



CLEAN AIR SOLUTIONS



THE CAMFIL GROUP

HEPA Filtration
Changing Trends, Key Advances and the Associated Costs

Alan Sweeney



CAMFIL , GLOBAL CLEAN AIR SOLUTIONS SUSTAINABLY

Camfil aligns its strategy with the **UN SUSTAINABLE DEVELOPMENT GOALS**. We identified four goals that are the most relevant to our business and enable us to provide the most meaningful global contribution.



GOOD HEALTH AND WELL-BEING

High indoor air quality that promotes good health and well-being



DECENT WORK AND ECONOMIC GROWTH

Satisfactory working conditions for 4,500 employees at 30 manufacturing plants



SUSTAINABLE CITIES AND COMMUNITIES

The most energy-efficient clean air solutions on the market



RESPONSIBLE CONSUMPTION AND PRODUCTION

Production plants' environmental impact is continuously being reduced

CHALLENGES TO BUSINESS

PwC > Pharmaceuticals

Pharmaceuticals

Pharmaceuticals Industry Challenges

- Managing regulatory compliance
- Pricing pressures and shrinking margins

BG. Net Zero Now

AstraZeneca promises to get to net zero 10 years ahead of schedule

FiercePharma
MANUFACTURING MARKETING PHARMA VACCINES SPECIAL REPORTS

Pharma
Merck CEO Frazier finds fault in new studies suggesting pharma profits are too high

By [Andrea Vittoria](#) | Mar 3, 2020 2:27pm

Food and drink firms pledge to improve dairy sustainability

By [Noli Dinkowski](#) | 23-Sep-2019 | Last updated on 23-Sep-2019 at 13:36 GMT

[f](#) [G+](#) [t](#) [in](#) [e](#)

CHALLENGES FOR HEPA FILTRATION

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Ensure lo
to the pro



Maintaining air
cleanliness levels



Reducing operational costs
& increase quality

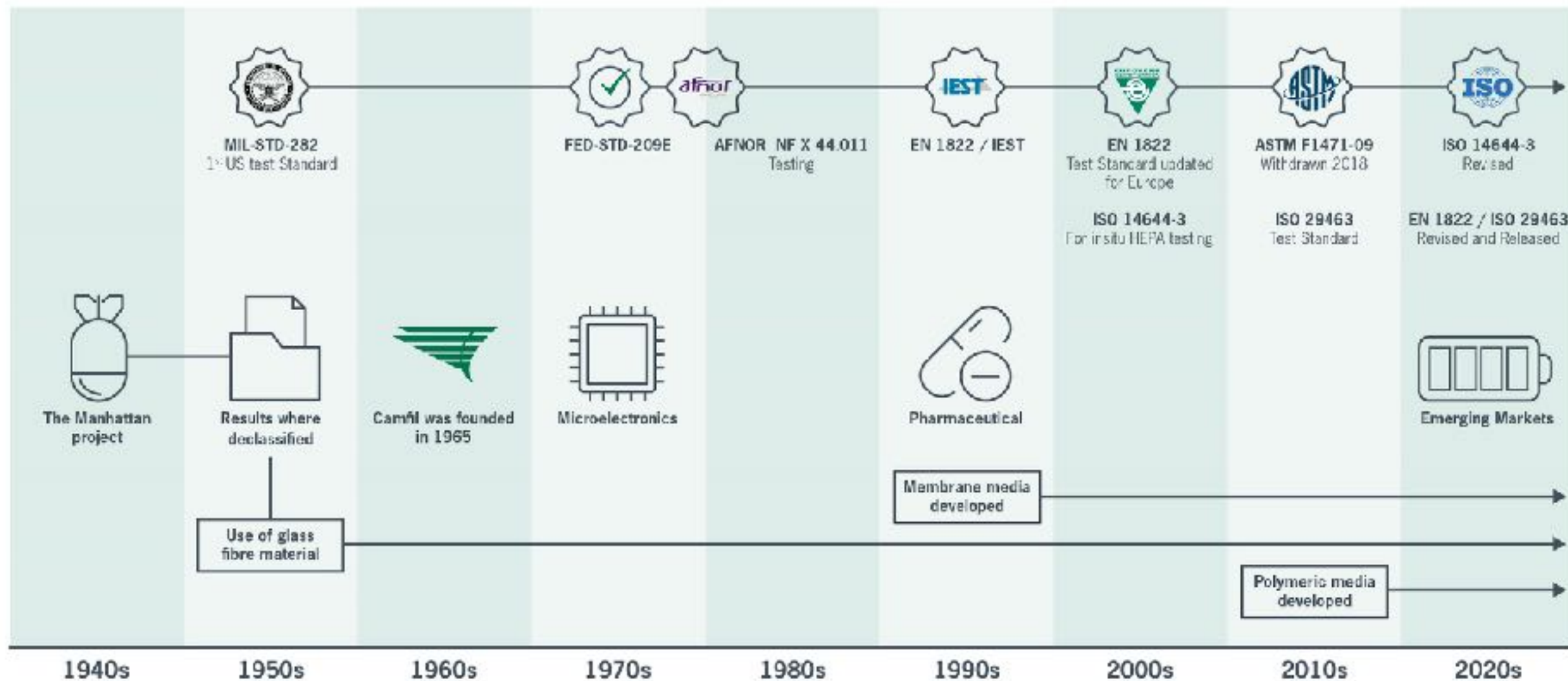


Ensuring compliance to
Industry Standards



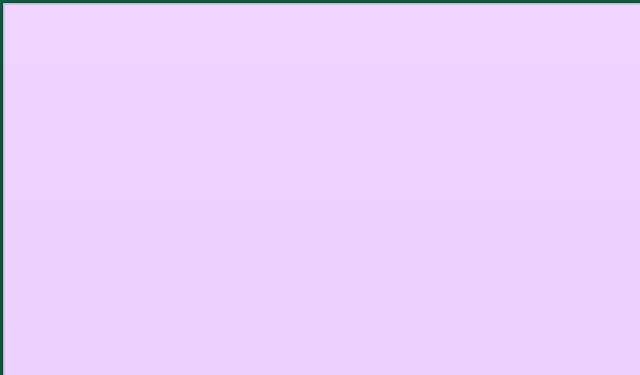
Reducing Energy
consumption

THE EVOLUTION OF HEPA FILTRATION



WHERE ARE HEPA FILTERS USED IN A TYPICAL FACILITY

DEPENDS ON WHICH INDUSTRIES HEPA FILTERS ARE DEPLOYED IN



ENSURING COMPLIANCE TO STANDARDS

does this slide help anyone? Compare with slide 8?

PERFORMANCE TESTING – STANDARDS (NON NUCLEAR)

What industry standards?

- FDA Guideline for Aseptic Processing
- EMA European Medicines Agency
 - EUGMP Annex 1
- EN1822 Parts 1-5 and ISO 29436
 - Part 1: Classification & required tests
 - Part 2: Aerosol Production
 - Part 3: Flat Sheet Media Testing (MPPS)
 - Part 4: Filter Leak Testing
 - Part 5: Filter Efficiency Testing



European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

ORGANISATION
INTERNATIONALE DE
NORMALISATION



INTERNATIONAL
ORGANIZATION FOR
STANDARDIZATION



U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

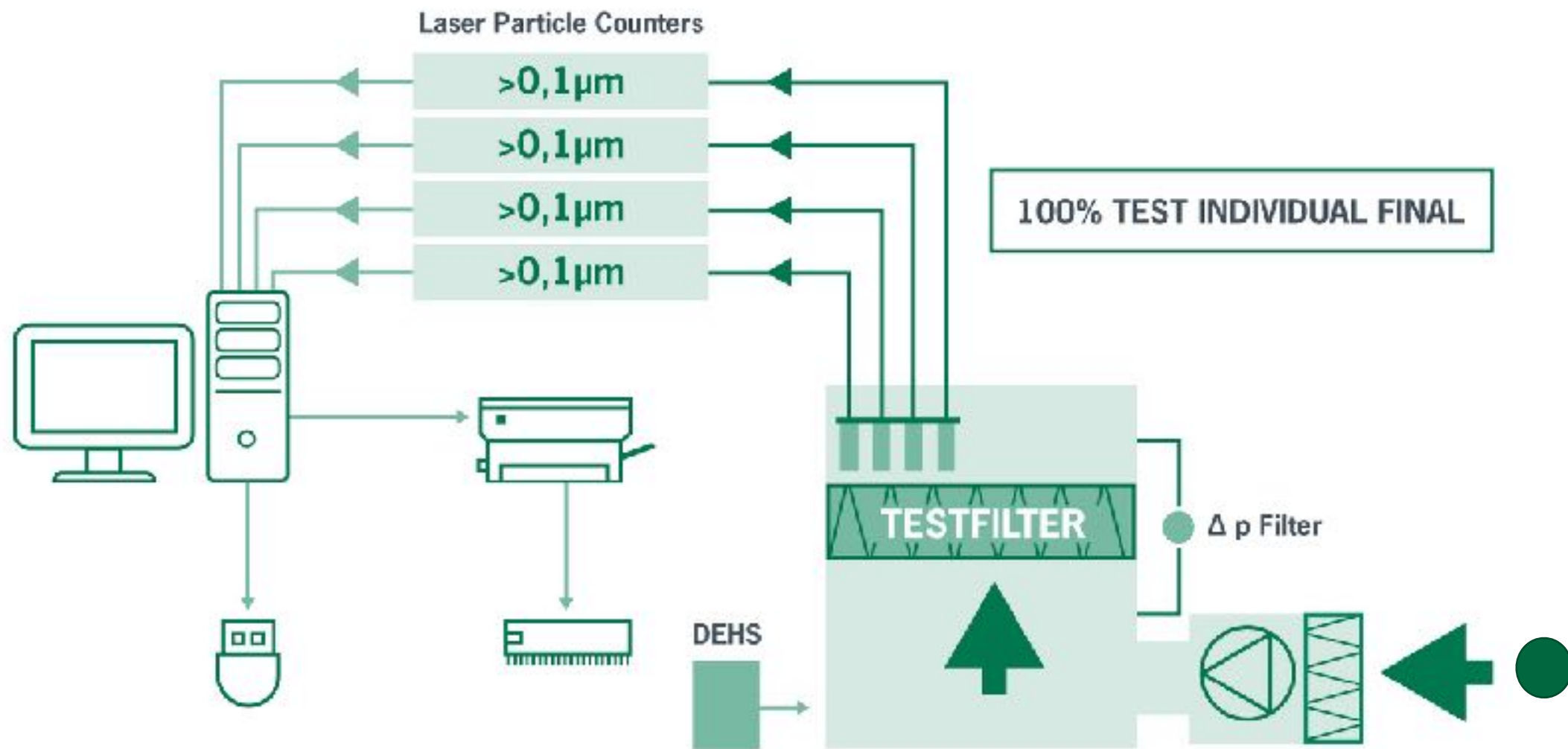


EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

Other Questions To Ask ?

- | | | | |
|---|---|---|---|
| • Air Filter with reliable performance | ➡ | Low Dp / Low Energy Consumption / Longer Life / Less Waste etc..... | ✓ |
| • Free of bisphenol A, Phthalate and formaldehyde | ➡ | In reference to the Infant Milk Powder Contamination in China. Customers are extremely interested in this point!!!!!! | ? |
| • VDI 6022 concurrent | ➡ | Hygienic Air Conditioning & IAQ Guarantee | ? |
| • ISO 846 Certified | ➡ | Antimicrobial Inert which means Micro organisms cannot grow on the products | ? |
| • Tested with all common Cleansing agent and disinfectant | ➡ | Will the components of hepa products be affected by harsh chemicals used for cleaning in F&B or LS | ? |
| • EC 1935/2005 concurrent | ➡ | Are filter products certified for food Contact | ? |
| • Online Certificates / Documentation | ➡ | Is all product material available to the customer online by scanning a QR Code or similar | ? |

EN 1822 SCANNING RIG PRINCIPLE



FILTER PERFORMANCE TESTING STANDARDS COMPARISON

EN 1822 Classification

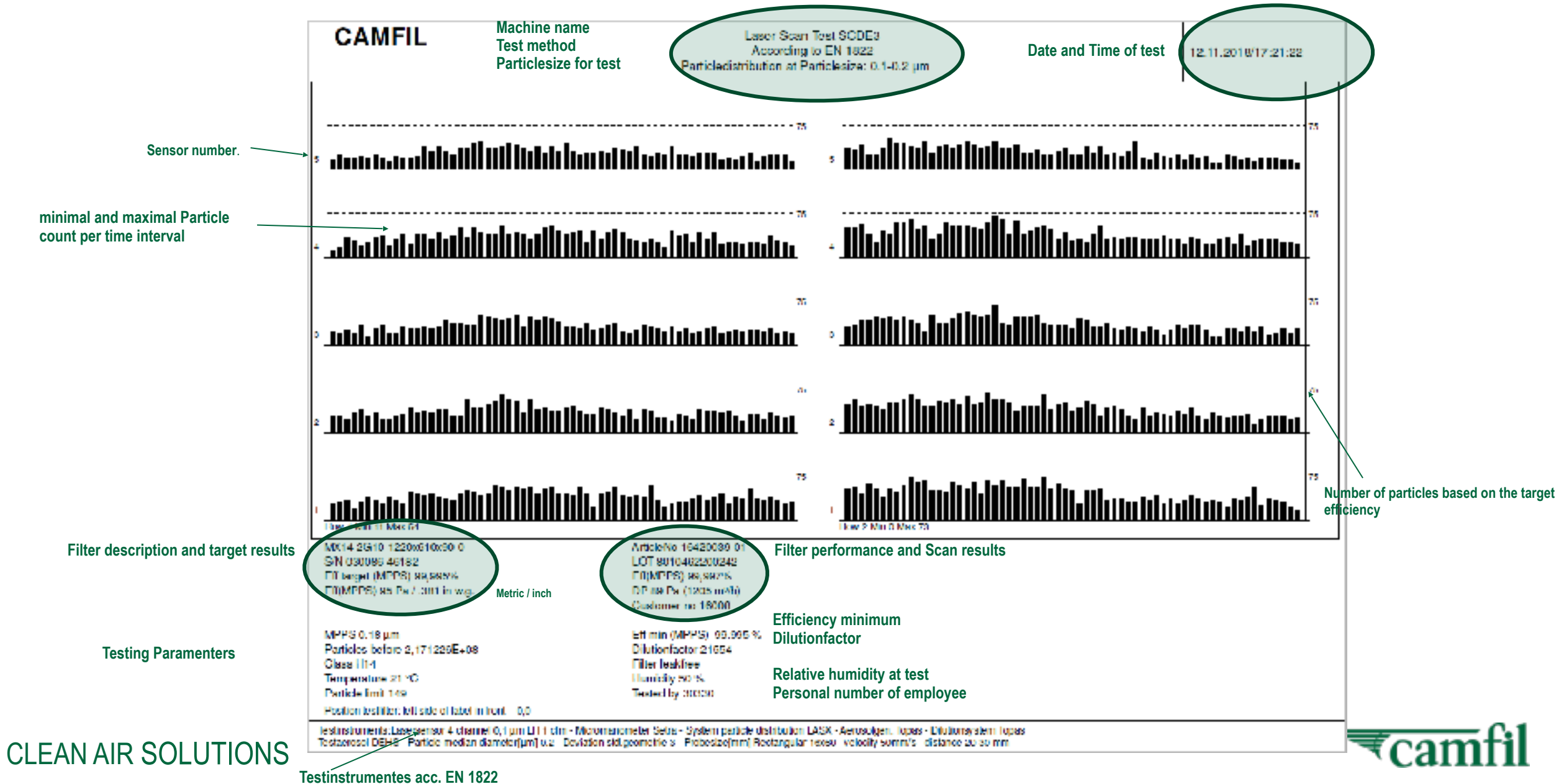
		Global Value	Local Value
Filter Class	Particle Size for Testing	Collection Efficiency in %	Multiple of Global Efficiency %
E10		≥ 85	
E11		≥ 95	
E12		≥ 99,5	
H13	MPPS	≥ 99,95	5
H14	MPPS	≥ 99,995	5
U15	MPPS	≥ 99,9995	5
U16	MPPS	> 99,99995	5
U17	MPPS	≥ 99,999995	20

ISO 29463 Classification

		Global Value	Local Value
Filter Class (Group)	Particle Size for Testing	Collection Efficiency in %	Multiple of Global Efficiency %
ISO 15 E		≥ 95	-
ISO 20 E		≥ 99	-
ISO 25 E		≥ 99,5	-
ISO 30 E		≥ 99,9	-
ISO 35 H	MPPS	≥ 99,95	5
ISO 40 H	MPPS	≥ 99,99	5
ISO 45 H	MPPS	> 99,995	5
ISO 50 U	MPPS	> 99,999	5
ISO 55 U	MPPS	≥ 99,9995	5
ISO 60 U	MPPS	≥ 99,9999	5
ISO 65 U	MPPS	≥ 99,99995	5
ISO 70 U	MPPS	≥ 99,99999	10
ISO 75 U	MPPS	≥ 99,999995	20

**Filterclass
H13, H14, U15-
U17
=
STRICT
EQUIVALENCE
EN 1822 + ISO
29463**

DIN EN 1822 INDIVIDUAL SCAN TEST REPORT – WHAT TO EXPECT



HEPA FILTRATION STANDARDS – PRODUCTION VS IN-SITU

EN1822:2019/ISO 29463 (PRODUCTION TEST)

- Scantest of HEPA/ULPA filter at filter production
- Individual certificate as proof of conformity & filter classification
- Ensure leak free filter construction
- Ensure no media leaks
- Uses Laser Particle Counters

ISO 14644-3 (IN-SITU/ONSITE TEST)

- Procedure for testing HEPA filters during Installation and Validation on leak-freeness of filter and framework .
- Ensuring that air quality is maintained to desired standards
- Ensures highest air quality is present between filter and frame or interface
- Can be carried out using Photometer or Particle counter on site

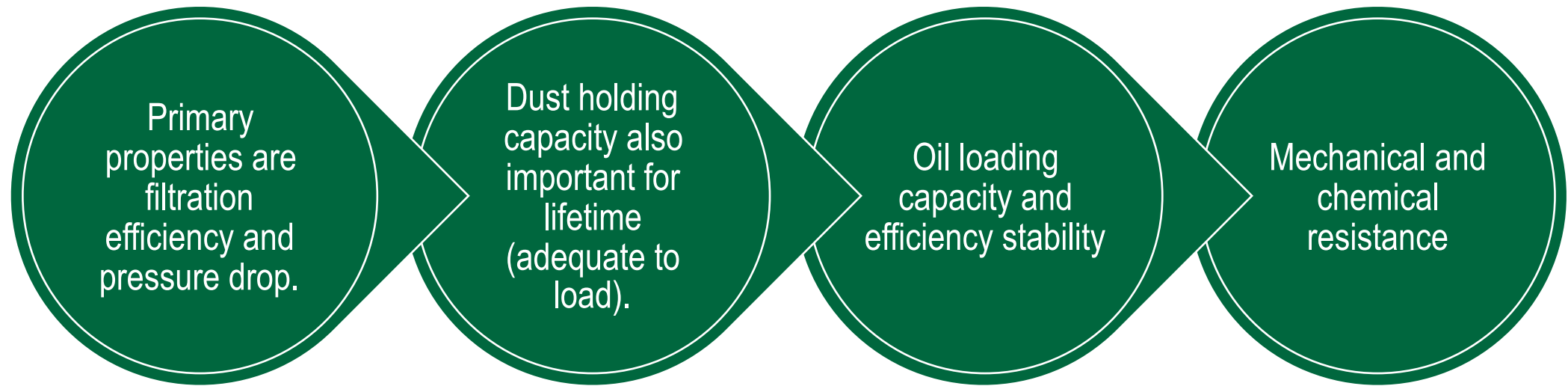
WHAT IS A HEPA FILTER MADE OF

COMPONENTS OF A HEPA FILTER

- Filter Media –glass fibre, membrane, multi fibre polymeric HEPA media
- Frame – aluminium, plastic, stainless steel, wood, galvanised steel, other
- Sealant – polyurethane, silicone, ceramic, other
- Separators – aluminium, string, filter media, hot-melt, other
- Gasket – PU, fluid seal, neoprene, silicone, other



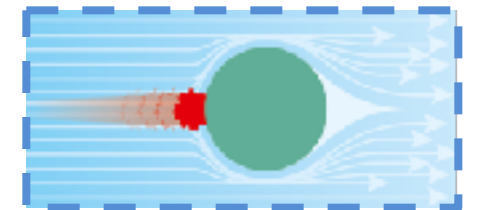
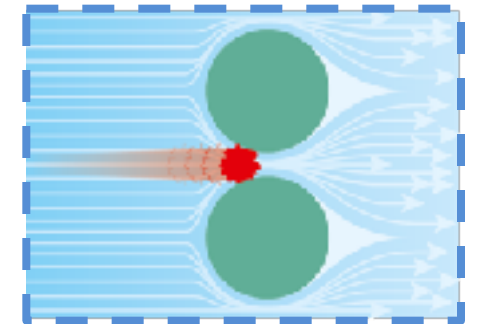
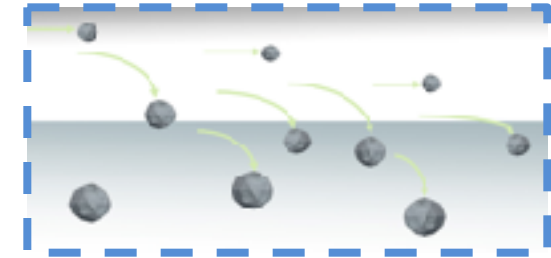
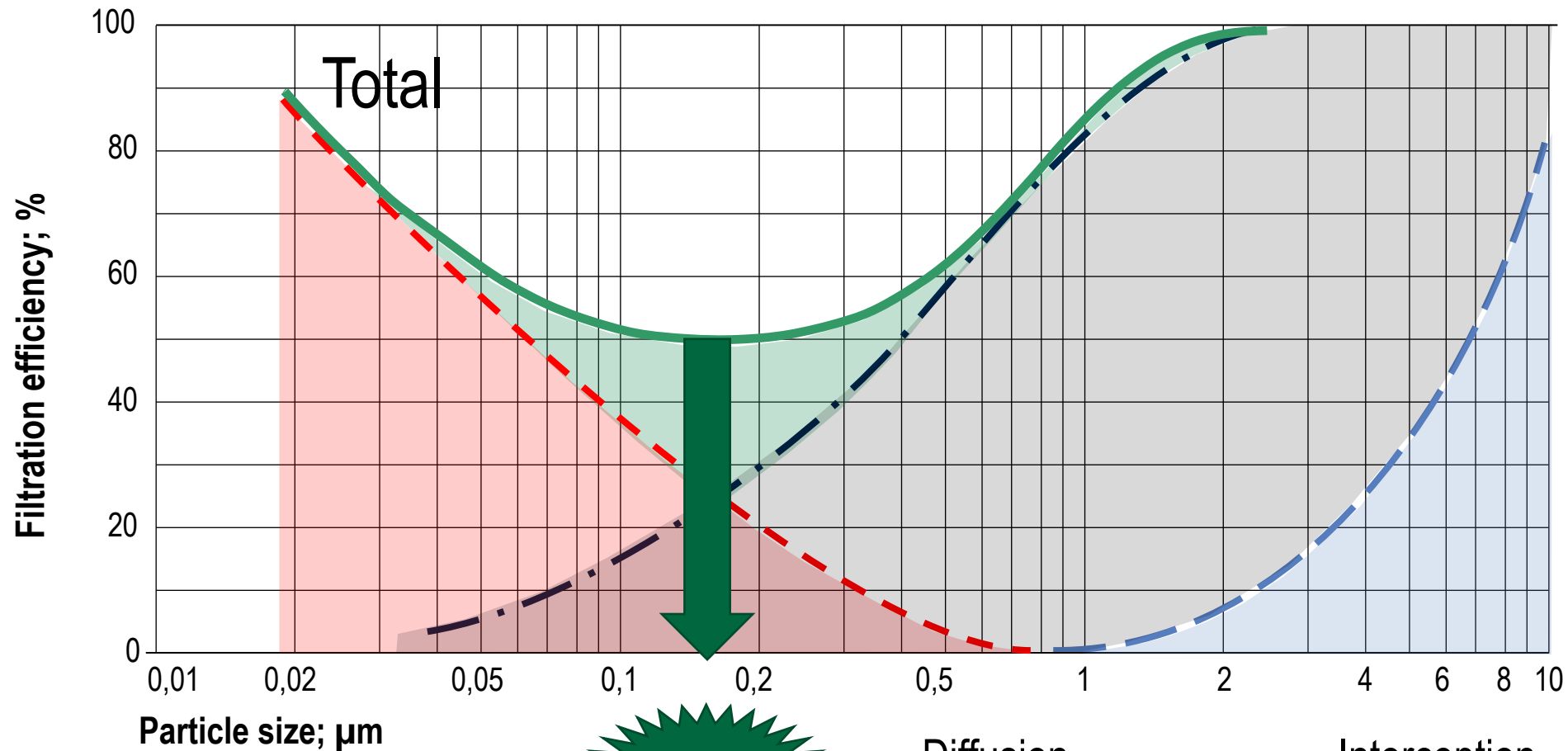
FILTER MEDIA



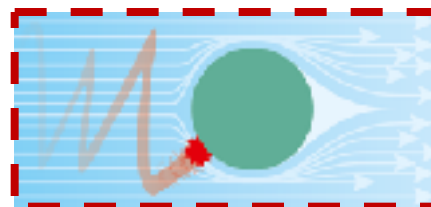
Property	Why is it important to Industry
Solid Particle loading	For long lifetime and performance
Oil Particle loading	For routine in-situ tests
Chemical resistance	To survive cleaning and disinfection
Physical resistance	High, to be durable with “Handling” forgiveness
Pressure Drop	Low, to reduce energy consumption, noise etc.
Lifetime	10 years lifetime are desired (in good conditions)
Efficiency stability	Filter class must be reliable (is not checked)
Outgassing	Very low, to not contaminate process

COMBINED FILTRATION EFFICIENCY

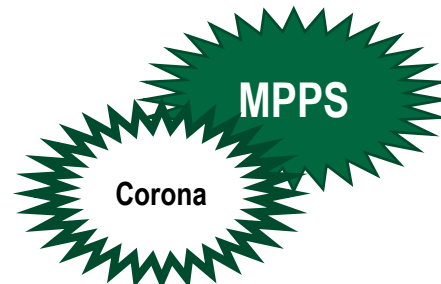
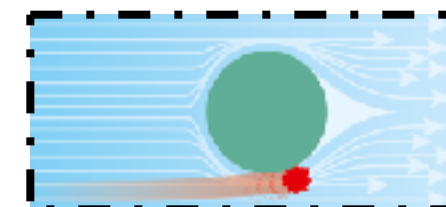
Sedimentation, straining, inertia



Diffusion

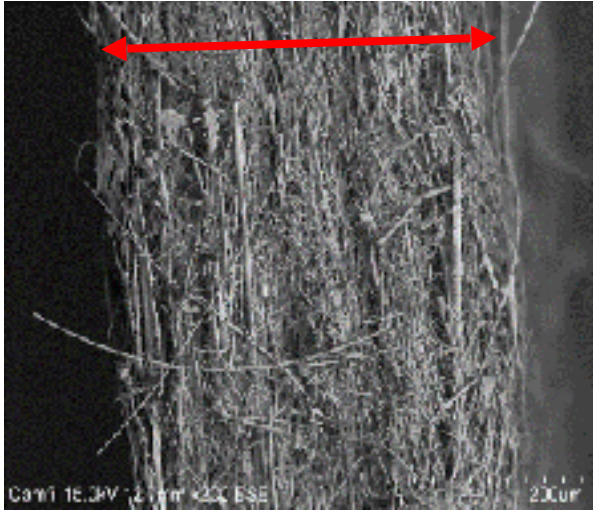


Interception



GLASS FIBRE MEDIA

„6,0 km“

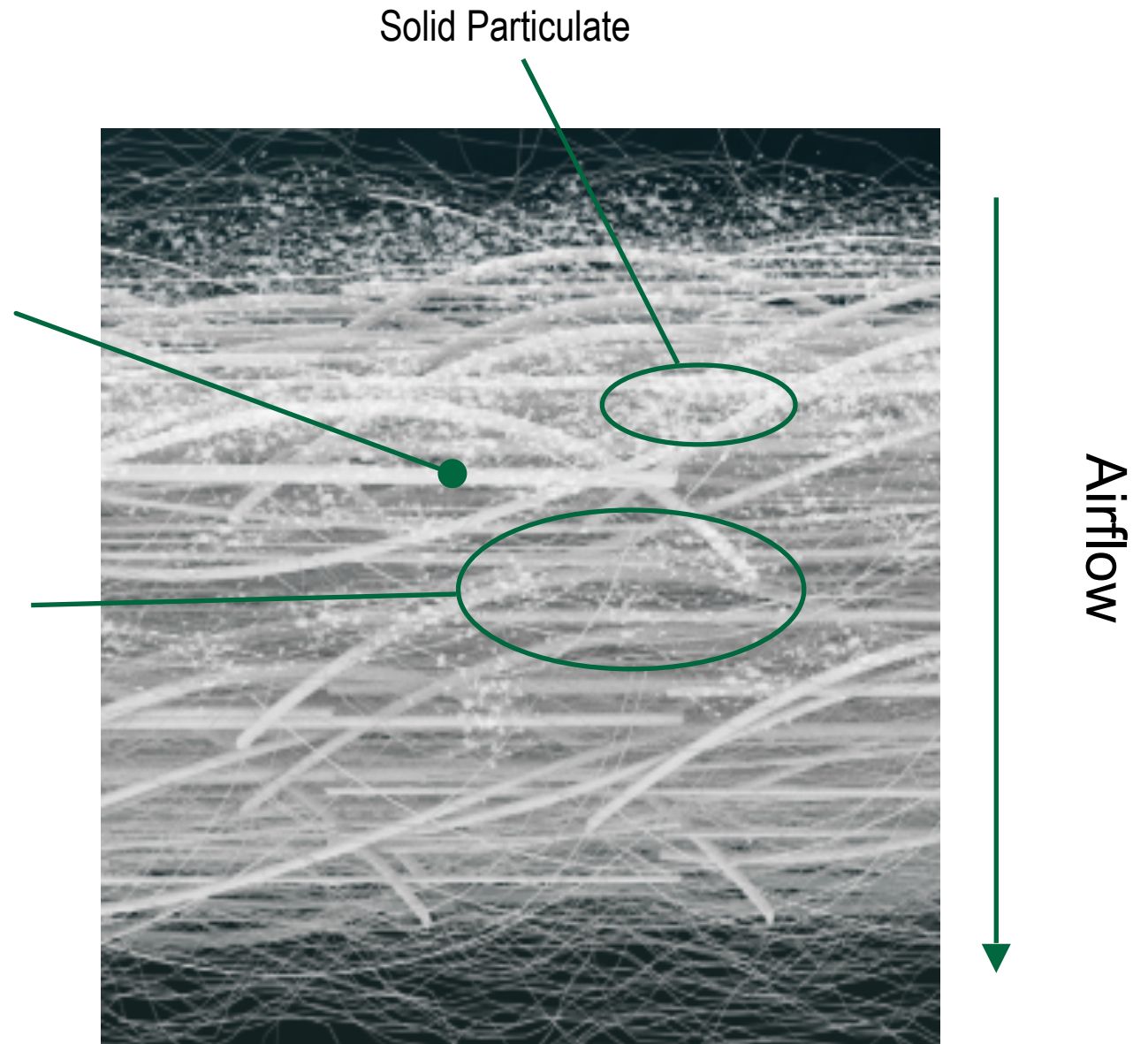


Glass reinforcement fibres

Glass fibres – wide diameter range



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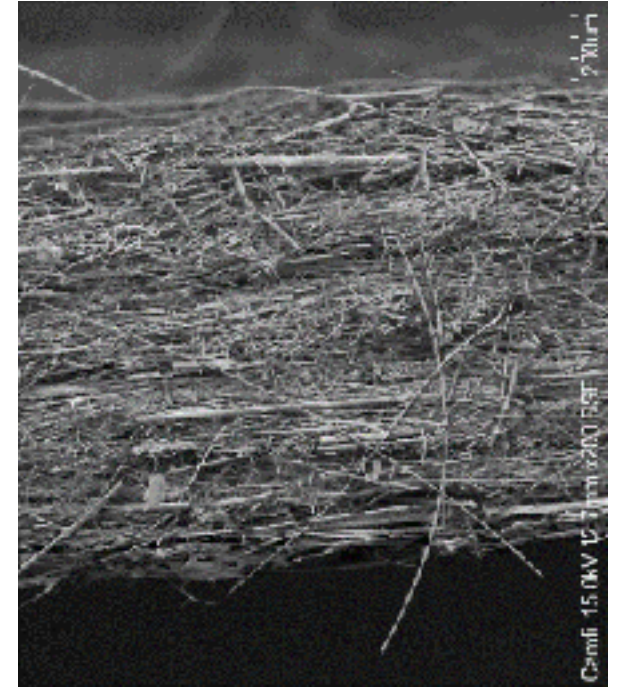
GLASS FIBRE MEDIA

STRENGTHS

- ✓ High and reliable filtration efficiency
- ✓ Qualified standard with decades of experience
- ✓ Continuously improved
- ✓ Very long life time
- ✓ Chemical stability

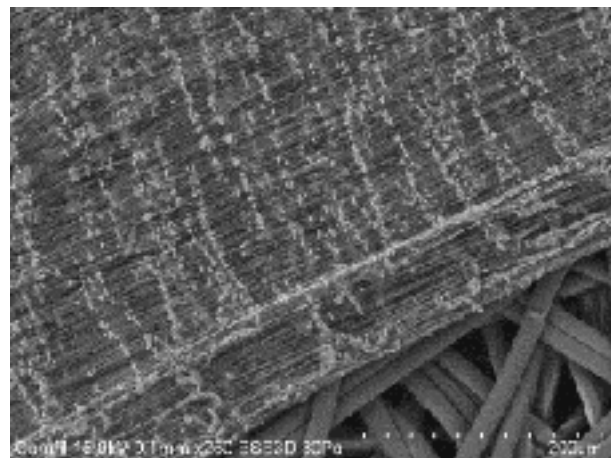
LIMITATIONS

- Requires protection grill and careful handling
- Boron (dopant) content can disturb some processes in microelectronics



Property	Glass Fibre
Solid Particle loading	Good
Oil Particle loading	Good
Chemical resistance	Good
Physical resistance	Fragile
Pressure Drop	Acceptable
Lifetime	Good
Efficiency stability	Good
Outgassing	Marginal

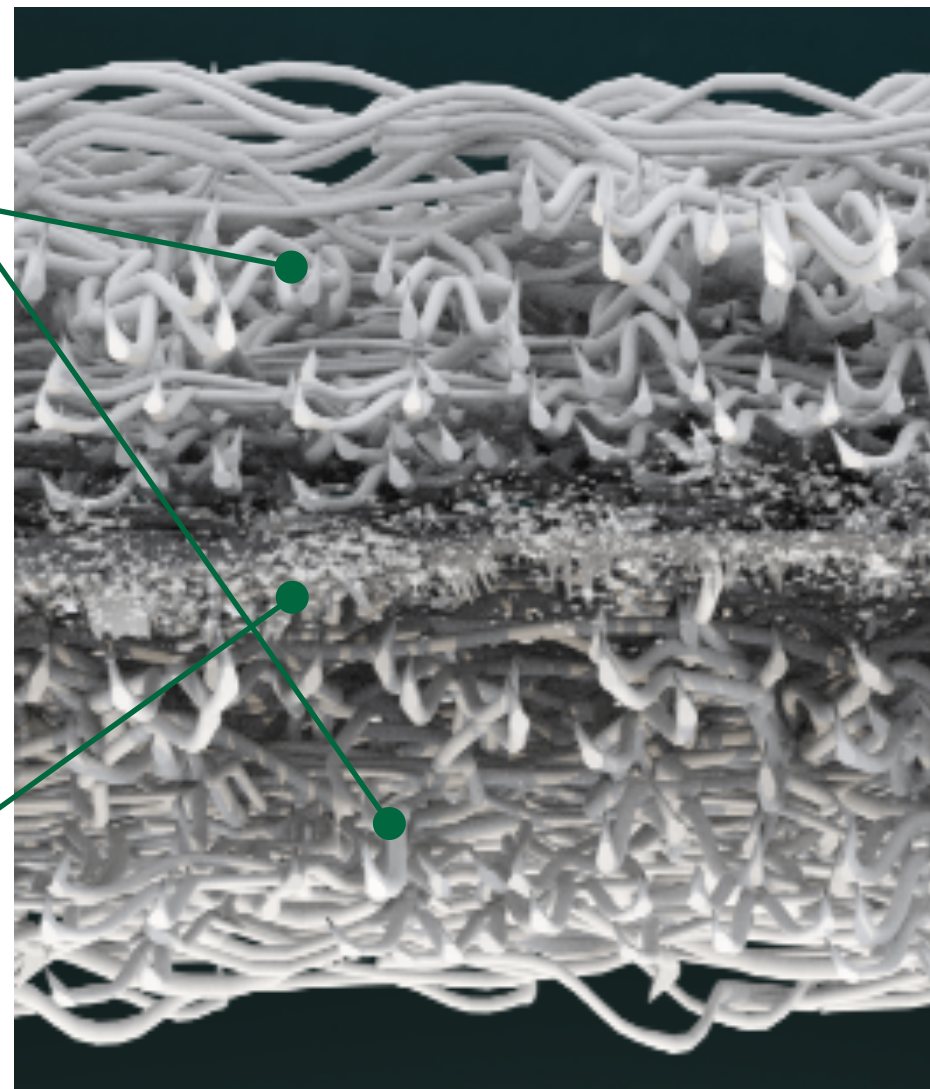
MEMBRANE MEDIA



Upstream and downstream backing layers – No particles



Very thin membrane, loaded with solid particulate



Airflow

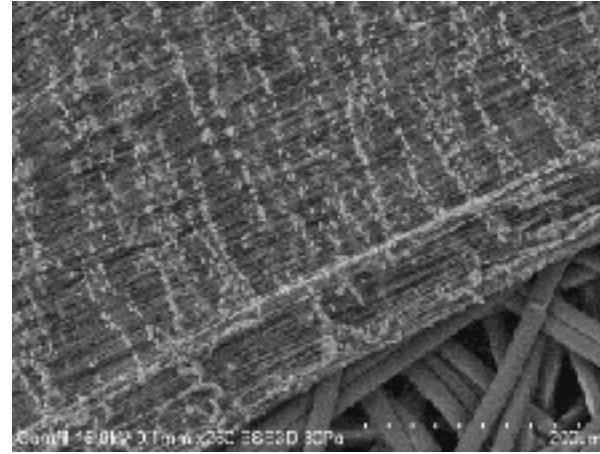
MEMBRANE MEDIA

STRENGTHS

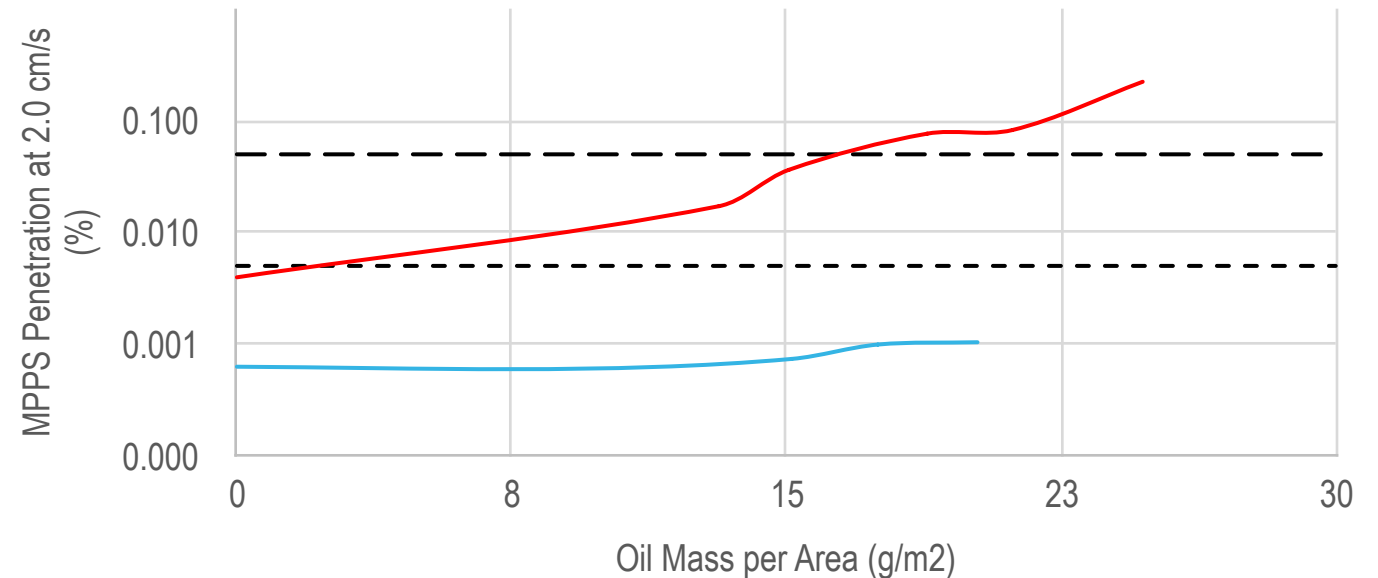
- ✓ No boron content
- ✓ High filtration efficiency
- ✓ Low pressure drop
- ✓ Mechanically robust backing layers
- ✓ Chemical stability

LIMITATIONS

- Uncertain dust holding capacity (darkening)
- Membrane layer can be clogged by test oil aerosols (needs additional layers)
- Efficiency decreased by oil aerosols



Oil Loading on HEPA/ULPA Media: Penetration



Property	Glass Fibre	Membrane	What If
Solid Particle loading	Good	Acceptable	
Oil Particle loading	Good	Low	
Chemical resistance	Good	Good	
Physical resistance	Fragile	Good	
Pressure Drop	Acceptable	Good	
Lifetime	Good	Inconsistent	
Efficiency stability	Good	Low	
Outgassing	Marginal	Good	

MULTI FIBRE POLYMERIC HEPA MEDIA



3,5 years of development



10 people (core team)



12k hours of testing



+1 Million data points

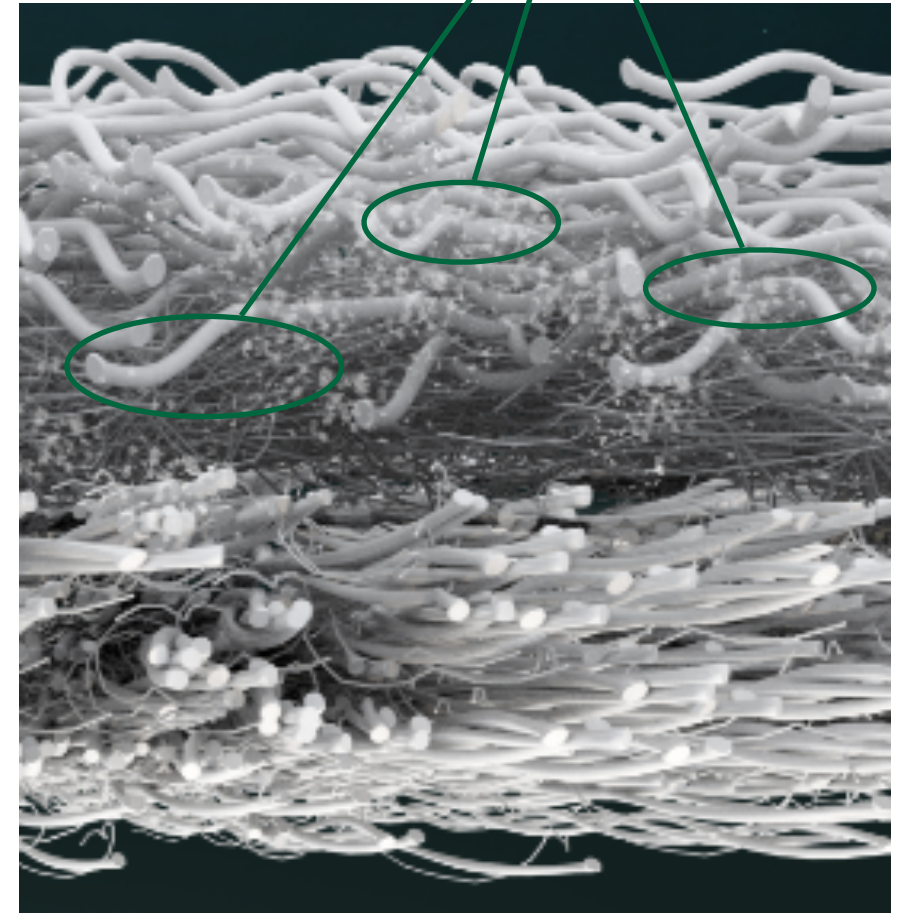


H13 (99,95%)
H14 (99,995%)

gradient
fiber density
structure

Backing
layer –
particulate-
free

Solid particulate arrested by
multifunctional fibers providing
depth loading capability

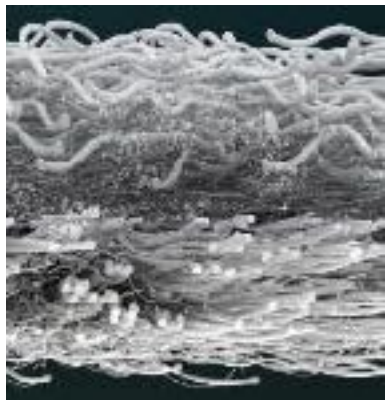


Airflow

MULTI FIBRE POLYMERIC HEPA MEDIA

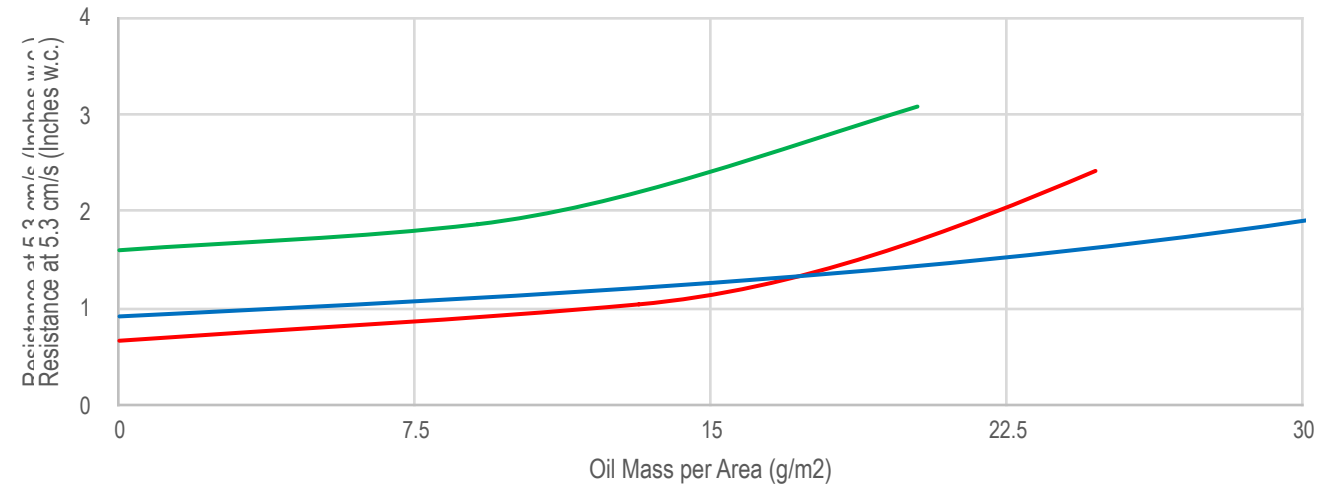
STRENGTHS

- No boron content
- High filtration efficiency
- Low pressure drop
- Long life time
- Mechanically robust backing layers
- Chemical stability

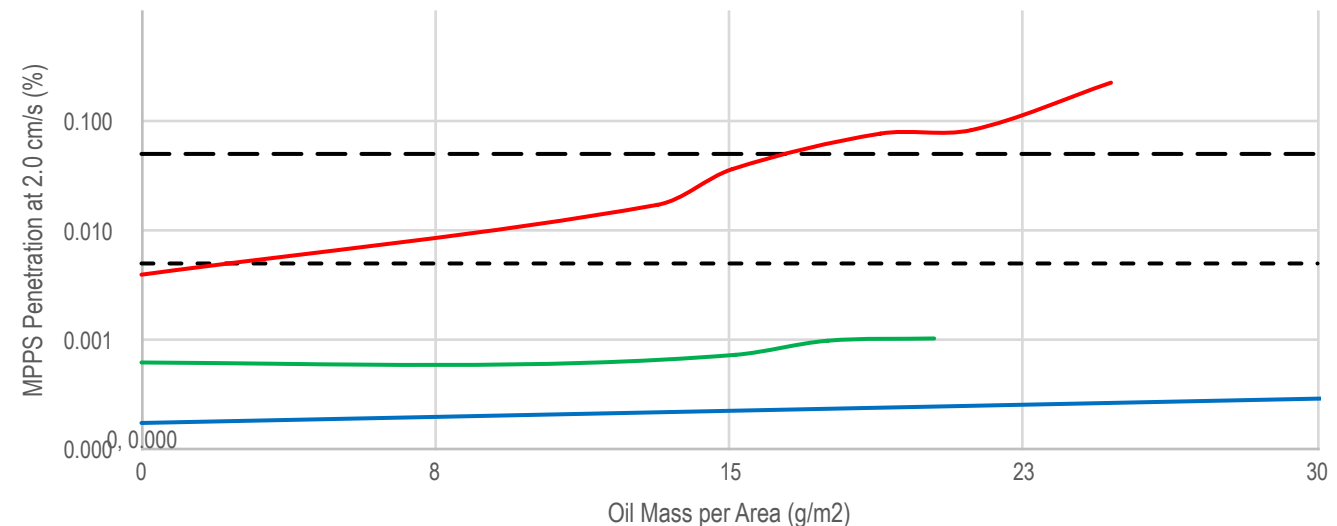


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Oil Loading on HEPA/ULPA Media: Resistance



Oil Loading on HEPA/ULPA Media: Penetration



DURABILITY –HANDLING FORGIVENESS

Megalam EnerGuard can survive extraordinary deviations from proper handling and installation procedures.

- Scientific product tests (e.g. filter drop 1m)
- 15lbs in an unsupported hard hat placed on the filter surface.
- Elimination of installation failures and cleanroom certification delays



Property	Glass Fibre	ePTFE	Multi-fibre Polymeric
Solid Particle loading	Good	Acceptable	Good
Oil Particle loading	Good	Low	Good
Chemical resistance	Good	Good	Good
Physical resistance	Fragile	Good	Good
Pressure Drop	Acceptable	Good	Good
Lifetime	Good	Inconsistent	Good
Efficiency stability	Good	Low	Good
Outgassing	Marginal	Good	Good

FILTER DESIGN IMPROVEMENTS

CHALLENGES FOR HEPA FILTRATION

Ensure lo
to the pr



Maintaining air
cleanliness levels



Reducing operational costs
& increase quality



Ensuring compliance to
Industry Standards



Reducing Energy
consumption

displaced?

COMPANIES CHANGING THE CONSTRUCTION?



- ✓ Reduced risk for transportation and handling damages (cost)
- ✓ Increased process safety



- ✓ Reduced risk to operator health
- ✓ Quicker and easier filter change out
- ✓ Reduce disposal fees



- ✓ Reduced Energy consumption
- ✓ Reduced operational costs
- ✓ Reduced CO2 consumption

WHAT ABOUT THE OTHER COMPONENTS?

- Filter Media –glass fibre, membrane, multi fibre polymeric HEPA media

- Frame – aluminium, plastic, stainless steel, wood, galvanised steel, other

- Sealant – polyurethane, silicone, ceramic, other

- Separators – aluminium, string, filter media, hot-melt, other

- Gasket – PU, fluid seal, neoprene, silicone, other

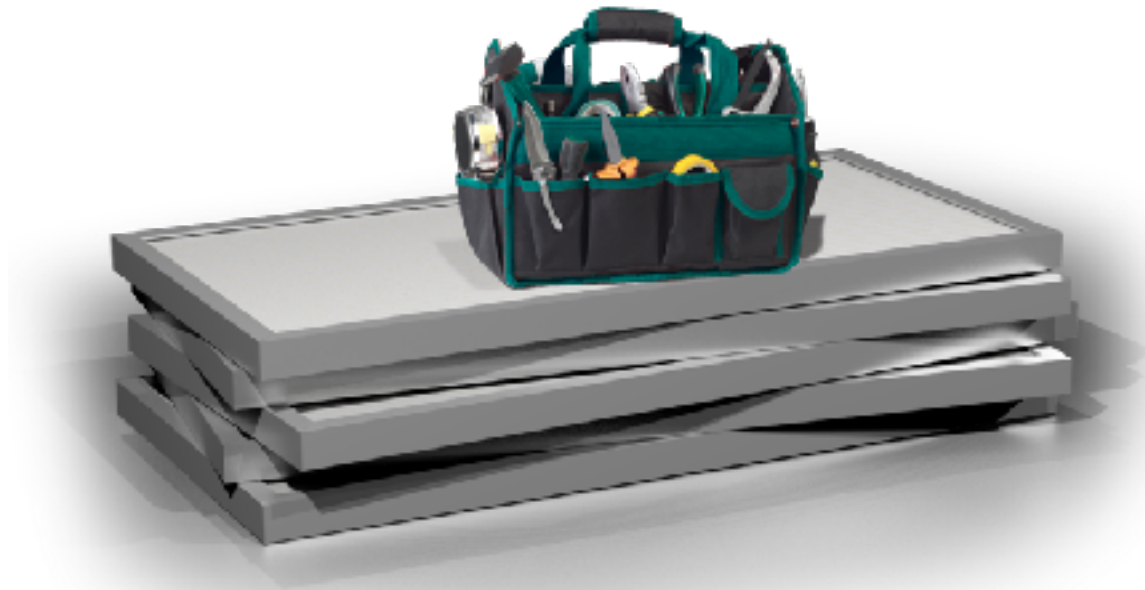


EVOLUTION IN FILTER CONSTRUCTION



HANDLING FORGIVENESS

- Multifibre polymeric media
- Elimination of installation failures and cleanroom certification delays
- Forgiveness for production, maintenance, and cleaning mishaps



DURABILITY – COST IMPACT ON A PROJECT



The \$1, \$10, \$100 Rule



Filter damaged at factory



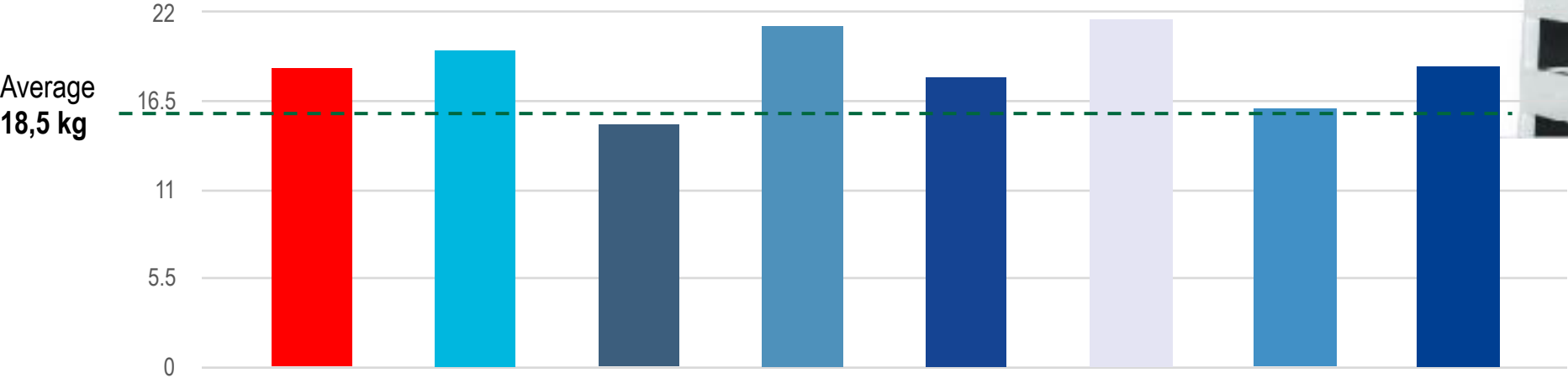
Damaged at customer site



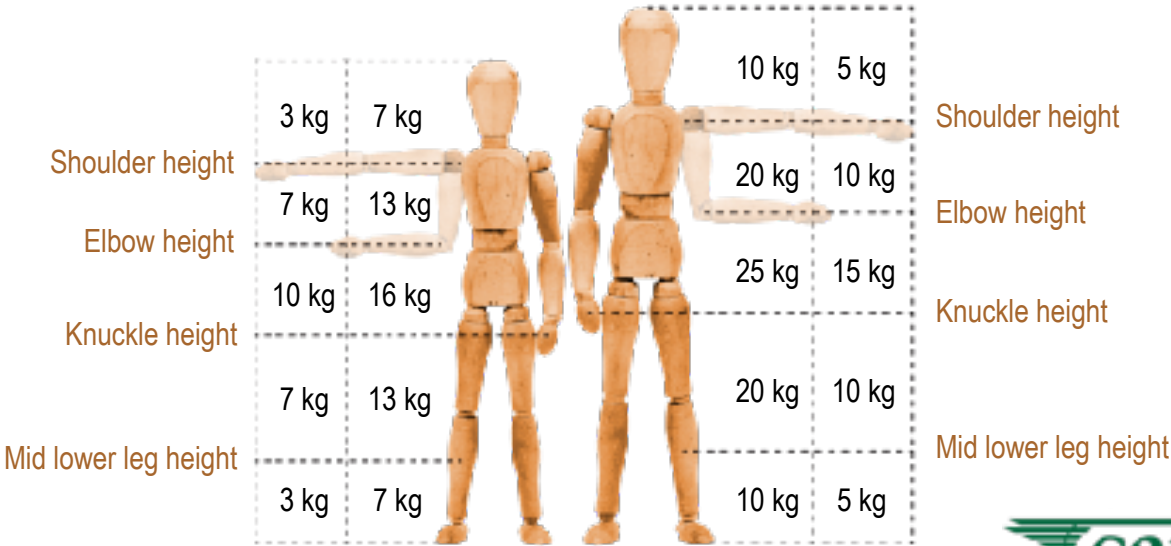
Damaged while in ceiling



LIGHTER



- ✓ Easier faster installation
- ✓ Reduced risk for injury
- ✓ In line with work safety laws
- ✓ Less struggle with BiBo
- ✓ Less disposal fees



CHALLENGES FOR HEPA FILTRATION

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BACKGROUND

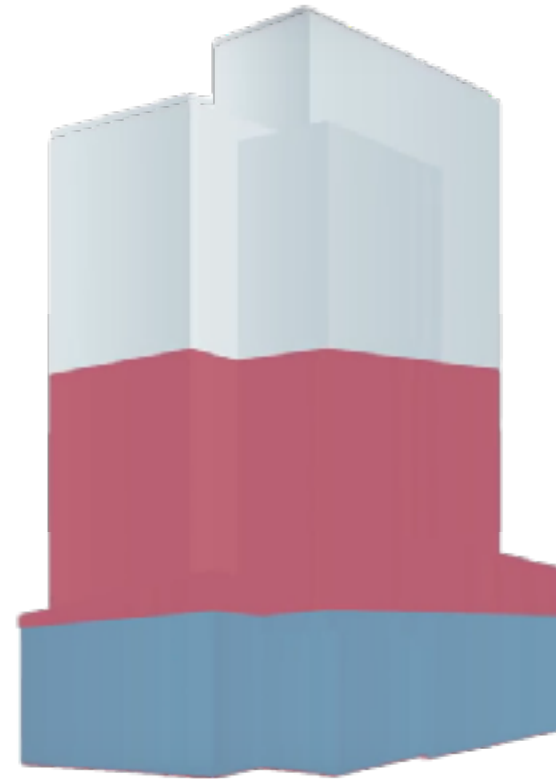
More than 50% of the Energy consumption = HVAC

Can only be improved with high efforts

- Fans?
- Ducts?
- Heat exchangers?
- Sound adsorption?



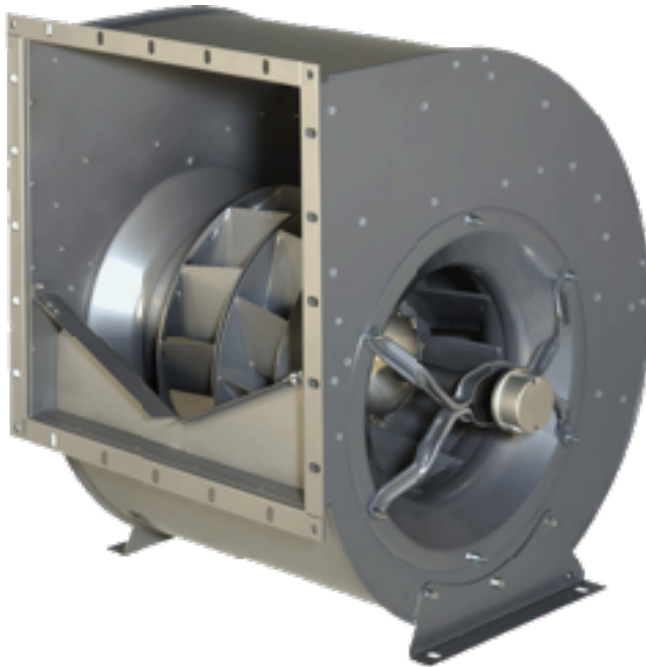
Air filters -> +30% of that Energy!!



THE FAN IN AHU'S USE ENERGY – NOT THE AIR FILTER



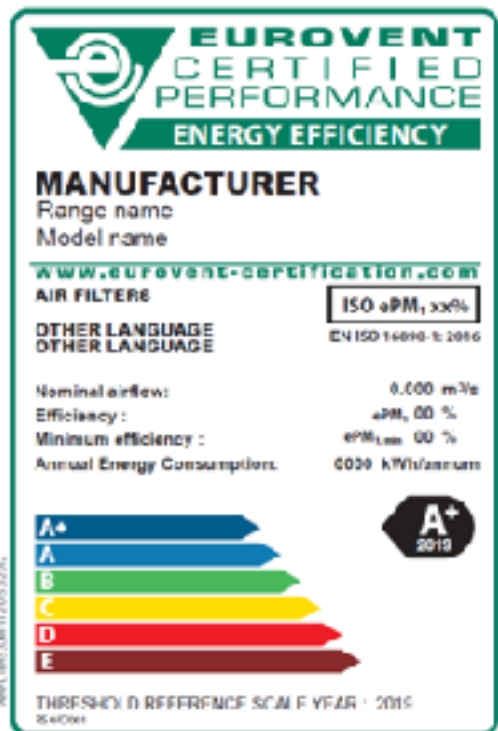
- Energy use [kWh]



- Average dp [Pa]



BUT FILTERS ARE A FACTOR IN ENERGY CONSUMPTION



1. Full size 592x592, to EN 15805

- Filter class
- Nominal air flow rate, m³/s
- Minimum efficiency, % (f7-f9)
- Annual energy consumption, kWh/annum
- kWh/annum energy class

2. Other “family” sizes of standard filters

- Filter class, according to 592x592 energy class, according to 592x592

SO EUROVENT CERTIFY ACCORDING TO ENERGY CONSUMED

CALCULATING ANNUAL ENERGY USE USING THE SAME FORMULA



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

$$\text{Energy} = \frac{\text{"air flow"} \cdot \text{"average pressure drop"} \cdot \text{"time"}}{\text{"efficiency of the fan"} \cdot 1000}$$

Remember
Air flow in **m³/s**
Pressure drop in **Pa**
Time in **hour**
Energy in **kWh**

EXAMPLES OF ENERGY SAVINGS AVAILABLE



$$\frac{q \cdot \Delta p}{\eta} \times \frac{t}{1000}$$

➔

$$\frac{1,11 \text{ m}^3/\text{s} \times 73 \text{ Pa} \times 8760 \text{ h}}{0,5 \times 1000} = 1420 \text{ kWh}$$

	 Megalam Energuard vs. MD14	 New Absolute V vs. Market average
Airflow q	1200 m³/h	4000m³/h
Δp advantage	-62 Pa	-73 Pa
Savings when changing	-362 kWh	-1421 kWh
Δ€ (0,15€/kWh) =	-54,3 €/year/per filter	<u>-213,1 €/year/per filter</u>

TOTAL COST OF OWNERSHIP APPROACH TO HEPA FILTRATION

WHAT IS TOTAL COST OF OWNERSHIP (TCO)



CAMFIL SOLUTIONS FOR BEST IN CLASS HEPA FILTRATION

INTRODUCING



Reducing Energy consumption



Reducing operational Costs



Maintaining air cleanliness levels



Ensuring compliance to Industry Standards

Lowest initial dP of existing alternatives :

- 30% to 50% less energy consumption
- Comparable energy efficiency

Durability – Physical strength and

- Potential elimination of maintenance
- No failure at installation

Long Product Life :

- EnerGuard has a proven track record
- Chemical inertness

Process

- High efficiency
- Low pressure drop
- Long life
- Low maintenance
- High durability
- High chemical resistance
- High physical resistance
- High efficiency stability
- High outgassing

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Outgassing	Marginal	Good	Good

CLEAN AIR SOLUTIONS



THE ABSOLUTE V

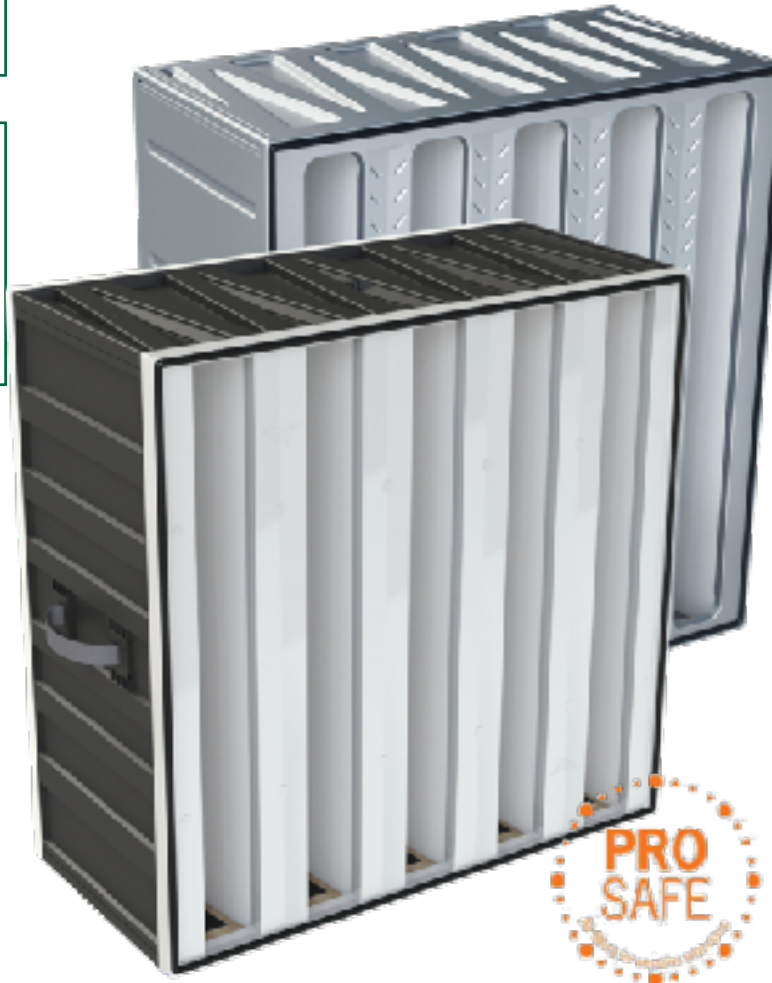


- ✓ Metal – 11kg
- ✓ Plastic – 9.6kg

- ✓ Easier faster installation
- ✓ Reduced risk for injury
- ✓ In line with work safety laws
- ✓ Less struggle with BiBo
- ✓ Less disposal fees



- ✓ Reduced risk for transportation and handling damages (cost)
- ✓ Increased process safety through reduced risk of unnoticed leakages



- ✓ 710,-€ Energy Saving
- ✓ Less downtime for filter changes
- ✓ Reduced labor cost
- ✓ Reduced disposal cost
- ✓ Supporting sustainability & CO₂ footprint targets

...AND

- ✓ Increased cleanliness (ISO14644 leak-free)
- ✓ Reduced filter costs
- ✓ Applicable in Camfil ACV-Probe housings
- ✓ Higher safety for all Bag-in-Bag-out Containment applications
- ✓ All VG are Prosafe

Some Other Questions Answered



- Air Filter with reliable performance → Low Dp / Low Energy Consumption / Longer Life / Less Waste etc..... 
- Free of bisphenol A, Phthalate and formaldehyde → In reference to the Infant Milk Powder Contamination in China. Customers are extremely interested in this point!!!!!! 
- VDI 6022 concurrent → Hygienic Air Conditioning & IAQ Guarantee 
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- EC 1935/2005 concurrent → Products are certified for food Contact 
- Online Certificates / Documentation → All product material is available to the customer online by scanning the QR Code 

THANK YOU