressure: pressure of the air which is dormant relative to atmospheric pressure
- Dynamic pressure: The difference between total pressure and static pressure. As air moves occur due to inertial forces a dynamic pressure proportional to the square of velocity.
- Total pressure: the static pressure plus dynamic pressure

Pressure Drop

Filters prevents air flow through a ventilation system.
Static pressure is higher before the filter than after the filter
a static pressure loss occurs. The difference is the pressure drop.
Measured with a manometer with hoses connected in the right way
at the level of the canal wall.



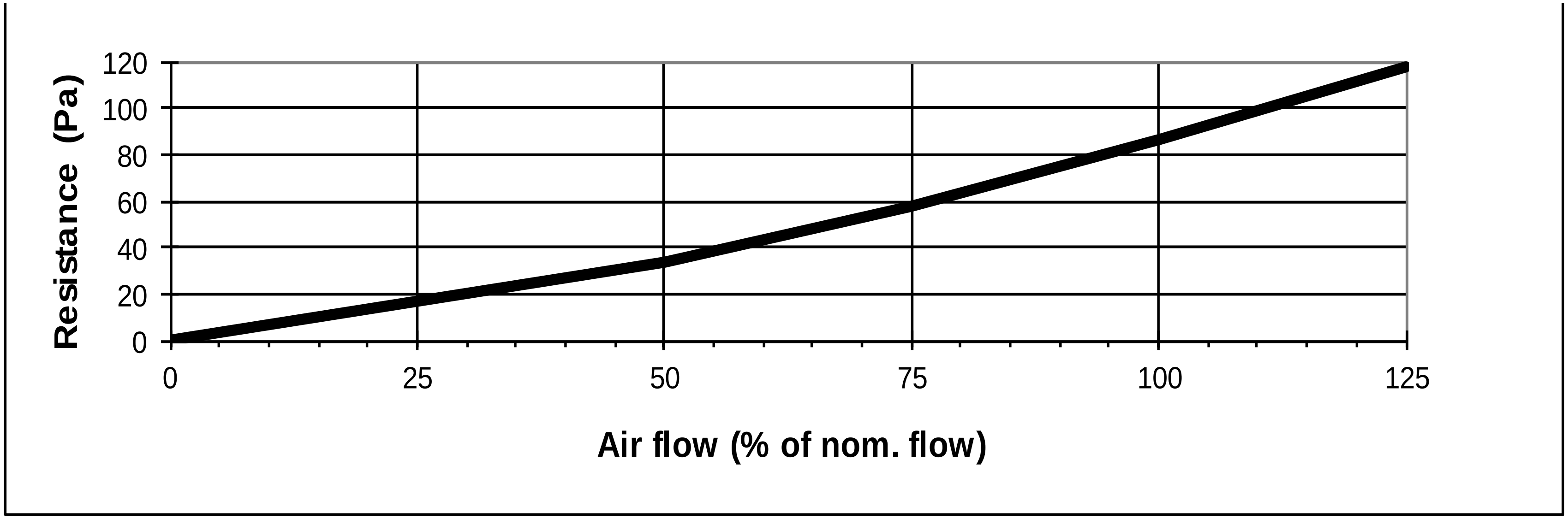
Initial and final pressure drop

Initial pressure drop: The pressure drop in a new and unused filter at a given airflow.

Final Pressure drop: The pressure drop where the operation is interrupted.

1) Ventilation systems are rated at a given final pressure drop where the filter should be changed. Continuing operation reduces airflow into the premises if you have a constant fan speed and increases the energy use if you have a fan with various speed.
2) When tested in the laboratory, the test is stopped when the final pressure drop is achieved.
3) The air filter ***never*** gives you the system final pressure drop.

Pressure drop change when airflow changes

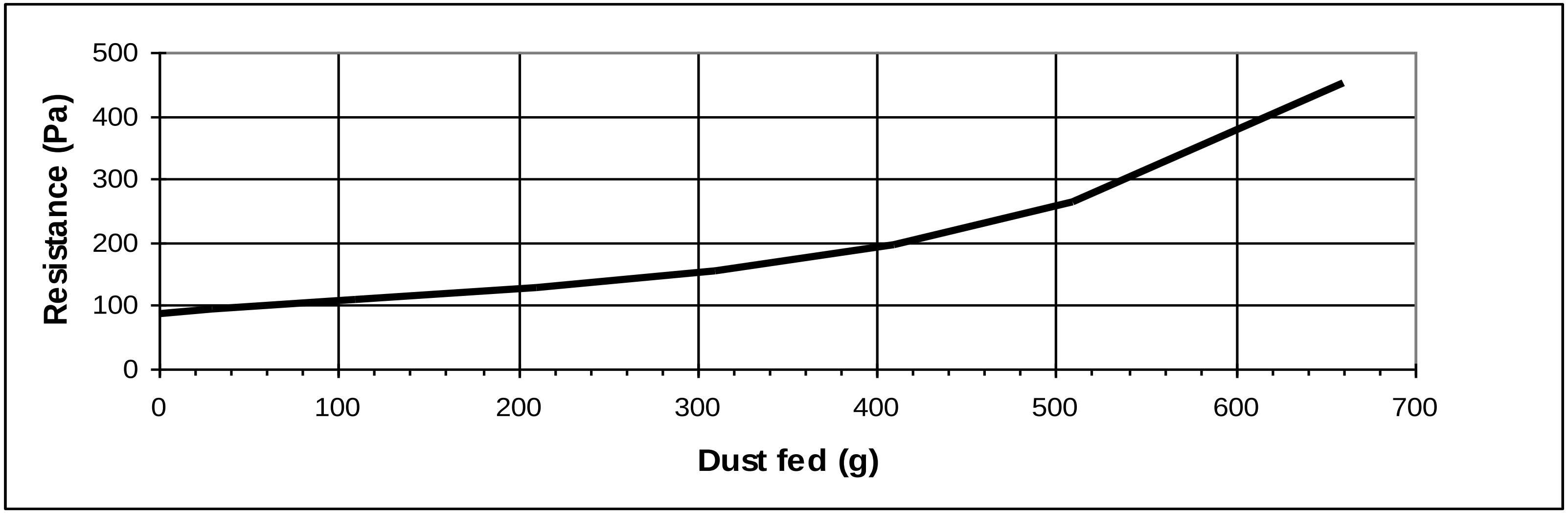


Date Sign.

The changed air flow changes pressure drop. 100% here is 0.94 m³ / s.

Examples from the chart
Airflow Pressure
0.47 m³ / s (50%) 33 Pa.
1.17 m³ / s (125%) 118 Pa.

Pressure drop change when dust is feed



The pressure drop increases when the filter are filled with dust.
Airflow is here 0.94 m³ / s.

Examples from the chart

Dust feed	Pressure
100 g,	110 Pa.
500 g	260 Pa

The importance of correct air flow and air velocity

Filters are designed to a specific airflow and air velocities.

Rule of thumb: On bagfilter ± 25%

(Pressure drop is related to the airflow, lower flow = lower pressure drop)

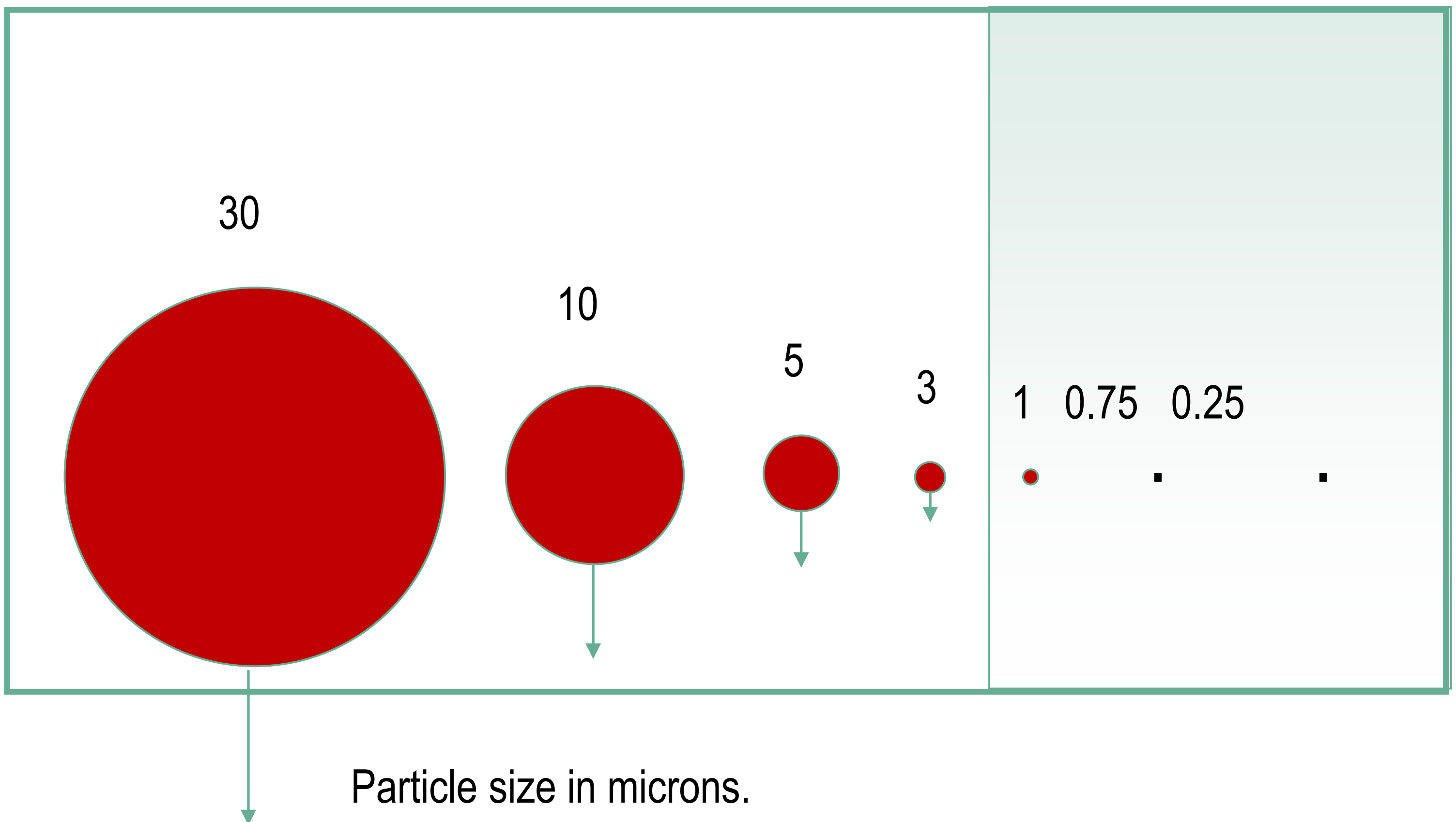
Differs airflow/air speed to much, then the filter may not work as predicted. Especially if the values are higher than recommended.

Beware of units that have special dimensions.

Use standard dimensions and follow the recommended air flow!

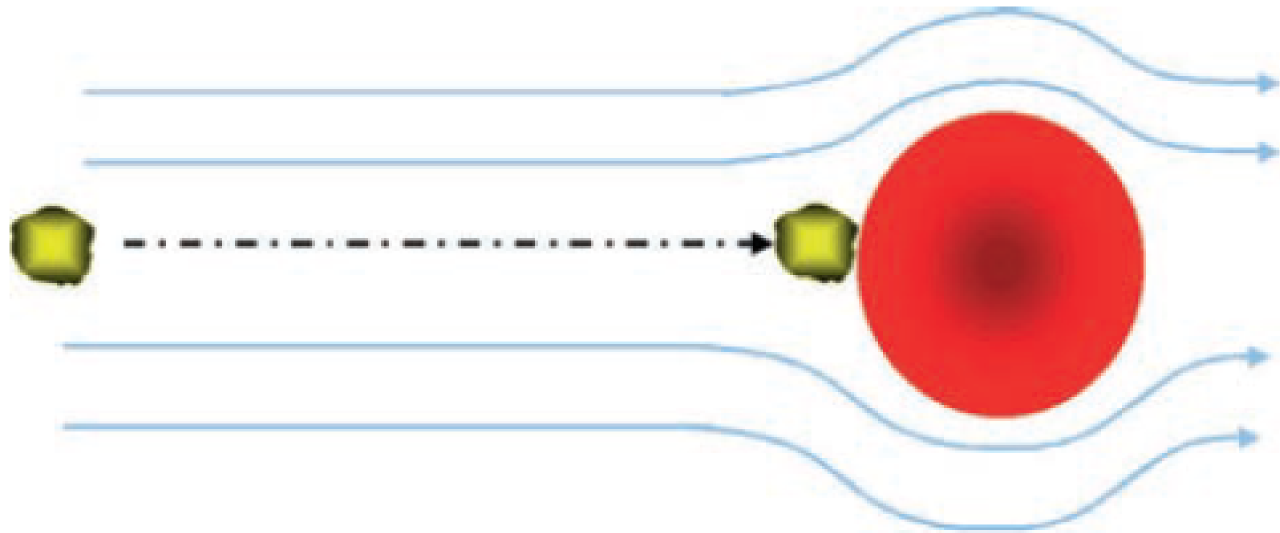
How do Air Filters work?

Behavior of particles in the air



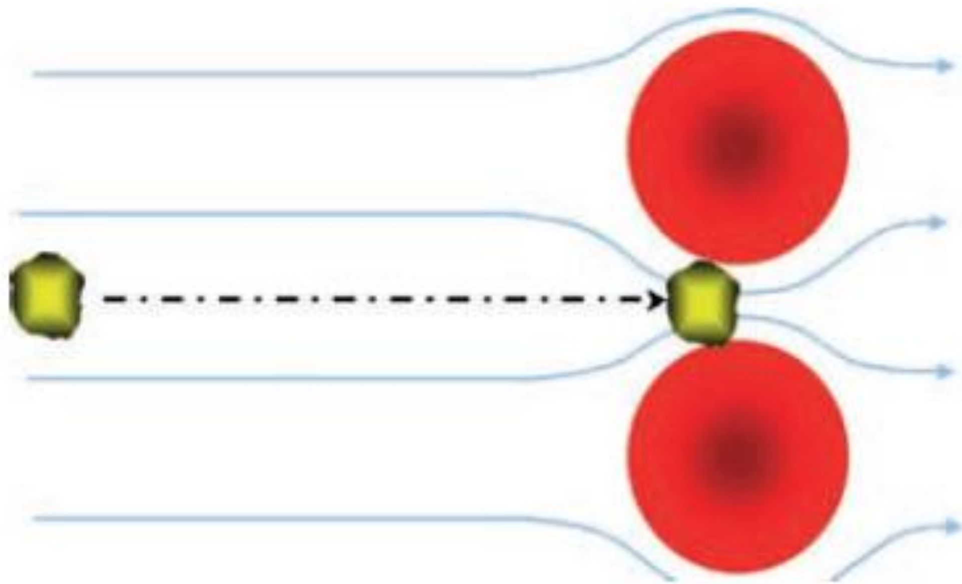
Particle size in microns.
The arrow represents the particle falling velocity.

The 5 Principles of Air Filtration: Inertial seperation



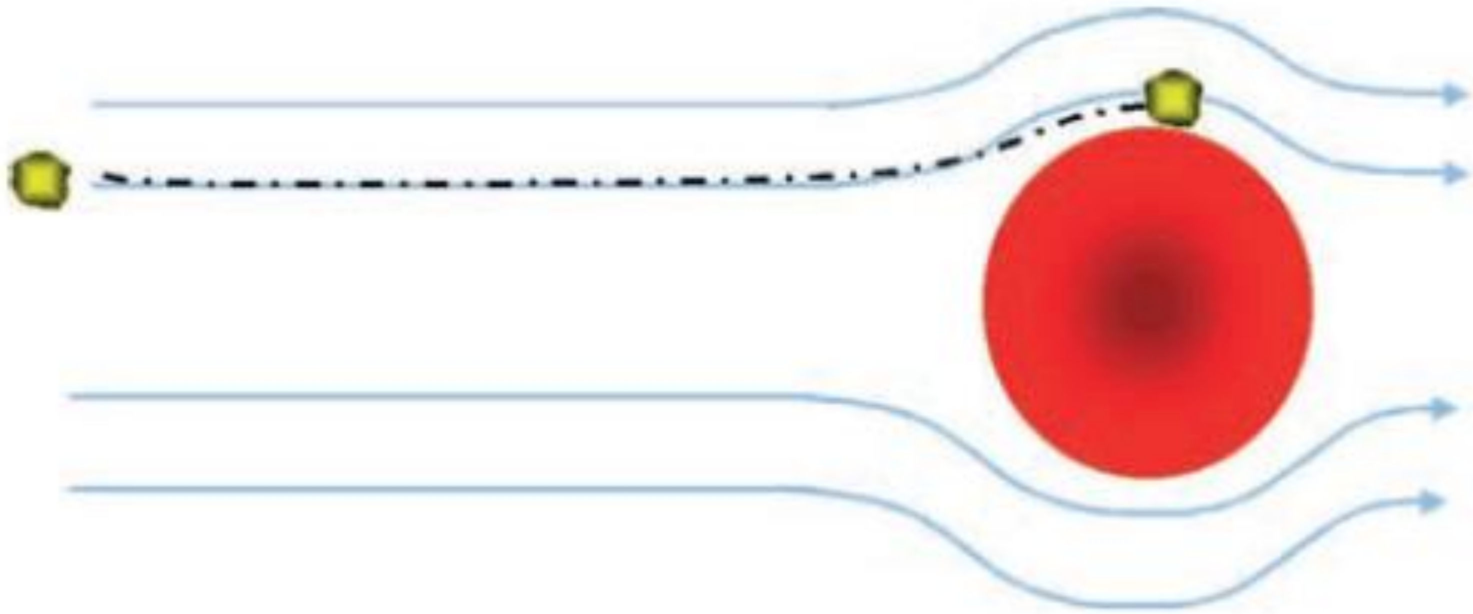
Inertial separation uses a rapid change in air direction and the principles of inertia to separate mass (particulate) from the air stream. Particles at a certain velocity tend to remain at that velocity and travel in a continuous direction. This principle is normally applied when there is a high concentration of coarse particulate, and in many cases as prefiltration mode to higher efficiency final filters.

The 5 Principles of Air Filtration: Straining (sieving)



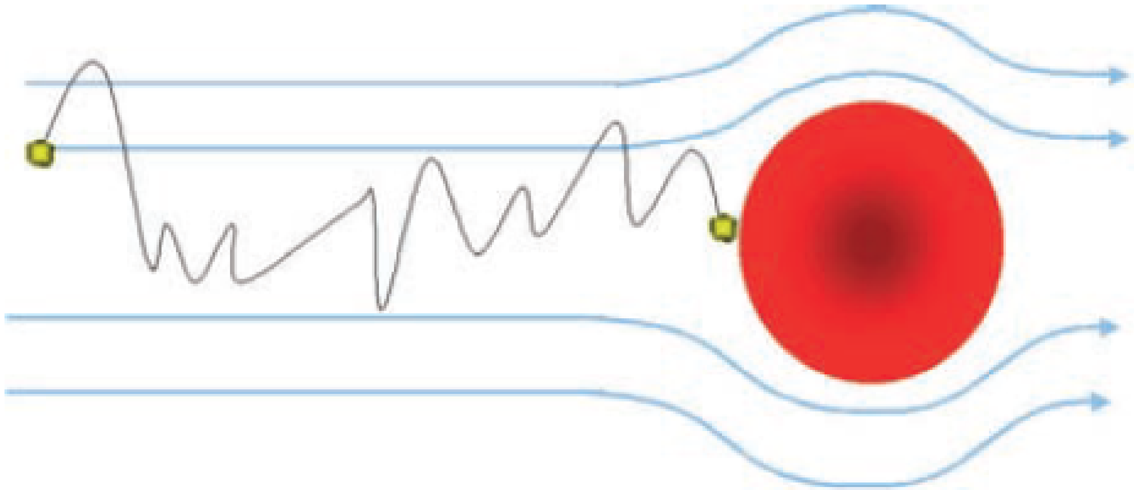
Straining (sieving) occurs when the opening between the media members (fibers, screen mesh, corrugated metal, etc.) is smaller than the particle diameter of the particle the filter is designed to capture. This principle spans across most filter designs, and is entirely related to the size of the particle, media spacing, and media density.

The 5 Principles of Air Filtration: Interception



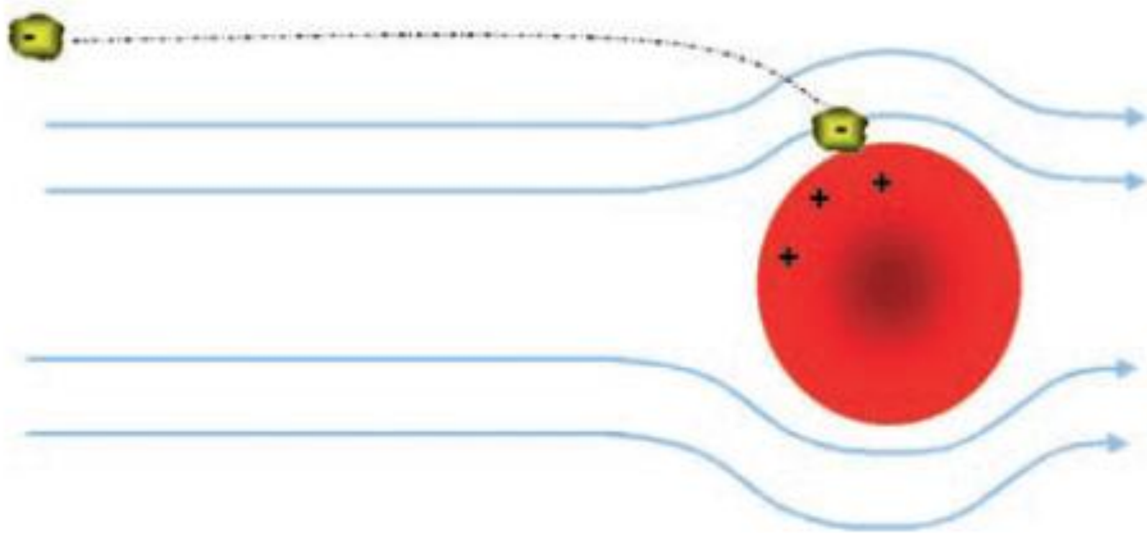
Interception occurs when a large particle, because of its size, collides with a fiber in the filter that the air stream is passing through.

The 5 Principles of Air Filtration: Diffusion



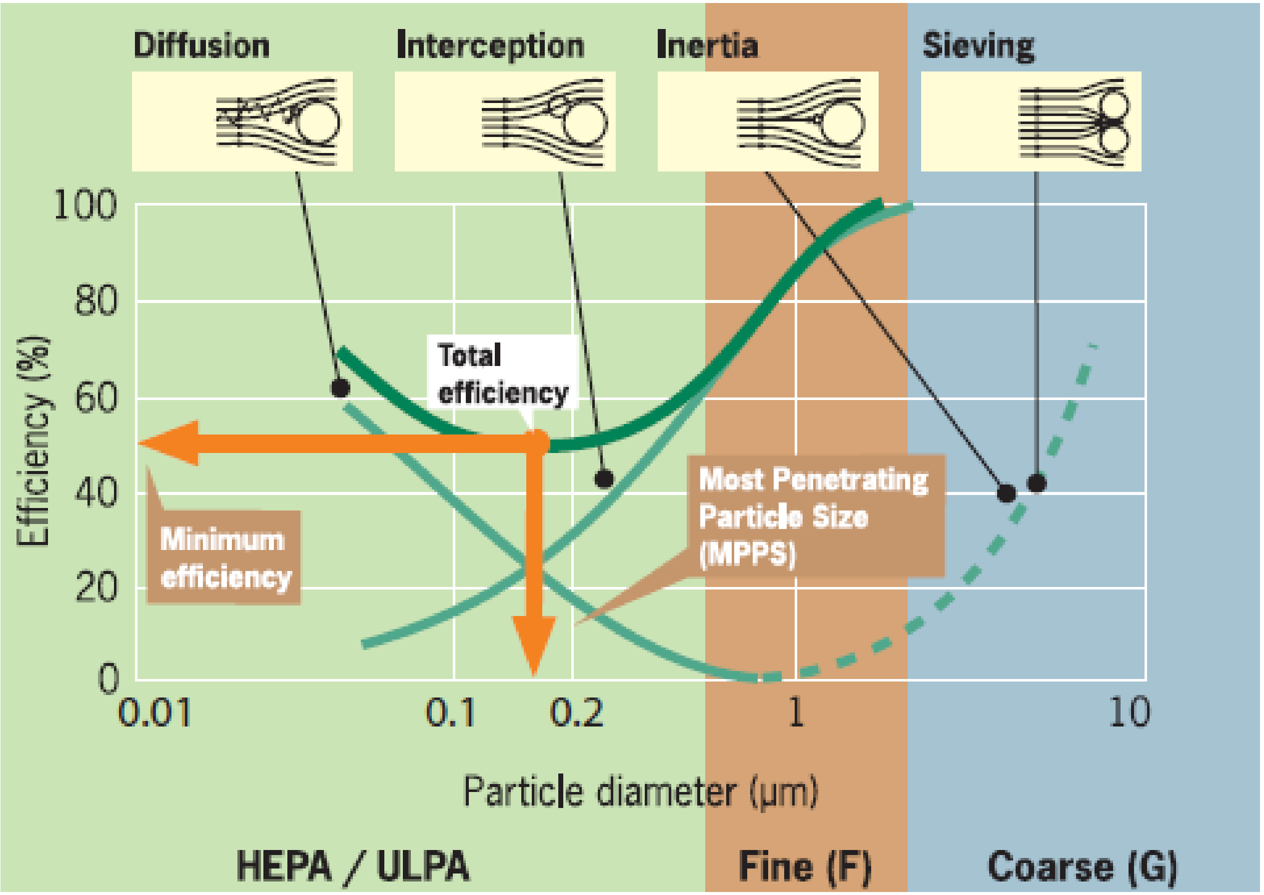
Diffusion occurs when the random (Brownian) motion of a particle causes that particle to contact a fiber. As a particle vacates an area within the media, by attraction and capture, it creates an area of lower concentration within the media to which another particle diffuses, only to be captured itself. To enhance the possibility of this attraction, filters employing this principle operate at low media velocities and/or high concentrations of microfine fibers, glass or otherwise.

The 5 Principles of Air Filtration: Electrostatic attraction

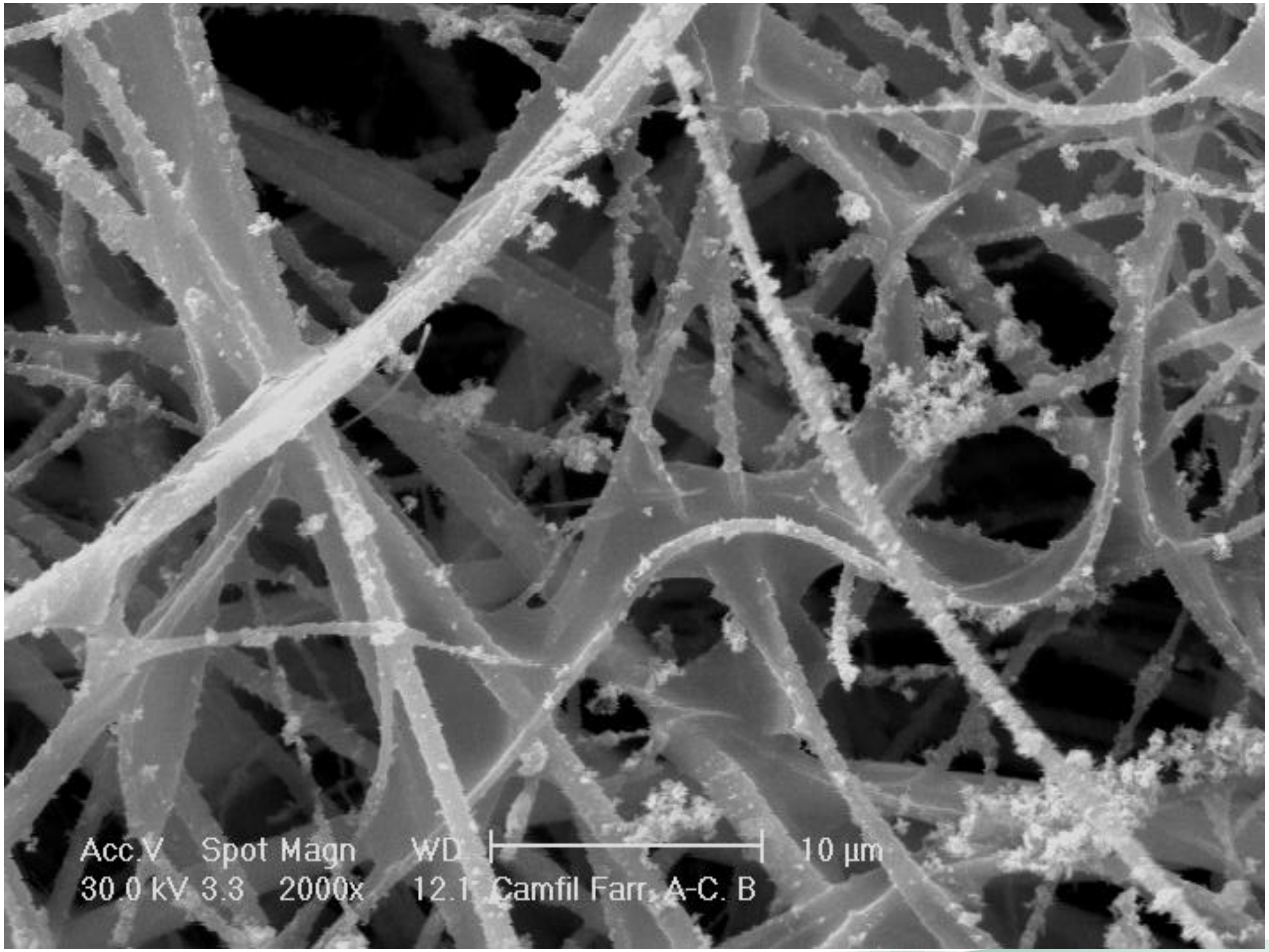


Electrostatic attraction plays a minor role in mechanical filtration. After fiber contact is made, smaller particles are retained on the fibers by a weak electrostatic force. The force may be created through a manufacturing process, or be dependent upon airflow across media fibers. The force is eradicated as media fibers collect contaminant that acts as an insulator to a charge.

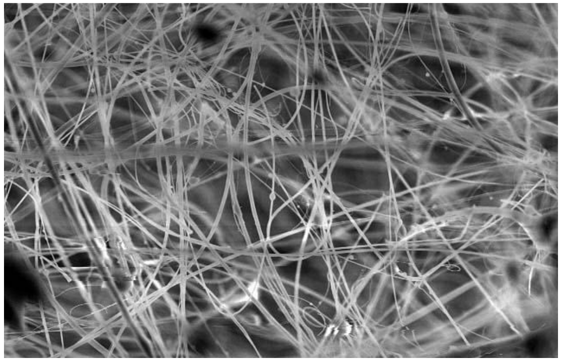
Combined Filtration Efficiency



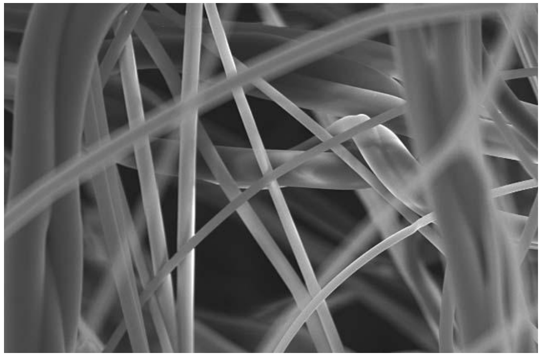
Fine fibers – small particles!



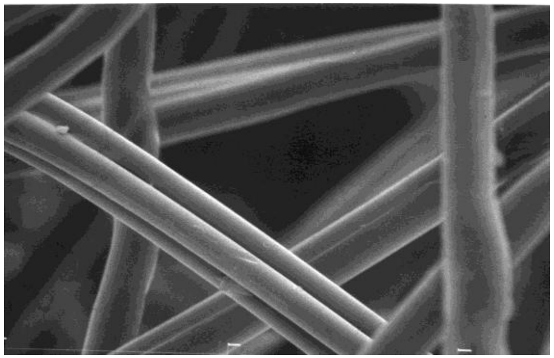
Scaled in SEM microscope 500 times



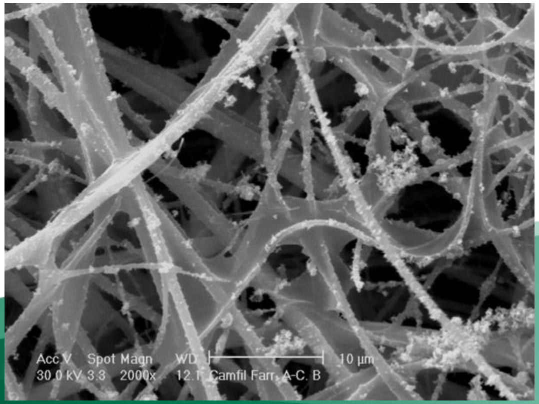
Micro glass fibre
F7



Synthetic
Meltblown fibre F7



Synthetic Coarse
`electret´ fibre F7



The filter design

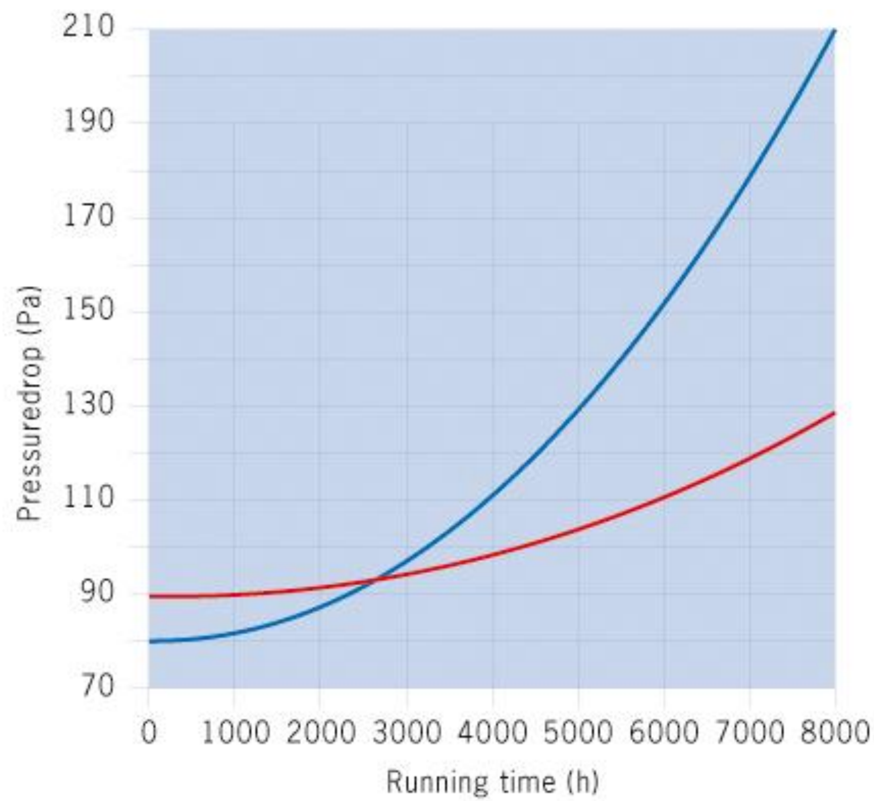
A low filter pressure drop over its entire service life is the key to a low energy cost. The pressure drop depends on:

- filter surface
- filter design
- filter material

The filter design

Filter surface

The service life of a filter increases exponentially to the surface area. 50% more area will double the service life.



The filter design

Filter design

The pressure drop of the filter is the sum of the media pressure drop and the design pressure drop.

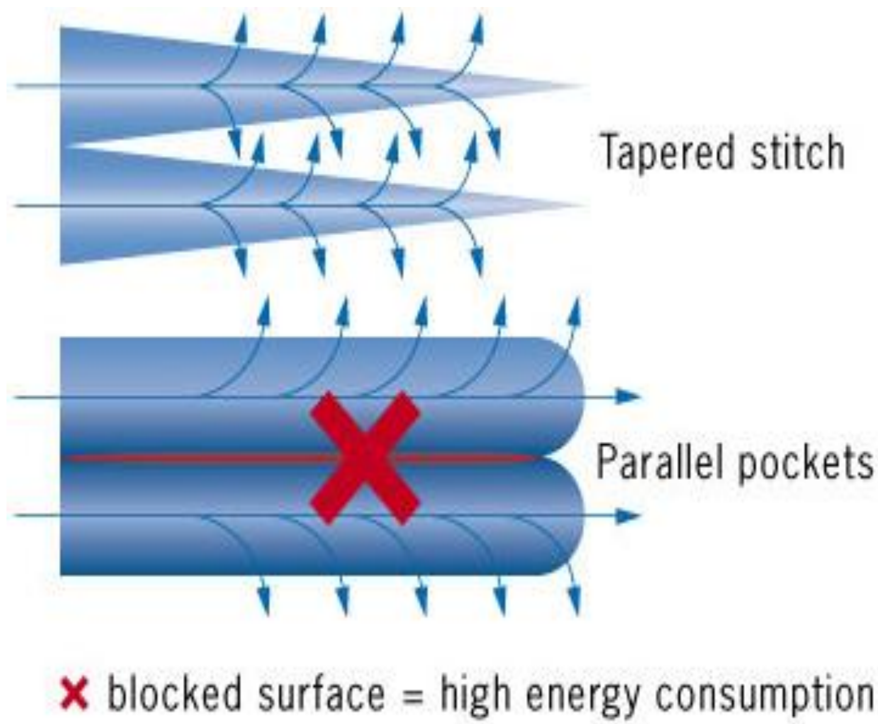
The design pressure drop will differ significantly between a good and a bad design.

	Pressure Drop dP (Pa)			
	From Material	From Design	Total	% From design
30/30	22	47	69	68
Hi-Flo M7	47	38	85	45
Opakfil F8	50	38	88	43

Product design will have direct impact on the energy cost and the service life of the filter.

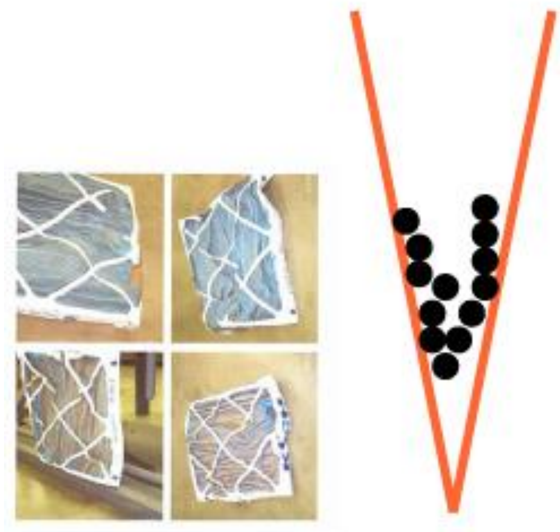
The filter design

- Camfil use an optimised design in order to minimise the energy consumption
- For bag filter – ask for tapered stitch

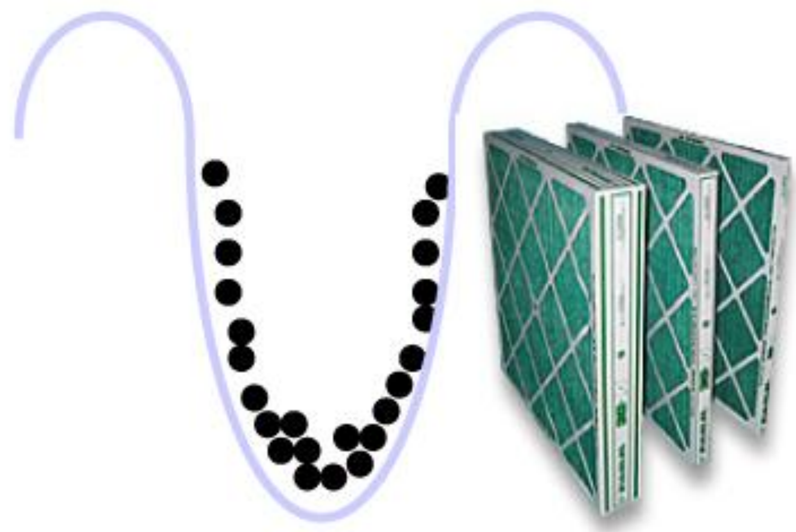


The filter design

Chandler or ‘V”type pleat will blind causing rapid increase in pressure drop.

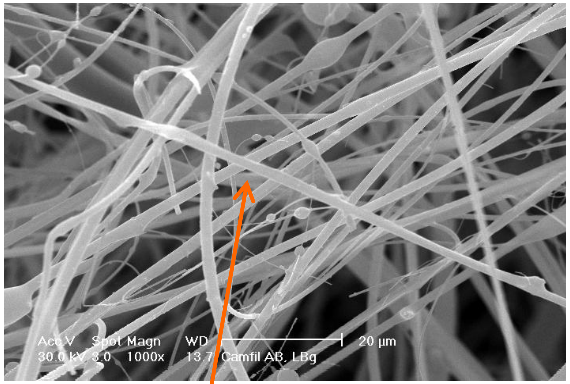


Uniform radial style pleat loads evenly resulting, in lower average pressure drop and long loading curve.

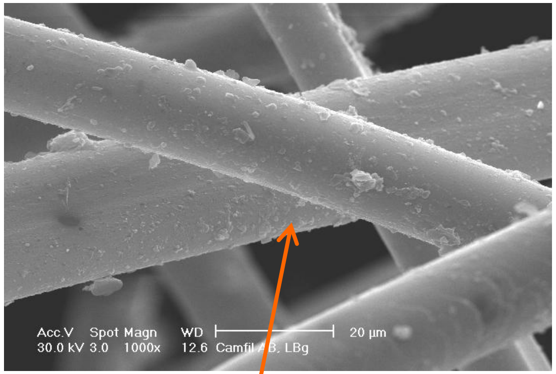


The efficiency step

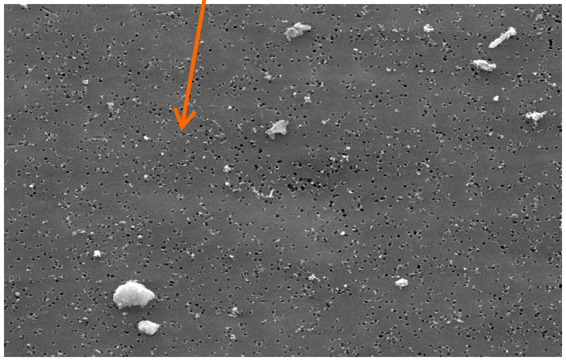
Glass fiber media (class F7)



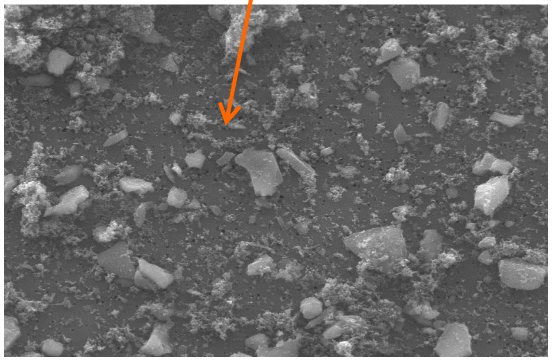
Synthetic polyester media (class F7)



Same magnification



Outdoor air particles. Average diameter ~0.08mm



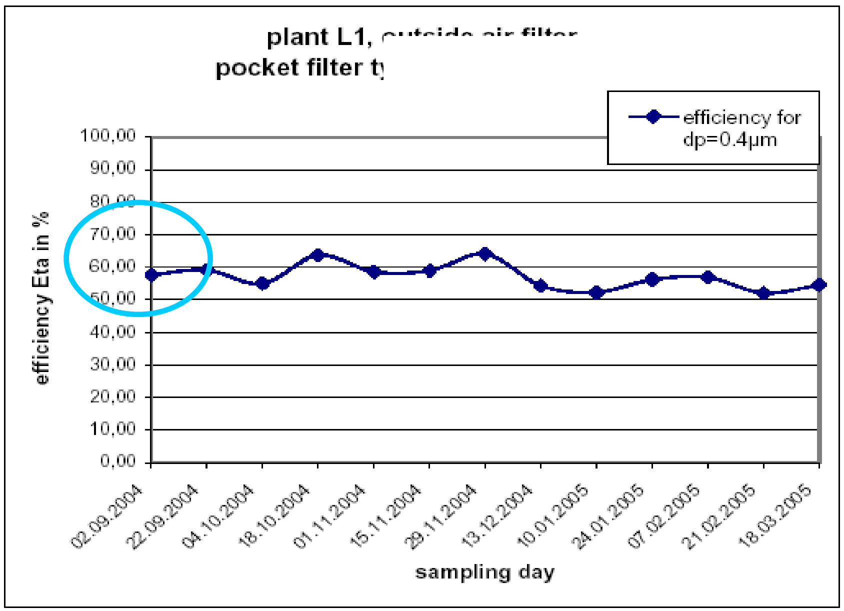
Test dust
Average diameter ~7.7mm

The efficiency step

Outside Air filter Measurement Results

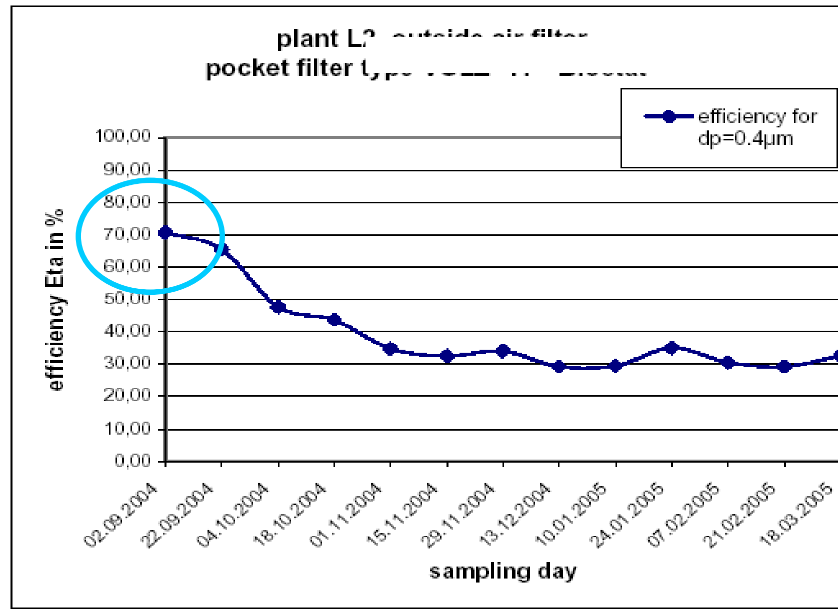
Outside Air Filter Measurement Results (1st filter stages), Second Measurement Period

In accordance with DIN EN 779, only measurement results for particle size of 0.4 µm are used.



Outside Air Filter, Plant L1

Glass Fibre Pocket Filter Camfil - F7



Outside Air Filter, Plant L2

Synthetic Fibre Pocket Filter - F7

The optimum filters

An example of the importance of correct filter area.

<u>Case 1, A7 filter</u>

F7-filter (EN779-2002)

Efficiency (0.4 μm) = 60%

4.6 m^2

$\Delta p_{ini} \approx$ 150 Pa

<u>Case 2, M7 filter</u>

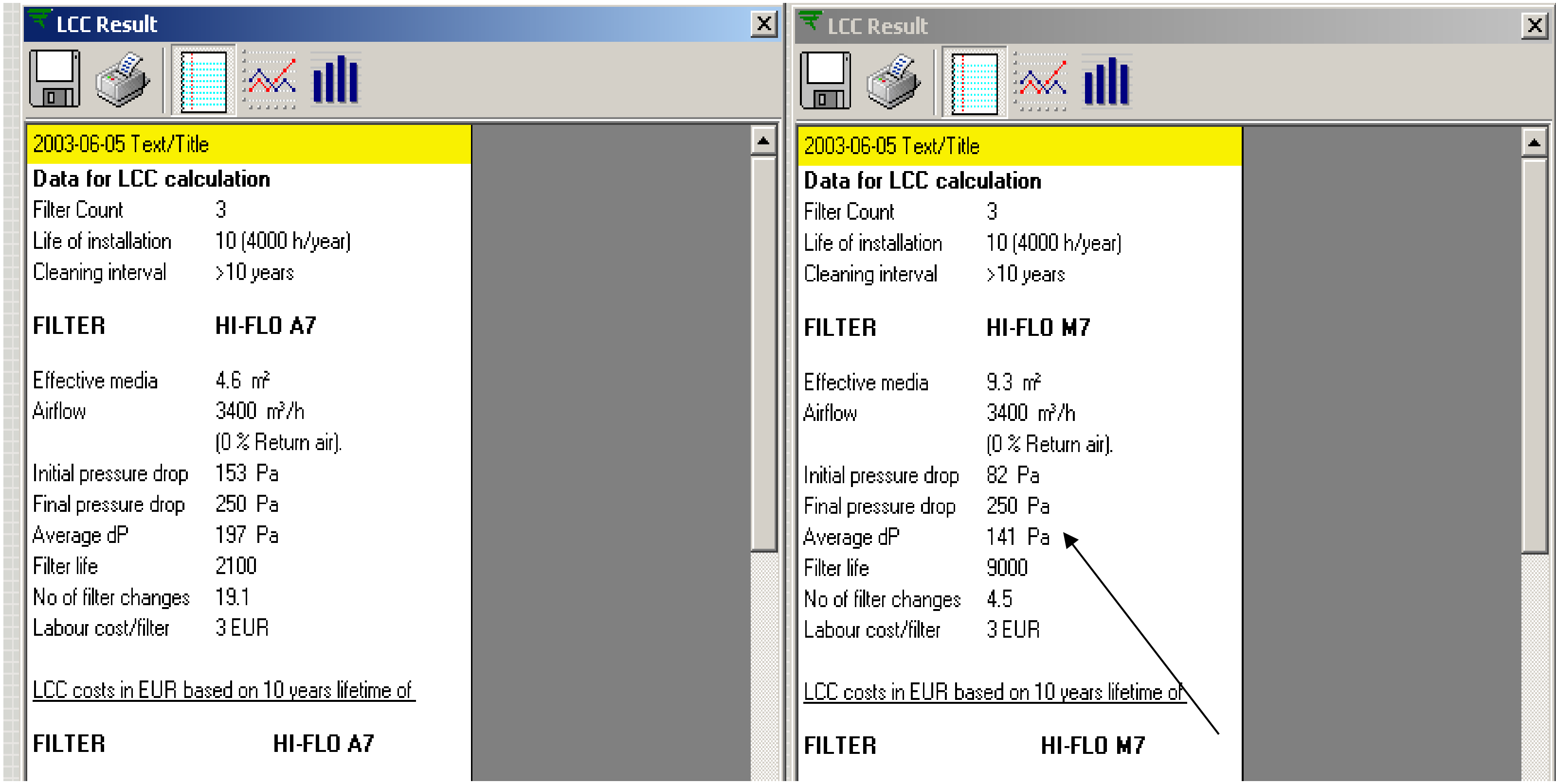
F7-filter (EN779-2002)

Efficiency (0.4 μm) = 60%

9.3 m^2

$\Delta p_{ini} \approx$ 80 Pa

The optimum filters



Average pressure drop

The optimum filters

LCC Result

LCC costs in EUR based on 10 years lifetime of installation

FILTER	EUR	(%)	HI-FLO A7 EUR	(%)
Filter Cost	1860	(47.7)	201	(10.8)
Installation cost	0	(0.0)	0	(0.0)
Labour cost	147	(3.8)	9	(0.4)
Energy	1839	(47.2)	1647	(88.7)
Disposal cost	54	(1.4)	3	(0.2)
Cleaning	0	(0.0)	0	(0.0)
LCC for filter	3903	(100.0)	1857	(100.0)

Total LCC cost (EUR)	
Filter Cost	2061
Installation cost	0
Labour cost	156
Energy	3486
Disposal cost	57
Cleaning	0
Total	**5760**

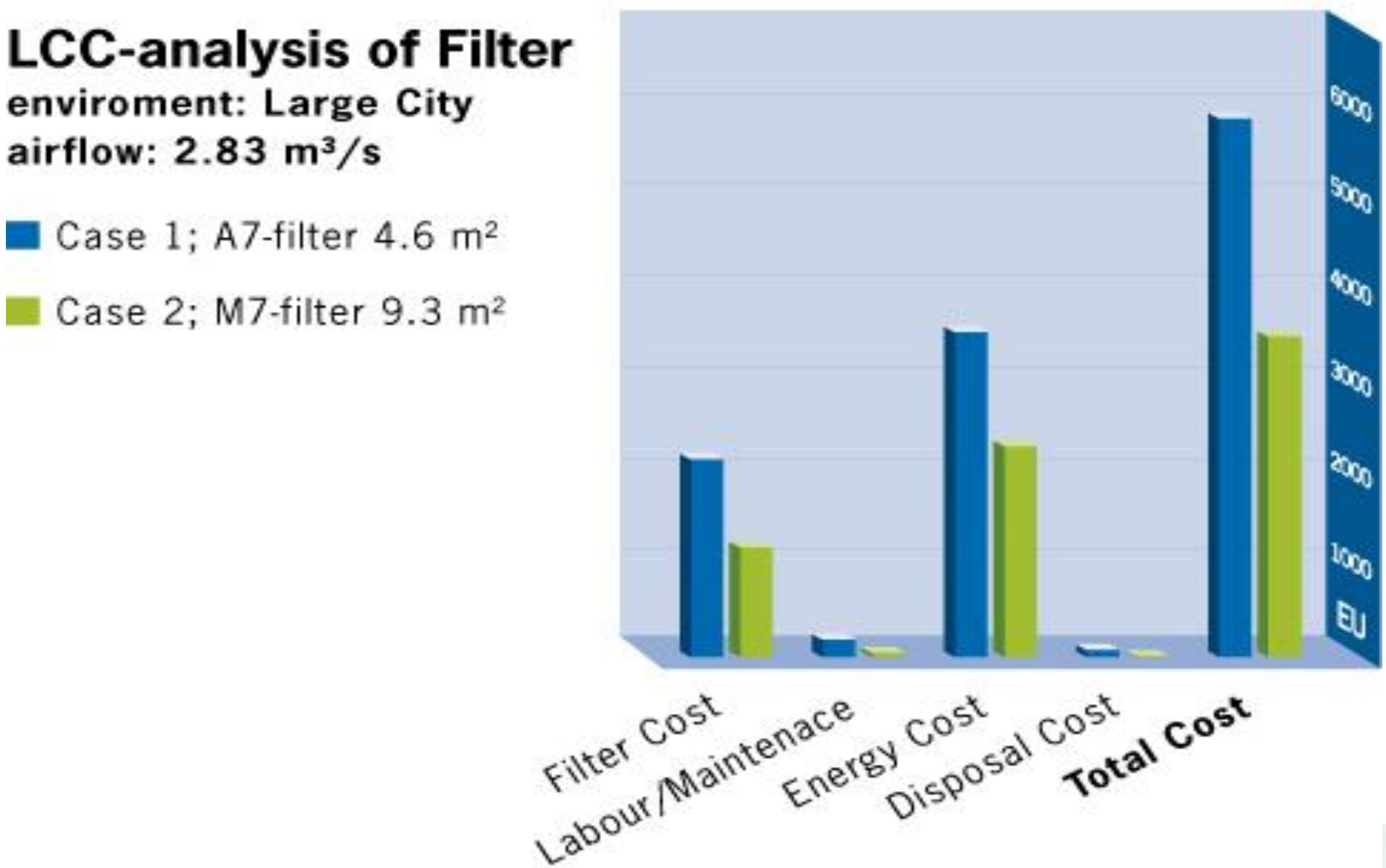
LCC Result

LCC costs in EUR based on 10 years lifetime of installation

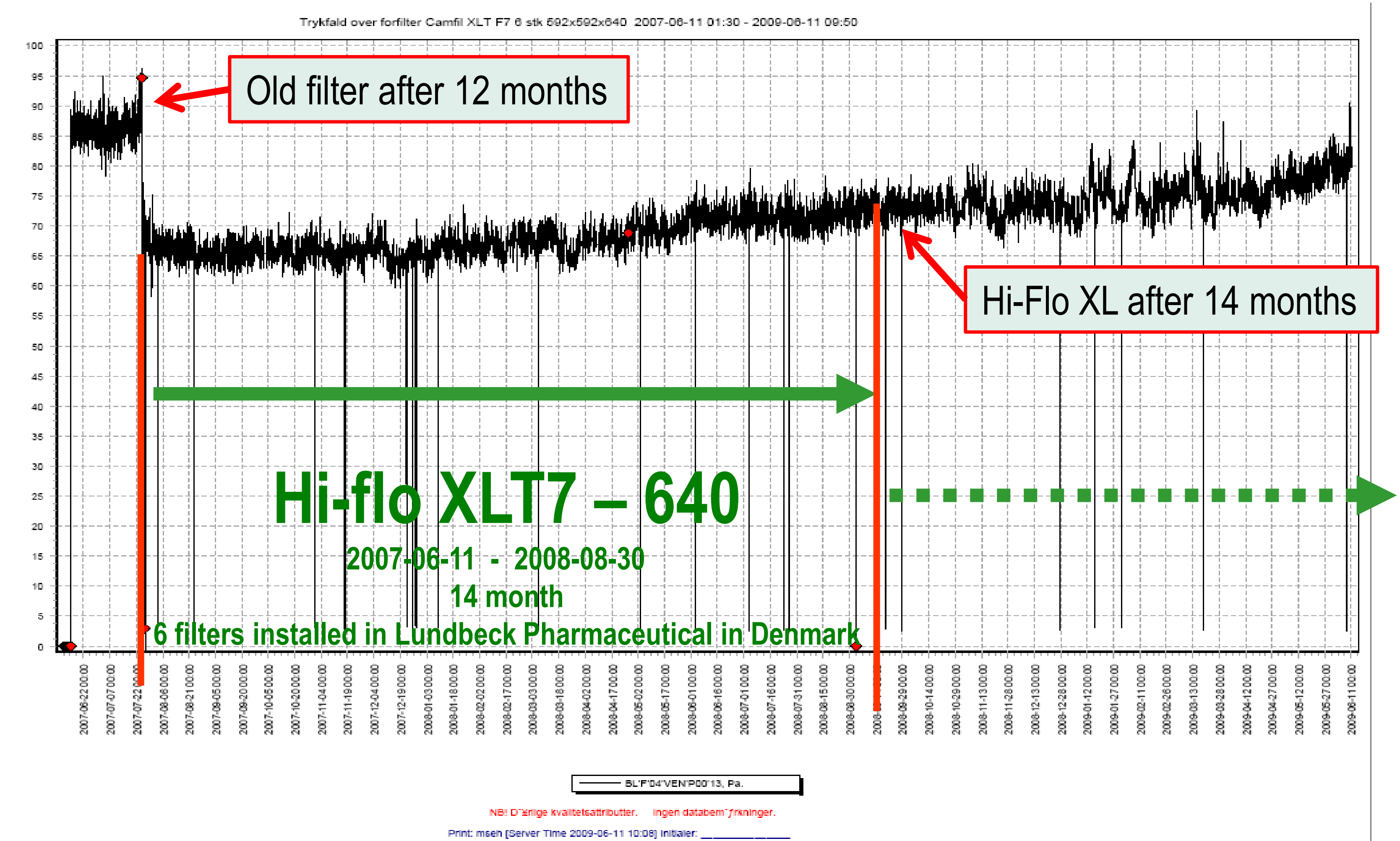
FILTER	EUR	(%)	HI-FLO M7 EUR	(%)
Filter Cost	819	(37.7)	348	(29.9)
Installation cost	0	(0.0)	0	(0.0)
Labour cost	30	(1.4)	9	(0.7)
Energy	1314	(60.4)	804	(69.2)
Disposal cost	12	(0.5)	3	(0.2)
Cleaning	0	(0.0)	0	(0.0)
LCC for filter	2178	(100.0)	1161	(100.0)

Total LCC cost (EUR)	
Filter Cost	1167
Installation cost	0
Labour cost	39
Energy	2118
Disposal cost	15
Cleaning	0
Total	**3339**

The optimum filters



Optimized design works in real life



Gas filtration

We not only remove particles from the air but also gases.
The filters for this application goes under names like:

- Carbon filters, chemical filters, Gas phase filters and AMC filters.

Removal of gases rely on completely different technologies
and will be covered in a different session.