



EFFICIENCY TESTS ON FLAT SHEET MEDIA

Test Report SA 200201

Mainleus, February 19th, 2020

According DIN 71460-1

1. Objectives and test set-up

This test project focused on the initial efficiencies on flat sheet media and the test procedure below. All test conditions and parameters not given will be chosen according to DIN 71460-1.

The test shall indicate if the media is suitable regarding particle efficiency for the use in a FFP3 mask according EN149.

- a) Test requested by:
- b) Test specimen / Construction: flat sheet media
- c) Media ID: FW1: 8600 ffp3
FW2: 8601 ffp1
FW3 :8602 ffp2
- d) Media Type : synthetic
- e) Flow direction: upstream side labeled
- f) Dimension: $\varnothing 190$ mm ; effective $\varnothing 150$ mm
- g) Samples received on: February 14th, 2020
- h) Test performed on: February 17th, 2020

Test conditions

Media velocity:	8 cm/s
Temperature:	22°C \pm 1°C
Relative humidity:	50%
Absolute pressure:	981 mbar
Particle efficiency size range:	0,3 – 3 μ m
Particle Counter:	Optical Particle Counter, TSI Inc., Model 3330
Test aerosol:	DEHS (pure) polydisperse
Test Sample Size:	\varnothing 150 mm

Comments / Information on EN 149:

Test Aerosol:	Sodium Chloride (NaCl) + Paraffin oil. DEHS efficiencies can be considered equivalent to paraffin oil (see ISO 29463 / EN1822). Efficiencies with NaCl are usually higher than with DEHS.
Particle detector:	It is referenced to EN 13274-7 in which a photometer is used. A photometer usually detects the sum of all particles (as a volume or mass signal) > 0,2-0,3 μ m over the full measuring range and does not differentiate small particle size ranges. Therefore we reported also the mass signal measured with the optical particle counter.

The accuracy of the airflow control is 3% of the nominal value.

Pressure drops were measured using three sensors of the ranges 0 – 100 Pa, 0 - 500 Pa and 0 - 3000 Pa. The accuracy of the pressure transducers is 1% of the range maximum.

The DEHS aerosol was generated by an atomizer ATM 220 (Topas GmbH). The sodium chloride aerosol was generated by an atomizer AGK 2000 (PALAS GmbH).
The test aerosols were not electro-statically neutralized

The fractional filter efficiency graphs were derived from a total of six to eight measurements of particle size distributions. Minimum three measurements were taken upstream and min. three were taken downstream of the filter. The figures and the tables in the attachments show the average values of the three efficiency measurements as well as the total scattering range for each size channel.

2. Results

The detailed results are reported in the attachment.

Table 1: Summary of the results, 8 cm/s DEHS

Particle Size (µm)	Mean Efficiency (%) FW1	Mean Efficiency (%) FW2	Mean Efficiency (%) FW3
0,33	99,90	92,77	97,38
0,42	>99,95	95,34	98,61
0,52	>99,95	97,17	99,28
0,65	>99,95	98,21	99,63
0,80	>99,95	98,84	99,77
1,00	>99,95	99,28	>99,9
1,25	>99,95	99,49	>99,9
1,55	>99,95	99,75	>99,9
1,93	>99,95	99,86	>99,9
2,41	>99,95	>99,9	>99,9
3,00	>99,95	>99,9	>99,9

Table 2: Summary of the pressure drop results, 8 cm/s, DEHS

Sample	Pressure Drop (Pa)	Mass Efficiency *
FW1:	120	>99,95
FW2:	43	99,45
FW3:	63	99,83

* Average of minimum 3 scans up and downstream. The value has been taken from the same scans as for the fractional efficiencies. The optical particle counter calculates from the particle counts vs. particle size a value in mg/m³ for each scan. The mass efficiency is calculated from the µg/m³ values up and downstream the sample.

Table 3: Summary of the results, 8 cm/s NaCl

Particle Size (µm)	Mean Efficiency (%) FW1	Mean Efficiency (%) FW2	Mean Efficiency (%) FW3
0,33	>99,95	97,73	99,64
0,42	>99,95	98,46	99,78
0,52	>99,95	99,09	99,90
0,65	>99,95	99,38	99,93
0,80	>99,95	99,56	>99,95
1,00	>99,95	99,71	>99,95
1,25	>99,95	99,86	>99,95
1,55	>99,95	>99,9	>99,95
1,93	>99,95	>99,9	>99,95
2,41	>99,95	>99,9	>99,95
3,00	>99,95	>99,9	>99,95



Table 4: Summary of the pressure drop results, 8 cm/s, NaCl

Sample	Pressure Drop (Pa)	Mass Efficiency * (%)
FW1:	120	>99,95
FW2:	43	99,92
FW3:	63	99,99



Matthias Eber
(Managing Director)



Hanna Michel
(Lab Technician)

Attachment: 1-3

Attachment 1 to Test Report SA 200201

Summary of test results for sample

8600 ffp 3

fiatec-no.: SA 200201 - FW1

1.1 Particle collection efficiency DEHS

Test aerosol:	DEHS	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			DEHS, new flat sheet media	
Particle Size $d_{m,i}$ (optical)	Particle Size d_i (optical)	Particle Size d_{i+1} (optical)	η_{mean}^*	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	99,90	0,01
0,42	0,37	0,47	>99,95	0,01
0,52	0,47	0,58	>99,95	0,01
0,65	0,58	0,72	>99,95	0,01
0,80	0,72	0,90	>99,95	0,00
1,00	0,90	1,12	>99,95	0,01
1,25	1,12	1,39	>99,95	0,00
1,55	1,39	1,73	>99,95	0,00
1,93	1,73	2,16	>99,95	0,00
2,41	2,16	2,69	>99,95	0,00
3,00	2,69	3,34	>99,95	0,00

Particle size	Efficiency [%]
[μm] (geometric)	DEHS, new flat sheet media
0,3 - 0,5	99,94
0,5 - 1,0	>99,95
1,0 - 3,0	>99,95

$d_{m,i}$: Geometric mean diameter of a size range i , μm

d_i : Lower limit particle diameter in a size range i , μm

d_{i+1} : Upper limit particle diameter in a size range i , μm

Mass Efficiency (%)
>99,995

Average of minimum 3 scans up and downstream. The value has been taken from the same scans as for the fractional efficiencies. The optical particle counter calculates from the particle counts vs. particle size a value in $\mu\text{g}/\text{m}^3$ for each scan. The mass efficiency is calculated from the $\mu\text{g}/\text{m}^3$ values up and downstream the sample.

Attachment 1 to Test Report SA 200201

Summary of test results for sample

8600 ffp 3

fiatec-no.: SA 200201 - FW1

1.2 Particle collection efficiency NaCl

Test aerosol:	NaCl (2%)	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			NaCl, new flat sheet media	
Particle size d_i (optical)	Particle size d_{i+1} (optical)	Particle size $dm_{,i}$ (optical)	η_{mean}^*	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	>99,95	0,01
0,42	0,37	0,47	>99,95	0,00
0,52	0,47	0,58	>99,95	0,00
0,65	0,58	0,72	>99,95	0,01
0,80	0,72	0,90	>99,95	0,00
1,00	0,90	1,12	>99,95	0,00
1,25	1,12	1,39	>99,95	0,00
1,55	1,39	1,73	>99,95	0,00
1,93	1,73	2,16	>99,95	0,00
2,41	2,16	2,69	>99,95	0,00
3,00	2,69	3,34	>99,95	0,00

Particle size [μm] (geometric)	Efficiency [%] NaCl, new flat sheet media
0,3 - 0,5	>99,95
0,5 - 1,0	>99,95
1,0 - 3,0	>99,95

Mass Efficiency (%)
>99,995

2. Pressure drop

Flow velocity [cm/s]	8
new flat sheet media [Pa]	120

3. Mass

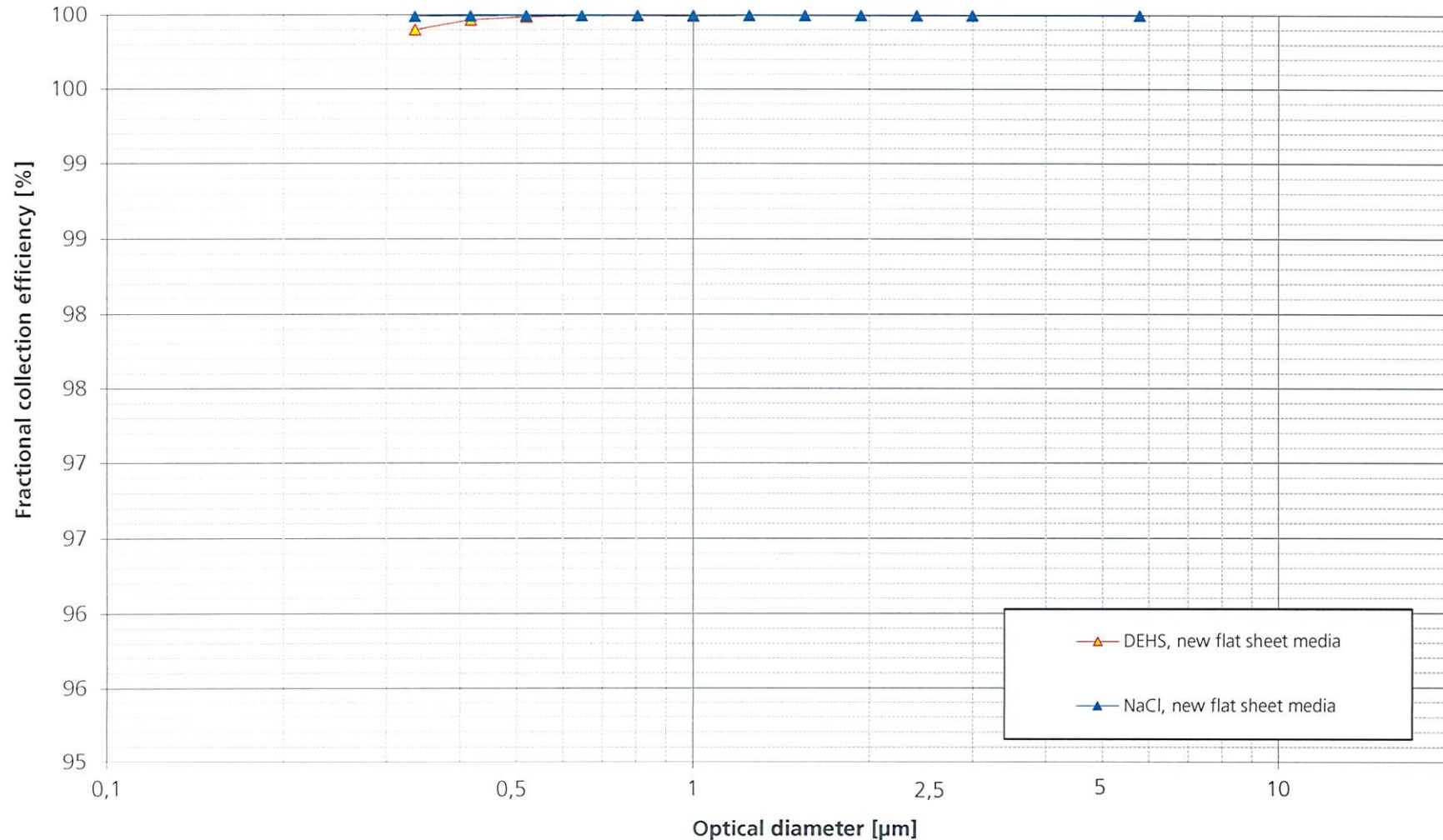
Mass <small>New flat sheet</small>	[g]	2,3
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4. Dimensions

Cut to: $\varnothing 190$ [mm]

Effectiv filter media area : $\varnothing 150$ [mm]

Particle collection efficiencies



Customer:
Sandler Vliesstoffe AG

Date:
17.02.2020

Sample:
8600 ffp 3

fiatec-no.:
SA 200201 - FW1

Flow velocity [cm/s]:
8,0

Particle counter:
OPC 3330

Attachment 2 to Test Report SA 200201

Summary of test results for sample
8601 ffp 1
fiatec-no.: SA 200201 - FW2

1.1 Particle collection efficiency DEHS

Test aerosol:	DEHS	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			DEHS, new flat sheet media	
Particle Size $d_{m,i}$ (optical)	Particle Size d_i (optical)	Particle Size d_{i+1} (optical)	η_{mean}^*	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	92,77	0,14
0,42	0,37	0,47	95,34	0,19
0,52	0,47	0,58	97,17	0,04
0,65	0,58	0,72	98,21	0,14
0,80	0,72	0,90	98,84	0,11
1,00	0,90	1,12	99,28	0,19
1,25	1,12	1,39	99,49	0,11
1,55	1,39	1,73	99,75	0,07
1,93	1,73	2,16	99,86	0,02
2,41	2,16	2,69	>99,9	0,07
3,00	2,69	3,34	>99,9	0,00

Particle size [μm] (geometric)	Efficiency [%] DEHS, new flat sheet media
0,3 - 0,5	94,6
0,5 - 1,0	98,7
1,0 - 3,0	99,7

$d_{m,i}$: Geometric mean diameter of a size range i , μm
 d_i : Lower limit particle diameter in a size range i , μm
 d_{i+1} : Upper limit particle diameter in a size range i , μm

Mass Efficiency (%)
99,45

Average of minimum 3 scans up and downstream. The value has been taken from the same scans as for the fractional efficiencies. The optical particle counter calculates from the particle counts vs. particle size a value in $\mu\text{g}/\text{m}^3$ for each scan. The mass efficiency is calculated from the $\mu\text{g}/\text{m}^3$ values up and downstream the sample.

Attachment 2 to Test Report SA 200201

Summary of test results for sample

8601 ffp 1

fiatec-no.: SA 200201 - FW2

1.2 Particle collection efficiency NaCl

Test aerosol:	NaCl (2%)	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			NaCl, new flat sheet media	
Particle size d_i (optical)	Particle size d_{i+1} (optical)	Particle size $dm_{,i}$ (optical)	$\eta_{m, \text{ein}}^*$	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	97,73	0,16
0,42	0,37	0,47	98,46	0,06
0,52	0,47	0,58	99,09	0,02
0,65	0,58	0,72	99,38	0,04
0,80	0,72	0,90	99,56	0,13
1,00	0,90	1,12	99,71	0,12
1,25	1,12	1,39	99,86	0,10
1,55	1,39	1,73	>99,9	0,10
1,93	1,73	2,16	>99,9	0,05
2,41	2,16	2,69	>99,9	0,03
3,00	2,69	3,34	>99,9	0,00

Particle size [μm] (geometric)	Efficiency [%] NaCl, new flat sheet media
0,3 - 0,5	98,2
0,5 - 1,0	99,5
1,0 - 3,0	99,9

Mass Efficiency (%)
99,92

2. Pressure drop

Flow velocity [cm/s]	8
new flat sheet media [Pa]	43

3. Mass

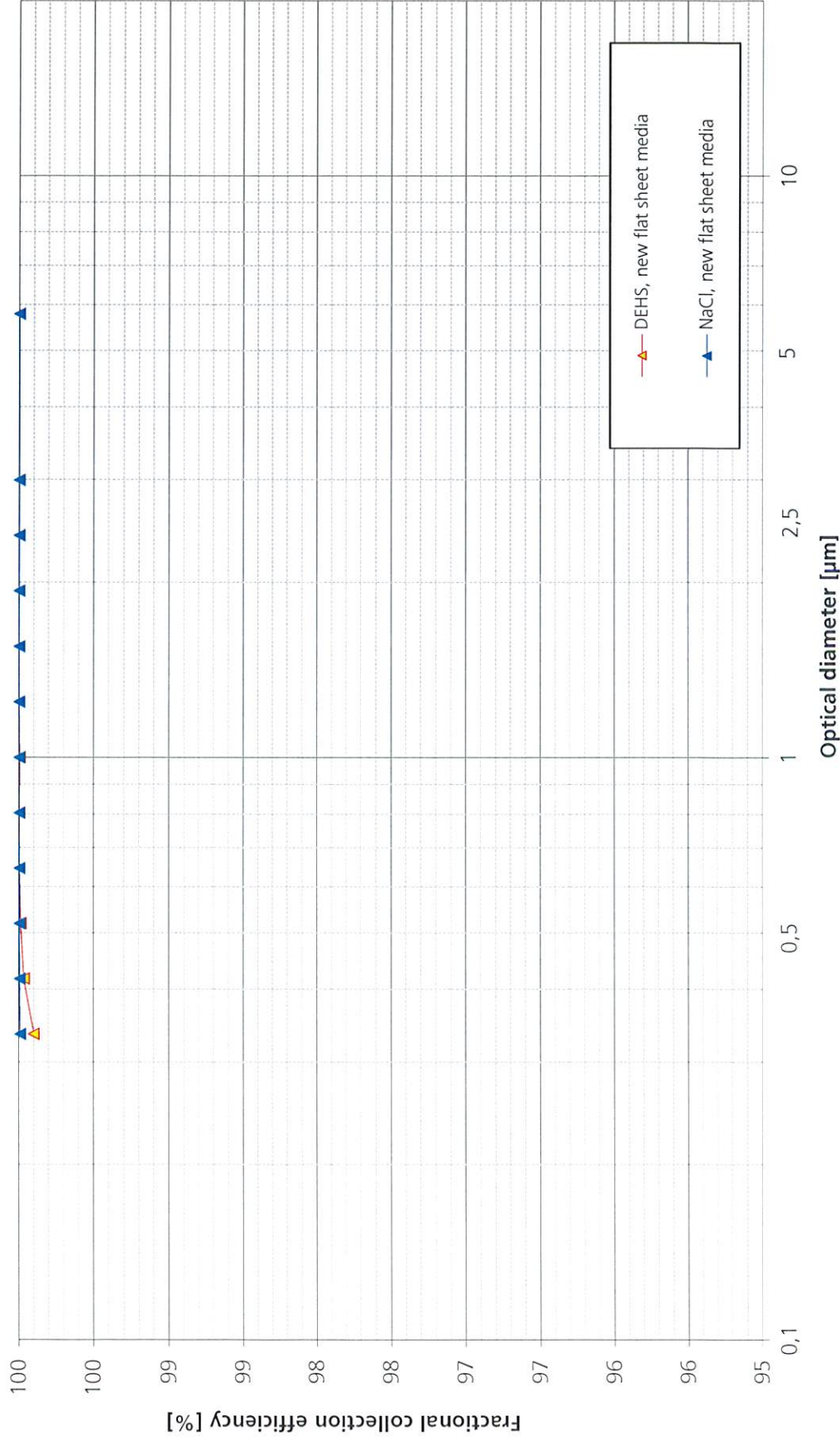
Mass <small>New flat sheet</small>	[g]	1,7
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4. Dimensions

Cut to: $\varnothing 190$ [mm]

Effectiv filter media area : $\varnothing 150$ [mm]

Particle collection efficiencies



Customer:
Sandler Vliesstoffe AG

Date:
17.02.2020

Sample:
8600 ffp 3

fiatec-no.:
SA 200201 - FW1

Flow velocity [cm/s]:
8,0

Particle counter:
OPC 3330

Attachment 3 to Test Report SA 200201

Summary of test results for sample
8602 ffp2
fiatec-no.: SA 200201 - FW3

1.1 Particle collection efficiency DEHS

Test aerosol:	DEHS	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			DEHS, new flat sheet media	
Particle Size $d_{m,i}$ (optical)	Particle Size d_i (optical)	Particle Size d_{i+1} (optical)	η_{mech}^*	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	97,38	0,06
0,42	0,37	0,47	98,61	0,19
0,52	0,47	0,58	99,28	0,04
0,65	0,58	0,72	99,63	0,08
0,80	0,72	0,90	99,77	0,05
1,00	0,90	1,12	>99,9	0,07
1,25	1,12	1,39	>99,9	0,04
1,55	1,39	1,73	>99,9	0,07
1,93	1,73	2,16	>99,9	0,04
2,41	2,16	2,69	>99,9	0,07
3,00	2,69	3,34	>99,9	0,00

Particle size	Efficiency [%]
[μm] (geometric)	DEHS, new flat sheet media
0,3 - 0,5	98,2
0,5 - 1,0	99,7
1,0 - 3,0	>99,9

$d_{m,i}$: Geometric mean diameter of a size range i , μm
 d_i : Lower limit particle diameter in a size range i , μm
 d_{i+1} : Upper limit particle diameter in a size range i , μm

Mass Efficiency (%)
99,83

Average of minimum 3 scans up and downstream. The value has been taken from the same scans as for the fractional efficiencies. The optical particle counter calculates from the particle counts vs. particle size a value in $\mu\text{g}/\text{m}^3$ for each scan. The mass efficiency is calculated from the $\mu\text{g}/\text{m}^3$ values up and downstream the sample.

Attachment 3 to Test Report SA 200201

Summary of test results for sample

8602 ffp2

fiatec-no.: SA 200201 - FW3

1.2 Particle collection efficiency NaCl

Test aerosol:	NaCl (2%)	Particle counter:	OPS 3330
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Flow velocity: 8 cm/s			NaCl, new flat sheet media	
Particle size d_i (optical)	Particle size d_{i+1} (optical)	Particle size dm_{i_i} (optical)	η_{mean}^*	Δ_{max}^{**}
[μm]	[μm]	[μm]	[%]	[%]
0,33	0,30	0,37	99,64	0,05
0,42	0,37	0,47	99,78	0,06
0,52	0,47	0,58	99,90	0,03
0,65	0,58	0,72	99,93	0,04
0,80	0,72	0,90	>99,95	0,01
1,00	0,90	1,12	>99,95	0,02
1,25	1,12	1,39	>99,95	0,01
1,55	1,39	1,73	>99,95	0,07
1,93	1,73	2,16	>99,95	0,00
2,41	2,16	2,69	>99,95	0,00
3,00	2,69	3,34	>99,95	0,00

Particle size	Efficiency [%]
[μm] (geometric)	NaCl, new flat sheet media
0,3 - 0,5	99,7
0,5 - 1,0	>99,9
1,0 - 3,0	>99,9

Mass Efficiency (%)
99,99

2. Pressure drop

Flow velocity [cm/s]	8
new flat sheet media [Pa]	63

3. Mass

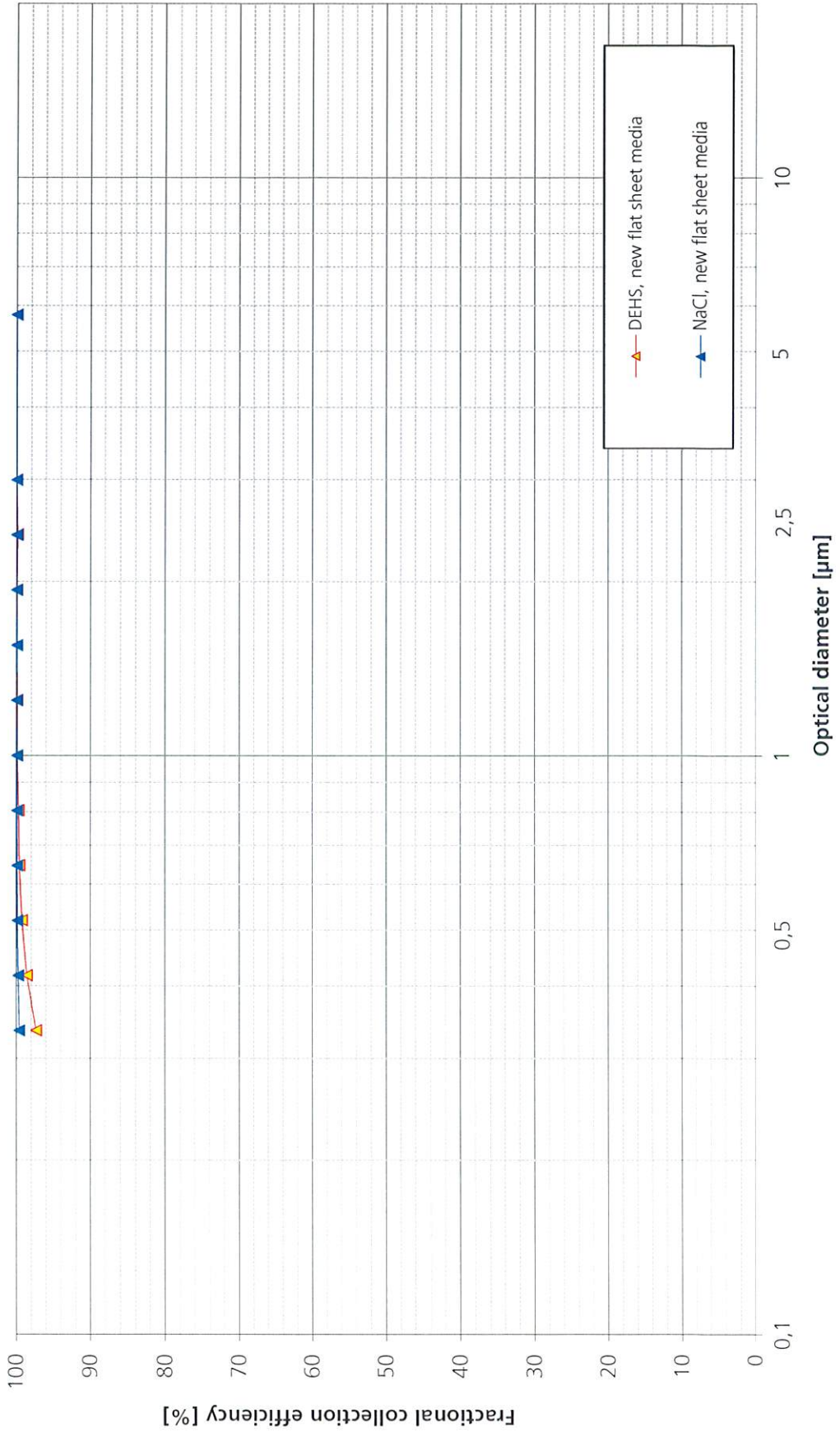
Mass <small>New flat sheet</small>	[g]	2,0
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4. Dimensions

Cut to: $\varnothing 190$ [mm]

Effectiv filter media area : $\varnothing 150$ [mm]

Particle collection efficiencies



Customer:
Sandler Vliesstoffe AG

Date:
17.02.2020

Sample:
8602 ffp2

fiatec-no.:
SA 200201 - FW3

Flow velocity [cm/s]:
8,0

Particle counter:
OPC 3330