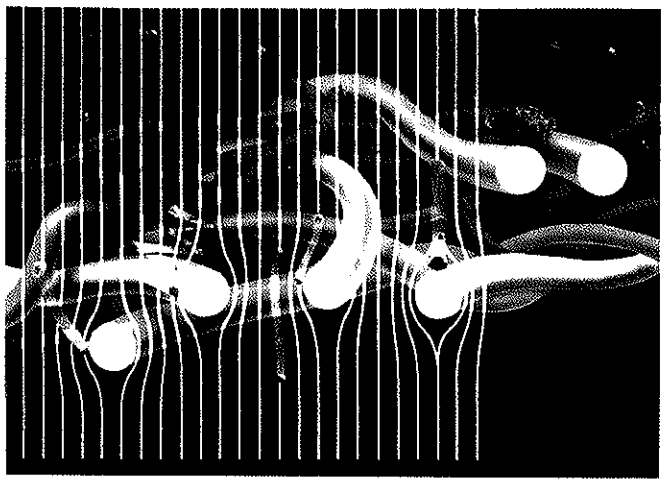
We make better clean air

micro FILTRATION

Proudly Present

Strategy & Benefits of Clean Air for HVAC, Indoor Air Quality & Clean Room Seminar





By

McLeod Russel

Carlton Hotel Singapore - 14 May 2002 (Tuesday)

We make better clean air

micro FILTRATION

Company Profile

Our company is incorporated in 1993, we specialized in total and practical solution on contamination control including design, supply and installation of air / gas purification system for industries such as semiconductors, hospital operating theatres, biological laboratory, wafer fab, pharmaceutical, etc...

We have years of experiences in air filtration and air engineering. Besides, our company is also supported by its representation of reliable and leading filtration & Pre-insulated Ducting products; McLeod Russel (Luwa) Air Filters and ALP from Switzerland and Italy respectively, that are renown for its ***optimum performance, economy, lower energy cost and ecology.***

Our clientele are mainly MNCs, statutory and government link companies. We had helps many to rectify and improve on air quality and solving contamination problems as well as reducing operating cost.

We would like to mention two of our many achievements since our inception. We have successfully designed, supply and built four major operating theatres for two local hospitals, that achieving ***bacteria count consistently less than 10 cfu/m3*** environments with an effective filtration and air distribution system from McLeod Russel. The system reduced the risk of post operation infection caused by cross contamination during operations.

We are also well equipped; acquiring up to date measuring equipment to provide better service for customers; ensuring design and product performance. This is part of our company's objective to be a professional market leader and ***set standard to meet beyond customer expectation.***

Clean air costs more to operate, but we have the knowledge and experience in making better clean air at the lower operating costs.

We look forward for the opportunity to have a working relationship with your esteemed company.

Mr. Thomas Chan
Managing Director

Introduction of McLeod Russel Filter Group

and

McLeod Russel Filter AG
(former Luwa F.T.)

Johan Bergdahl
Export Sales Manager

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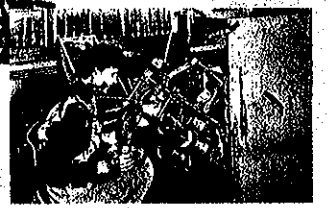
Carlton Singapore, 14.01.07

McLeod Russel

The beginning of Luwa Filter!

1939





Production of face masks for the Swiss army

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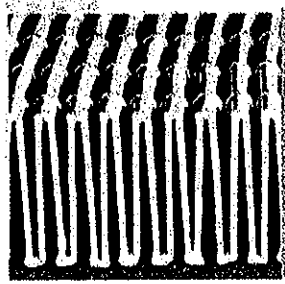
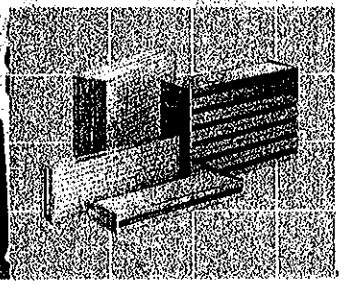
McLeod Russel

Highlights at Luwa Filter Technology

1950
Licence for manufacturing mini-pleats with thread spacers in rotary process





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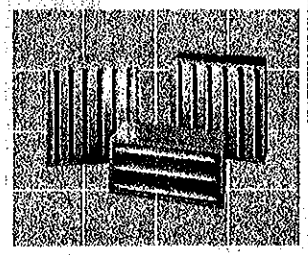
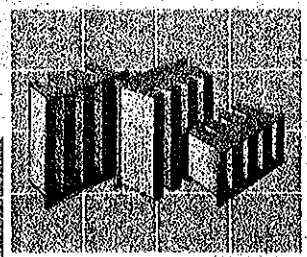
Highlights at Luwa Filter Technology

1960
Sales release for N HEPA filters for the HVAC market





1973
Sales release for FP Fine dust Filters for the HVAC market

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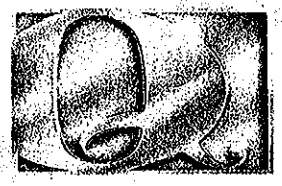
Highlights at Luwa Filter Technology



1991
ISO 9001 (first certified European filter company)

1984
Luwa ULPACATS, the new dimension for testing filters



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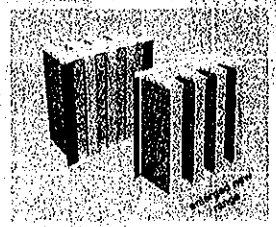
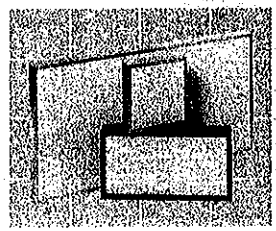
McLeod Russel

Highlights at Luwa Filter Technology



1992-94
Non-dusting, low pressure drop AFP gas adsorpt. filters

1996-98
PTFE-membrane, low Boron and low out-gassing CR filters



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McLeod Russel

Main Markets for Luwa Filters

- Clean Rooms in Microelectronic
- Pharma & Food Industry
- Hospitals
- Nuclear Industry
- General HVAC applications









Note! In Europe and Asia

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Main Luwa Filter Products

- FP, TMP & TMPC Filters (F6 - H13)
- N, Duct Installation Filters (F8 - U15)
- CR, Clean Room Panels (H11 - U17)
- AFP and AN Gas Adsorption Filters
- Special Filters for OEM applications
- Filter casings of our own design

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McLeod Russel

New owner from 01.01.2001



McLeod Russel
McLeod Russel Holdings PLC - UK

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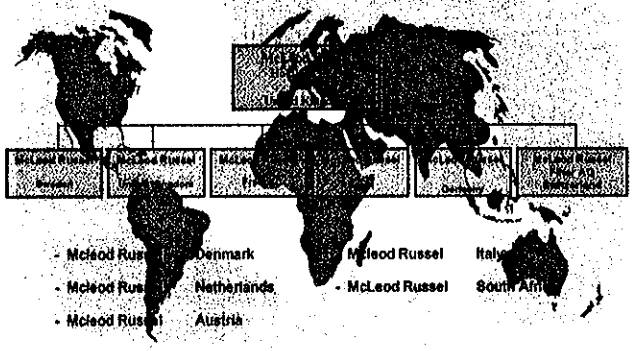
McLeod Russel

McLeod Russel Filtration Companies



- Mcleod Russel Denmark
- Mcleod Russel Netherlands
- Mcleod Russel Austria
- Mcleod Russel Italy
- McLeod Russel South Africa

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McLeod Russel

Main Competences of McLeod Russel

- **Technically leading Filter Products**
- **Consistent high Quality**
- **Technical competence**
  (Own, fully equipped filter Laboratory)
- **Complete product range**
- **World wide distribution network**

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McLeod Russel

Facts and Figures of McLeod Russel

- Turnover McLeod Russel Y2001 > 100 Mio EURO
- Employees McLeod Russel Y2001 >1000

With the acquisition of Luwa Filter Technology, McLeod Russel has become the second largest European filter company!

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McLeod Russel

Facts about McLeod Russel Filter AG

- **Production of Fine dust, HEPA and ULPA filters**
- **Production of High End Gas Filter Range**
- **75 employees in Uster** (15 min. outside Zürich)
- **2 Sales Divisions** – Domestic and Export
- **Export to 41 countries world wide**
- **Turnover approx. 15 MEUR**
  - Switzerland approx. 3 MEUR
  - Export approx. 12 MEUR

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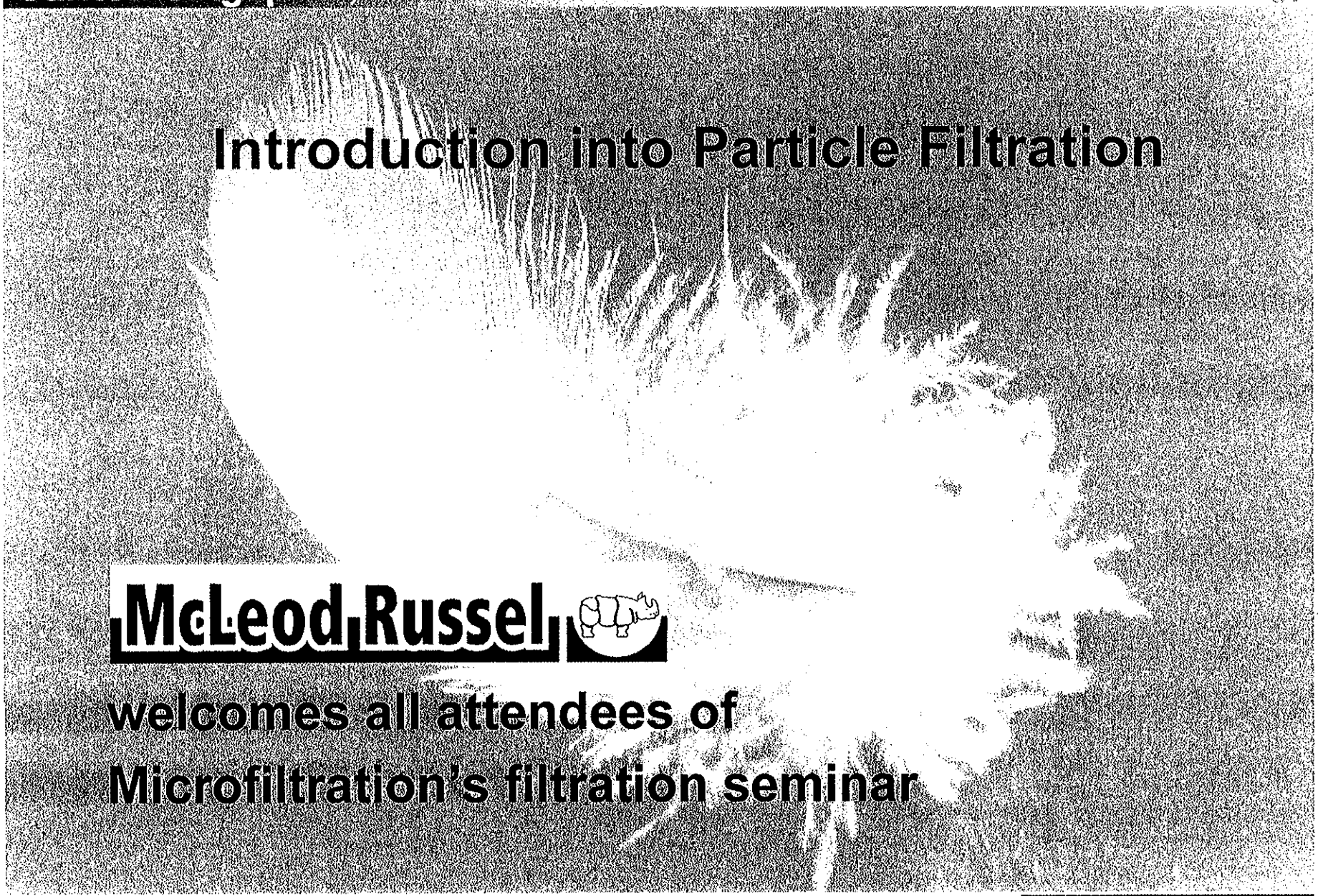
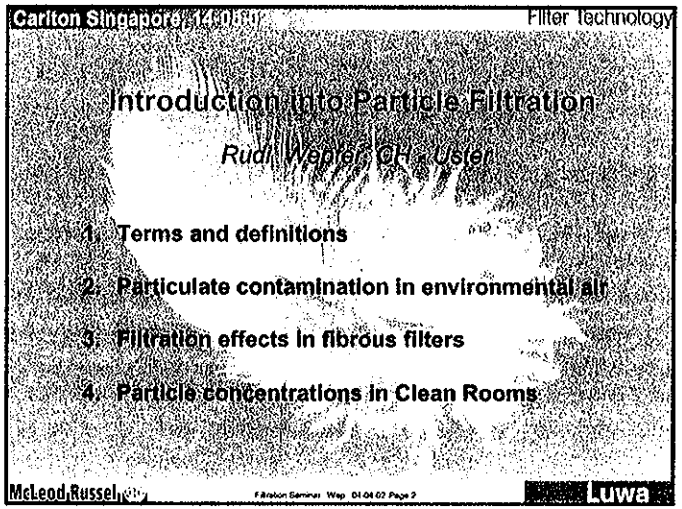
Introduction into Particle Filtration

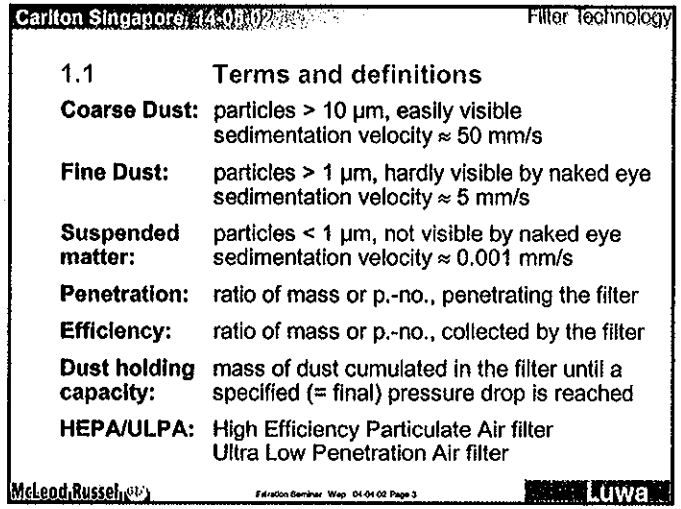


McLeod Russel

welcomes all attendees of

Microfiltration's filtration seminar


Filter Technology
Introduction into Particle Filtration
Rudi Wepfer, CH - Uster
1. Terms and definitions
2. Particulate contamination in environmental air
3. Filtration effects in fibrous filters
4. Particle concentrations in Clean Rooms
McLeod Russel
Luwa


Filter Technology
1.1 Terms and definitions
Coarse Dust: particles > 10 µm, easily visible sedimentation velocity ≈ 50 mm/s
Fine Dust: particles > 1 µm, hardly visible by naked eye sedimentation velocity ≈ 5 mm/s
Suspended matter: particles < 1 µm, not visible by naked eye sedimentation velocity ≈ 0.001 mm/s
Penetration: ratio of mass or p.-no., penetrating the filter
Efficiency: ratio of mass or p.-no., collected by the filter
Dust holding capacity: mass of dust cumulated in the filter until a specified (= final) pressure drop is reached
HEPA/ULPA: High Efficiency Particulate Air filter Ultra Low Penetration Air filter
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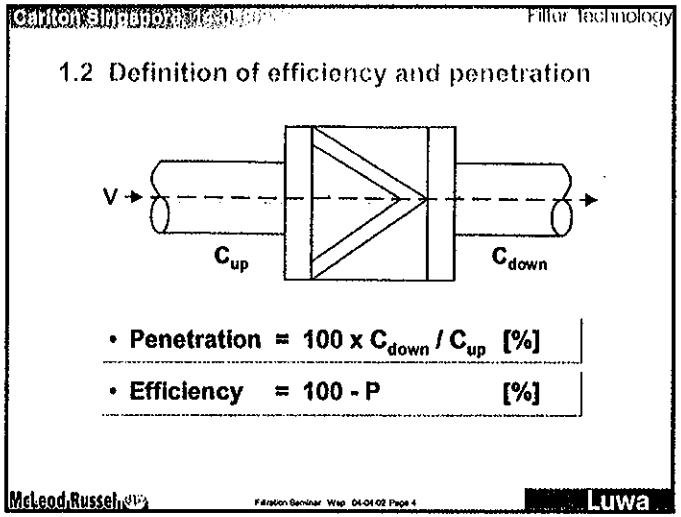
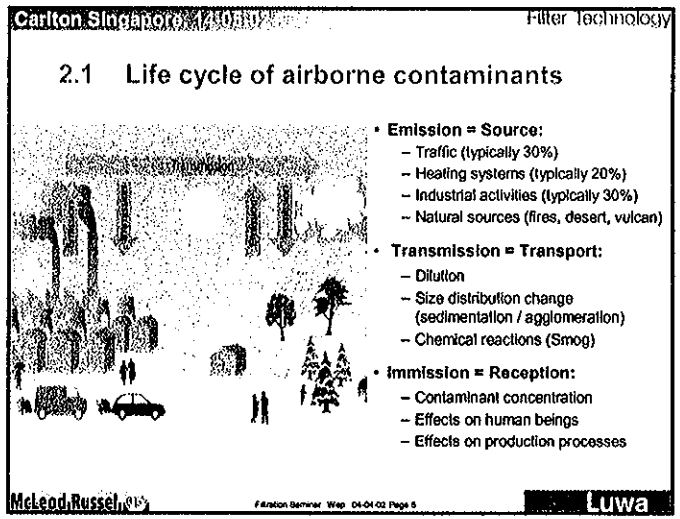
Luwa


Filter Technology
1.2 Definition of efficiency and penetration
V
C_{up}
C_{down}
• Penetration = 100 x C_{down} / C_{up} [%]
• Efficiency = 100 - P [%]
McLeod Russel
Luwa


Filter Technology
2.1 Life cycle of airborne contaminants
• Emission = Source:
– Traffic (typically 30%)
– Heating systems (typically 20%)
– Industrial activities (typically 30%)
– Natural sources (fires, desert, vulcan)
• Transmission = Transport:
– Dilution
– Size distribution change (sedimentation / agglomeration)
– Chemical reactions (Smog)
• Immission = Reception:
– Contaminant concentration
– Effects on human beings
– Effects on production processes
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2.2 Typical dust concentrations in mg/m³

Place, Region	Min.	Max.	Avg.	Part.-Ø
Jungfraujoch, CH [3500 m a.s.l.]	-	-	0.005	0.01 – 1.0 µm
Rural [alt. >1500 m a.s.l., CH]	0.002	0.05	0.010	0.01 – 5 µm
Rural [alt. 0-500 m a.s.l., CH]	0.005	0.10	0.020	0.01 – 10 µm
Small cities [e.g. Zurich]	0.01	0.20	0.025	0,01 – 10 µm
Singapore [ENV: Poll. Contr. Rep. 2000]	0.01	0,20	0.031	0.01 – 10 µm
Big cities [e.g. London]	0.03	0.5	0.07	0.01 – 20 µm
Zones with heavy industry	0.05	1.0	0.15	0.01 – 30 µm
Deserts [Sand storms]	0.05	[400]	-	0.01 -100 µm

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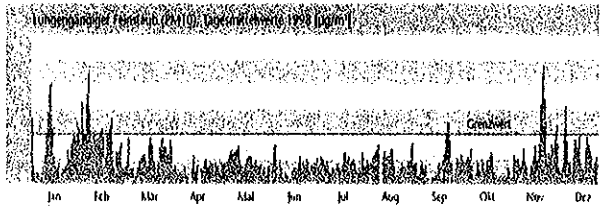
2.3 Average daily dust concentrations in Zurich



Daily averages of PM10 dust concentrations, measured 1998 in Zurich in µg/m³ Source: NABEL

Conclusions:
- Concentration fluctuations by factor 10 are typical, by factor 100 possible
- Concentrations in summer are lower than in winter

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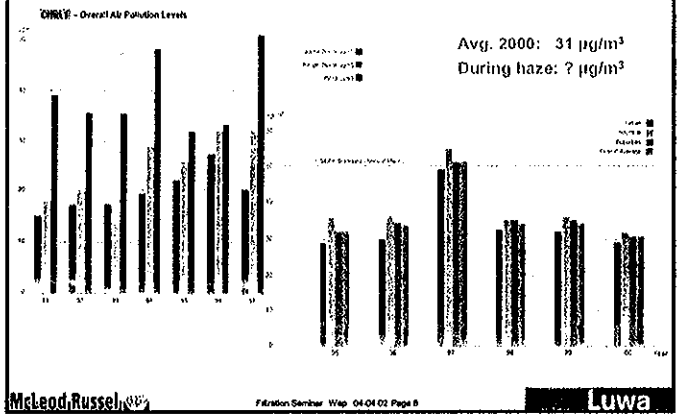
2.4 Long term dust concentrat. in Singapore



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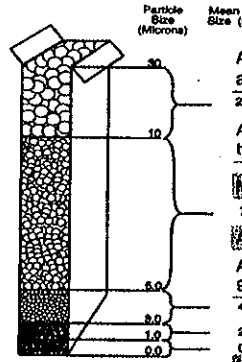
2.5 Size distribution of atmospheric aerosols



Amount of coarse dust in atmosphere is only 28% and decreasing over the years

20.0 0.006% 28%

A coarse dust filter (95% / G4) holds back typically only 25% of atmospheric dust mass

Main dust mass in atmosphere is fine dust (70%)

7.5 0.175 52

Amount of fine dust is increasing over the years

A fine dust filter (95% / F8) holds back typically 95% of atmospheric dust mass

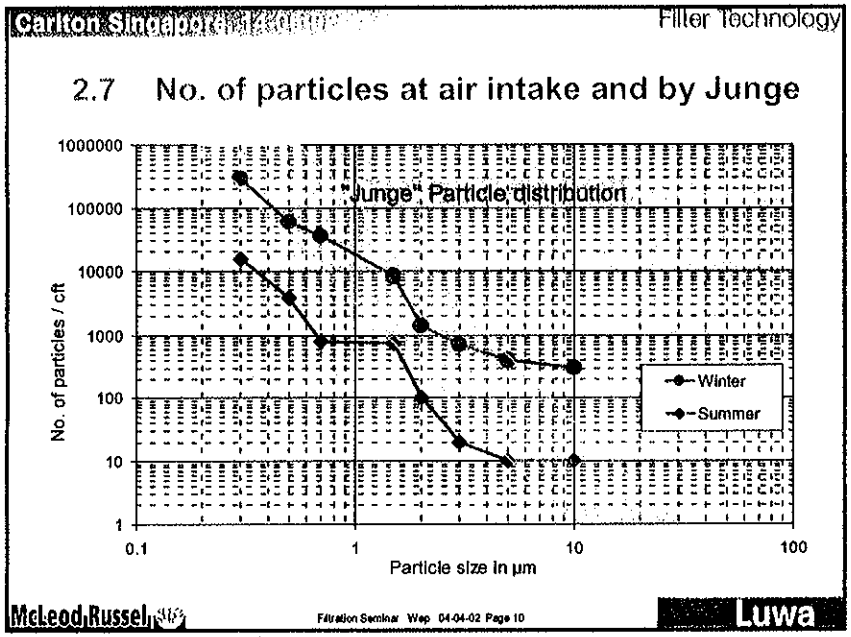
4.0 0.25 11

2.0 1.07 6

0.5 98.5 3

Main particle quantity is of sub-micron size (99.5%)

McLeod Russel Filtration Seminar Wap 04-04-02 Page 9 Luwa


Carlton Singapore
Filter Technology
2.7 No. of particles at air intake and by Junge
"Junge" Particle distribution
No. of particles / cft
1000000
100000
10000
1000
100
10
1
0.1
1
10
100
Particle size in µm
Winter
Summer
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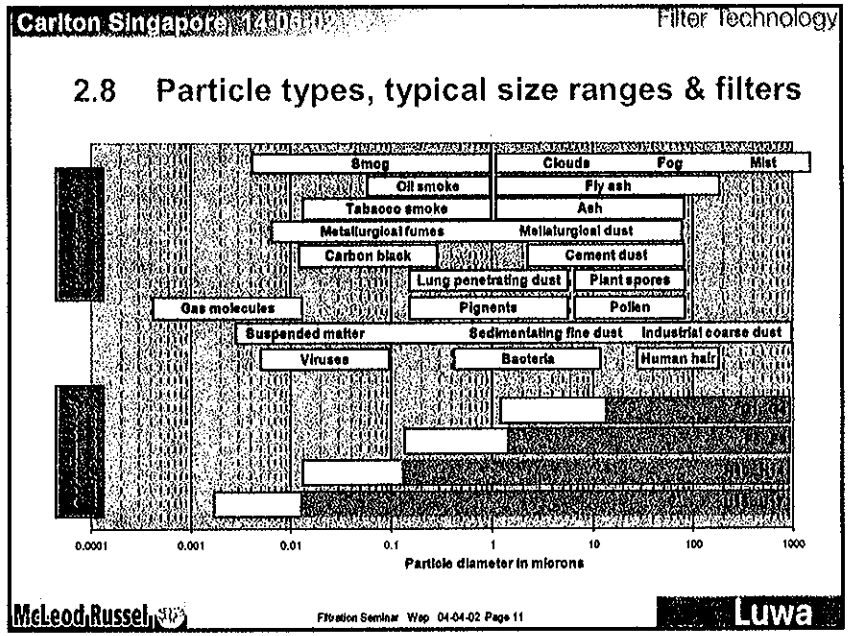
Filtration Seminar Wep 04-04-02 Page 10
Luwa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Filter Technology
2.8 Particle types, typical size ranges & filters
Smog
Clouds
Fog
Mist
Oil smoke
Fly ash
Tobacco smoke
Ash
Metallurgical fumes
Metallurgical dust
Carbon black
Cement dust
Lung penetrating dust
Plant spores
Gas molecules
Pigments
Pollen
Suspended matter
Sedimentating fine dust
Industrial coarse dust
Viruses
Bacteria
Human hair
0.0001
0.001
0.01
0.1
1
10
100
1000
Particle diameter in microns
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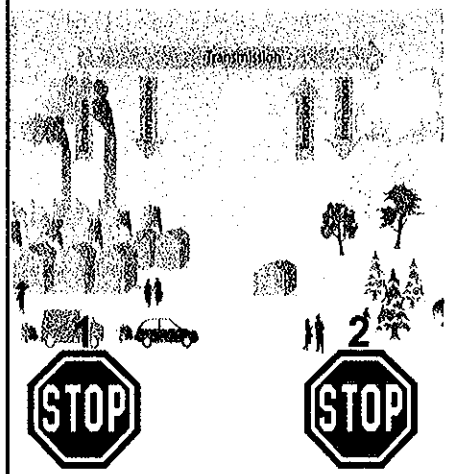
Luwa

2.9 Possible typical environmental conditions



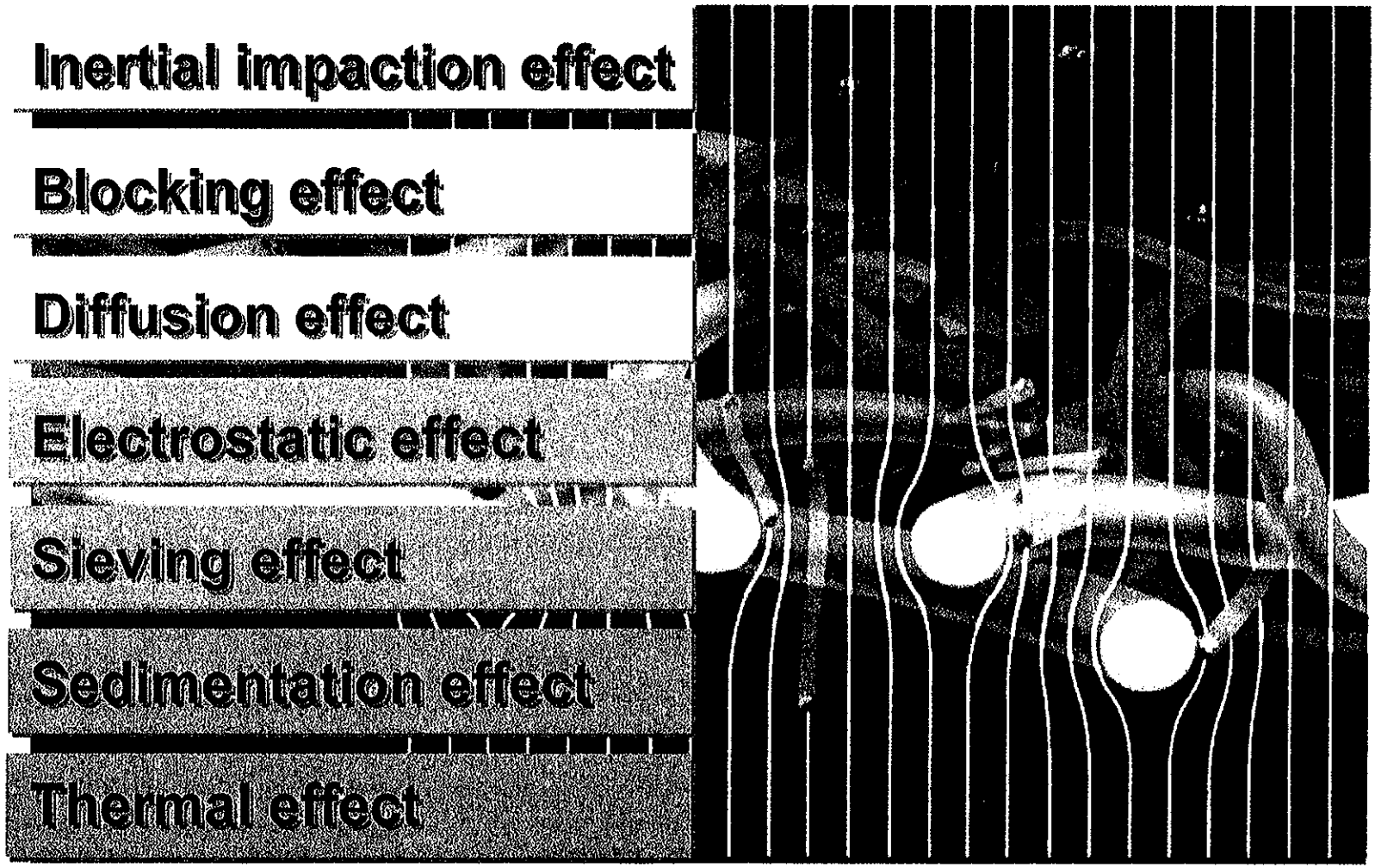
Rural	Urban Industrial	Offshore	Costal	Desert	Tropical	Arctic
Sun, rain, snow, mist, mostly dry	Sun, rain snow, fog, ice	Sun, spray, rain, wind, fog squalls, salt	Sun, rain, fog squalls, salt, wind, mist	Dry & hot, sun, little rain, wind, storms	Humid & hot, fog, monsoon rain, mist	Cold, snow, ice fog, frost, high winds
-20 - +35°C	-20 - +35°C	-20 - +30°C	-20 - +30°C	-0 - +50°C	-5 - +45°C	-50 - +20°C
0.01 – 30 µm	0.01 – 10 µm	0.1 – 100 µm	0.01 – 7 µm	0.01 – 30 µm	0.01 – 30 µm	0.1 – 15 µm
0.02-10 mg/m³	0.05-0.5mg/m³	0.1–10 mg/m³	0.01-0.1mg/m³	0.1-700 mg/m³	0.02-10 mg/m³	0.01-0.3 mg/m³
Fine, coarse & erosive dry dust, insects	Corrosive fine dust, soot, fibres, VOC's	Drilling dust, grit, burning smoke, salt	Dry fine dust, salt, sulphate, magnesium	Dry fine sand: cont. calcium silica, magn.	Wet fine dust, salt, smoke, insects	Silica, quartz, carbon, oxides, some insects

2.10 Control of airborne contaminants by law



- **Stop 1:**
  Control by law through "Max. Emission Concentration" values:
  - MEC's per substance or substance group (see LRV / Clean air act) è
  - Process reengineering
  - Installation of an exhaust filtration plant
- **Stop 2:**
  Control by law through "Max. Immission Concentration" values:
  - MIC's per substance or substance group (see corr. Standards (e.g. VDI 2310 / LRV / Clean air act) è
  - Intake air filters for buildings
  - Additional pressure to tighten the MEC limits

3.1 Separation effects in fibrous particle filters



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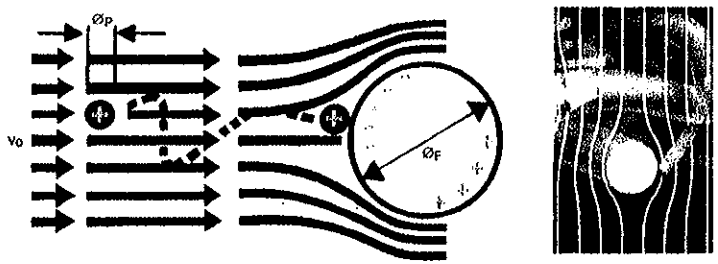
3.2 Separation effects in fibrous particle filters

• The electrostatic effect



More effective for higher charges and smaller particles
But: only effective for new filters and in EN 779 tests !
But: natural aerosol discharges the fibre within 1 to 3 month !

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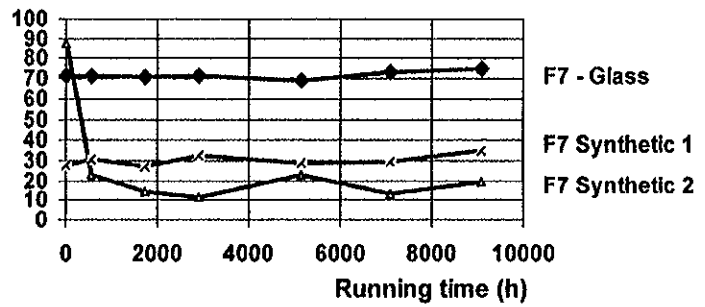
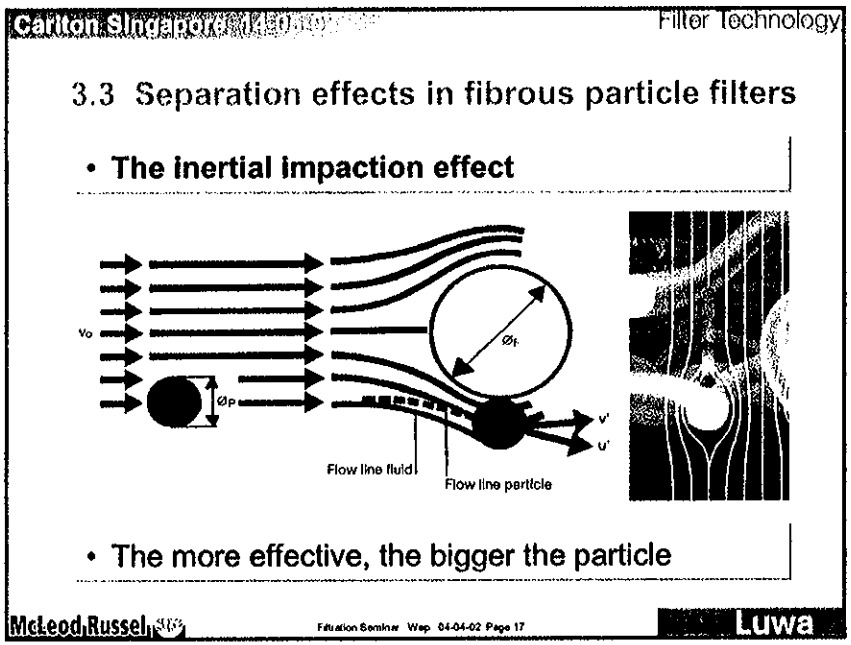
Filters with electrostatically charged medium

Real life test at "Sintef", Norway, 1995



But: natural aerosol discharges the fibre within 1 to 3 month !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Filter Technology
3.3 Separation effects in fibrous particle filters
• The inertial impaction effect
Vo
Øf
Øp
Flow line fluid
Flow line particle
v'
u'
• The more effective, the bigger the particle
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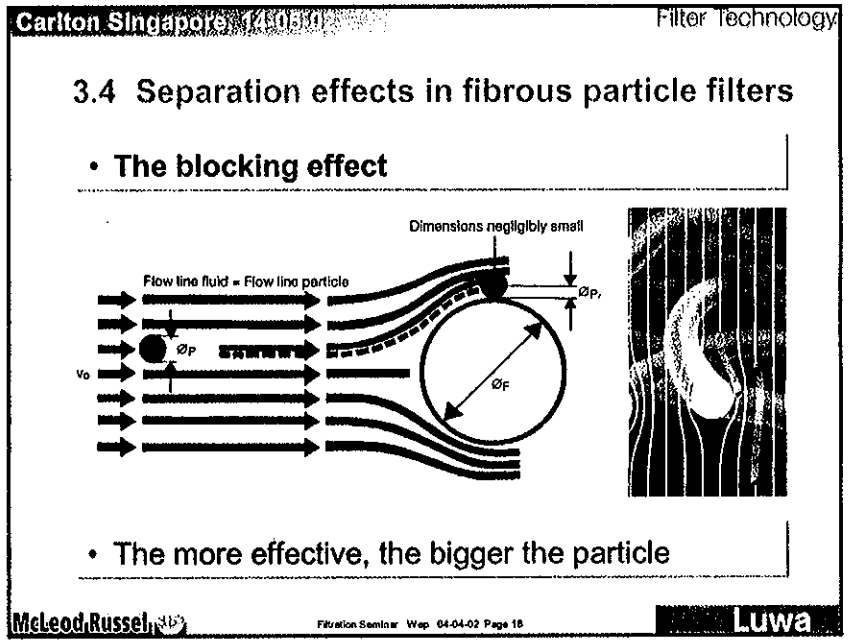
Luwa


Carlton Singapore
Filter Technology
3.4 Separation effects in fibrous particle filters
• The blocking effect
Dimensions negligibly small
Flow line fluid = Flow line particle
Øp
Vo
ØF
• The more effective, the bigger the particle
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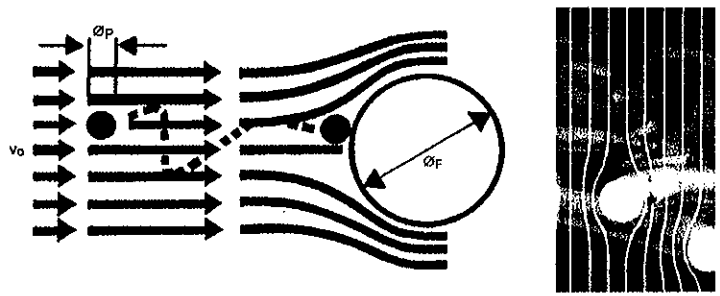
Filtration Seminar Wep 04-04-02 Page 18
Luwa

Carlton Singapore Filter Technology

3.5 Separation effects in fibrous particle filters

- **The diffusion effect**

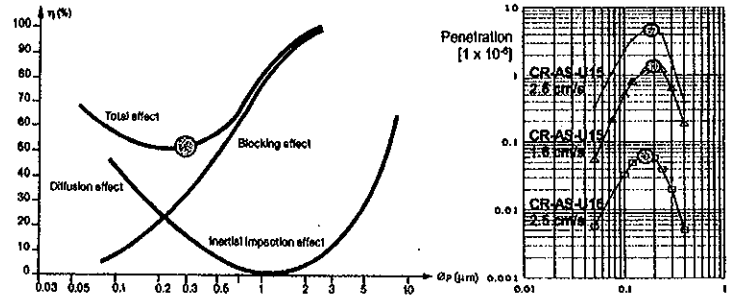


- The more effective, the smaller the particle

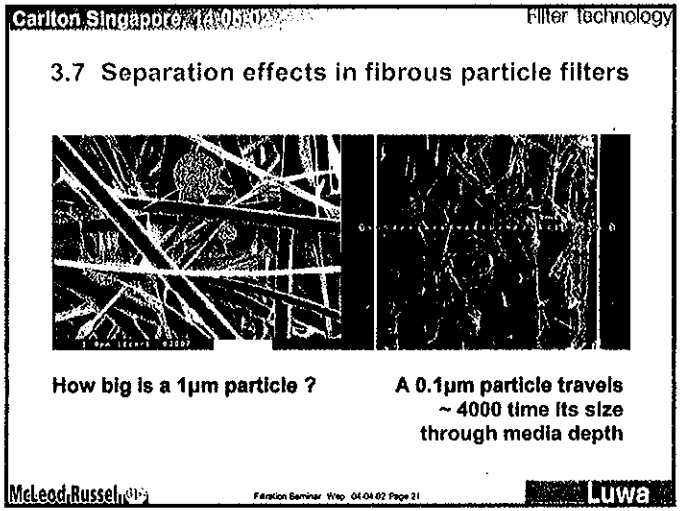
Carlton Singapore Filter Technology

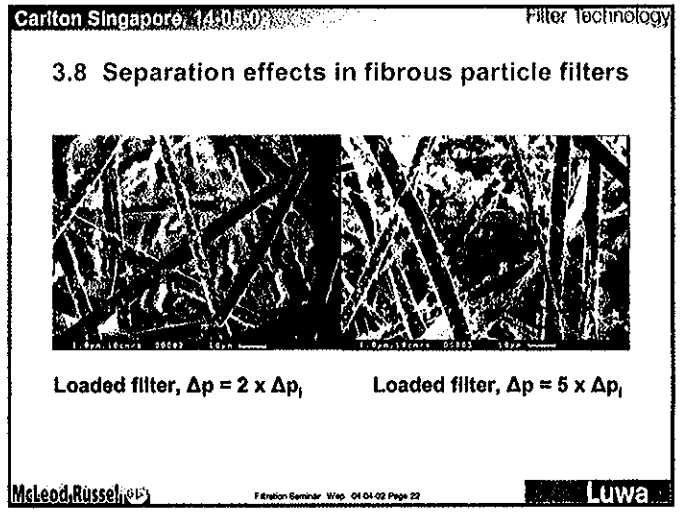
3.6 Separation effects in fibrous particle filters

- **The total effect = fractional efficiency curve**



Fibrous filters have an MPPS (= Most Penetrating Particle Size)


Filter Technology
3.7 Separation effects in fibrous particle filters
How big is a 1µm particle ?
A 0.1µm particle travels ~ 4000 time its size through media depth
McLeod Russel
Luwa


Filter Technology
3.8 Separation effects in fibrous particle filters
Loaded filter, Δp = 2 x Δp$_i$
Loaded filter, Δp = 5 x Δp$_i$
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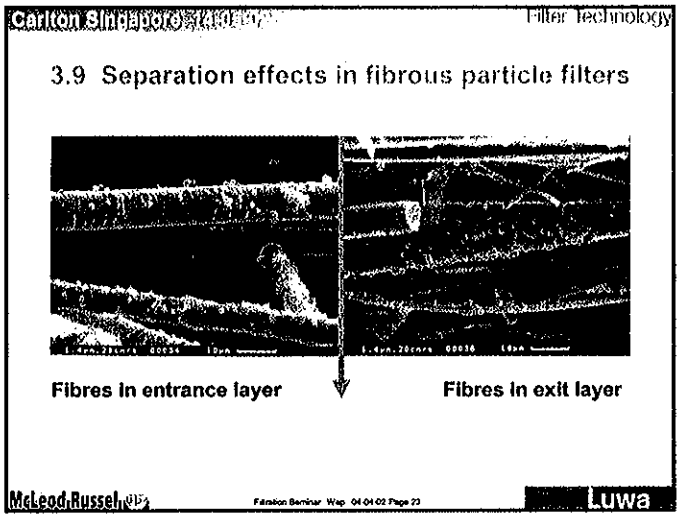
Luwa


Filter Technology
3.9 Separation effects in fibrous particle filters
Fibres in entrance layer
Fibres in exit layer
McLeod Russel
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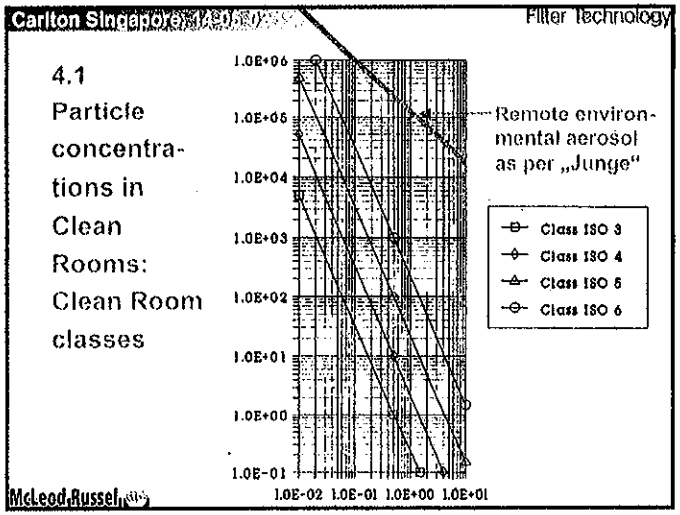
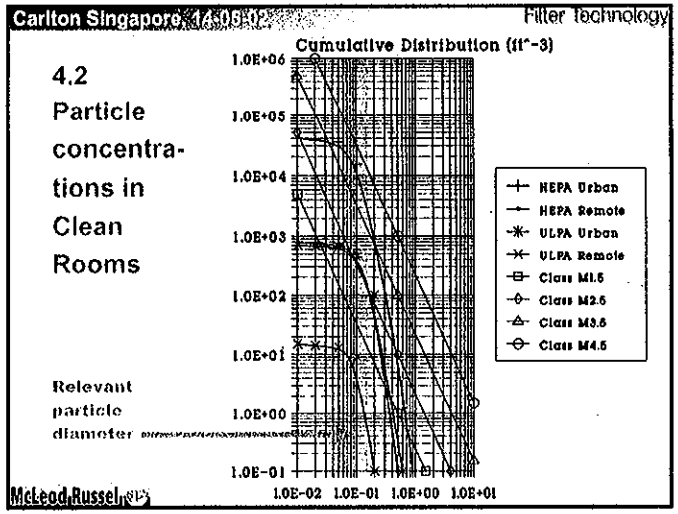
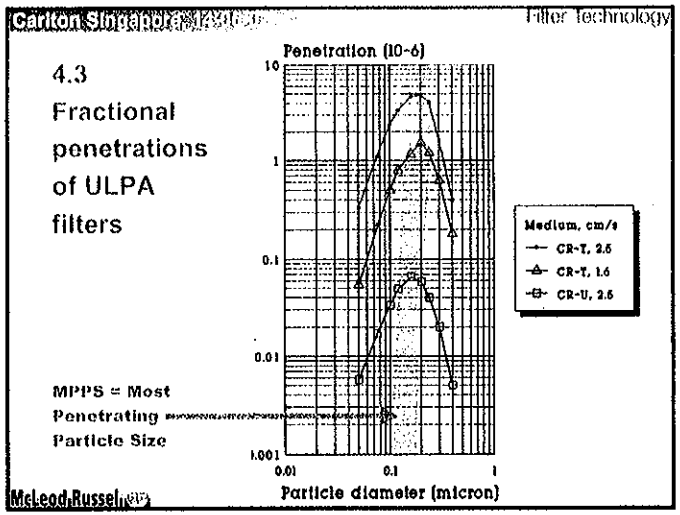
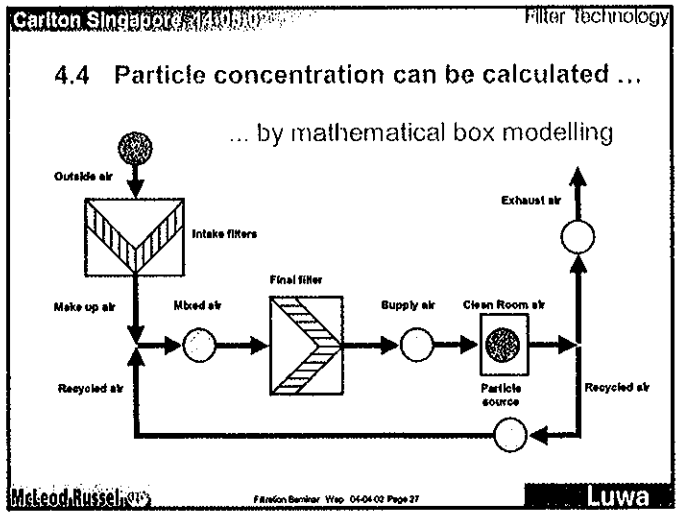

Filter Technology
4.1
Particle concentrations in Clean Rooms: Clean Room classes
Remote environmental aerosol as per „Junge"
Class ISO 3
Class ISO 4
Class ISO 5
Class ISO 6
McLeod Russel


Filter Technology
Cumulative Distribution (ft^-3)
4.2
Particle concentrations in Clean Rooms
Relevant particle diameter
HEPA Urban
HEPA Remote
ULPA Urban
ULPA Remote
Class M1.5
Class M2.5
Class M3.5
Class M4.5
McLeod Russel


Filter Technology
Penetration (10-6)
4.3
Fractional penetrations of ULPA filters
Medium, cm/s
CR-T, 2.5
CR-T, 1.6
CR-U, 2.5
MPPS = Most Penetrating Particle Size
Particle diameter (micron)
McLeod Russel


Filter Technology
4.4 Particle concentration can be calculated ...
... by mathematical box modelling
Outside air
Intake filters
Exhaust air
Final filter
Make up air
Mixed air
Supply air
Clean Room air
Recycled air
Particle source
Recycled air
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Luwa

4.5 Achievable Clean Room class, calculated ...at MPPS

Parameters	Unit	Variable resp. Limit value	MPPS con-centration [1/m^3]	MPPS con-centration [1/ft^3]
Fresh air at intake (urban location)	m^{-3}	2.0E+09	2.0E+09	5.7E+07
Decontamination factors of prefilters:				
1st filter stage: 95% gravimetric	-	1.0	2.0E+09	5.7E+07
2nd filter stage: Luwa FP-75	-	1.2	1.7E+09	4.7E+07
3rd filter stage: Luwa FP-95	-	2.5	6.7E+08	1.9E+07
Fresh air admixture	%	10.0	6.7E+08	1.9E+07
Class of return air acc. 209d at 0.5µm	ft^{-3}	1000	1.2E+06	3.5E+04
Room air admixture	%	90.0	1.2E+06	3.5E+04
Supply air (= result of mixture)	-		6.8E+07	1.9E+06
Luwa CR-AS-U15 filter: efficiency >=	%	99.999500		
penetration <=	-	5.0E-06	3.4E+02	9.6E+00
Room supply air quality	-		3.4E+02	9.6E+00

Parameters	Unit	Variable resp. Limit value	>= 0.5µm concentrat. [1/m^3]	>= 0.5µm concentrat. [1/ft^3]
Room Class acc. to 209d for 0.5µm	-		1.7E+01	4.8E-01
Specified room class acc. 209d for 0.5µm	ft^{-3}	10	3.5E+02	1.0E+01
Safety factor on specification*	-		21	21

Parameters	Unit	Variable resp. Limit value	MPPS con-centration [1/m^3]	MPPS con-centration [1/ft^3]
Fresh air at intake (urban location)	m^{-3}	2.0E+09	2.0E+09	5.7E+07
Decontamination factors of prefilters:				
1st filter stage: 95% gravimetric	-	1.0	2.0E+09	5.7E+07
2nd filter stage: Luwa FP-95	-	2.5	8.0E+08	2.3E+07
3rd filter stage: Luwa FP-R	-	35.0	2.4E+07	6.9E+05
Fresh air admixture	%	10.0	2.4E+07	6.9E+05
Class of return air acc. 209d at 0.5µm	ft^{-3}	1000	1.2E+06	3.5E+04
Room air admixture	%	90.0	1.2E+06	3.5E+04
Supply air (= result of mixture)	-		3.5E+06	1.0E+05
Luwa CR-AS-H14 filter: efficiency >=	%	99.995000		
penetration <=	-	5.0E-05	1.8E+02	5.0E+00
Room supply air quality	-		1.8E+02	5.0E+00

Parameters	Unit	Variable resp. Limit value	>= 0.5µm concentrat. [1/m^3]	>= 0.5µm concentrat. [1/ft^3]
Room Class acc. to 209d for 0.5µm	-		8.8E+00	2.5E-01
Specified room class acc. 209d for 0.5µm	ft^{-3}	10	3.5E+02	1.0E+01
Safety factor on specification*	-		40	40

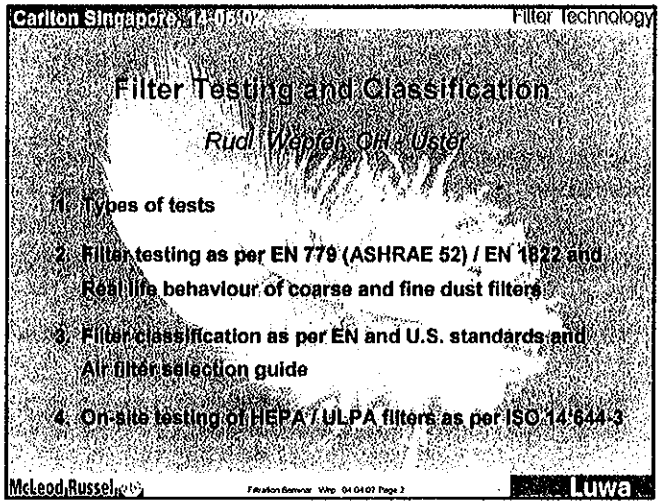
Filter Testing and Classification



McLeod Russel

welcomes all attendees of

Microfiltration's filtration seminar


Carlton Singapore 14.05.02
Filter Technology
Filter Testing and Classification
Rudi Wepfer, CH - Uster
1. Types of tests
2. Filter testing as per EN 779 (ASHRAE 52) / EN 1822 and Real life behaviour of coarse and fine dust filters
3. Filter classification as per EN and U.S. standards and Air filter selection guide
4. On-site testing of HEPA / ULPA filters as per ISO 14644-3
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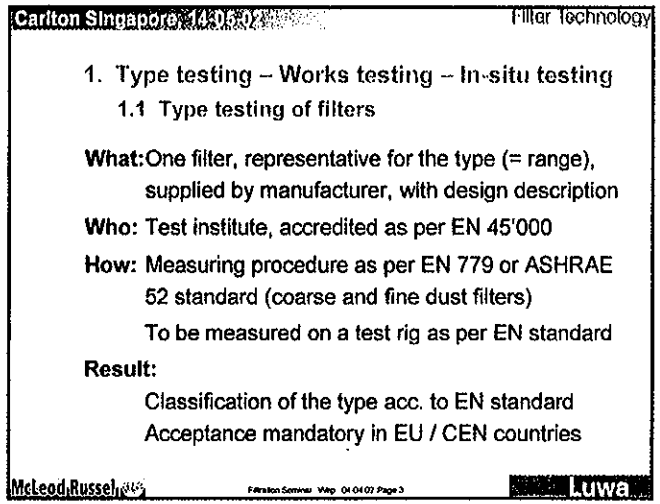
Luwa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Filter Technology
1. Type testing – Works testing – In-situ testing
1.1 Type testing of filters
What: One filter, representative for the type (= range), supplied by manufacturer, with design description
Who: Test institute, accredited as per EN 45'000
How: Measuring procedure as per EN 779 or ASHRAE 52 standard (coarse and fine dust filters)
To be measured on a test rig as per EN standard
Result:
Classification of the type acc. to EN standard
Acceptance mandatory in EU / CEN countries
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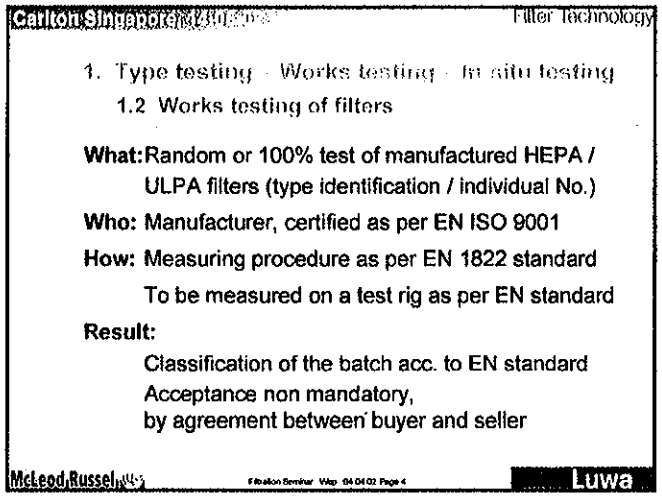
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Filter Technology
1. Type testing – Works testing – In-situ testing
1.2 Works testing of filters
What: Random or 100% test of manufactured HEPA / ULPA filters (type identification / individual No.)
Who: Manufacturer, certified as per EN ISO 9001
How: Measuring procedure as per EN 1822 standard
To be measured on a test rig as per EN standard
Result:
Classification of the batch acc. to EN standard
Acceptance non mandatory,
by agreement between buyer and seller
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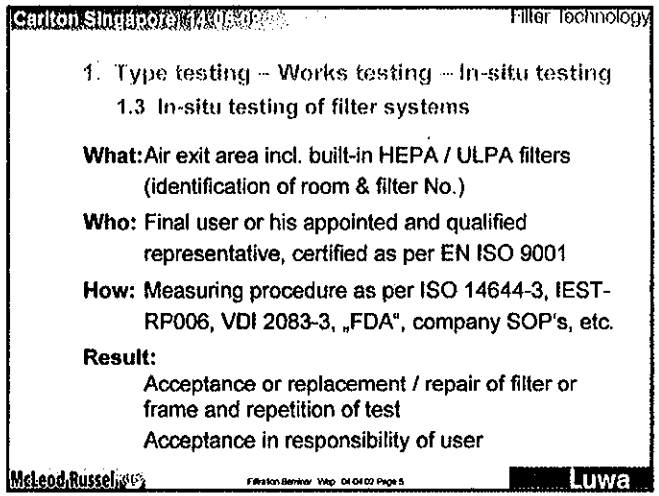
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Filter Technology
1. Type testing – Works testing – In-situ testing
1.3 In-situ testing of filter systems
What: Air exit area incl. built-in HEPA / ULPA filters (identification of room & filter No.)
Who: Final user or his appointed and qualified representative, certified as per EN ISO 9001
How: Measuring procedure as per ISO 14644-3, IEST-RP006, VDI 2083-3, „FDA", company SOP's, etc.
Result:
Acceptance or replacement / repair of filter or frame and repetition of test
Acceptance in responsibility of user
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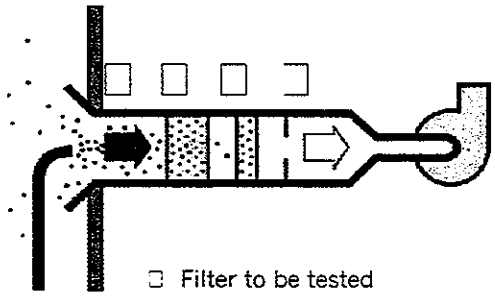
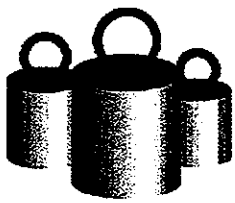
2. Filter testing acc. to EN 779 / ASHRAE 52

2.1 Coarse dust filters



- Filter to be tested
- Final HEPA filter
- Raw air with test dust
- Clean air

Measuring principle
Gravimetric (Weight)



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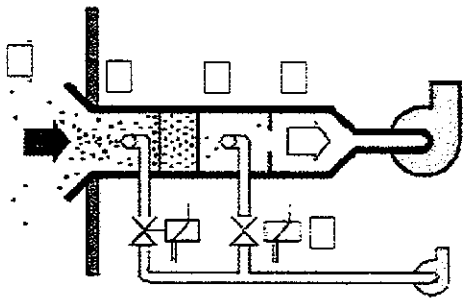
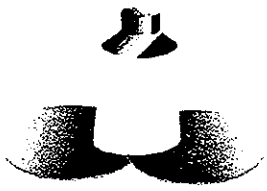
2. Filter testing acc. to EN 779 / ASHRAE 52

2.2 Fine dust filters

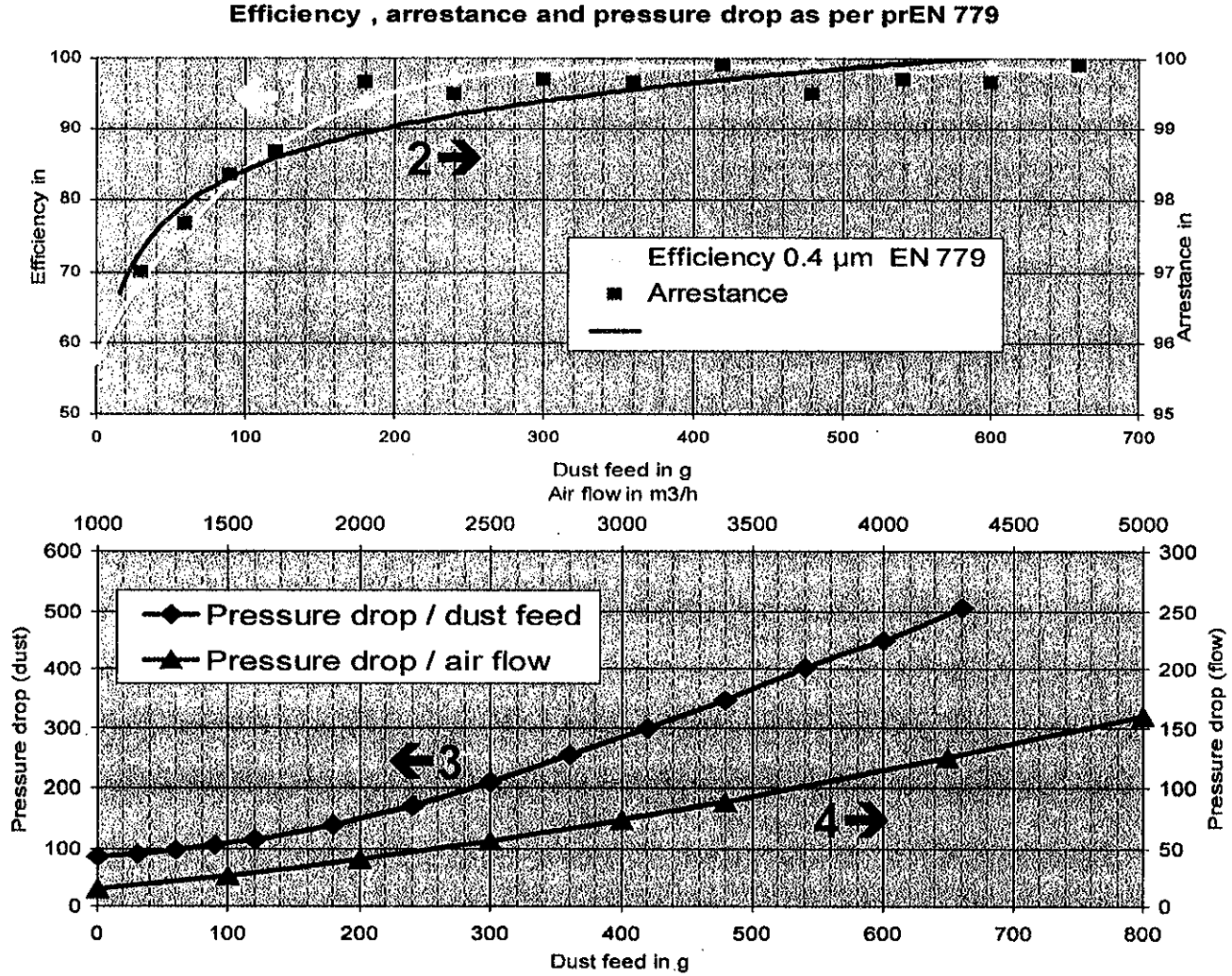


- Measuring probes with filter membranes
- Control valves with sequence timer
- Raw air with test natural aerosol
- Clean air

Measuring principle
Discoloration of filter membranes



Behaviour of fine filters in standardised testing



Efficiency for 0.4 µm particles as function of dust feed

Curve 2: Arrestance (gravimetric) as function of dust feed

Curve 3: Pressure drop as function of dust feed

Curve 4: Initial pressure drop as function of air flow)

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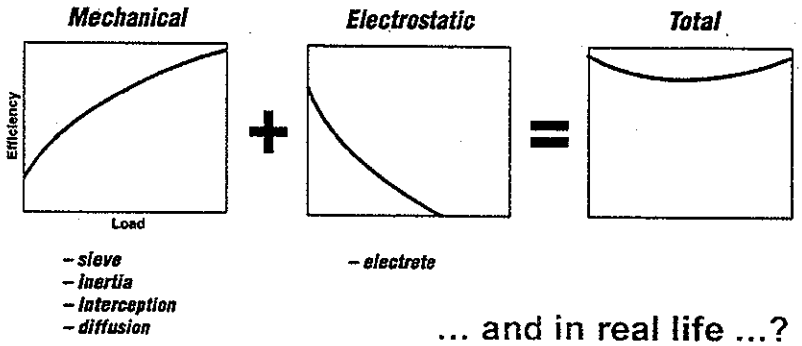
Behaviour of synthetic fine filters with electro-statically charged medium according to "wishful thinking" of a manufacturer ...



... and in real life ...?

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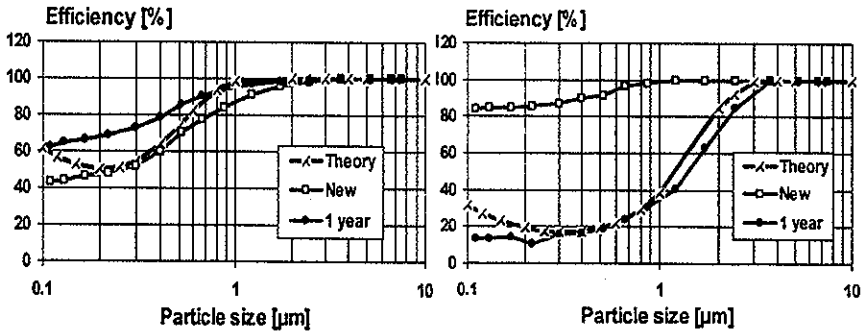
Real Life behaviour of fine dust filters



Glass fibre medium filter	Synthetic fibre medium filter
Class F7 [EN 779]	Class F7 [EN 779]
85% [ASHRAE 52.1]	85% [ASHRAE 52.1]

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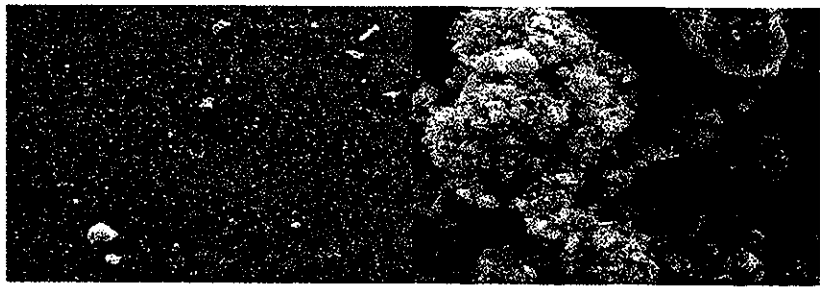
The difference: Aerosol type and concentration



Natural dust	ASHRAE 52.1 or EN 779 dust
Typical concentration 0.05 mg/m³	Typical concentration 70 mg/m³ !
Dust sampled on membrane filters	Pictures made in the same scale

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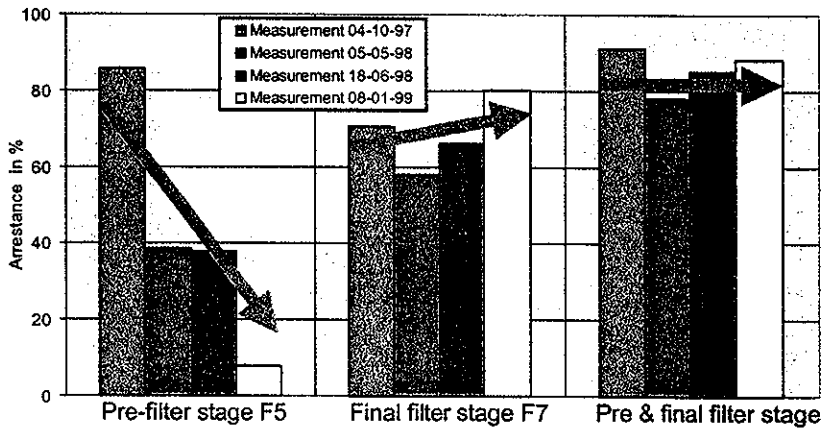
Real life behaviour of coarse and fine filters

Arrestance (gravimetric), calculated from individual fractional particle concentration measurements in an AC plant in Leuna, Germany



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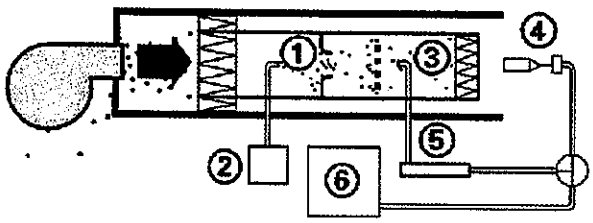
2. Filter testing according to EN 1822

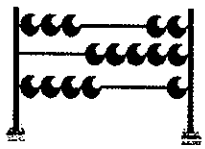
2.7 HEPA filters



+ Leak testing
Visual oil tread test

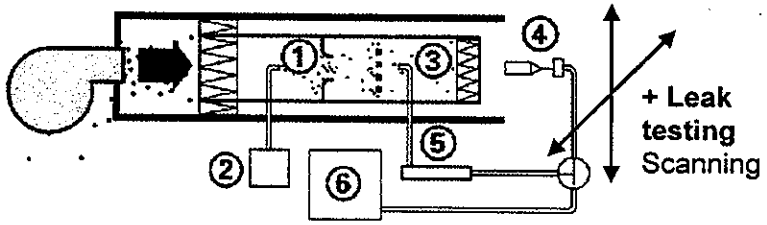
- Particle injection & distribution
- Particle generator
- Raw air measuring probe
- Clean air measuring probe
- Raw air particle dilutor
- Particle counter

Measuring principle
Particle counting



2. Filter testing according to EN 1822

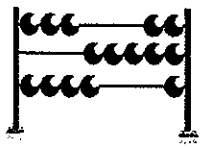
2.8 ULPA filters



+ Leak testing
Scanning

- Particle injection & distribution
- Particle generator
- Raw air measuring probe
- Clean air measuring probe
- Raw air particle dilutor
- Particle counter

Measuring principle
Particle counting



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3. Filter classification per EN / U.S. standards

3.1 The principle in EN classification

Group	=	**Measuring principle**
Letters G, F, H & U		G = Gravimetric, F = Discoloration, H & U = Particle counting, Scanning
Class	=	**Separation performance band**
Numbers 1 to 17		Related to the measuring procedure of the group

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3. Filter classification to EN / U.S. standards

3.2 New EN 779 and old EU filter classes

New standard	Old standard	Efficiency range		
EN 779	**EUROVENT 4/5**	**from**	**%**	**to**
G 1	EU 1	..	A_m	65
G 2	EU 2	65	A_m	80
G 3	EU 3	80	A_m	90
G 4	EU 4	90	A_m	..
F 5	EU 5	40	E_m	60
F 6	EU 6	60	E_m	80
F 7	EU 7	80	E_m	90
F 8	EU 8	90	E_m	95
F 9	EU 9	95	E_m	..

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3.3 U.S. ASHRAE 52.2 and EN classification

ASHRAE 52.2 Classification		Separation performance in % for: Particle size range efficiency			Arrestance	EN 779 / 1822 Separation	
Category	MERV	0.3 - 1 µm	1 - 3 µm	3 - 10 µm	ASHRAE 52.1	perform. in %	Class
Coarse	1	n/a	n/a	< 20	< 65	A: 50 - 65	G 1
	2	n/a	n/a	< 20	65 - 70		
	3	n/a	n/a	< 20	70 - 75	A: 65 - 80	G 2
	4	n/a	n/a	< 20	> 75		
Low efficiency	5	n/a	n/a	20 - 35	n/a	A: 80 -90	G 3
	6	n/a	n/a	35 - 50	n/a		
	7	n/a	n/a	50 - 70	n/a	A: > 90	G 4
	8	n/a	n/a	> 70	n/a		
Medium efficiency	9	n/a	< 50	> 85	n/a	E: 40 - 60	F 5
	10	n/a	50 - 65	> 85	n/a		
	11	n/a	65 - 80	> 85	n/a	E: 60 - 80	F 6
	12	n/a	> 80	> 90	n/a		
High efficiency	13	< 75	> 90	> 90	n/a	E: 80 - 90	F 7
	14	75 - 85	> 90	> 90	n/a	E: 90 - 95	F 8
	15	85 - 95	> 90	> 90	n/a	E: > 95	F 9
	16	> 95	> 95	> 95	n/a	MPPS: > 95	H10

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3. Filter classification to EN / U.S. standards

3.4 New EN 1822, old EU and U.S. filter classes

New EU standard	Old EU standard	US standard
EN 1822 H 10 (> 85 %) H 11 (> 95 %) H 12 (> 99.5 %) H 13 (> 99.95 %) H 14 (> 99.995 %) U 15 (> 99.9995 %) U 16 (> 99.99995%) U 17 (>99.999995%)	**EUROVENT 4/4** EU 10 (> 95 %) EU 11 (> 99.9 %) EU 12 (> 99.97 %) EU 13 (> 99.99 %) EU 14 (> 99.999 %)	**IEST-RP-CC 001.3** Types A, B, C (HEPA) Type D Type F (ULPA)
DEHS - MPPS (~ 0.1 - 0.2 µm)	NaCl (~ 0.6 µm)	DOP (A ... D = 0.3 µm, F = 0.12 µm)

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3.5 Selection guide for particle filters

First Stage	Second Stage	Third stage	Forth stage	Clean Room Class*
F 5	F 9	H 13	U 17	ISO 1
F 5	F 9	H 13	U 16	ISO 2
F 5	F 8	H 12	U 16	ISO 3 (1)
G 3	F 7	H 11	U 15	ISO 4 (10)
F 5	F 9	H 14	-	ISO 5 (100)
F 5	F 8	H 13	-	ISO 6 (1'000)
G 4	F 7	H 12	-	ISO 7 (10'000)
G 3	F 6	H 10	-	ISO 8 (100'000)
G 2	F 5	F 9	-	ISO 9

← Pre-filter Final filter →

Normally not necessary

* As per ISO 14'644-1 (U.S. Fed. Std. 209 E)
Clean room class is not only depending on filter selection

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4. On-site testing of HEPA / ULPA filters

4.1 Purpose of on-site or "in-situ" filter testing

The test is performed to confirm ...

- the absence of leakage (in filters, gaskets or frames), relevant for the cleanliness performance of the installation
- that the filter system is properly installed ... *or*
- that leaks have not developed during use

The test is performed by ...

- introducing an aerosol challenge upstream of the filters, and ...
- scanning immediately downstream of filters and their support frames with a DPC

The test is not ...

- a filter efficiency test (such tests shall be performed at the place of manufacture of the filters !!!)

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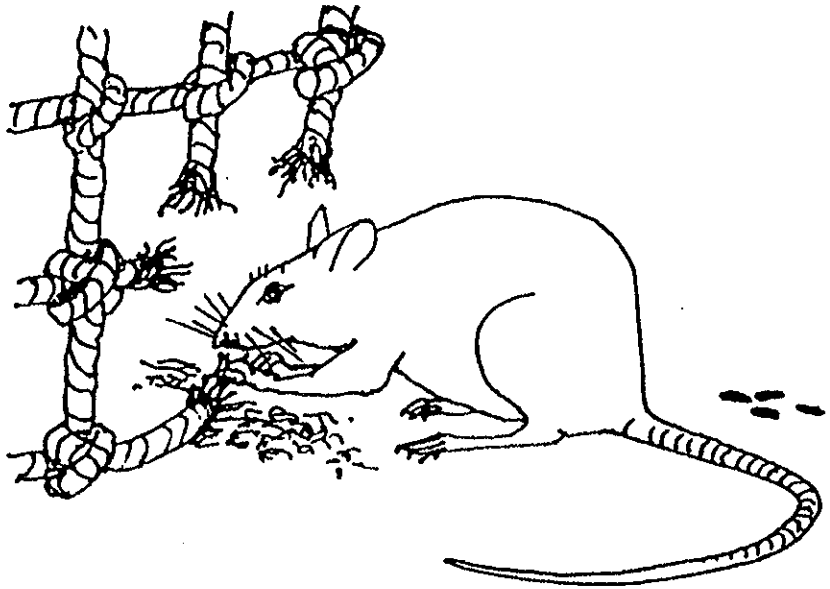
4.2 Internationally standardised in-situ tests

Document	Year of issue	Measuring instrument	Aerosol type	Aerosol diameter[1)]	Leak criteria f. penetration
US Fed. Std. 209B[2)]	1973	Photometer[3)]	„cold" DOP	≈ 0,7 µm	< 0,01 %
US Fed. 209C ... 209E	1988 ...1992	-[4)]	-[4)]	-[4)]	-[4)]
IES-RP-CC006.2	1995	Photometer[3)] DPC[5)]	„cold" DOP ctbabas[6)]	≈ 0,7 µm ctbabas[6)]	< 0,01 % ctbabas[6)]
ASME N 510	1989	Photometer[3)]	„cold" DOP	≈ 0,7 µm	< 0,01 %
ASTM F 1471	1993	DPC[5)]	ctbabas[6)]	ctbabas[6)]	ctbabas[6)]
BS 5295, Part 1	1989	Photometer[3]	„cold" DOP	≈ 0,7 µm	< 0,001 %
VDI 2083, Sheet 3, E	1993	DPC[5)]	nicht spez.	< 1,0 µm	Dep. on filter
ISO CD 14644-3	1998	Photometer[3)] DPC[5)]	„cold" DOP DEHS, etc.	≈ 0,7 µm 0,1 – 0,3µm	< 0,01 % Dep. on filter

4. On-site testing of HEPA / ULPA filters

4.3 What is a leak ?



A leak is ...

where the particle counter makes beep !

A leak is ...

an area of limited extension where the specified nominal penetration is exceeded

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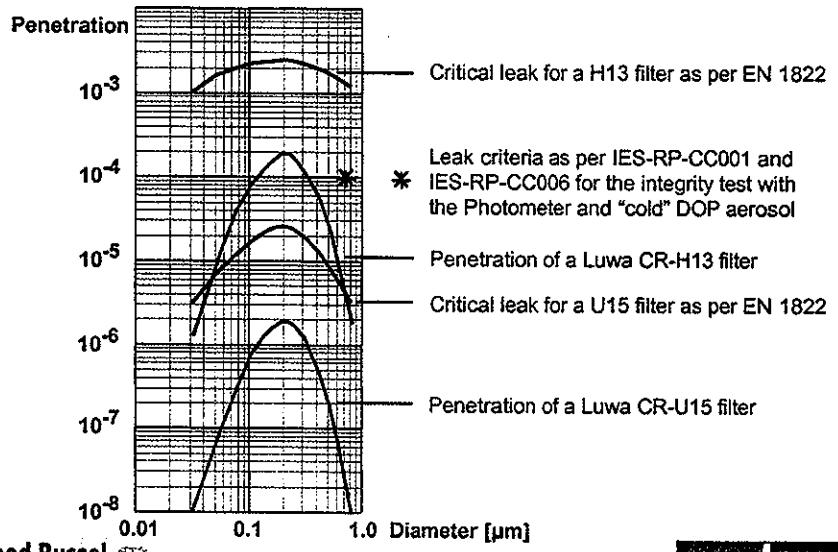
4.4 Leak definition according to „FDA" and ISO



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4. On-site testing of HEPA / ULPA filters

4.5 The three integrity test procedures as per ISO DIS 14644-3, Appendix B 6

There is a choice between ...

- Filter system integrity scan test with Photometer (Appendix B 6.2)
- Filter system integrity scan test with DPC (Appendix B 6.3)
- Filter system integrity efficiency test of filters, mounted in ducts or air handlers, with Photometer or DPC (Appendix B 6.4)

McLeod Russel Filtration Seminar Wep 04-04-02 Page 24 Luwa

4.6 The three procedures of ISO in comparison

Filter system integrity test	Scan test with Photometer	Scan test with DPC	Efficiency test with: Photometer or DPC
ISO DIS 14644-3	Annex B 6.2	Annex B 6.3	Annex B 6.4
Application and Conditions	· „Small" air flows (= individual filters and small plenums) · Clean Rooms ≥ class ISO 5 · Filters up to class H14 · DOP as substance permitted and outgassing not critical	· Indiv. filters and plenums · Clean Rooms of all ISO classes (≥ ISO 1) · Filters up to class U17 · Aerosol substance may be adapted to application	· Any air flows, individual filters and plenums · Filters up to class U17 · Filter systems of more than one stage may also be checked
Measuring instruments	Photometer	DPC	Photometer DPC
Probe guidance	Full area scanning with moved probe	Full area scanning with moved probe	Single points, resting probe / Single points, resting probe
Probe distance	5 cm	5 cm	30–100 cm / 30–100 cm
Average aerosol-Ø	0,7 µm	0,1 – 0,3 µm	0,7 µm / 0,1–0,3 µm
Acceptance criteria for penetration	< 0,01 % (independent from filter)	< 0,5 % for H13 < 0,05 % for H14 < 0,015 % for U15 < 0,005 % for U16 < 0,0015 % for U17	< 0,01 % (independent from filter) / < 5 x the Penetration of the filters
Aerosol feed (typical)	**≈ 80 g / m² / h** **≈ 20 g / m²**	**≈ 0,01 g / m² / h** **≈ 2,5 mg / m²**	**≈ 50 mg/m³** / **< 0,01 mg/m³**

4. On-site testing of HEPA / ULPA filters

4.7 Filter class – Filter penetration – Maximum leak penetration

Filter class EN 1822	Max. integrale MPPS-penetration [P_S]	Maximum leck-penetration [P_L]	Factor K
H 13	≤ 0.05%	≤ 0.5%	10
H 14	≤ 0.005%	≤ 0.05%	10
U 15	≤ 0.0005%	≤ 0.015%	30
U 16	≤ 0.00005%	≤ 0.005%	100
U 17	≤ 0.000005%	≤ 0.0015%	300

Seminar „Strategy & Benefits of Clean Air for HVAC, Indoor Air Quality (IAQ) and Clean Rooms", Singapore 14th of May 2002

Introduction into Gas Filtration

Dr. Jost Kames; Group Product Management Gas Filtration;
McLeod Russel Filter AG, CH-8635 Uster (ZH)

Carlton Singapore

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Content of the presentation

- Characteristic of Gases
- Mechanisms of Gas Separation
- Characteristic of Sorption & Sorbents
- Efficiency of Gas Filtration
- Modelling & Prediction of Efficiency of Gas Filtration
- Application of Gas Filtration Systems
- Optimisation of Gas Filtration Systems

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Definition of „Gas"

The word „gas" is derived from greek „cháos" = „empty room"

- A large number of atoms or molecules for which the size is very small compared to the mean distance to each other
- The molecules are in a constant, chaotic motion
- Each individual molecule travels and behaves totally independent from the others

To „filter" gases means to „organize" a large number of individuals

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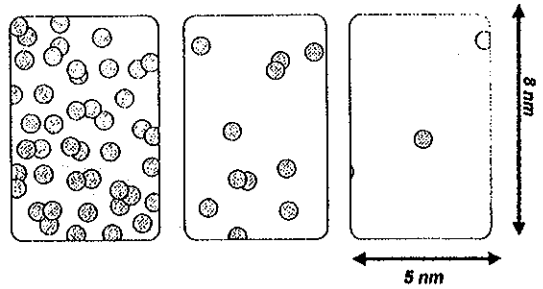
Characteristic of „Gas"

Samples of Argon (Ar) gas at 1, 10 and 30 atm pressure



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Comparison – „structure" in a macroscopic view

Volume & weight of 1 mol of a substance (6 10^{23} atoms/molecules)

Substance	Mass (g)	Volume (ml)
Nitrogen (gas)	28	24'500
Water (liquid)	18	18
Iron (solid)	56	7

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Typical sizes of gas molecules compared to particles

Compound	Collision cross section (nm)	Diameter (nm)
Helium	0.21	0.52
Nitrogen	0.43	0.74
Carbon dioxide	0.52	0.81
Benzene	0.88	1.1
particle		50 - 1000

Gases are not „very small particle – they are very different

Introduction_to_Gasfiltration.ppt, JK, 24.04.2002 8

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Definition of Gasfiltration

Separation (unwanted) gases from other (bulk) gases

Separation from hydrogen sulfide from natural gas (methane)

Separation of helium gas from natural gas

Very often: Separation of unwanted trace gases from air

Odorous gases (Comfort, Acceptance, Wellness)

Toxic gases (Health)

Corrosive gases (Economic losses)

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Definition of Gasfiltration

Separation (unwanted) gases from other (bulk) gases

Features that distinguish gases from particles:

- The individual gas molecules are very small (some nm)
- They are often „same sized"
- They do not have any „mechanical property"
- They are normally not electrically charged

No mechanical or electrical effect can be applied to separate gases

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Which mechanisms can be used to separate gases?

Forced intermolecular attraction

Use the difference of intermolecular attraction

If gas molecules come to a ***close contact***

Change molecular characteristic by chemical reaction

Use the different ***chemical reactivity*** of gases

If they come ***close*** to a potential reaction partner

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Which mechanisms can be used to separate gases?

Features of the bulk gas „air" (nitrogen & oxygen)

These gases have very low intermolecular attraction (e.g. low boiling point, - 190 °C

These gases are non-reactive under normal atmospheric conditions



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How to achieve „close contacts" & „reactions" ?

Create „attraction" by offering favorable sites to rest





Adsorption: Process of transfering molecules from the gas phase onto a solid phase, forming surface covers a liquid films

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How to achieve „close contacts" & „reactions" ?

Create an „unresistable offer" in sufficient quantity





Chemisorption: Process of transfering a gas to an immobilized compound by chemical reaction on surface (e.g. acid/base reaction)

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How to achieve „close contacts" & „reactions" ?

Gases are attracted by surfaces

How to provide large surface areas in a small volume?

Use *porous* materials with a high *inner surface*

These materials are often called *Adsorbents (or Sorbents)*

Gas filtration means providing the right *Sorbent* in the right System achieve optimum *Gas Separation*

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Performance characteristic of a gas filter - dynamics

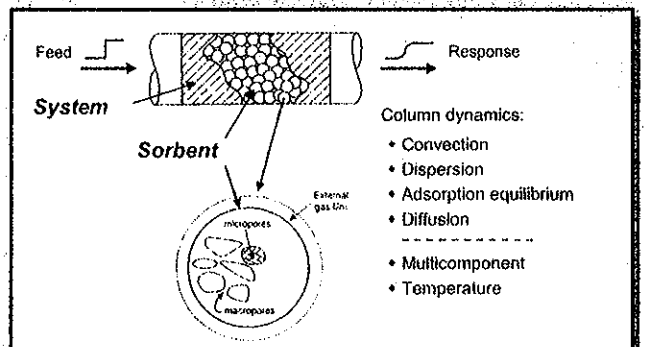

Figure 1: Schematic representation of an adsorption column, showing the most relevant aspects that determine the dynamics

from M. Linders „Prediction of breakthrough curves of AC based systems"

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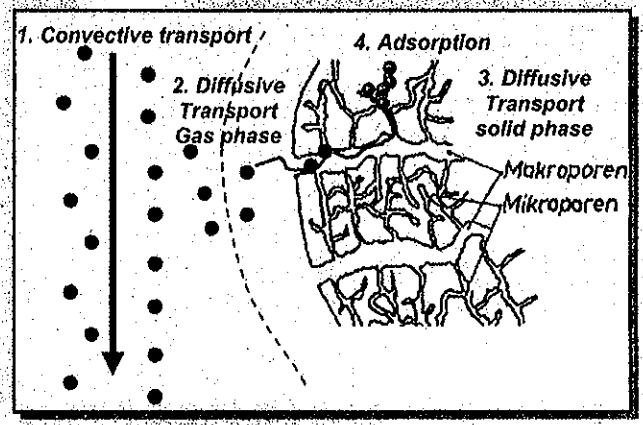
Performance characteristic of a gas filter - dynamics



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Performance characteristic of a gas filter - dynamics

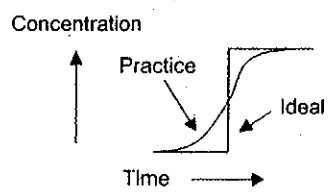

Figure 2: Breakthrough curves of an ideal and practical system.

from M. Linders „Prediction of breakthrough curves of AC based systems"

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Can the efficiency of gas filters be predicted ?

The performance of gas filters can be predicted by transport & sorption models

These models take into account:

- the fundamental sorption steps 1- 4 described by parameters
- the physico-chemical characteristic of the compound to be filtered
- the individual air velocity through the filter & filter material

Note: It is actually not possible to account for every component in complex mixtures & for desorption phenomena

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Can the efficiency of gas filters be predicted ?

In the past predictions („it works") were deduced from
- saturation capacities of activated carbon for compounds
- empirical observations on systems e.g. on „contact time"

These models could not predict:

- dynamic effects in high-air-flow systems
- the performance of systems with „mixed porosity" of the filter bed
- the performance of systems at low concentrations

Note: these models normally overestimate the importance of adsorbent mass due to the need for „contact time"

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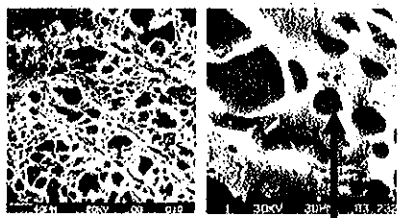
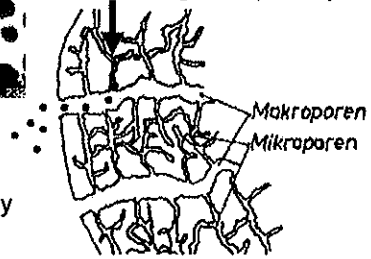
What are suitable sorbents for gas filtration ?

Activated carbon (Adsorption)



Microscopic view:

- material & activation steer the resulting microporosity



Macroscopic view:

- the solid structure of the raw material determines macroporosity

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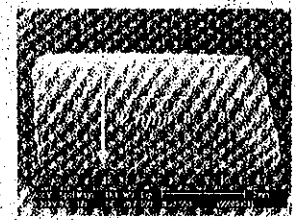
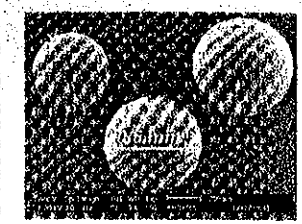
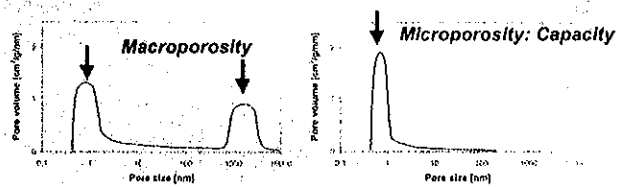
What are suitable sorbents for gas filtration ?

Activated carbon (Adsorption) – Pore size distribution







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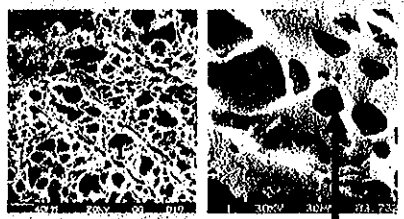
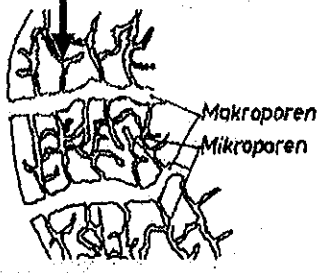
What are suitable sorbents for gas filtration ?

Impregnated Activated carbon (Chemisorption)



Microscopic view:

- gas reacts on surface



Macroscopic procedure:

- load the carbon's pore system with reactive chemical surfactants (salts)

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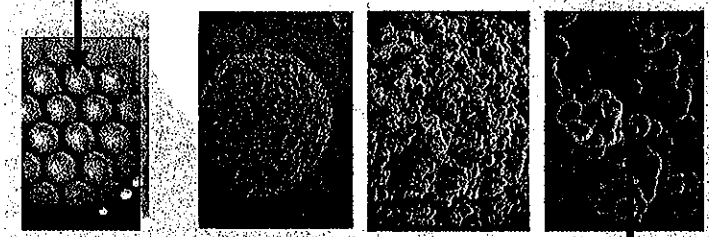
What are suitable sorbents for gas filtration ?

Functional polymers (Chemisorption)

Macroscopic view

- mono disperse spheres, wear resistant highly cross-linked PS



Microscopic view:

- chemically functionalised highly accessible micro spheres,

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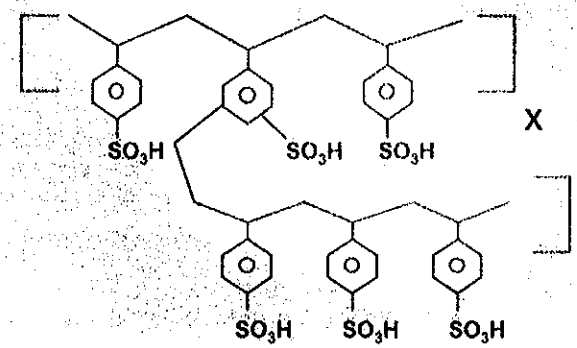
What are suitable sorbents for gas filtration ?

Functional polymers (Chemisorption)

Scheme : Styrene-DVB copolymer with sulfonic group



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What are suitable systems for gas filtration ?

Bulk carbon „canisters"

Easy to produce; low performance/weight ratio, bad TCO

Rather „no fit" with HVAC-systems/Particle filters; dusty

Fixed-bed systems

Composite media; high performance/weight ratio

„Good Fit" with HVAC-systems/Particle filters; non-dusty

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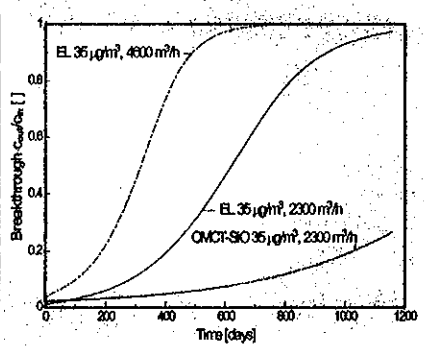
What are suitable systems for gas filtration ?

Fixed-bed systems (example)





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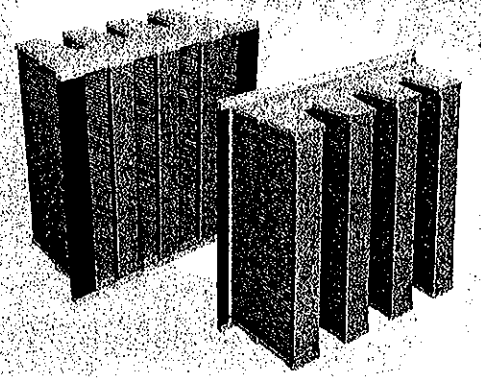
What are suitable systems for gas filtration ?

Fixed-bed systems (AFP- V-cell type filter)



Introduction_to_GasFiltration.ppt; JK, 24.04.2002 26

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How are gas filters characterized and tested ?

The characterization of Gas filters differs strongly from that of Particle Filters

- There are (nearly) no standards for the testing of gas filters
- There will be no classification for gas filters

The individual demands on gas filter applications make standardization & classification nearly impossible

- Therefore characterization and testing is done individually !

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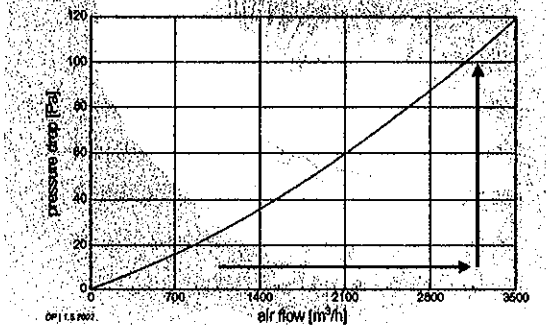
How are gas filters characterized and tested ?

1. Pressure drop: Adaptability to equipment & energy cost



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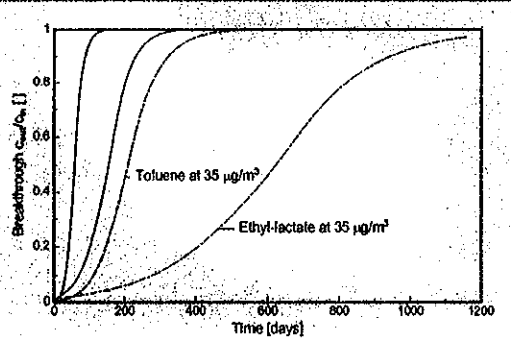
How are gas filters characterized and tested ?

2. Efficiency curve: Performance for target gas & service life



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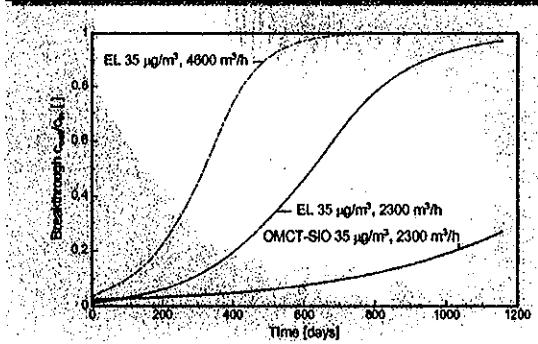
How are gas filters characterized and tested ?

Note: Performance varies with compounds, velocity etc.



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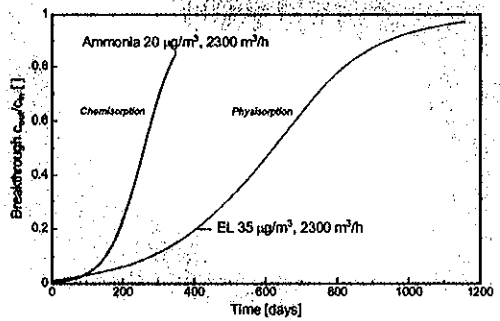
How are gas filters characterized and tested ?

Note: Performance & characteristic varies with mechanism



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How are gas filters characterized and tested ?

What should be the standard know-how after testing?

- *complete pressure drop curve* — for energy cost calculation
- *filter capacity for test substance* — for standard quality control
- *efficiency data for air flows* — for customer application
- *efficiency data for compounds* — for customer application
- *lifetime calculations/estimations* — for customer application

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How are gas filters characterized and tested ?

Note: Some values are *not* suitable to judge on filter performance

- *carbon mass of a filter system* — only a relative measure !
- *contact time of a filter system* — only a relative measure !
- *CTC values of carbon* — Saturated vapor capacity
- *Iodine number of carbon* — External surface influence

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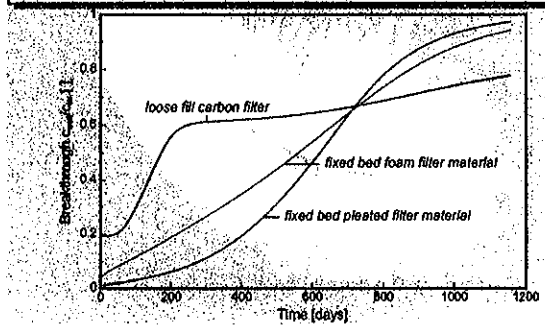
Can the efficiency of gas filters be predicted ?

Clean Room Filter: Size 610 mm x 610 mm; air flow 2500 m³/h; Target Gas: Ethyl-lactate (EL) at 35 µg/m³



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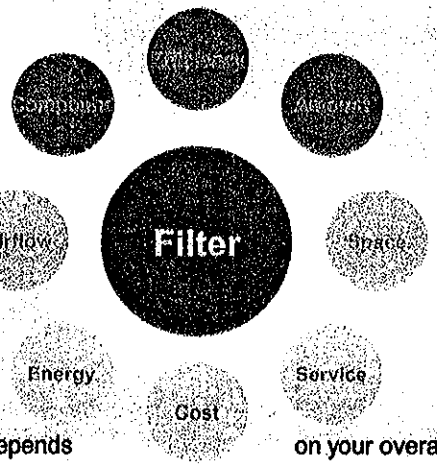
Which is the optimum gas filtration system?



The answer depends on your overall problem!

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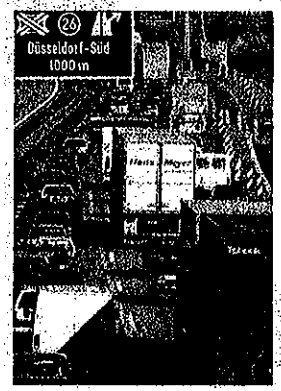
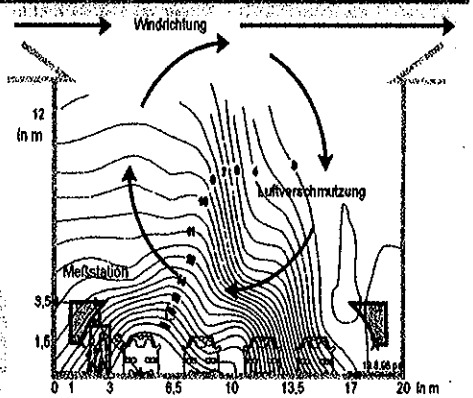
Sources of Gaseous Contaminations (Outdoor Air)

Combustion Processes (Traffic, local heating, Industrial Incineration)





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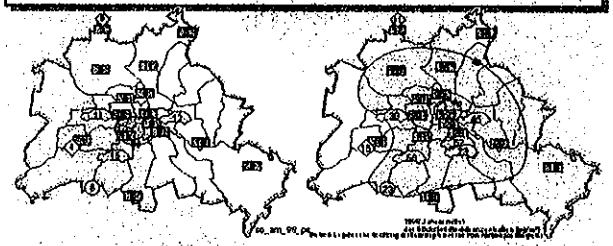
Sources of Gaseous Contaminations (Outdoor Air)

Urban Area (Berlin) – SO_2 & NO_2 as typical products of combustion



SO_2 no longer correlated to traffic density (low sulfur fuel) but NO_2 does

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Sources of Gaseous Contaminations (Indoor Air)

Emission Processes (outgassing, adhesive, paint, cleaner, toner)



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Sources of Gaseous Contaminations (Indoor Air)

Emission Processes (outgassing, adhesive, paint, cleaner, toner)



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Sources of Gaseous Contaminations (Indoor Air)

The most abundant IA Contaminations are due to indoor sources

Toluene	100	Bioeffluent, solvent, vehicles
c-HMT-siloxane	90	Printers, varnishes, sealing compounds
Benzene	90	Vehicles, plastic, rubber solvents, carpets
Benzaldehyde	70	Carpets, building materials
Phenol	70	Bioeffluent, building materials
Pentadecane	70	Carpets, building materials
p-Xylene	60	Adhesives, floor covering, carpets, vehicles
Hexadecane	60	Carpets, building materials
Tetradecane	60	Carpets, building materials
Octadecane	60	Carpets, building materials

A Singapore Case study, Tham et. Al., Healthy Buildings 2000, Vol.1, 449ff

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Which is the optimum gas filtration system?

Segment: Comfort Filtration

Application: Building Ventilation

Examples: Airports, Office Buildings



Pollutants: traffic fumes, material emissions, cleaning agents

Key factors: low concentrations of target gases (odours)
high airflow, high efficiency, low energy cost

Optimum filter solution: V-cell system, AFP-AZ & AFP-AZB

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Which is the optimum gas filtration system?

Segment: Clean Processes

Application: Microelectronic Products

Example: Chip & Display Production



Pollutants: traffic fumes, chemicals

Key factors: low concentrations of gases ABC, high air flow
high efficiency, highly specific filtration, lifetime

Optimum filter solution: V-cell system, AN-AZ, AN-AA, AN-AS

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Which is the optimum gas filtration system?

Segment: Clean Processes

Application: Building Ventilation

Example: Museums & Archives

Pollutants: Internal & external sources



Key factors: low concentrations of corrosive gases, high air flow, high efficiency, specific filtration, lifetime

Optimum filter solution: V-cell system, AFP-AS & AFP-AZ

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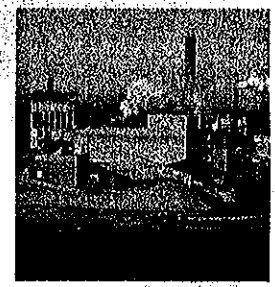
Which is the optimum gas filtration system?

Segment: Clean Processes

Application: Corrosion Protection

Example: Pulp & Paper Production

Pollutants: H2S, SOx, chlorine



Key factors: high concentrations of corrosive gases, low air flow, high efficiency, specific filtration

Optimum filter solution: V-cell impregnated bulk carbon filters

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Which is the optimum gas filtration system?

Segment: Workplace protection

Application: Vehicles

Example: Agricultural machinery

Pollutants: Pesticide spray



Key factors: low concentration of harmful substances
low air flow, high efficiency, safe service life

Optimum filter solution: combined HEPA and fixed bed carbon systems (customized solutions including housing)

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Introduction into Gas Filtration

Thank you for your attention !

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The range of Luwa FP, N and CR particle filter

Johan Bergdahl
Export Sales Manager

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The Luwa Range of Filters

The main products for particle filtration...

- Luwa filter type FP
- Luwa filter type CR
- Luwa filter type N

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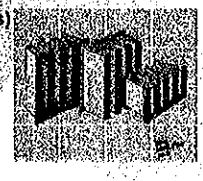
The Luwa FP Filter Range



- Fine Dust Filter F6 – F9 (substitute to bags)
- Avialable as Ultrafilter HEPA H10 – H13
- 25 mm header frame
- Airvolume up to 5000 m3/h
- Reverse airflow possible
- Pressure drop, 3400 m3/h; - F6 = 65 Pa
  - F7 = 70 Pa
  - F8 = 95 Pa
- Up to 1500 Pa without burst
- 4 Sizes 610 x 305 / 420 / 508 / 610 mm, deep = 300 mm
- Max temperature 75 degrees / 120 degrees (HT)
- Low weight – rigid frame – large surface – low initial pressure drop

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The Luwa FP Filter Range

Leaflets for type FP

- No. 42.11.01 / 03.1998 for FP Fine Dust 2 pages
- No. 42.12.01 / 10.2000 for FP Ultrafilter 2 pages
- No. 42.18.11 / 11.1999 for F frames 4 pages

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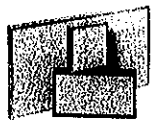
The CR HEPA & ULPA Filter Range

- The standard CR filter range
- The special CR filter range for the Microelectronics industry



Setting the Quality Standard

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The standard CR filter range

Main features

- Initial efficiency from 99 % to 99.999997 % DEHS for MPPS
- Low pressure drop - reduced energy consumption
- Optimised velocity distribution
- Various frame types and sizes
- 2 face guards and anodised aluminium frame
- Integrated one-piece half-round, gel or knife edge gasket
- Mechanically stable
- Guaranteed leak-free
- Certified quality: Luwa ULPACATS tested to EN 1822

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The standard CR filter range

Product designations

Order Code | Order example | Special versions

CR-AL-U16-610 x 610-(D)

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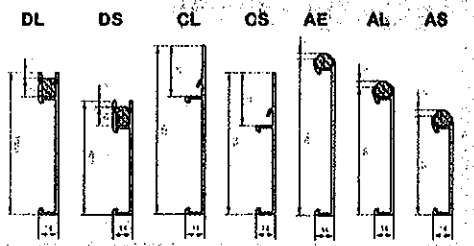
The standard CR filter range

Available Aluminium frames - standards



..other frame types are avilliable

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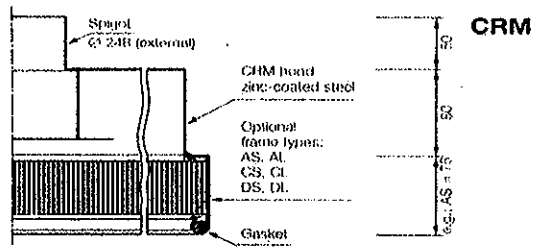
The standard CR filter range

CRM hooded filter module



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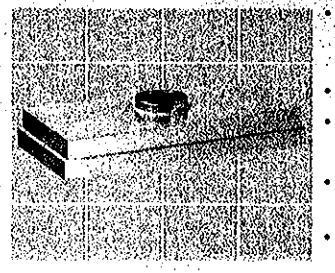
Luwa CRM Filter Module



The versatile terminal filter for Clean Room applications

- Factory-sealed filter air outlet with spigot and face guard - Ready to be installed
- Total height only 150 mm
- Filter classes H13 up to U17 as per EN 1822
- Various filter pleating heights, frame types and sizes
- Integrated one-piece foam-, gel- or knife-edge seal
- Fully automatic ULPACATS test - Leaves nothing to chance - Guaranteed leak-free

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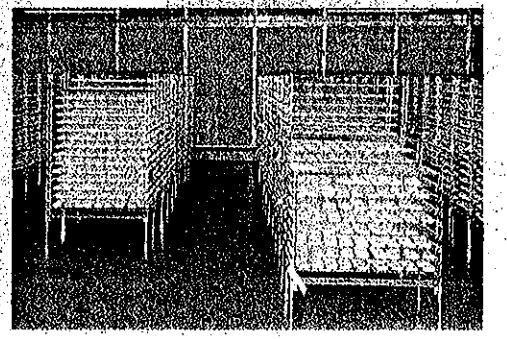
CR HEPA filters in use in food industry

For example in a cheese factory



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CR HEPA filters in use in chemical industry

For example in precision foil making



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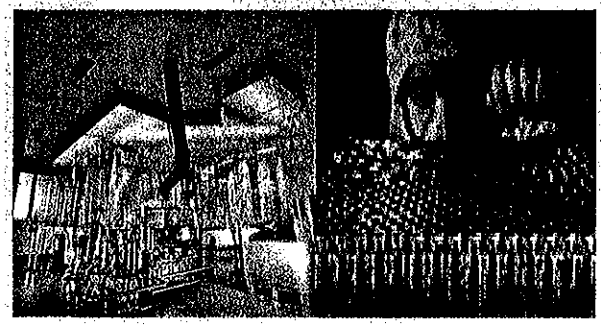
CR HEPA filters in Pharmaceutical Industry

For example in ampoule filling



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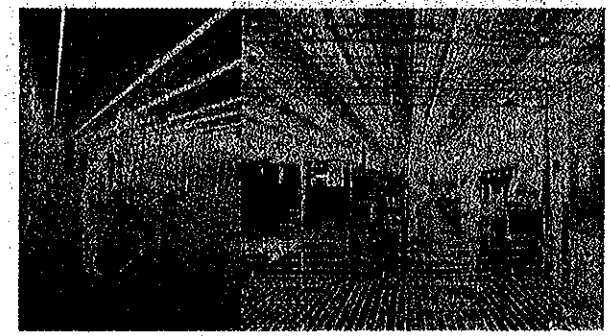
CR ULPA filters in Microelectronics Industry

For example testing/manufacturing in a yellow room



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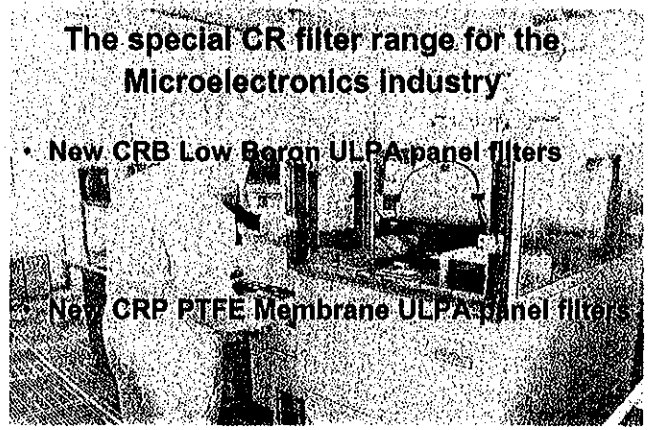
The special CR filter range for the Microelectronics Industry

- New CRB Low Boron ULPA panel filters
- New CRP PTFE Membrane ULPA panel filters



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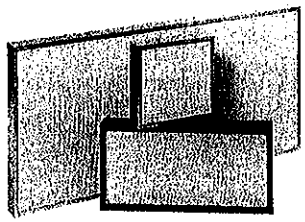
CRB Low Boron and CRP PTFE Membrane ULPA filters for Microelectronics Industry

Low Boron ULPA filters:
To reduce the AMC of Boron in Clean Rooms

PTFE-Membrane ULPA filters:
A future need for critical wet-process areas in Clean Rooms



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The CR HEPA & ULPA filter range

Leaflets for type CR

• No. 44.11.11/09.1997	for all CR Ultrafilters	8 pages
• No. 44.11.01/03.2000	for CRB and CRP filters	2 pages
• No. 47.14.01/04.1998	for CRM Filter Modules	2 pages

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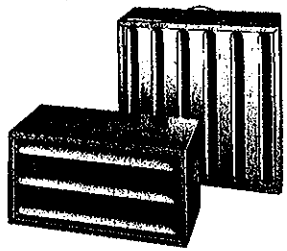
The Luwa N Filter Range

- The Space and Energy Saver
- HEPA and ULPA Filters for Duct Installation



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The Luwa N Filter Range

Main Features

- Airflow up to 4000 m³/h - Efficiencies up to 99.9998 %
- Filter classes from F7 (EN 779) to U15 (EN 1822)
- Large filter medium area gives long life service - reduced maintenance and service cost
- Low pressure drop - reduced energy consumption
- Guaranteed leak-free
- Fully automatic Luwa ULPACATS test available - leaves nothing to chance
- Rigid metal frame, robust construction - minimum risk of damage
- Compact space saving design - lower cost for housing
- 4 standard sizes 762, 610, 305 and 205, all with integrated handle

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Luwa Ultrafilter N
THE SAVER

Saves Space by:	Saves Energy by:	Saves Cost by:
Up to 4000m³/h of air per unit	Pressure drop 250 Pa at nominal flow	Large filter media area (40 m²) up to 4 times longer life
No of filter units and casings can be halfed Saves investment cost	Low pressure drops compared to traditional design - Cuts energy cost down to 50 %	Rare and easy filter changes - less maintenance
205-, 305-, 610- and 762 x 610 mm face dimensions available		Rigid one piece metal frame - reduced risk of damages
Corresponding NSC casings available		Leak tested and guaranteed leak free

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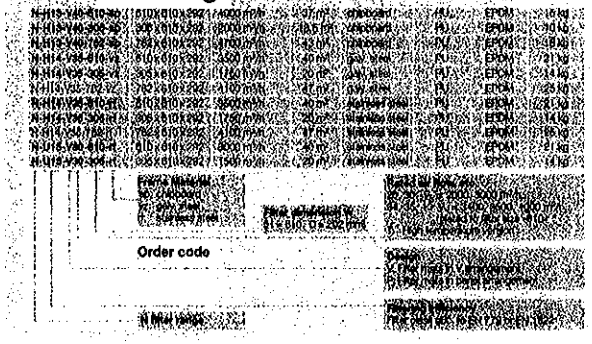
The Luwa N Filter Range

Product designations



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The Luwa N Filter Range

Leaflets for type N

- No. 43.11.11 / 05.2000 for all N filters 4 pages
- No. 43.14.11 / 06.2000 for NG housings 4 pages
- No. 43.15.11 / 02.1998 for NF frames 4 pages
- No. 43.13.11 / 01.1995 for NSC housings 6 pages

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The Luwa Filter Range

Other standard products.....

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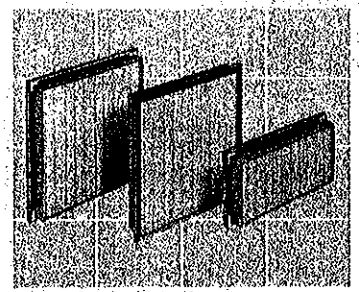
Luwa Fine Dust Filter FP-P



- Nominal air flow up to 3000 m^3/h per cell
- Low pressure drop - Maximum economy
- Large filter area (6.5 m^2) - Long service life
- Glass fibre paper - no fibre loss - No dust migration
- Light weight - Minimal installation depth of 88 mm

The superior solution - Filter classes F6 to F9, EN 779

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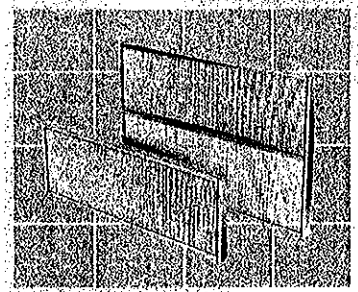
Luwa Ultrafilter P



- Filter classes H10 up to H13 as per EN 1822
- Economic solution for industrial class 10'000 clean rooms (US Fed Std. 209 E)
- Long life thanks to large filter area
- Fits into the versatile Luwa P-Duct System
- Low frame height - Only 23 mm

The cost effective solution for clean air

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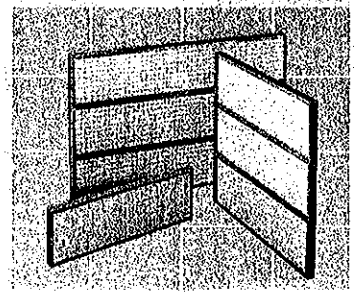
Luwa Ultrafilter PL



- Filter classes H11 and H13 as per EN 1822
- Long life thanks to large filter area
- Fits into Luwa Filtrasept air outlets
- 100% leak-tested - Guaranteed leak-free
- Aluminium frame of low height - Only 30 mm

The compact solution for highly pure air

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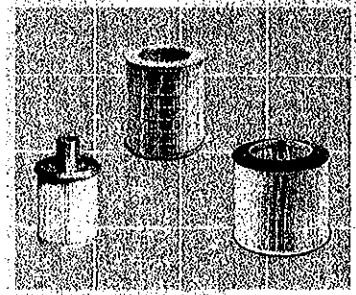
Luwa JG, JK, JP Ultrafilter



- Filter classes F9 up to H13
- Compact, space saving design - For small air flows
- Minimum pressure drop
- Simple to install - Versions with integrated casing available
- Corrosion resistant type (JK) with plastic casing (JKG)
- High final pressures and tear resistance
- Individually tested and leak-free

Cylindrical HEPA filters

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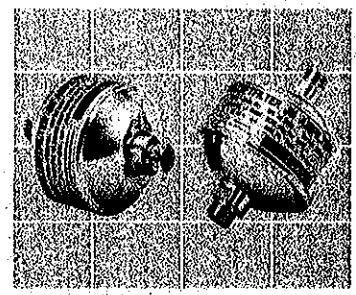
Luwa JM Sterile Air Filter



- MPPS-Efficiency 99.99998 % Class U16 as per EN 1822
- Compact and robust design
- Extremely save due to mechanically supported, two stage filter elements
- Compact stainless steel case Pressure resistant to 10 bar
- Individually tested for leaks and gas tightness at 6 bar

Compressed air in highest cleanliness

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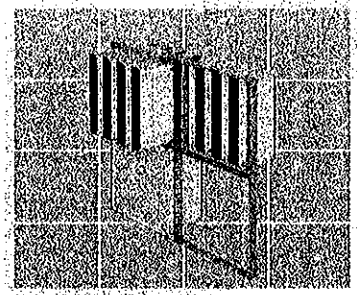
Luwa F Front Withdrawal Frame



- Simple and robust
- Gas tight welded mitre cuts - Suitable for filter classes up to H13 (EN 1822)
- All stainless steel version - Corrosion resistant
- Multiple assemblies possible for large air flows
- Suitable for „Dual Phase" filter combinations
- Combinations of pre- and final filters may be installed

Installation frame for coarse and fine-dust filters

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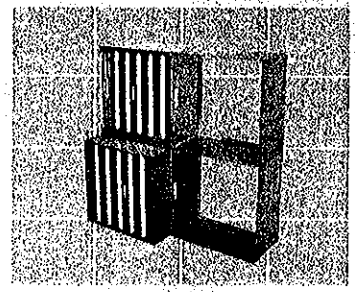
Luwa NF Front Withdrawal Frame



Wall frame for Luwa N style Ultrafilters

- Gas tight welded frames
- Built-in gasket sealing test groove (as per DIN 1946)
- All stainless steel corrosion resistant version
- Simple and robust
- Multiple assemblies for large air flows possible
- Built in pressure drop measuring device

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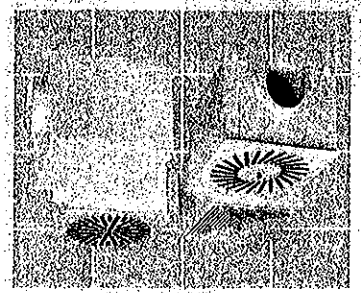
Luwa Filtrasept



HEPA filter air outlets for ceilings and walls

- 9 combinable casing sizes
- Many types and brands of air outlets can be attached
- Built-in gasket sealing test groove (as per DIN 1946)
- Built-in pressure drop measuring device
- Built-in, air tight (DIN 1946) shut of valves available
- Low overall height - Handy circular duct connections
- Easy maintenance from room side

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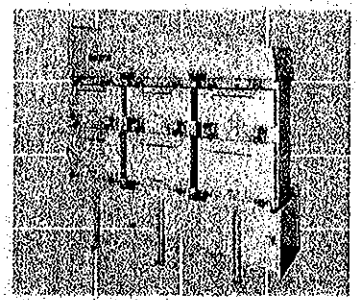
Luwa NSC Safe Change Housing



Containment system for contamination-free filter exchange

- Fully gas tight welded casing Highly rigid, shock and vibration resistant
- Operating pressure guaranteed up to ± 8000 Pa
- Built-in gasket sealing test groove (as per DIN 1946)
- Self-adjusting filter spring loaded sealing mechanism
- Practical, versatile modular system
- Comprehensive range, with various accessories

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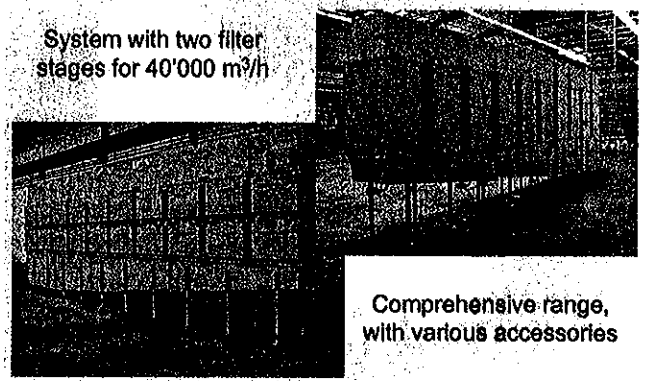
Luwa NSC Safe Change Housing

System with two filter stages for 40'000 m³/h



Comprehensive range, with various accessories

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Seminar „Strategy & Benefits of Clean Air for HVAC, Indoor Air Quality (IAQ) and Clean Rooms", Singapore 14th of May 2002

AMC (Airborne Molecular Contamination) in Microelectronic Industry – Classification, Sources & Reduction Strategy

Dr. Jost Kames; Group Product Management Gas Filtration;
McLeod Russel Filter AG, CH-8635 Uster (ZH)

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Content of the presentation

- Definition of AMC
- Classification of AMC as per SEMI F 21-95
- Effects and Critical Targets as per SEMI Roadmaps
- The Practice – Fab Situations
- Sources - Modelling & Prediction of Contribution
- AMC Mitigation Concepts
- AMC Projects – from Proposal to Approval

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Definition of „AMC"

AMC = *A*_irborne *M*_olecular *C*_ontamination

Airborne: The substance is normally in the gas phase

Molecular: It is a gas as it is a single molecule

Contamination: Substance is unwanted in the indoor air

Potential damage is the decrease of the overall product yield in the multistep manufacturing process

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Qualitative Classification of AMC per SEMI F 21-95

SEMI F 21-95 forms Categories of Compounds

Acids: Proton donors and precursors (e.g. HCl, SO_2)

Bases: Proton acceptors (e.g. NH_3, Me_3N, NMP)

Condensables:Compounds with bp > 150 °C (BHT, NMP, ...)

Dopants: able to change the electrical properties of Si

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Quantitative Classification of AMC per SEMI F 21-95

SEMI F 21-95 defines Categories of AMC-Contamination level

Class Category	1 ppt_M	10 ppt_M	100 ppt_M	1000 ppt_M	10'000 ppt_M
Acids	MA-1	MA-10	MA-100	MA-1'000	MA-10'000
Bases	MB-1	MB-10	MB-100	MB-1'000	MB-10'000
Condensables	MC-1	MC-10	MC-100	MC-1'000	MC-10'000
Dopants	MD-1	MD-10	MD-100	MD-1'000	MD-10'000

M- classes: maximum allowable cumulative concentration

Analogous to the known classification on particle cleanliness

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Classification of AMC per SEMI F 21-95

Problems of SEMI F 21-95 classification

Causality: little relation of M-classes to damage e.g. *C*

Bases: Proton acceptors (e.g. NH_3, Me_3N, NMP)

Condensables: Compounds with b.p. > 150 °C (BHT, NMP, ..)

Fab layout: Is individual as the interference of processes

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Classification of AMC per SEMI F 21-95

Acids
NO_x HBr HCl SO_x HF
HNO_3 H_2SO_4 H_3PO_4 H_3BO_3

Bases
NH_3 NMP Amines
Trimethyl-silane

Condens-ables MEP TEP
b.p. >150°C
HMDS BHT
DOP Siloxanes

Dopants
BF_3
Organo Phosphates
B P Arsenates

a belong to more than one class

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Critical Processes & Effects as per SEMI-Roadmap

SEMATECH Roadmap of AMC-limits for 250 nm process (1995)

Process Step	Projected AMC limits [pptM]				
	Sit time [h]	MA	MB	MC	MD
DUV-Lithography	2	10'000	1'000	100'000	10'000
Pre-Gate oxidation	4	13'000	13'000	1'000	0.1
Salicidation	1	180	13'000	35'000	1'000
Contact Formation	24	6	13'000	2'000	100'000

Not concentration, but dose to surfaces is causing problems

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Critical Processes & Effects as per SEMI-Roadmap

SEMATECH Roadmap of AMC-limits for 250 nm process (1995)

Process Step	Subjected AMC effects on wafer	
	AMC	Concern
DUV-Lithography	NH3	e.g. "T"-topping
Pre-Gate oxidation	Dopants	e.g. un-intentional doping
Salicidation	Acids	e.g corrosion
Contact Formation	Acids, VOC	e.g. corrosion, hydrophobization

Defect probability increases with number of process steps

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Critical Processes & Effects as per SEMI-Roadmap

SEMATECH Roadmap of AMC-limits for < 250 nm (1999)

Year width	2002 130 nm	2005 100 nm	2008 70 nm	2011 50 nm	2014 35 nm
Particle d/count	65 nm/5 m^{-3}	50 nm/2 m^{-3}	35 nm/1 m^{-3}	25 nm/1 m^{-3}	18 nm/1 m^{-3}
Bases	750 ppt	750 ppt	< 750 ppt	< 750 ppt	< 750 ppt
VOC's	100 ppt	70 ppt	70 ppt	70 ppt	50 ppt
Acids	10 ppt	10 ppt	10 ppt	10 ppt	10 ppt
Dopant	< 10 ppt	< 10 ppt	< 10 ppt	< 10 ppt	< 10 ppt

Dopants less important, A, B, C much more important

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Critical Processes & Effects in Practice

In practice demands for AMC-target levels are very individual

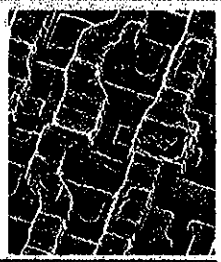
The processes are not identical

The „accepted practice" is individual

The environmental conditions differ

The clean room layouts vary

The situation on „tools" is different



As a consequence the „System Requirements" are individual!

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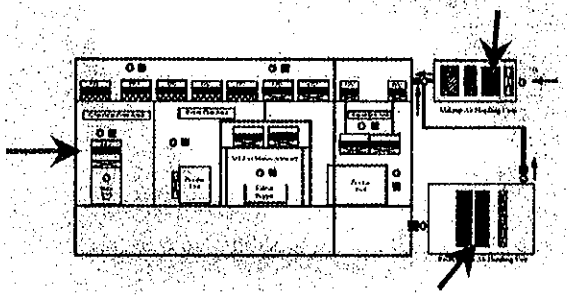
Critical Processes & Effects in Practice

Sources & Air Handling situation determine the AMC-concept



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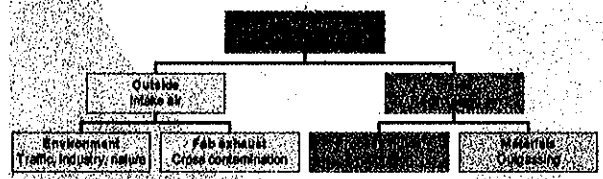
Which sources are dominant for the AMC-level

Many sources contribute in a qualitative sense to AMC level



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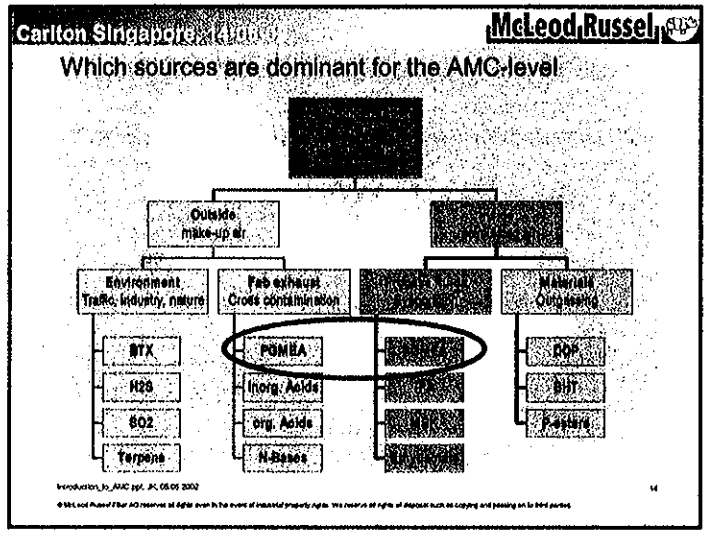
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Which sources are dominant for the AMC-level
Outside make-up air
Environment Traffic, industry, nature
Fab exhaust Cross contamination
Materials Outgassing
BTX
H2S
SO2
Terpene
PGMEA
Inorg. Acids
org. Acids
N-Bases
DOP
BHT
P-esters
Introduction_to_AMC ppt. JK, 05.05.2002
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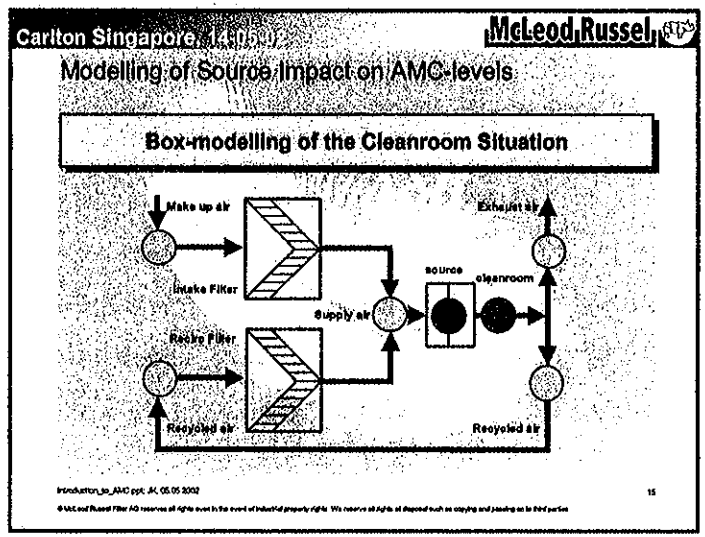
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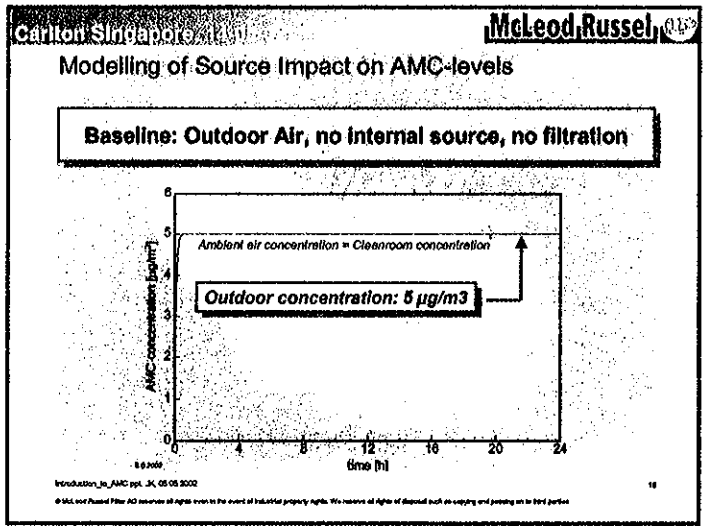
Modelling of Source Impact on AMC-levels
Box-modelling of the Cleanroom Situation
Make up air
Intake Filter
Recirc Filter
Recycled air
Supply air
source
cleanroom
Exhaust air
Recycled air
Introduction_to_AMC ppt. JK, 05.05.2002
15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Modelling of Source Impact on AMC-levels
Baseline: Outdoor Air, no internal source, no filtration
Ambient air concentration = Cleanroom concentration
Outdoor concentration: 5 µg/m3
AMC concentration [µg/m³]
time [h]
Introduction_to_AMC ppt. JK, 05.05.2002
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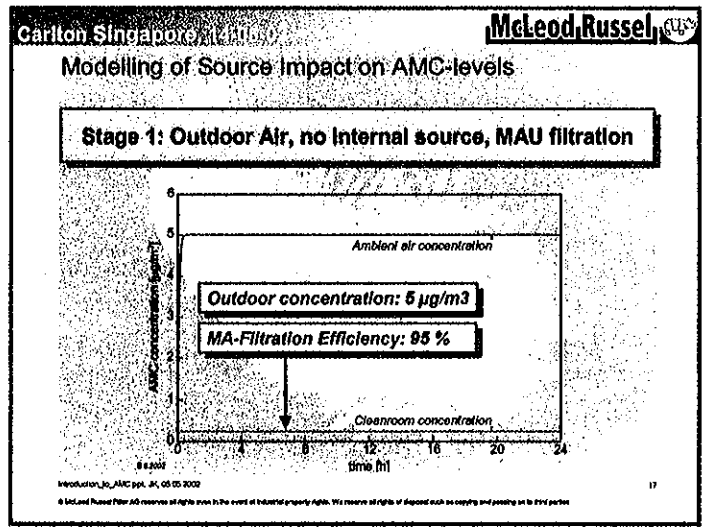
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Modelling of Source Impact on AMC-levels
Stage 1: Outdoor Air, no internal source, MAU filtration
Ambient air concentration
Outdoor concentration: 5 µg/m3
MA-Filtration Efficiency: 95 %
Cleanroom concentration
AMC concentration [µg/m³]
time [h]
Introduction_to_AMC ppt. JK, 05.05.2002
17

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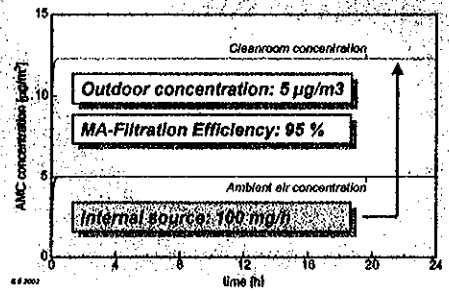
Modelling of Source Impact on AMC-levels

Stage 2: Outdoor Air, Internal source, MAU filtration



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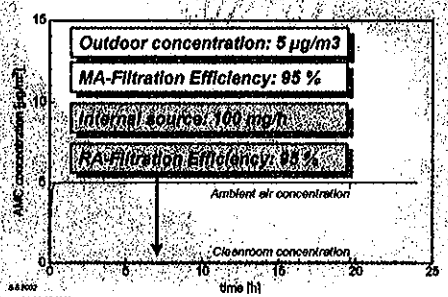
Modelling of Source Impact on AMC-levels

Stage 3: Outdoor Air, Internal source, MAU/RAU filtration



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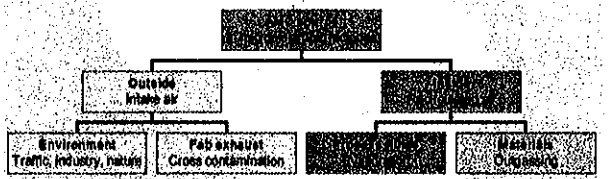
Modelling of Source Impact on AMC-levels

Very often internal sources are dominant for AMC level



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Mitigation Concepts for low AMC level

Source Control – primary concept for low AMC levels

"Natural" outdoor source:	Check environmental conditions
Man-Made outdoor source:	Proper effluent abatement
Indoor source "materials":	Low outgassing material
Indoor source "process":	Spills, use of process chemicals

Uncontrolled sources sets the best AMC-filter to "no perform"

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Mitigation Concepts for low AMC level

Traffic & Fab Exhaust – a Problem for Make-up Air (MAU)

Compound	RAU 1 [µg/g filter]	RAU 2 [µg/g filter]	[illegible]
Toluene	43	404	1740
Ethyl-lactate	3165	60	1375
PGMEA	210	6684	9895
m,p-Xylene	26	138	3395
o-Xylene	13	36	1356
Trimethyl-benzene	28	12	1286
Undecane	< DL	< DL	583
Dodecane	< DL	< DL	369
Tridecane	< DL	10	186

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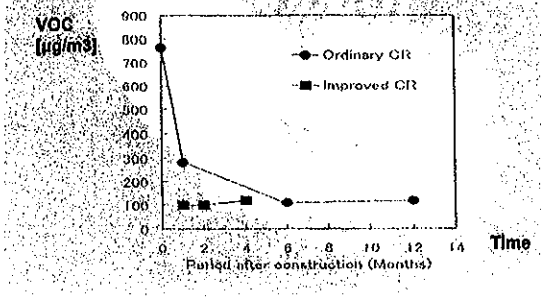
Mitigation Concepts for low AMC level

Material emission – a problem for new cleanrooms



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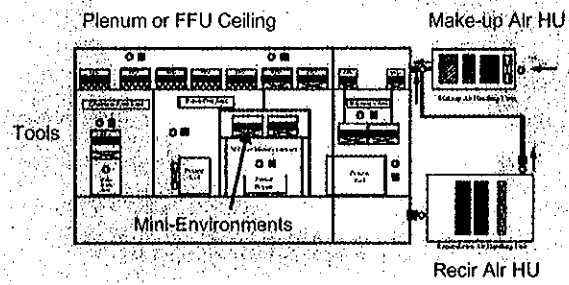
Mitigation Concepts for low AMC level - customizing

AMC-Filtration concepts – problem oriented solutions



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Mitigation Concepts for low AMC level – design criteria

Different demands on Chemical Filters per Application

Type	Make-up Air HU	Recirc-Air HU	Tool
Air flow treated	Low	High	Very low
Particulate Class	Ambient/Max. H 13	Class 1	Class 0.1
Efficiency	High/medium	High/medium	High
Outgassing	Not very important	Important	Very important

Filter products are to be designed to the important factors

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Mitigation Concepts for low AMC levelm - focus

Predominance of certain AMC-concern per unit

Type	Make-up Air HU	Recirc-Air HU	Tool
Acids	●	●	●
Bases		●	●
Condensables	●	●	●
Dopants		●	●

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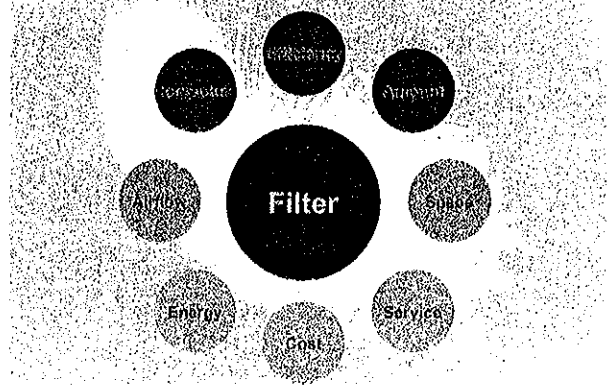
Mitigation Concepts for low AMC level – Filter choice



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Which is the optimum gas filtration system?

- Segment: Clean Processes
- Application: Microelectronic Products
- Example: Chip & Display Production
- Pollutants: traffic fumes, chemicals



Key factors: low concentrations of gases ABC, high air flow
high efficiency, highly specific filtration, lifetime

Optimum filter solution: V-cell system, AN-AZ, AN-AA, AN-AS

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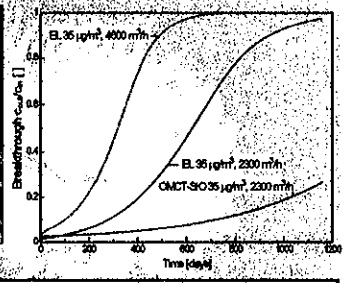
AN-type V-shape filters from fixed-bed pleated media

High efficiency Carbon-non-woven composites





Performance data can be modelled for new situations

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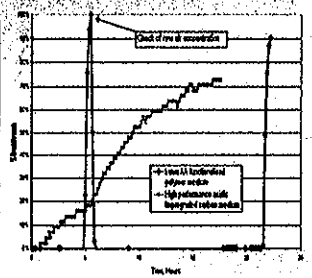
AN-type V-shape filters from fixed-bed pleated media

Multiple layer materials from high performance adsorbents





Media designed to treat mixed AMC-atmospheres

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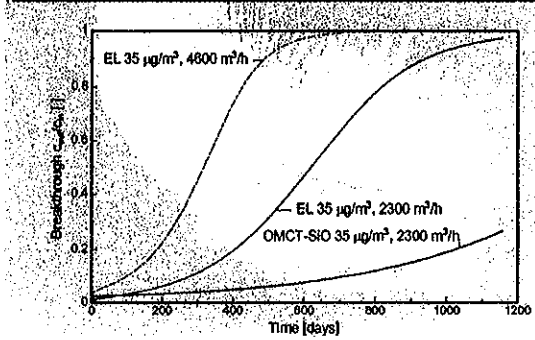
Performance of AMC-concepts - Calculations

Velocity dependant efficiency curves form the model basis



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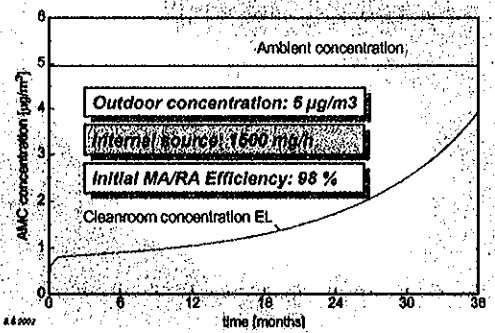
Performance of AMC concepts - Calculations

A sound AMC-concept includes lifetime calculations



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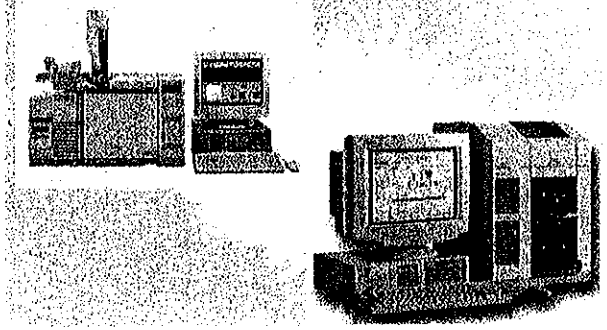
Approval and control of AMC-concepts

Performance of AMC filters should be monitored routinely



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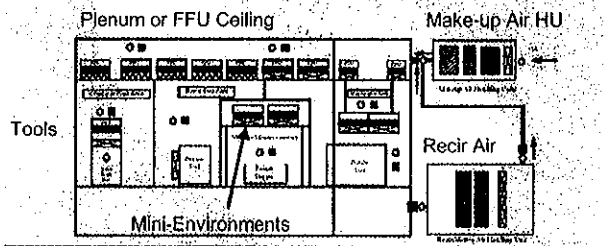
Flexibility of AMC-concepts

What is sufficient today may have to be improved tomorrow.



Stay modular – stay flexible – stay open for development

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AMC (Airborne Molecular Contamination) in Microelectronic Industry – Classification, Sources & Reduction Strategy

Thank you for your attention !

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The range of Luwa AFP and AN Gas filter

Johan Bergdahl
Export Sales Manager

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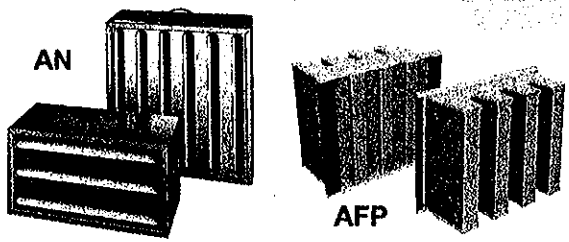
The Luwa Range of Gas Adsorption Filters

For the elimination of gaseous contaminants in the re-circulated or intake air



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The Luwa Range of Gas Adsorption Filters
Comparison of the main technical data

AFP filters
- AFP-AZ-610/-508/-420/-305
- AFP-AS-610/-508/-420/-305
- AFP-AA-610/-508/-420/-305

AN filters
- AN-AZ-610 / -305
- AN-AS-610 / -305
- AN-AA-610 / -305

AFP-...-610
- Nom. air flow 1700 m³/h
- Pressure drop 20 Pa
- Max. air flow 3400 m³/h (HVAC applications only)
- Filter weight 7.6 kg
- Adsorbent mass 4.8 kg

AN-...-610
- Nom. air flow 2750 m³/h
- Pressure drop 60 Pa
- Max. air flow 5000 m³/h (HVAC applications only)
- Filter weight 26 kg
- Adsorbent mass 8.8 kg

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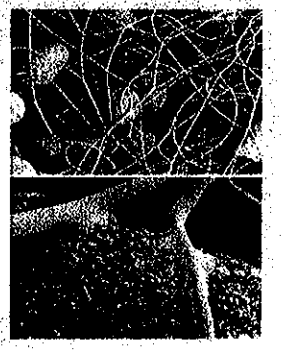
The Luwa Range of Gas Adsorption Filters

Main Features
- High efficiency (>90%) – and,
- Long, predictable service life – both laboratory verified
- Lowest pressure drop
- Non dusting due to immo-bilised adsorptive media
- Specific filter media types for VOC's, acids and bases
- Unique AS dual layer media for wide acidic gas spectrum
- Unique AA dual layer media: ion-exchange polymer & carbon



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Luwa Gas Adsorption Filters AN- / AFP-AZ

- To filter VOC's and Condensables in Microelectronics industry (e.g.: DOP, BHT, Siloxanes, etc.)

Technical data		AFP-AZ-305	AFP-AZ-610
Max. air flow $\dot{V}_M$ (short service life)	m³/h	1700	3400
Pressure drop at $\dot{V}_M$	Pa	70	65
Rated air flow $\dot{V}_R$ (long service life)	m³/h	850	1700
Pressure drop at $\dot{V}_R$	Pa	25	20
Total weight of filter	kg	4.3	7.6
Activated carbon net weight	kg	2.2	4.8
Filter medium area	m²	4.7	10.3
Adsorpt. capacity[1] at $\dot{V}_R$ for Toluene*	ppb·h	43'135	95'760
Initial efficiency at $\dot{V}_R$ for Toluene	%	97	97

[1] down to 70% efficiency at 23 °C and 50% relative humidity

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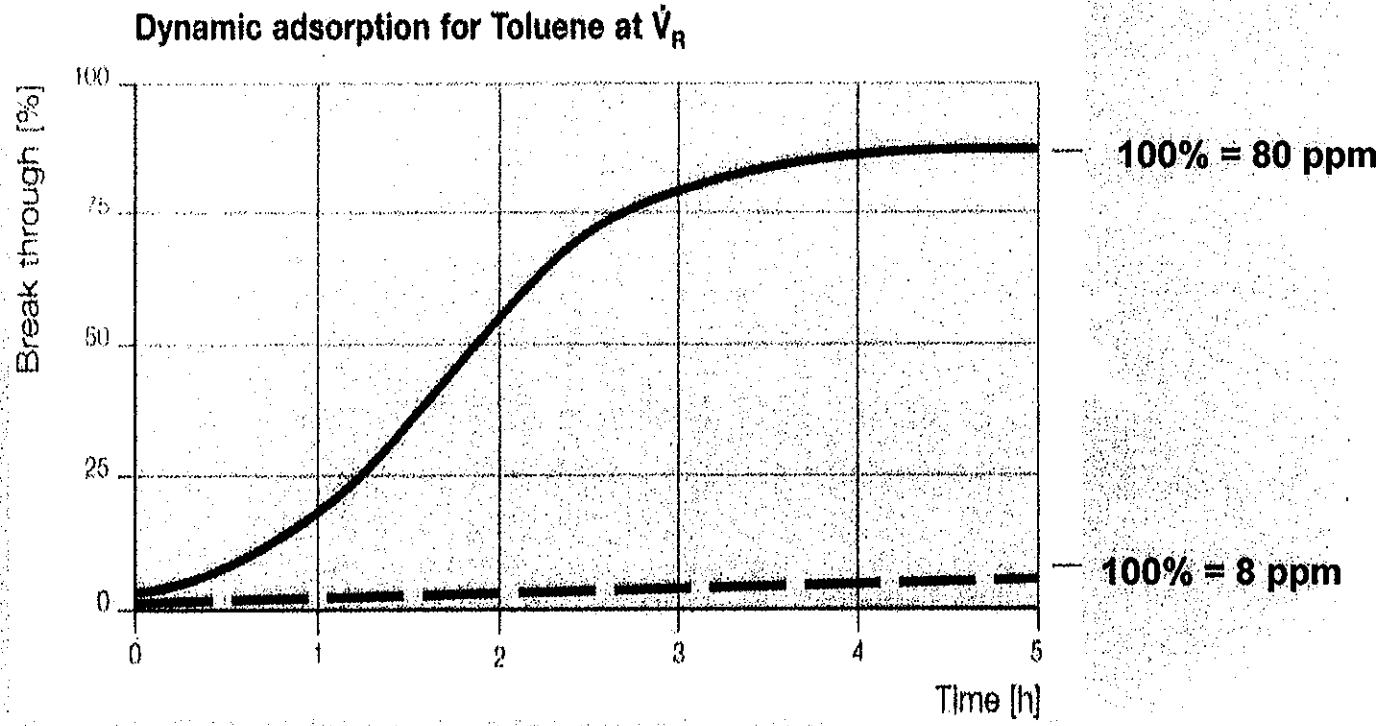
Luwa Gas Adsorption Filters AN- / AFP-AZ

- To filter VOC's and Condensables in Microelectronics industry (e.g.: DOP, BHT, Siloxanes, etc.)



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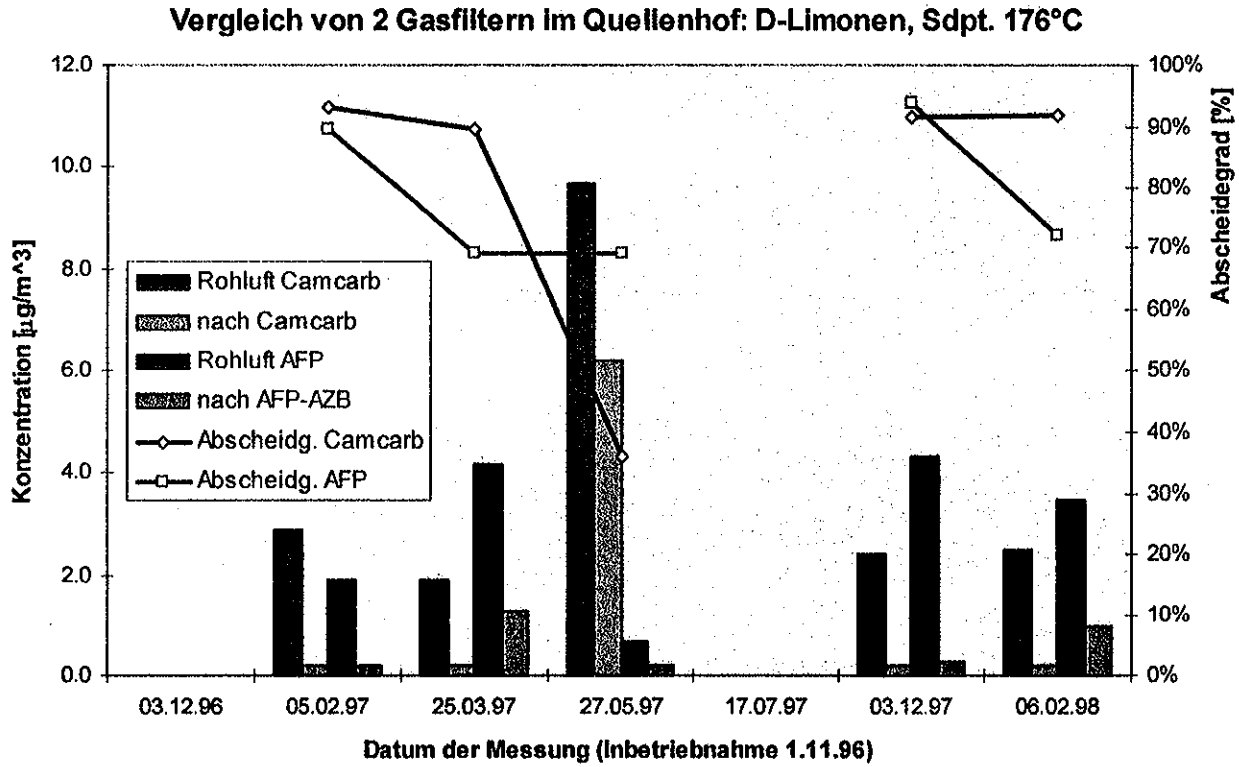
Luwa Gas Adsorption Filters AN- / AFP-AZ

Efficiency comparison of Luwa AFP to granulated cartridges



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Luwa Gas Adsorption Filters AN- / AFP-AZ

Comparison of Luwa AFP to Granular Cartridges: Energy

Filter type	Granular Cart.	Luwa AFP-810	Luwa AN-810
Weight	67 kg	11 kg	29 kg
Air flow	1700 m^3/h	1700 m^3/h	1700 m^3/h
	3000 m^3/h	3000 m^3/h	3000 m^3/h
Pressure drop	70 Pa	20 Pa	20 Pa
	160 Pa	50 Pa	75 Pa
Energy per year	4'826 kWh	1'380 kWh	1'380 kWh
	11'030 kWh	3'447 kWh	5'170 kWh
Cost of energy	426.- $/y	121.- $/y	121.- $/y
	973.- $/y	304.- $/y	456.- $/y
Savings		70 %	50 to 70 %

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Luwa Gas Adsorption Filters AN- / AFP-AZ

Comparison of Luwa AFP to Granulated cartridges: Particles

Filter type	Granulated	Luwa AFP-AZB	Luwa AFP-AZ
Weight	67 kg	10 kg	8 kg
Air flow	1700 m^3/h	1700 m^3/h	1700 m^3/h
	3000 m^3/h	3000 m^3/h	3000 m^3/h
Particles before	150 P/28 l	150 P/28 l	150 P/28 l
Particles after	424 P/28 l	65 P/28 l	100 P/28 l
	18'935 P/28 l	80 P/28 l	125 P/28 l
Difference	+ 274 P/28 l	- 85 P/28 l	- 50 P/28 l
	+ 18'785 P/28 l	- 70 P/28 l	- 25 P/28 l

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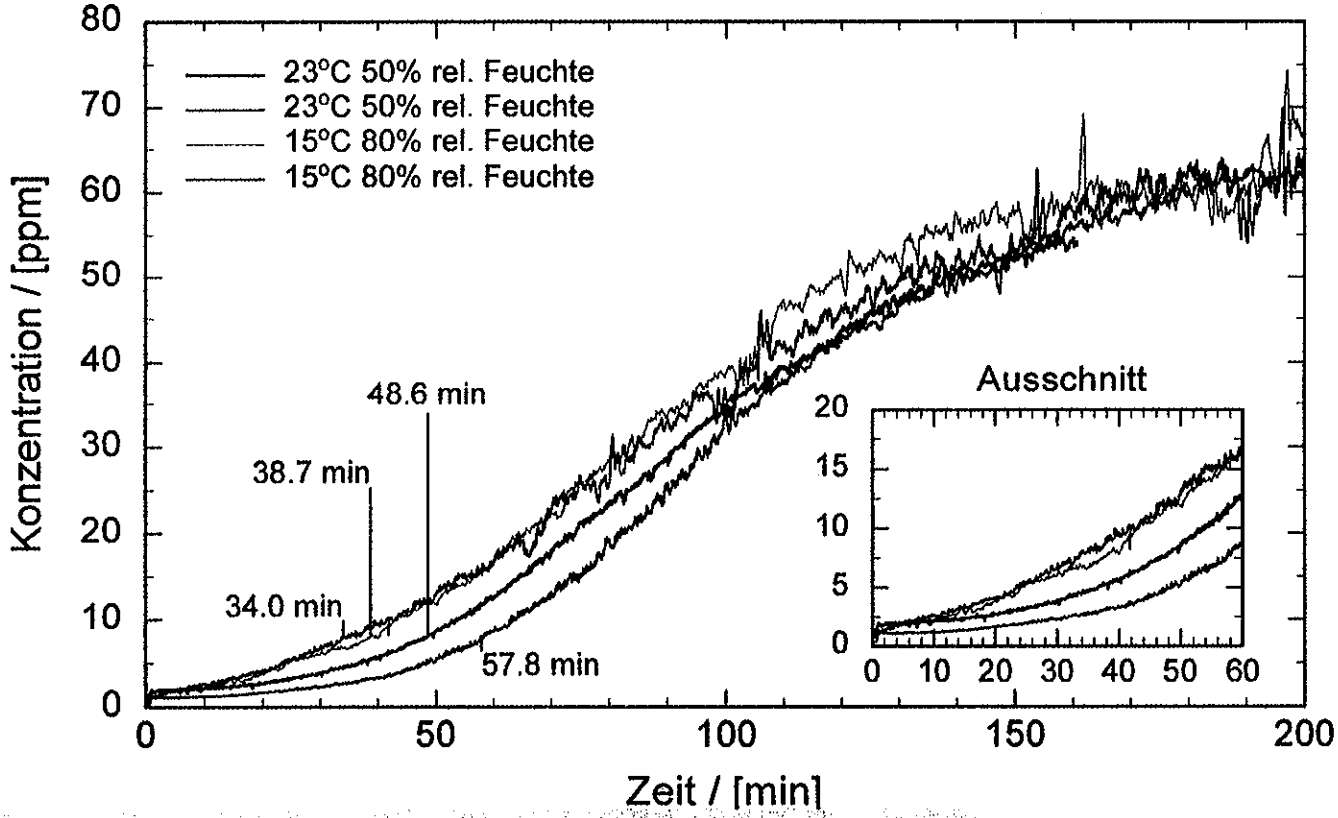
Luwa Gas Adsorption Filters AN- / AFP-AZ

Toluene break through at different relative humidity
AFP-AZ-610 with air flow of 1700 m³/h



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Luwa Gas Adsorption Filters AN- / AFP-AS

- To filter Acids and some Dopants in Microelectronics Industry (e.g.: SO_2, NO_2, HCl, H_2S, HF, BCl_3, PO_3, etc.)

Technical data		AFP-	AS-305	AS-610
Max. air flow V_M (short service life)	m³/h	1700	3400
Pressure drop at V_M	Pa	70	65
Rated air flow V_R (long service life)	m³/h	850	1700
Pressure drop at V_R	Pa	25	20
Total weight of filter	kg	4.3	7.6
Activated carbon net weight	kg	2.2	4.8
Filter medium area	m²	4.7	10.3
Adsorption capacity[1] at V_R for SO_2*	ppb·h	28'176	62'550
Initial efficiency at V_R for SO_2	%	97	97
Adsorption capacity[1] at V_R for H_2S*	ppb·h	8'108	18'000
Initial efficiency at V_R for H_2S	%	>99	>99
Adsorption capacity[1] at V_R for NO_2*	ppb·h	40'541	90'000
Initial efficiency at V_R for NO_2	%	>99	>99
Adsorption capacity[1] at V_R for HCl**	ppb·h	36'036	80'000
Initial efficiency at V_R for HCl	%	>99	>99

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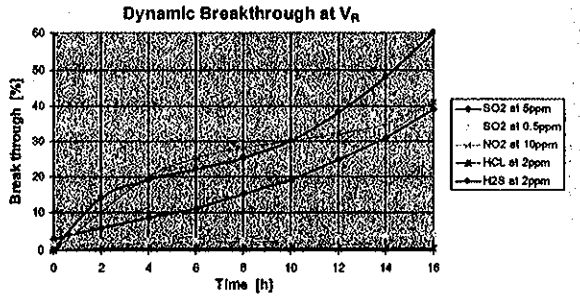
Luwa Gas Adsorption Filters AN- / AFP-AS

- With unique double layer small grain impr. carbon medium



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Luwa Gas Adsorption Filters AN- / AFP-AA

- To filter bases in Microelectronics industry (e.g.: NH_3, NH_4, NF_3, SiH_4, HMDS, NMP, etc.)

Technical data	AFP-	AA-305	AA-610
Max. air flow $\dot{V}_M$ (short service life)	m³/h	1700	3400
Pressure drop at $\dot{V}_M$	Pa	70	65
Rated air flow $\dot{V}_R$ (long service life)	m³/h	850	1700
Pressure drop at $\dot{V}_R$	Pa	30	25
Total weight of filter	kg	4.3	7.6
Net weight of adsorbant	kg	2.4	5.4
Filter medium area	m²	4.7	10.3
Adsorption capacity* at $\dot{V}_R$ for NH_3**	ppb·h	67'374	149'571
Initial efficiency at $\dot{V}_R$ for NH_3	%	99	99

*down to 70% efficiency at 23 °C and 50% relative humidity

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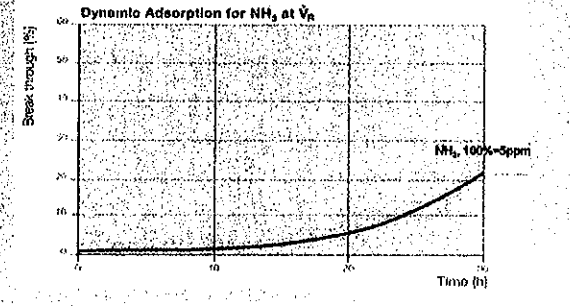
Luwa Gas Adsorption Filters AN- / AFP-AA

- With unique functionalised polymer medium with final barrier layer for absorption of by-products



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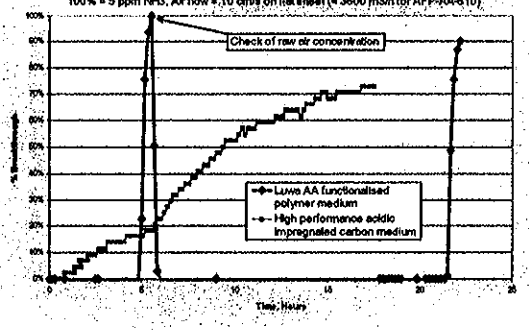
Luwa Gas Adsorption Filters AN- / AFP-AA

Comparison of dynamic breakthrough for 2 Ammonia filters

100% = 5 ppm NH3, Air flow = 10 cm/s on flat sheet (= 3600 m3/h for AFP-AA-610)



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Indoor Air Quality (IAQ)



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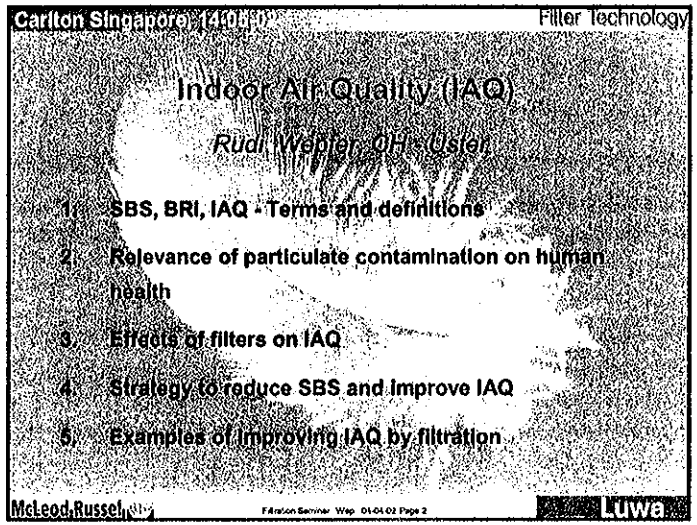
welcomes all attendees of

Microfiltration's filtration seminar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Filter Technology
Indoor Air Quality (IAQ)
Rudi Wepfer, CH - Uster
1. SBS, BRI, IAQ - Terms and definitions
2. Relevance of particulate contamination on human health
3. Effects of filters on IAQ
4. Strategy to reduce SBS and improve IAQ
5. Examples of improving IAQ by filtration
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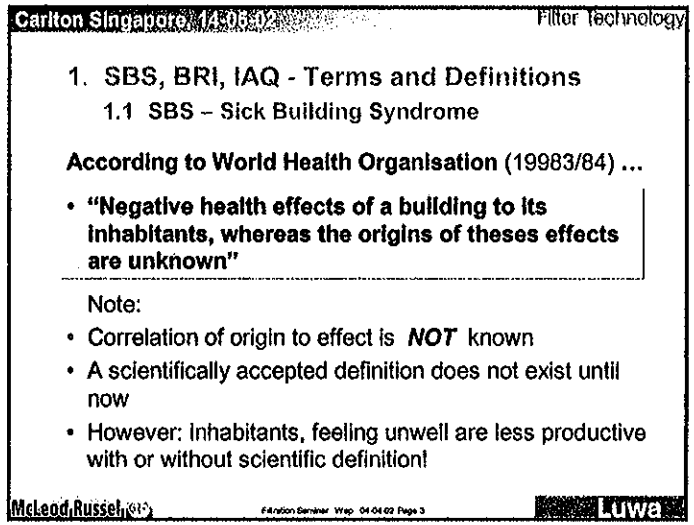
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Filter Technology
1. SBS, BRI, IAQ - Terms and Definitions
1.1 SBS – Sick Building Syndrome
According to World Health Organisation (19983/84) ...
• "Negative health effects of a building to its inhabitants, whereas the origins of theses effects are unknown"
Note:
• Correlation of origin to effect is NOT known
• A scientifically accepted definition does not exist until now
• However: Inhabitants, feeling unwell are less productive with or without scientific definition!
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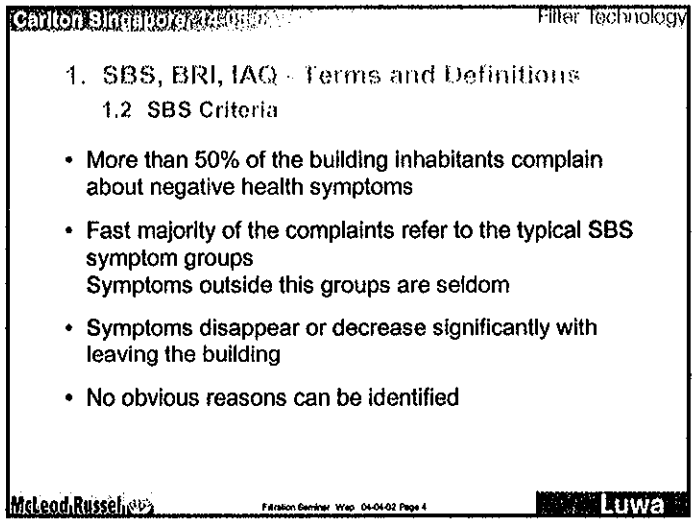
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Filter Technology
1. SBS, BRI, IAQ - Terms and Definitions
1.2 SBS Criteria
• More than 50% of the building inhabitants complain about negative health symptoms
• Fast majority of the complaints refer to the typical SBS symptom groups
Symptoms outside this groups are seldom
• Symptoms disappear or decrease significantly with leaving the building
• No obvious reasons can be identified
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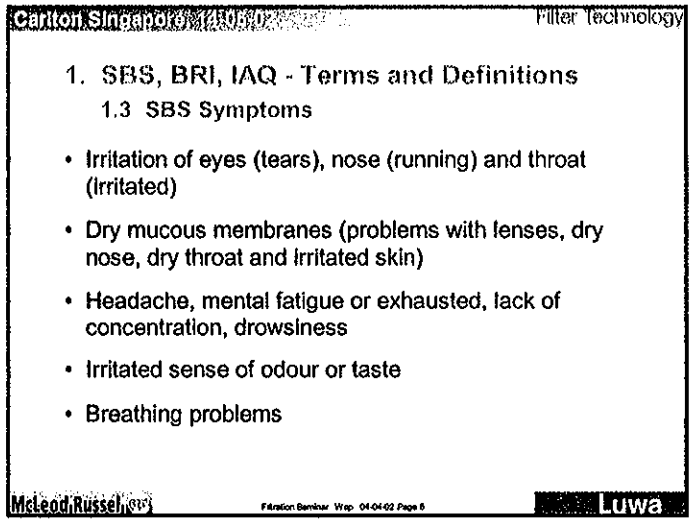
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Filter Technology
1. SBS, BRI, IAQ - Terms and Definitions
1.3 SBS Symptoms
• Irritation of eyes (tears), nose (running) and throat (irritated)
• Dry mucous membranes (problems with lenses, dry nose, dry throat and irritated skin)
• Headache, mental fatigue or exhausted, lack of concentration, drowsiness
• Irritated sense of odour or taste
• Breathing problems
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1. SBS, BRI, IAQ - Terms and Definitions

1.4 BRI – Building Related Illness

According to World Health Organisation (19983/84) ...

- **"Negative health effects of a building to its inhabitants, whereas the origins of these effects are known"**

Note:

- Difference to SBS: Correlation of origin to effect ***IS*** known

1. SBS, BRI, IAQ - Terms and Definitions

1.6 Scientific studies about factors for SBS

Author	Year	Analysed reasons for SBS
Skov	1987	Organic dust
Skov	1990	Air temperature
Raw	1993	Inefficient air filtration and dirty ductwork
Broder	1993	Tobacco smoke (passive smoking)
Norbäck	1994	Humidity, mould
Gyntеberg	1995	Dust composition (Bacteria, particles), VOC
Hedge	1995	Stress, problematic human relations
Jaakola	1995	Insufficient fresh air supply (less than 15 l/s/P)
Eriksson	1996	Psychosocial work environment, work load
Mölhave	1997	VOC and TVOC concentrations

1. SBS, BRI, IAQ - Terms and Definitions

1.7 Scientific studies about factors for SBS

WHO Study	NIOSH	Minnesota
No. of buildings analysed	450	203
Analysed reasons for SBS problem(s)		
Air distribution / Ventilation	52 %	13 %
Temperature	0 %	19 %
Indoor air contamination	17 %	14 %
Outdoor air contamination	11 %	7 %
Building material	3 %	4 %
Micro organisms	5 %	29 %
Unknown reasons	12 %	14 %
Improvable by filtration	33 %	60 %

2. Particulate contamination and human health

2.1 Did you know that ...

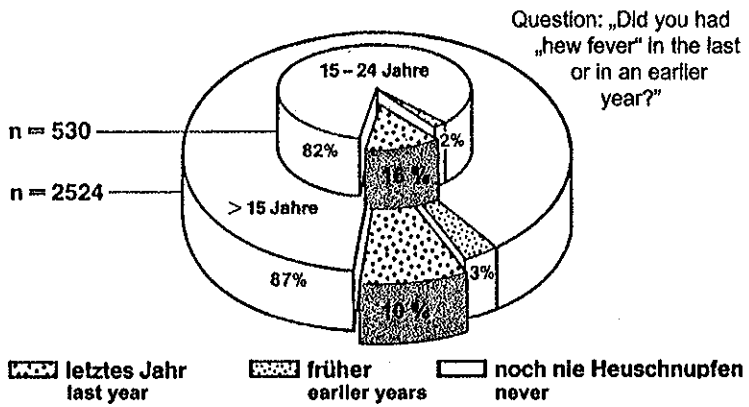
- Allergies and Asthma are the most frequent illnesses of children
- In one cubic meter of outdoor air, one typically finds 10'000'000 PM 2.5 particles (= 10'000 per litre)
- Indoor air may be more polluted than outdoor air
- In Singapore, most people stay 90% of their life time indoor
- An adult person incorporates per day approximately:
  - 2.0 kg of beverage
  - 1.0 kg of solid food
  - 25 kg or 22 m³ of air (by breathing)

➢ **Air is our most important „foodstuff"**

➢ **We care for the quality of what we drink and eat. Why shouldn't we care for the quality of the air we breath?**

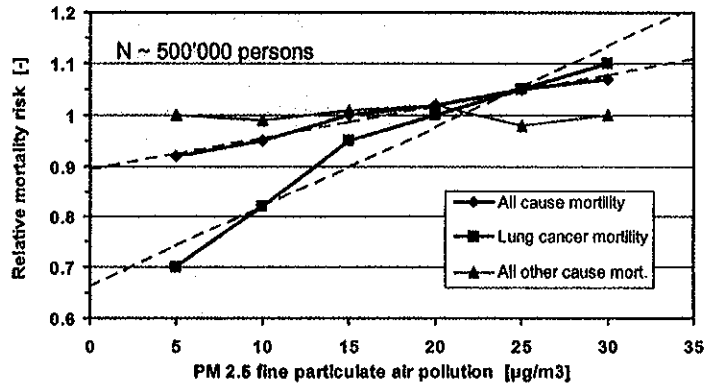
2. Particulate contamination and human health

2.2 Survey on allergic reaction, Switzerland, 1984



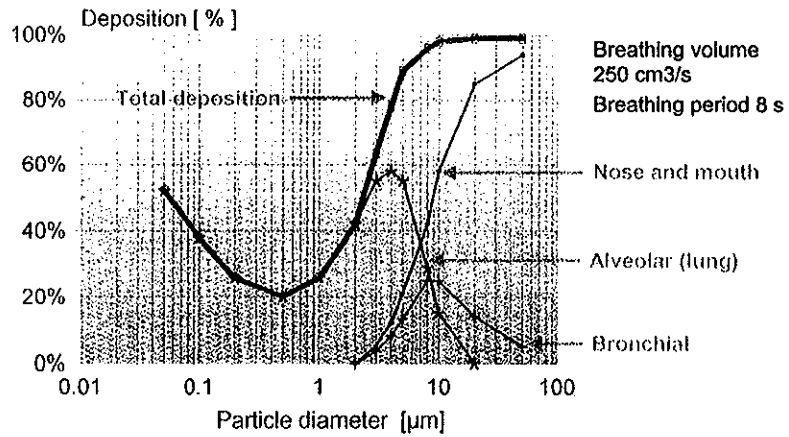
2. Particulate contamination and human health

2.3 A.C.S. mortality study: long term fine dust exposure



Result: Each 10 µg/m3 particulate air pollution increases mortality risk by ~5%

2.4 Particle size, relevant for human health



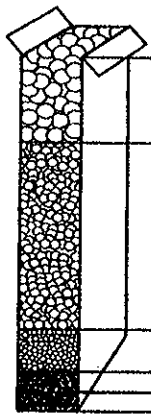
3. Effects of Filters for improving IAQ

3.1 SBS causing contamination and corr. source

Contamination	F8 part. filter	Gas filter	Source
CO_2	not effective	not effective	indoor, human beings
VOC's	not effective	very effective	outdoor and indoor
NO_X	not effective	little effective	outdoor, traffic
Particles	very effective	not effective	outdoor, some indoor
Tobacco smoke	effective	effective	indoor, smokers
Bacteria	elimination	not effective	outdoor and indoor
Viruses, spores	effective	not effective	outdoor and AC-plant
SO_X	not effective	little effective	outdoor, heating
Ozone	not effective	elimination	outdoor, electro filters
Radon	not effective	not effective	indoor, building mat.

3. Effects of Filters for improving IAQ

3.2 Reduction of dust intrusion from environment



Particle Ø [µm]	Average Ø [µm]	Weight ratio [%]	Arrestance G4 filter [%]	Intrusion w. G4 filter [%]	Arrestance F8 filter [%]	Intrusion w. F8 filter [%]
	20 µm	28 %	97 %	0.84 %	100 %	0 %
	7.5 µm	52 %	80 %	10.4 %	100 %	0 %
	4.5 µm	11 %	60 %	4.4 %	99 %	0.11 %
	2.5 µm	6 %	20 %	4.8 %	98 %	0.12 %
	0.5 µm	3 %	4 %	2.88 %	40 %	1.80 %
	Total	100 %	Total G4	23.32 %	Total F8	2.03 %

3. Effects of Filters for improving IAQ

3.2 Reduction of dust intrusion from environment

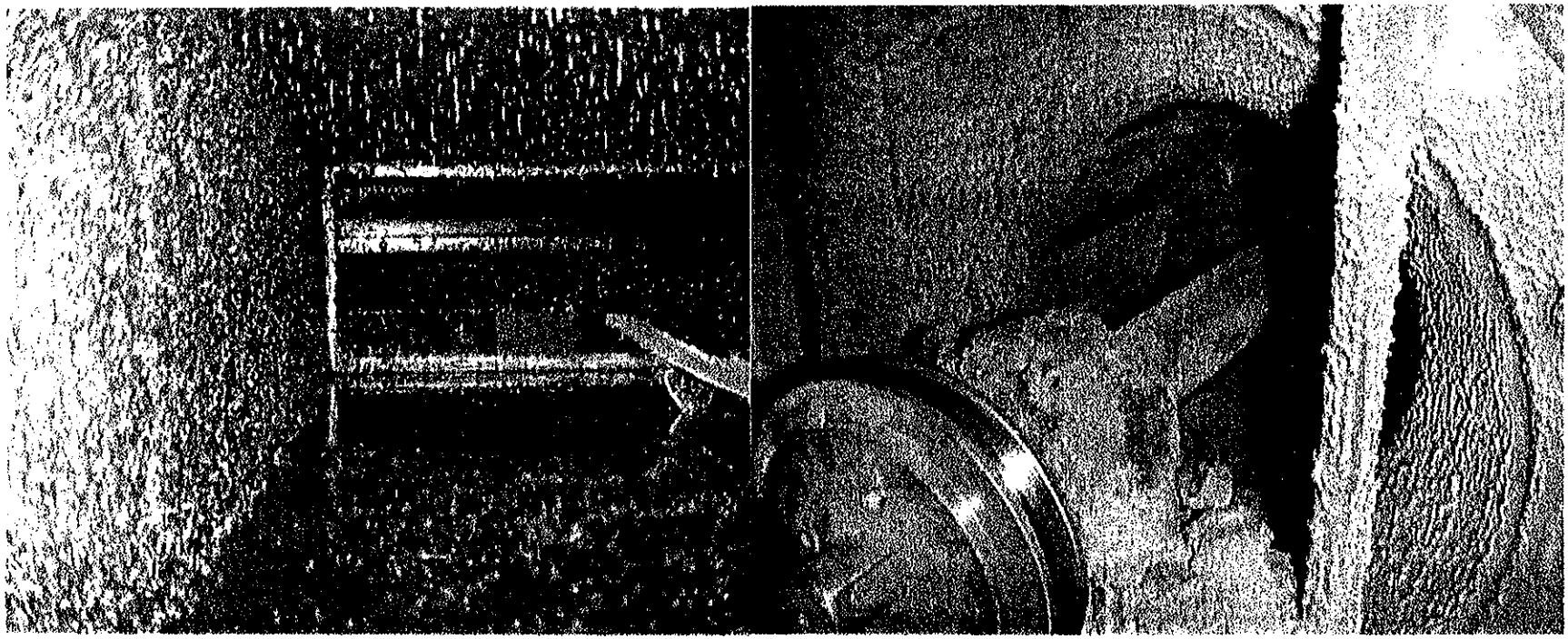
	Weight ratio [%]	Arrestance G4 filter [%]	Intrusion G4 filter [%]	Arrestance F8 filter [%]	Intrusion F8 filter [%]
Total	**100 %**	**Total G4**	**23.3 %**	**Total F8**	**2.0 %**

Example

Air conditioning plant in Singapore,
Fresh air intake = 270'000 m³/h,
Dust concentration in ambient air 31 µg/m³
Full time operation (8760 h / year)

Dust intrusion / year	**73.6 kg**		**17.1 kg**		**1.5 kg**
Weight ratio, total	**50**	**:**	**11**	**:**	**1**
Ø 2.5 µm particle ratio (& mean hazardous particle size)	**50**	**:**	**40**	**:**	**1**

3.3 Effects of Filters: reduction of dirt intrusion



Beside all IAQ aspects, better filters also means:

- ➢ **Higher performance of heat exchangers ★**
- ➢ **Lower risk of hidden microbial contamination**
- ➢ **Less cleaning work in HVAC plant and of duct system ★**
- ★ **Lower long term operation cost of HVAC plant**

4. Strategy to reduce SBS and improve IAQ

4.1 Basic principles – Minimum requirements

- Elimination or reduction of contamination sources
  - air intake of AC plant at correct place
  - use low emission building materials
  - control behaviour of building inhabitants
  - extraction of strong sources at point of emission
- Correct min. fresh air rate (= air changes / hour / person)
- Last stage of particulate filtration must be of min. class F7 as per EN 779 (= 85% discoloration efficiency) See VDI 6022, SWKI 96-2 and other IAQ standards

4. Strategy to reduce SBS and improve IAQ

4.2 State of the art IAQ – A wise investment

- Consider basic principles / minimum requirements
- Reduce fresh air rate (air changes / hour / person) to min. requirement as per ASHRAE 62 standard
- Increase rate of recycled air correspondingly
- Install last stage of particle filters of min. class F9 as per EN 779 (> 95% discoloration efficiency) and of Rigid design with pleated glass fibre paper
- Install gas adsorption filters for VOC's in recycled air flow

4. Strategy to reduce SBS and improve IAQ

4.3 Benefits of a state of the art IAQ

- No cleaning of ductwork required in life time of building
- Tobacco smoke and bacteria eliminated, viruses reduced by 80% ! – infection risk of staff significantly lower
- IAQ is widely independent of - and significantly better than outdoor air quality
- SBS due to IAQ problems is eliminated
- Presence time and work performance of staff increased
- Energy is saved by significantly reduced power consumption for cooling, heating and dehumidification

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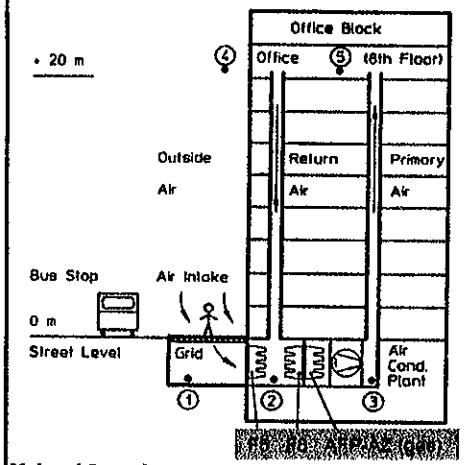
4. Examples of improving IAQ by filtration

4.4 Historical office building in downtown Milan, I



The problem:

- SBS symptoms in offices of Helene Curtis on 8th floor

The case:

- Measurements show 3 times higher PAHC levels (carcinogenic) than in outside air
- H.C. accuses the land lord
- H. C. wins the law suit
- Land lord has to improve situation to "better or equal than outside air"

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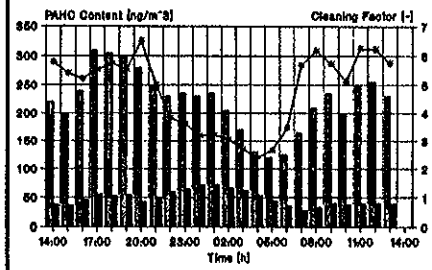
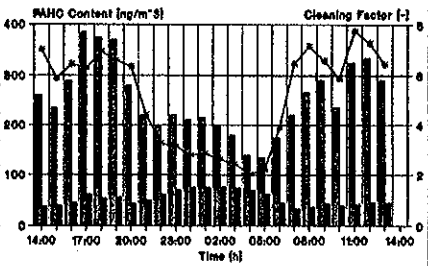
4. Examples of improving IAQ by filtration

4.4 Historical office building in Milan after change

PAHC Content and Filter Cleaning Factor



PAHC Content and Plant Cleaning Factor



Filter cleaning factor: 2.5 ... Plant cleaning factor: 7
Improvement from initial situation: Factor 21 ... or ~ 95% !

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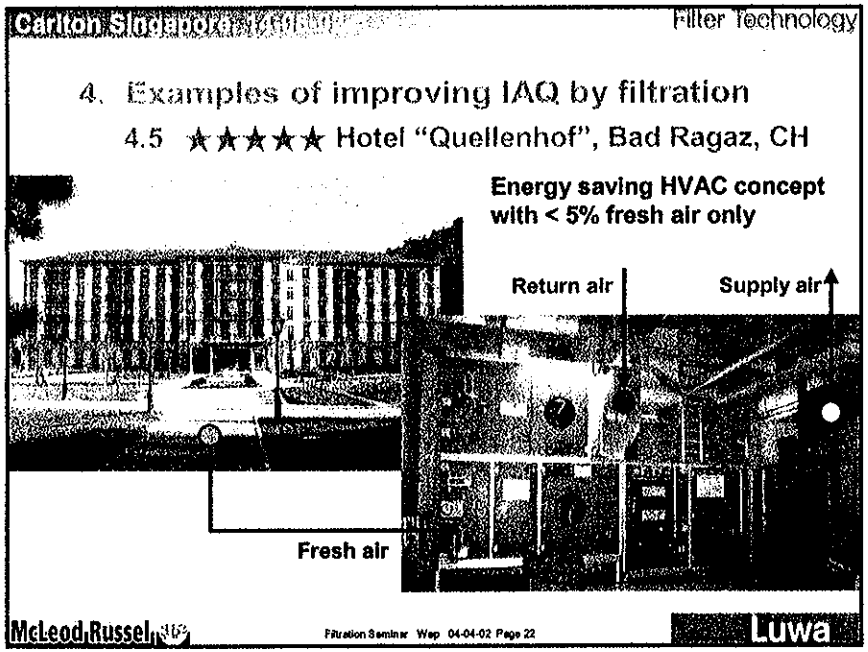
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4. Examples of improving IAQ by filtration
4.5 ★★★★★ Hotel "Quellenhof", Bad Ragaz, CH
Energy saving HVAC concept
with < 5% fresh air only
Return air
Supply air
Fresh air
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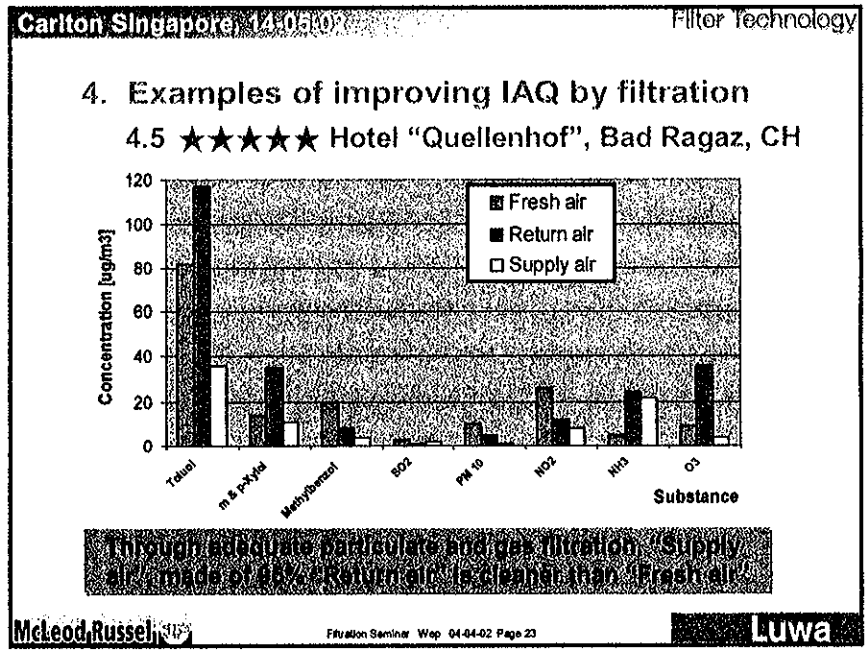
Luwa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Filter Technology
4. Examples of improving IAQ by filtration
4.5 ★★★★★ Hotel "Quellenhof", Bad Ragaz, CH
Concentration [ug/m3]
120
100
80
60
40
20
0
Fresh air
Return air
Supply air
Toluol
m & p-Xylol
Methylbenzol
SO2
PM 10
NO2
NH3
O3
Substance
Through adequate particulate and gas filtration "Supply air" made of 95% "Return air" is cleaner than "Fresh air".
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Luwa