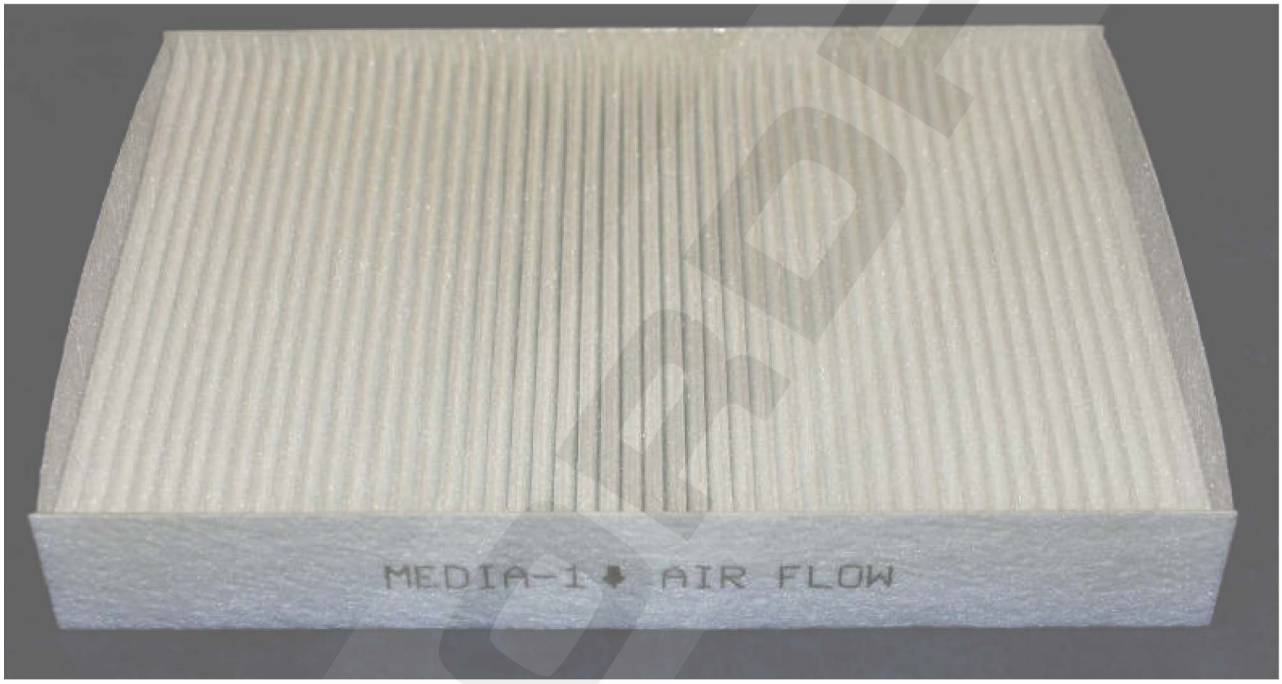
CABIN AIR FILTER PERFORMANCE TEST ON PARTICLE FILTERS



TEST REPORT NCL 210202

Mainleus, May 26th, 2021

acc. to DIN 71460 -1

initiated by:

Nordfil LCC

1. Objectives and test set-up

This test project focused on the filtration performance of cabin air filters according to Nissan specification 27275NDS00 [5] (Renault 32-02-832 -- I) and the test procedure below.
All test conditions and parameters not given will be chosen according to DIN 71460-1 „Air filters for passenger compartments".

a)	Test requested by:	Nordfil LCC
b)	Test specimen / Construction:	Cabin air filter with flexible textile frame
c)	Model / Parts ID:	Nissan CAF
d)	Flow direction:	see picture on front page (acc. air flow arrow)
e)	Label / Identification:	MEDIA-1
f)	Dimensions:	ca. 250 x 180 x 36 mm
g)	Samples received:	March 9th , 2021 (*P1.2 and P2) April 12th, 2021
h)	Test performed:	March 15th – 16th, April 20th and May 07th – 20th, 2021

Test conditions

Flow rate:	200 / 500 m³/h
Temperature:	23°C ± 3°C
Relative humidity:	50% ± 5%
Test dust:	1. Sodium Chloride (2% NaCl) 2. ISO 12103-1 A2 fine
Particle size range:	1. 0,05 – 0,5 µm 2. 0,5 – >10 µm
Particle counter:	1. SMPS (TSI Inc.) 2. APS 3321 (TSI Inc.)
Dust loading concentration:	75 mg/m³

A SMPS (Scanning Mobility Particle Sizer, TSI Inc.) was used to determine the fractional efficiencies in the particle size range of 0,05 to 0,5 µm. For efficiency measurements in the size range of 0,5 to >10 µm (aerodynamic) an APS 3321 (Aerodynamic Particle Sizer, TSI Inc.) was used.
To generate the sodium chloride aerosol an atomizer AGK 2000 (PALAS GmbH) was used. The test dust (ISO 12103-1 A2 fine) was injected using a rotating brush generator (RBG 1000 PALAS GmbH). It has not been electrostatically neutralized.

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

The accuracy of the airflow control is 2% of the nominal value.

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

Table 1: Test procedure

No.	Test fiatec-no.: NCL 210202_	P1	P1.2	P2	P3	P4	P5	P6	P7	P8
IN01	Dimension and number of pleats	x	x	x	x	x	x	x		
	Filter weight	x	x	x	x	x	x	x		
IN02	Conditioning under test conditions	x	x	x	x	x				
RE04	Conditioning in climate chamber acc Renault Spec.							x		
IN04/ FR01	Pressure drop curve 0-600 m³/h +450 m/h		x							
FR04	Fractional filtration efficiency 0,05-0,5 µm, 2% NaCl, 200 m³/h		x							
FR02	Fractional filtration efficiency >0,5 µm, A2, 200 m³/h		x							
FR02	Fractional filtration efficiency >0,5 µm, A2, 500 m³/h		x					x		
FR03	Fractional filtration efficiency >0,5 µm, Mulberry Paper, 300 m³/h			x						
FR02 /04	Dust holding capacity, A2, +50 Pa	x								
	Filter weight	x								
FR04	Fractional filtration efficiency 0,05-0,5 µm, 2% NaCl, 200 m³/h	x								
FR02	Fractional filtration efficiency >0,5 µm, A2, 200 m³/h	x								
FR02	Fractional filtration efficiency >0,5 µm, A2, 500 m³/h	x								
FR02	Dust holding capacity, A2, +100 Pa	x								
	Filter weight	x								x
FR04	Fractional filtration efficiency 0,05-0,5 µm, 2% NaCl, 200 m³/h	x								
FR05	Dust holding capacity, A2, +200 Pa				x	x				x
	Filter weight				x	x				x
FR05	Gravimetric Efficiency or Loss				x	x				
RE01	Resistance to overpressure, 1000Pa, 1 min				x					
	Dust holding capacity, A2, until 1000 Pa, 200 m³/h					x				
	Filter weight				x	x				
RE01	Gravimetric Efficiency or Loss					x				
RE05	Fungal test acc. EN ISO 846 A+C, media+adhesive/frame								x	
RE05	Water resistance acc Nissan Specification						x			
RE05	Dimensions, Visual Inspection						x			

Ageing Test according specification (RE04)

The climate change test has been done in a climate chamber with an accuracy of temperature control of ± 1°C and ±3% rel. humidity.
Following the procedure described in specification 32-02-832/--I the storage of the filter in circulating air was:

- 7 hours at 23°C
- 5 hours at 85°C
- 7 hours at 23 °C
- 5 hours at -30°C

After the storage the fractional efficiency with A2 at an air flow of 500 m³/h had to be measured.

Pic.1: NCL 210202_P6 after ageing

Filter length (frame) and width did not change. (The pleats are a little bit closer to each other, but no visible damages)

2. Test results

Following tables show a summary of important test results.
The detailed results are reported in the attachments 1 through 8.

Table 2: Summary of the pressure drop results

Filter	Filter state	Flow rate [m³/h]						
		100	200	300	400	450	500	600
		Pressure drop [Pa]						
P1.2	new	12	26	42	59	70	82	105

Table 3: Summary of the efficiency results

Particle size (geometric) [µm]	new 200 m³/h P1.2 [%]	new 500 m³/h P1.2 [%]	loaded +50Pa 200 m³/h P1 [%]	loaded +50Pa 500 m³/h P1 [%]	new 300 m³/h P2 [%]	aged 500 m³/h P6 [%]	Particle counter
0,05 0,1 0,2 0,3 0,4 0,5	76 70 58 53 53 54	-	78 66 59 61 65 73	83 73 68 69 74 81	-	-	SMPS (NaCl)
(aerodynamic)	A2	A2	A2	A2	Mulberry	A2	
0,5 1,0 3,0 5,0 7,0 10,0	95,0 96,1 99,0 99,8 99,8 >99,9	86,9 89,4 96,8 97,3 97,3 97,5	93,3 95,7 >99,9 >99,9 >99,9 >99,9	85,1 94,8 >99,9 >99,9 >99,9 >99,9	Mean value: 99,1	82,9 87,5 94,7 93,1 92,8 92,6	APS

Table 4: Summary of the dust holding capacity and gravimetric efficiency

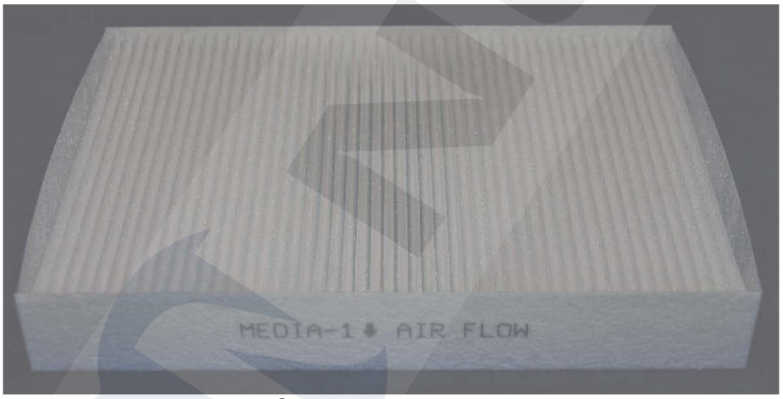
	+50Pa	+100Pa	+200Pa	1000Pa
Dust holding cap. (g), P1	12,4	17,2	-	-
Dust holding cap. (g), P3	-	-	20,2	-
Grav. Efficiency (%) P3	-	-	99,3	-
Dust holding cap. (g), P4	-	-	21,0	40,5
Grav. Efficiency (%), P4	-	-	99,0	99,2
Dust holding cap. (g), P8	-	-	20,8	-
Grav. Efficiency (%), P8	-	-	99,4	-

2.2 Water Resistance (RE05)

For the determination of the behavior during water exposition the filters are dipped in water for 30 min, and then allowed to drip of excessive water from both sides for 60 sec and dry for 5 min. After installation in the test rig the pressure drop at an air flow of 600 m³/h has been recorded until +5% of the initial pressure drop or up to 60 min.

Table 5: Summary of the water resistance test

	Pressure Drop at 600 m³/h, new [Pa]	Time until +5 % (115 Pa) [min]	Pressure Drop at end of test [Pa]	Time after end of test [min]
P5	110	8	114	60



Pic. 1: NCL 210202 after water resistance test

2.3 Resistance to Over pressure (RE01)

On the clogged filter (P3, +200 Pa) by increasing the air flow a Δp of 1000 Pa will be applied for a period of 1 minute.
Mf1: weight of clogged filter before the test / Mf2 : weight of filter after the test.

M : weight of dust collected by the tested filter up to 200 Pa.
Requirements **:** Mf1 - Mf2 < 5% of M

Table 6: Test results overpressure test

	Mf1	MF2	M	Mf1-Mf2	Mf1-Mf2 / M
	[g]	[g]	[g]	[g]	[%]
P4	94,1	93,2	20,2	0,46	2,3

Mf1 / MF2: Mass before and after Over Pressure Test
Mf1-Mf2: Released mass from Filter
M: Mass loaded up to +200 Pa

2.4 Fungal Test acc. EN ISO 846 A+C

One filter element was sent to which did the tests as cooperation partner.
Test report number: 07-10047-21

Table 7: Evaluation of the results for the tested products

	Procedure A Basic resistance against fungal growth in absence of organic contamination		**Procedure C** Resistance against bacteria	
Material	Growth intensity	Evaluation of the material	Result	Evaluation of the material
Particle filter media	0	The material contains no nutrients for the growth of fungi. It is "inert" or "fungistatic".	No growth	The material contains no nutrients for the growth of bacteria.
Frame + adhesive of the particle filter	0	The material contains no nutrients for the growth of fungi. It is "inert" or "fungistatic".	No growth	The material contains no nutrients for the growth of bacteria.

The full test report is attached.

(Managing Director)

No. of attachments: 7
Attachment 1 - 6: Summary of Test Results of Sample NCI 190301_P1-P6+P8
test report 07-10047-21

Attachment 1.1 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1

1. Particle collection efficiency

Test dust:	ISO 12103-1 A2 (PTI)	Particle counter:	APS 3321

Flow rate		A2, loading to +50Pa 200 m³/h		A2, loading to +50Pa 500 m³/h	
Particle size (aerodyn.)	Particle size (geometric) ***	η_{mean} *	Δ_{max} **	η_{mean} *	Δ_{max} **
[µm]	[µm]	[%]	[%]	[%]	[%]
0,54	0,33	93,3	0,1	85,1	0,2
0,58	0,36	93,5	0,1	85,9	0,3
0,63	0,38	93,8	0,3	87,0	0,1
0,67	0,41	94,1	0,1	88,5	0,3
0,72	0,44	94,2	0,1	89,7	0,1
0,78	0,48	94,6	0,2	91,0	0,2
0,84	0,51	94,9	0,1	92,3	0,2
0,90	0,55	95,3	0,1	93,3	0,2
0,97	0,59	95,6	0,2	94,3	0,1
1,04	0,64	95,9	0,2	95,3	0,1
1,11	0,68	96,5	0,1	96,1	0,2
1,20	0,74	96,8	0,1	96,9	0,2
1,29	0,79	97,3	0,0	97,6	0,2
1,38	0,85	97,8	0,1	98,2	0,1
1,49	0,91	98,2	0,1	98,7	0,1
1,60	0,98	98,6	0,1	99,0	0,1
1,72	1,05	98,9	0,1	99,3	0,1
1,84	1,13	99,1	0,1	99,6	0,0
1,98	1,22	99,4	0,1	99,7	0,1
2,13	1,31	99,6	0,1	99,7	0,1
2,29	1,41	99,7	0,1	99,8	0,0
2,46	1,51	99,8	0,1	99,8	0,0
2,64	1,62	99,9	0,1	99,9	0,0
2,84	1,74	>99,9	0,0	99,9	0,1
3,05	1,87	>99,9	0,1	>99,9	0,2
3,28	2,01	>99,9	0,0	>99,9	0,0
3,52	2,16	>99,9	0,0	>99,9	0,0
3,79	2,33	>99,9	0,0	99,8	0,0
4,07	2,50	>99,9	0,0	>99,9	0,1
4,37	2,69	>99,9	0,0	>99,9	0,0
4,70	2,89	>99,9	0,0	>99,9	0,1
5,05	3,10	>99,9	0,0	>99,9	0,0
5,43	3,33	>99,9	0,0	>99,9	0,1
5,83	3,58	>99,9	0,0	>99,9	0,1
6,26	3,85	>99,9	0,0	>99,9	0,0
6,73	4,14	>99,9	0,0	>99,9	0,0
7,23	4,44	>99,9	0,0	>99,9	0,0
7,77	4,78	>99,9	0,0	>99,9	0,0
8,35	5,13	>99,9	0,0	>99,9	0,0
8,98	5,51	>99,9	0,0	>99,9	0,0
9,65	5,93	>99,9	0,0	>99,9	0,0
10,37	6,37	>99,9	0,0	>99,9	0,0
11,14	6,84	>99,9	0,0	>99,9	0,0

* η_{mean} is the average particle collection calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel
*** Particle Size (geometric) = Particle Size (aerodynamic)/root from the density of the test aerosol

Attachment 1.1 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1

Test dust:	NaCl (2%)	Particle counter:	SMPS

Flow rate: 200 m³/h	NaCl, loading to + 50Pa		NaCl, loading to + 100Pa	
Particle size (mobility diameter)	η_{mean} *	Δ_{max} **	η_{mean} *	Δ_{max} **
[µm]	[%]	[%]	[%]	[%]
0,029	86,2	0,6	90,9	0,9
0,034	84,1	0,4	89,0	0,8
0,039	82,1	1,1	87,1	0,7
0,045	79,9	0,8	85,1	0,4
0,052	77,7	0,8	82,7	0,4
0,060	75,4	0,6	80,5	0,5
0,070	72,4	0,7	78,2	0,5
0,081	69,9	0,8	75,9	0,2
0,093	67,7	0,8	73,9	0,4
0,108	64,7	0,4	71,6	0,6
0,124	62,7	0,9	70,6	0,2
0,143	60,8	0,5	69,1	0,8
0,166	59,8	0,2	68,3	0,8
0,191	58,7	0,9	67,6	1,1
0,221	58,0	0,9	67,9	1,0
0,255	58,8	2,2	68,2	1,1
0,294	60,6	1,0	69,3	0,7
0,340	62,2	1,7	71,4	1,7
0,392	64,6	3,2	74,0	2,6
0,453	69,4	1,6	78,0	1,7
0,523	76,2	1,7	83,7	1,9

* η_{mean} is the average particle collection efficiency calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel

Particle size	Efficiency [%]	Efficiency [%]
[µm] (mobility)	NaCl, loading to + 50Pa	NaCl, loading to + 100Pa
0,05	78	83
0,1	66	73
0,2	59	68
0,3	61	69
0,4	65	74
0,5	73	81
[µm] (aerodyn.)	A2, loading to +50Pa	A2, loading to +50Pa
Flow rate:	200 m³/h	500 m³/h
0,5	93,3	85,1
1,0	95,7	94,8
3,0	>99,9	>99,9
5,0	>99,9	>99,9
7,0	>99,9	>99,9
10,0	>99,9	>99,9

Attachment 1.1 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1

2. Pressure drop

Flow rate [m³/h]	200
New filter [Pa]	**26**

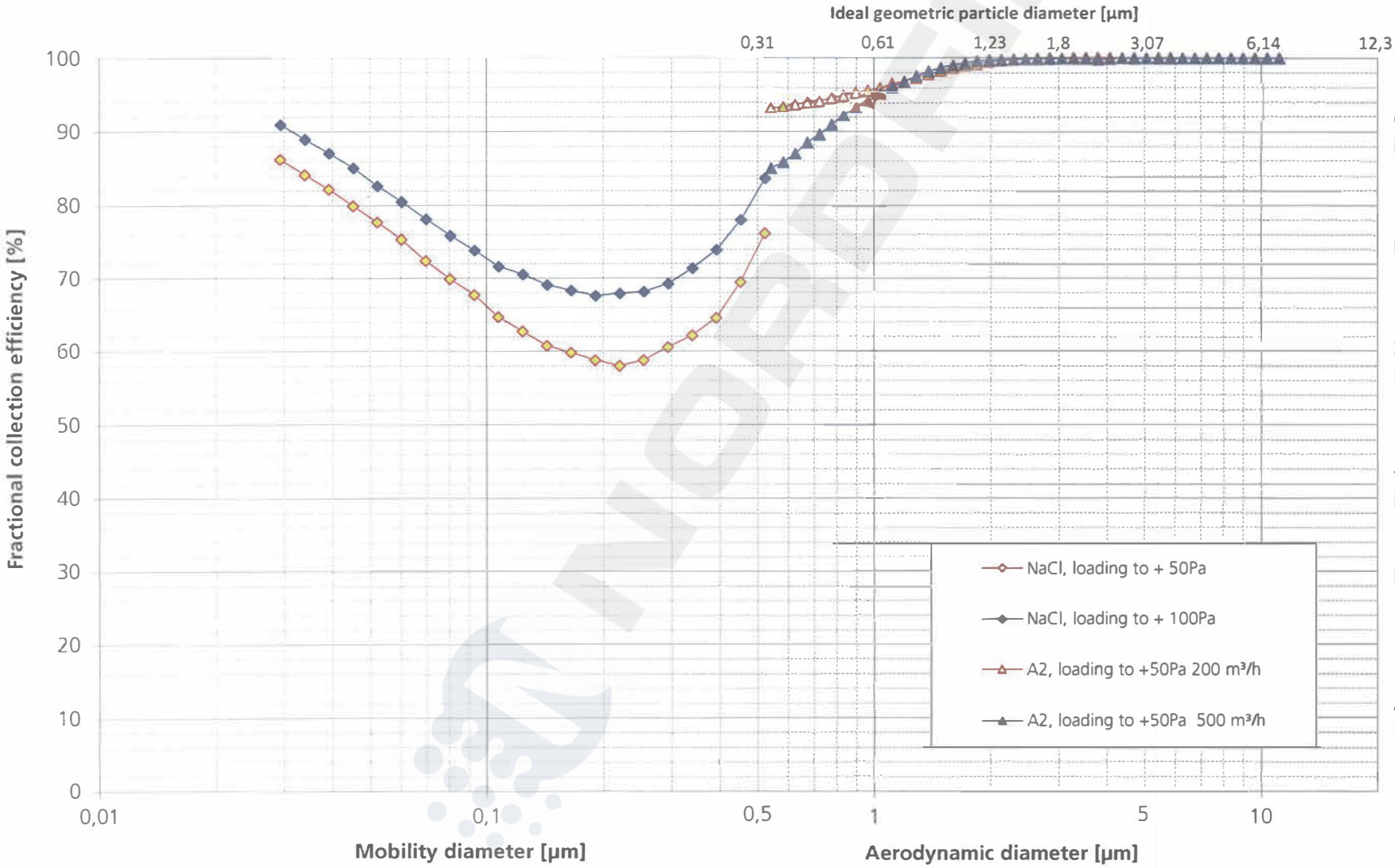
3. Dust loading

Flow rate: 200 [m³/h]

Test dust: ISO 12103-1 A2 (PTI)

$\Delta p_{\text{Initial}}$	[Pa]	26	
$\text{Mass}_{\text{new filter}}$	[g]	74,1	
$\text{Mass}_{\text{after aging}}$	[g]	N/A	
$\text{Mass}_{\text{conditioned}}$	[g]	74,1	**Dust holding capacity [g]**
$\text{Mass}_{+50\ Pa}$	[g]	86,5	**12,4**
$\text{Mass}_{+100\ Pa}$	[g]	91,3	**17,2**

Particle collection efficiencies



Customer:
Nordfil LLC

Date:
10.-11.05.2021

Sample:
MEDIA-1

fiatec-no.:
NCL 210202-P1

Flow rate [m³/h]:
200

Particle counters:
APS 3321
SMPS

Attachment 1.2 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1.2

1. Particle collection efficiency

Test dust:	ISO 12103-1 A2 (PTI)	Particle counter:	APS 3321

		A2, new filter		A2, new filter	
Flow rate:		200 m³/h		500 m³/h	
Particle size (aerodyn.)	Particle size (geometric) ***	η_{mean} *	Δ_{max} **	η_{mean} *	Δ_{max} **
[µm]	[µm]	[%]	[%]	[%]	[%]
0,54	0,33	95,0	0,1	86,9	0,3
0,58	0,36	95,1	0,1	87,0	0,6
0,63	0,38	95,2	0,0	87,3	0,4
0,67	0,41	95,3	0,1	87,6	0,2
0,72	0,44	95,6	0,1	87,8	0,2
0,78	0,48	95,7	0,2	88,0	0,1
0,84	0,51	95,8	0,0	88,4	0,4
0,90	0,55	95,9	0,1	89,0	0,1
0,97	0,59	96,0	0,2	89,2	0,3
1,04	0,64	96,2	0,1	89,7	0,2
1,11	0,68	96,3	0,1	90,1	0,4
1,20	0,74	96,3	0,1	90,7	0,1
1,29	0,79	96,6	0,2	91,3	0,3
1,38	0,85	96,8	0,1	91,9	0,3
1,49	0,91	97,0	0,2	92,6	0,1
1,60	0,98	97,3	0,2	93,2	0,1
1,72	1,05	97,5	0,1	94,0	0,2
1,84	1,13	97,7	0,2	94,6	0,0
1,98	1,22	97,9	0,1	95,1	0,4
2,13	1,31	98,1	0,2	95,5	0,4
2,29	1,41	98,3	0,2	96,1	0,4
2,46	1,51	98,5	0,1	96,3	0,2
2,64	1,62	98,7	0,1	96,8	0,3
2,84	1,74	98,9	0,2	96,8	0,4
3,05	1,87	99,0	0,0	96,8	0,4
3,28	2,01	99,3	0,2	97,0	0,5
3,52	2,16	99,2	0,3	97,1	0,6
3,79	2,33	99,3	0,2	97,3	0,4
4,07	2,50	99,6	0,2	97,5	0,2
4,37	2,69	99,4	0,2	97,5	0,8
4,70	2,89	99,7	0,2	97,4	0,2
5,05	3,10	99,8	0,0	97,3	0,4
5,43	3,33	99,8	0,2	97,5	0,6
5,83	3,58	99,8	0,3	97,5	0,7
6,26	3,85	99,9	0,2	97,4	0,3
6,73	4,14	99,8	0,2	97,3	0,9
7,23	4,44	99,9	0,2	97,3	1,7
7,77	4,78	>99,9	0,0	97,5	1,1
8,35	5,13	>99,9	0,0	97,3	0,4
8,98	5,51	>99,9	0,0	97,5	0,5
9,65	5,93	>99,9	0,0	97,5	1,2
10,37	6,37	>99,9	0,0	97,5	1,1
11,14	6,84	>99,9	0,0	97,1	0,0

* η_{mean} is the average particle collection calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel
*** Particle Size (geometric) = Particle Size (aerodynamic)/root from the density of the test aerosol

Attachment 1.2 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1.2

Test dust:	NaCl (2%)	Particle counter:	SMPS

Flow rate: 200 m³/h	NaCl, new filter 200 m³/h	
Particle size (mobility diameter)	η_{mean} *	Δ_{max} **
[µm]	[%]	[%]
0,029	76,1	0,9
0,034	76,7	0,3
0,039	76,8	0,1
0,045	76,6	0,1
0,052	76,1	0,3
0,060	75,9	0,6
0,070	74,5	0,2
0,081	73,4	0,4
0,093	71,0	0,5
0,108	68,4	0,2
0,124	66,2	0,5
0,143	63,8	0,9
0,166	61,4	0,7
0,191	58,1	1,1
0,221	55,8	0,9
0,255	54,7	0,5
0,294	53,2	0,8
0,340	52,5	1,4
0,392	52,8	1,8
0,453	53,9	1,6
0,523	55,1	0,9

* η_{mean} is the average particle collection efficiency calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel

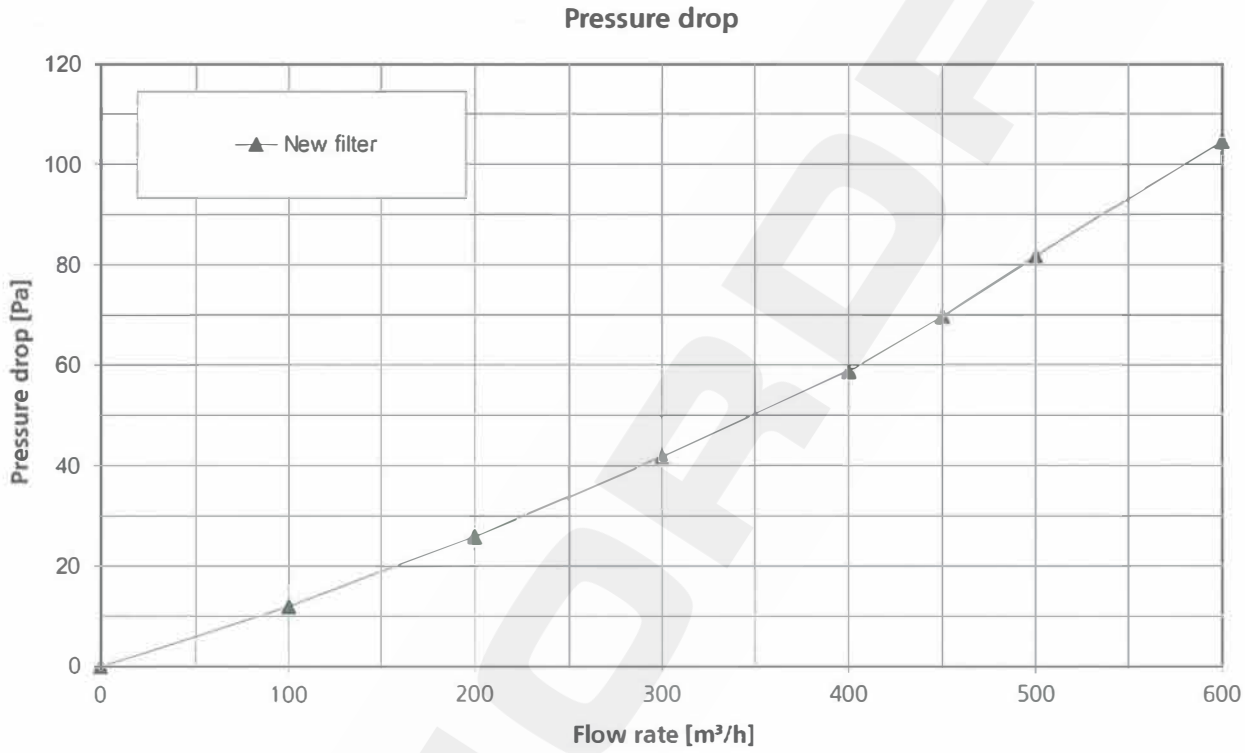
Particle size	Efficiency [%]	
[µm] (mobility)	NaCl, new filter 200 m³/h	
0,05	76	
0,1	70	
0,2	58	
0,3	53	
0,4	53	
0,5	54	
[µm] (aerodyn.)	A2, new filter 200 m³/h	A2, new filter 500 m³/h
0,5	95,0	86,9
1,0	96,1	89,4
3,0	99,0	96,8
5,0	99,8	97,3
7,0	99,8	97,3
10,0	>99,9	97,5

Attachment 1.2 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P1.2

2. Pressure drop

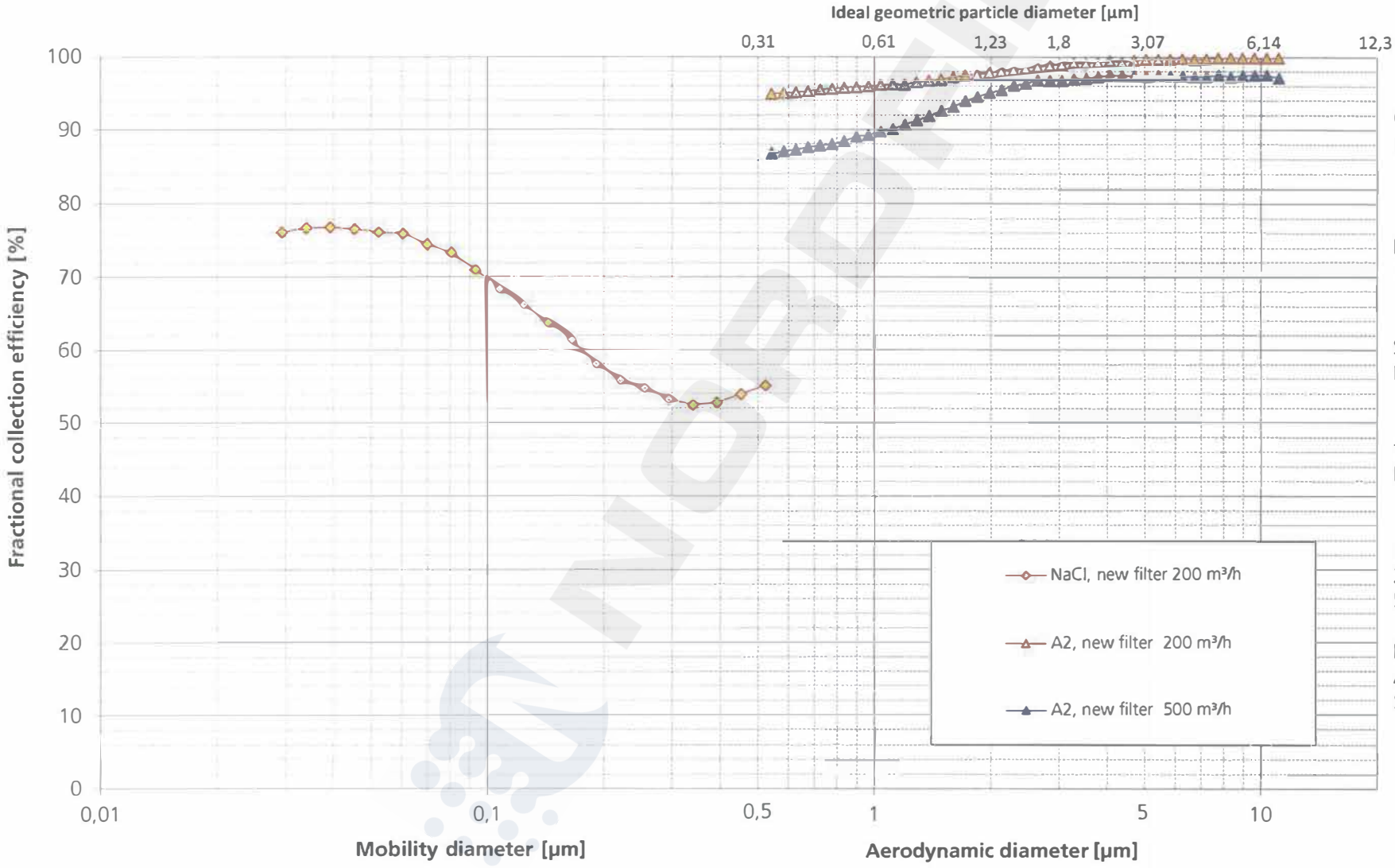
Flow rate [m³/h]	100	200	300	400	450	500	600
New filter [Pa]	**12**	**26**	**42**	**59**	**70**	**82**	**105**



3. Mass

Mass $_{new\ filter}$	[g]	74,9

Particle collection efficiencies



Customer:
Nordfil LLC.

Date:
15.03.2021

Sample:
MEDIA-1

fiatec-no.:
NCL 210202-P1.2

Flow rate [m³/h]:
200
500

Particle counters:
APS 3321
SMPS

Attachment 2 to rest report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P2

1. Particle collection efficiency

Test dust:	Mullberry paper		Particle counter:	APS 3321

Air flow: 300 m³/h	Mullberry paper, new filter	
Particle size (aerodyn.)	η_{mean} *	Δ_{max} **
[µm]	[%]	[%]
7,23	98,9	0,2
7,77	99,1	0,4
8,35	99,2	0,6
8,98	99,1	0,5
9,65	99,2	0,4
10,37	99,2	1,2
11,14	99,1	0,6

* η_{mean} is the average particle collection calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel
*** Particle Size (geometric) = Particle Size (aerodynamic)/root from the density of the test aerosol

Particle size	Efficiency [%]
[µm] (aerodyn.)	Mullberry paper, new filter
7,0	98,9
10,0	99,2

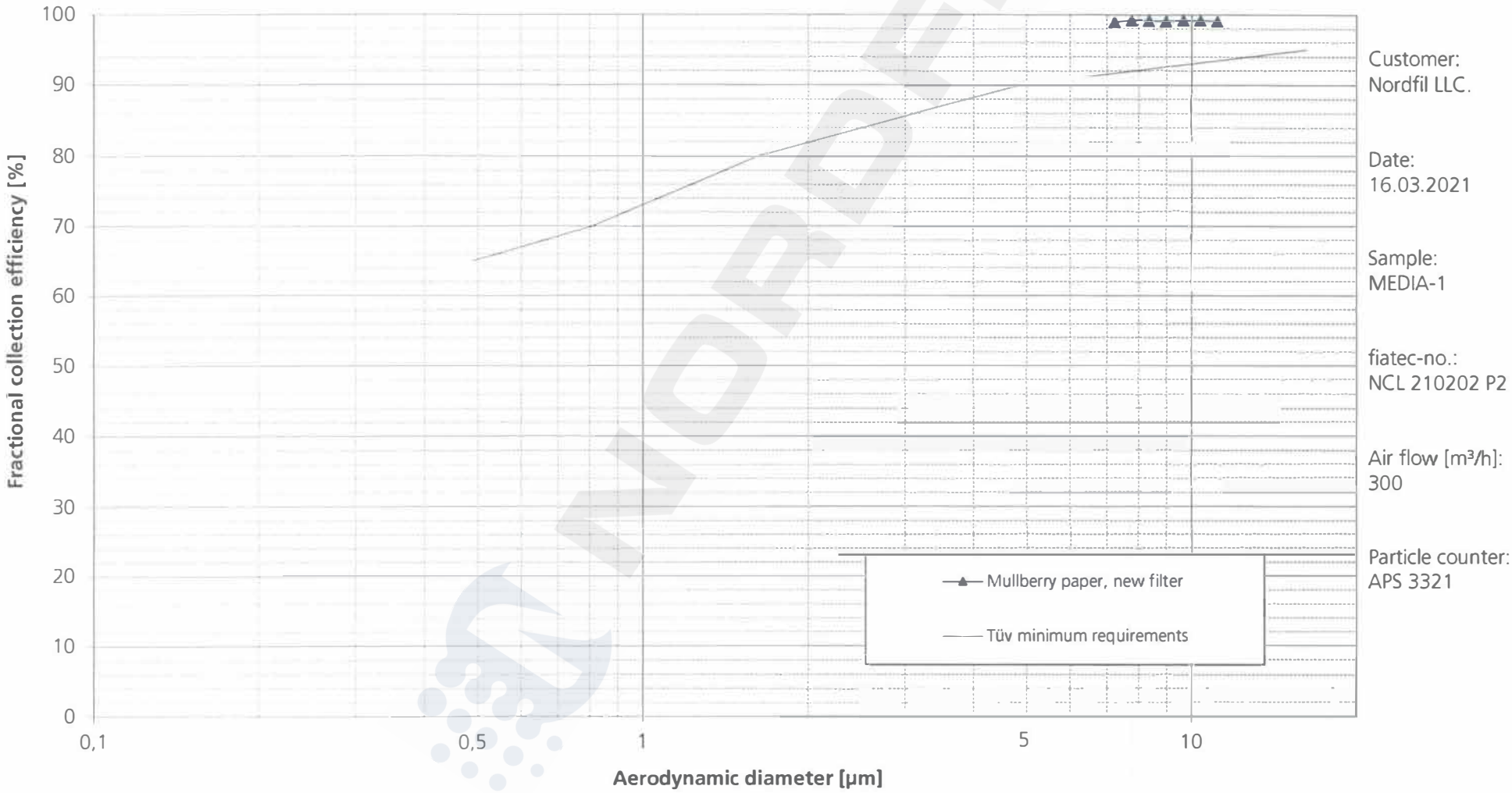
2. Pressure drop

Air flow [m³/h]	300
New filter [Pa]	**41**

3. Mass

Mass $_{New\ filter}$	[g]	74,7

Particle collection efficiencies



Customer:
Nordfil LLC.

Date:
16.03.2021

Sample:
MEDIA-1

fiatec-no.:
NCL 210202 P2

Air flow [m³/h]:
300

Particle counter:
APS 3321

Attachment 3 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P3

1. Dust loading

Flow rate: 200 [m³/h]

Test dust: ISO 12103-1 A2 (PTI)

$\Delta p_{Initial}$	[Pa]	24			
$Mass_{new\ filter}$	[g]	73,9			
$Mass_{after\ aging}$	[g]	N/A	**Dust holding capacity [g]**	+Mass absolutfilter [g], cum	**Gravimetric efficiency [%] cum**
$Mass_{conditioned}$	[g]	73,9			
$Mass_{+200\ Pa}$	[g]	94,1	**20,2**	0,15	**99,3**

Attachment 4 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P4

1. Dust loading

Flow rate: 200 [m³/h]

Test dust: ISO 12103-1 A2 (PTI)

$\Delta p_{initial}$	[Pa]	26			
$Mass_{new\ filter}$	[g]	73,7			
$Mass_{after\ aging}$	[g]	N/A	**Dust holding capacity [g]**	+Mass absolutfilter [g], cum	**Gravimetric efficiency [%] cum**
$Mass_{conditioned}$	[g]	73,7			
$Mass_{+200\ Pa}$	[g]	94,7	**21,0**	0,21	**99,0**
$Mass_{1000\ Pa}$	[g]	114,2	**40,5**	0,32	**99,2**

Attachment 5 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P5

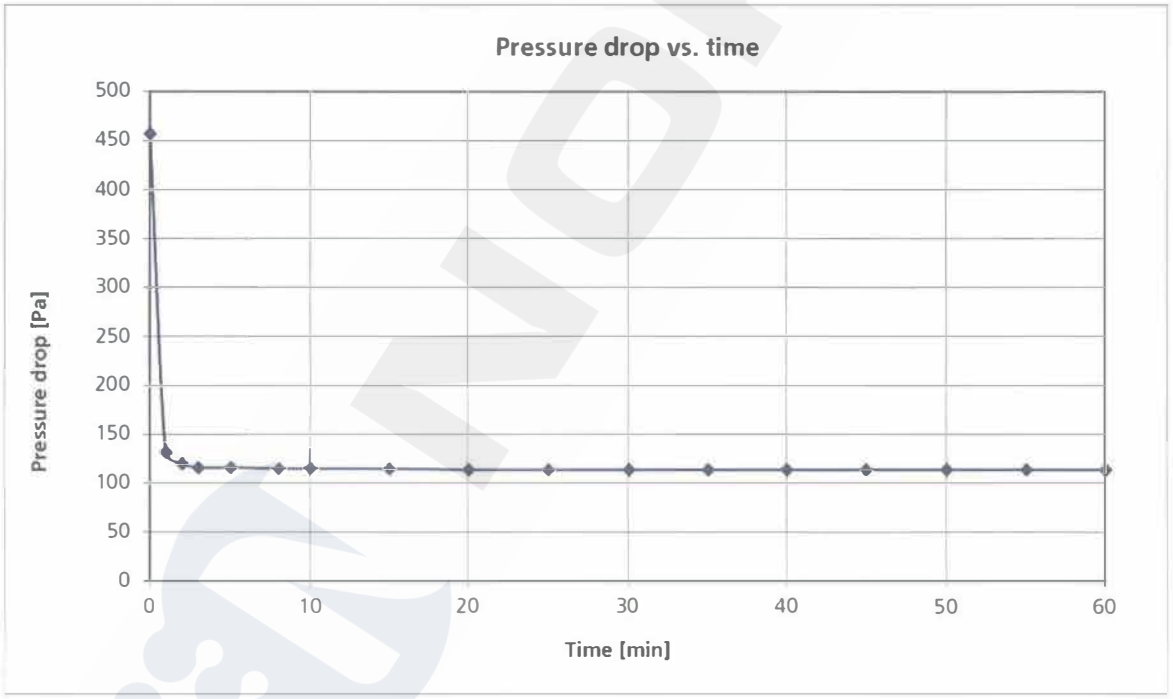
1. Water resistance

Flow rate	[m³/h]	600
Δp before test	[Pa]	110
Δp before test +5%	[Pa]	115
Δp after test	[Pa]	114

Mass $_{\text{new filter}}$	[g]	74,4
Mass $_{\text{aged filter}}$	[g]	N/A
Mass $_{\text{after water resistance}}$	[g]	74,5
Mass $_{\text{after drying at 50°C}}$	[g]	74,3

Pressure drop during drying in test duct:

[min]	[Pa]	[min]	[Pa]	[min]	[Pa]
0,0	457	10,0	115	40,0	114
1,0	132	15,0	115	45,0	114
2,0	120	20,0	114	50,0	114
3,0	116	25,0	114	55,0	114
5,0	116	30,0	114	60,0	114
8,0	115	35,0	114		



Comment: A light metal mesh was used to support the structure of the filter during this test to prevent the filter elements to be sucked through the face plate.

Attachment 6 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P6

1. Particle collection efficiency

Test dust:	ISO 12103-1 A2 (PTI)	Particle counter:	APS 3321

Flow rate: 500 m³/h		A2, aged filter	
Particle size (aerodyn.)	Particle size (geometric) ***	η_{mean} *	Δ_{max} **
[µm]	[µm]	[%]	[%]
0,54	0,33	82,9	0,2
0,58	0,36	83,1	0,1
0,63	0,38	83,7	0,2
0,67	0,41	84,3	0,1
0,72	0,44	85,0	0,2
0,78	0,48	85,4	0,3
0,84	0,51	86,1	0,6
0,90	0,55	86,6	0,2
0,97	0,59	87,2	0,4
1,04	0,64	87,7	0,4
1,11	0,68	88,5	0,4
1,20	0,74	89,2	0,0
1,29	0,79	90,0	0,3
1,38	0,85	90,8	0,2
1,49	0,91	91,4	0,4
1,60	0,98	92,0	0,4
1,72	1,05	92,8	0,2
1,84	1,13	93,3	0,5
1,98	1,22	93,8	0,3
2,13	1,31	94,2	0,6
2,29	1,41	94,7	0,4
2,46	1,51	94,8	0,2
2,64	1,62	94,7	0,8
2,84	1,74	94,7	0,5
3,05	1,87	94,6	0,8
3,28	2,01	94,5	0,6
3,52	2,16	94,1	1,0
3,79	2,33	93,9	0,3
4,07	2,50	93,6	0,5
4,37	2,69	93,5	1,1
4,70	2,89	93,4	0,5
5,05	3,10	93,0	1,1
5,43	3,33	92,8	0,7
5,83	3,58	92,8	0,6
6,26	3,85	92,8	1,8
6,73	4,14	92,8	0,9
7,23	4,44	92,7	2,0
7,77	4,78	92,5	1,8
8,35	5,13	92,4	1,5
8,98	5,51	92,5	1,6
9,65	5,93	92,6	1,8
10,37	6,37	92,6	1,3
11,14	6,84	92,4	1,9

* η_{mean} is the average particle collection calculated from three sets of up- and downstream measurements
** Δ_{max} represents the full scattering range of single values for each size channel
*** Particle Size (geometric) = Particle Size (aerodynamic)/root from the density of the test aerosol

Attachment 6 to test report NCL 210202

Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P6

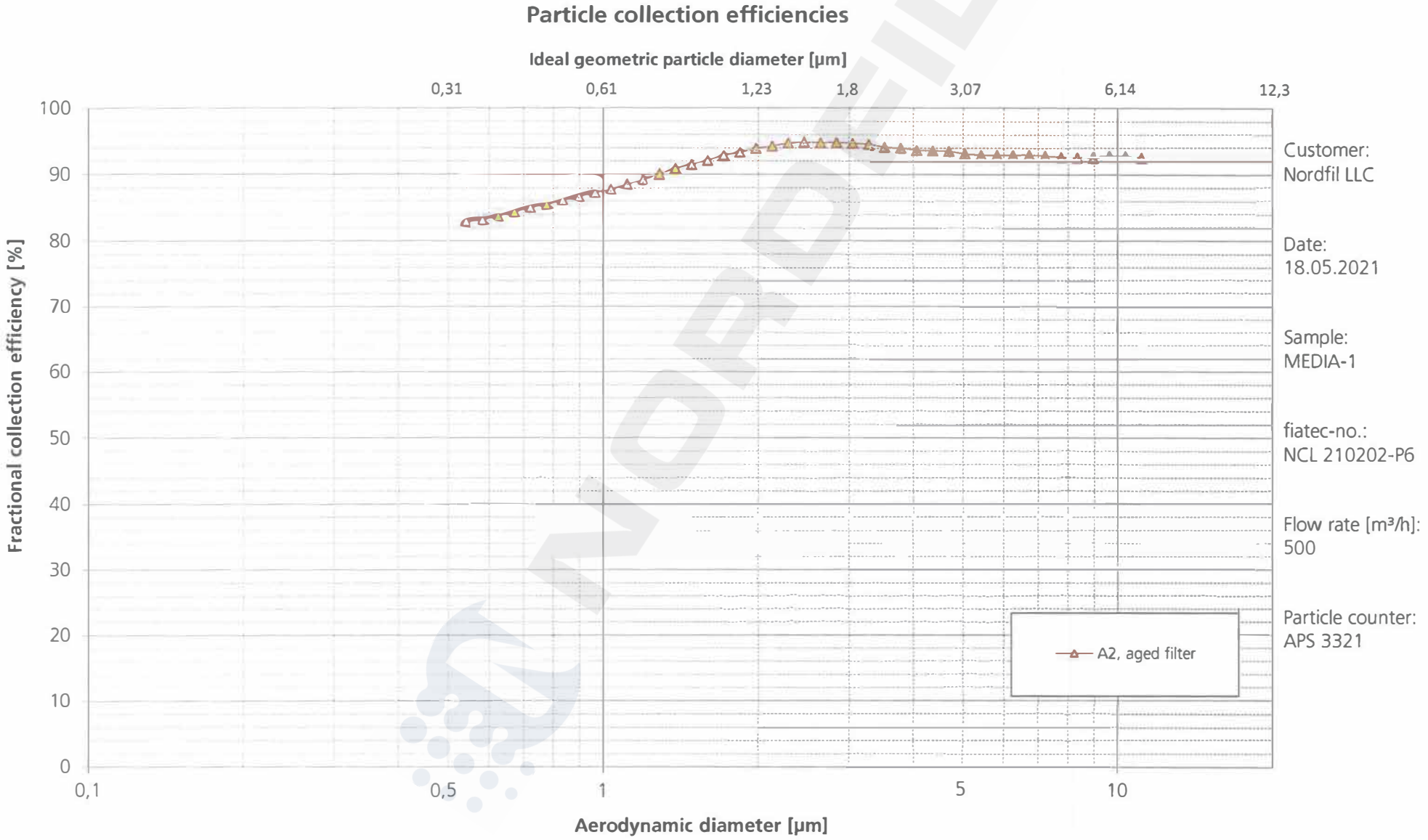
Particle size	Efficiency [%]
[µm] (aerodyn.)	A2, aged filter
0,5	82,9
1,0	87,5
3,0	94,7
5,0	93,1
7,0	92,8
10,0	92,6

2. Pressure drop

Flow rate [m³/h]	500
Aged filter [Pa]	**133**

3. Mass

Mass $_{\text{new filter}}$	[g]	73,9
Mass $_{\text{after aging}}$	[g]	73,7


Particle collection efficiencies
Ideal geometric particle diameter [µm]
0,31
0,61
1,23
1,8
3,07
6,14
12,3
Fractional collection efficiency [%]
100
90
80
70
60
50
40
30
20
10
0
0,1
0,5
1
5
10
Aerodynamic diameter [µm]
A2, aged filter
Customer:
Nordfil LLC
Date:
18.05.2021
Sample:
MEDIA-1
fiatec-no.:
NCL 210202-P6
Flow rate [m³/h]:
500
Particle counter:
APS 3321

Attachment 8 to test report NCL 210202
Summary of test results for sample
MEDIA-1
fiatec-no.: NCL 210202-P8

1. Dust loading

Flow rate: 200 [m³/h]

Test dust: ISO 12103-1 A2 (PTI)

$\Delta p_{initial}$	[Pa]	27			
$Mass_{new\ filter}$	[g]	73,9	**Dust holding capacity [g] cum**	+Mass absolutfilter [g], cum	**Gravimetric efficiency [%] cum**
$Mass_{conditioned}$		73,9			
$Mass_{+200\ Pa}$	[g]	94,7	**20,8**	0,13	**99,4**

Test report 07-10047-21

Customer

Report date:: 19.05.2021
Number of pages: 5
attachments: none
Date of order: 13.04.2021
Sample receipt: 15.04.2021
Investigation start: 21.04.2021

Customer's project number NCL 210202

Subject of analysis Particle filter Nissan 272774BR1A, filter medium, frame, and adhesive

Task Testing of a particle filter according to DIN EN ISO 846:1997, procedures A and C

Storage Remaining sample material will be stored for six weeks after the report is issued.

1 Task

The Microbiology Group at the was assigned to test the components of a particle filter according to DIN EN ISO 846:2019 "Plastics - Evaluation of the action of microorganisms ", procedures A (resistance against fungi – growth test) and C (resistance against bacteria).

2 Testing

Sample material:

The sample materials were provided by the customer in the form of sheets and strips of frame material. From these sample materials test specimens were cut and used for the testing. The dimensions of the test specimens were as notified in Table 1.

Table 1: Description of the sample materials (customer's project number: NCL 210202)

Internal identifier	Material identification	Dimensions of the test specimens used for testing [mm]
07-3-47-1	**Particle filter Nissan 272774BR1A**	50 x 50 x 1
07-3-47-2	**Particle filter Nissan 272774BR1A, frame + adhesive**	50 x 35 x 2

Divergent from the specifications of the DIN EN ISO 846:2019 porous plastic materials were tested.

Test organisms:

Table 2: Fungi used for testing according to procedure A of DIN EN ISO 846:2019

Fungi	Strain	Source of supply
Aspergillus niger	DSM 1957 = (ATCC6275)	DSMZ
Penicillium pinophilum	DSM 1944 = (CMI 114933)	DSMZ
Paecilomyces variotii	DSM 1961 = (ATCC 18502)	DSMZ
Trichoderma virens	DSM 1963 = (ATCC 69645)	DSMZ
Chaetomium globosum	DSM 1962 = (ATCC 6205)	DSMZ

DSMZ = Leibniz Institute DSMZ - German Collection of Microorganisms and Cell Cultures, Braunschweig

According to the test standard, the bacterium *Pseudomonas aeruginosa* DSM 1253 (NCTC 8060) was used for procedure C of DIN EN ISO 846:2019.

Disinfection of test specimen:

The test specimens of the filter medium were disinfected and cleaned using 70 % ethanol before testing. Drying time was extended to 18 h. The frame material with the adhesive was not treated with 70 % ethanol to prevent the solution and distribution of adhesive components.

Media

Table 3: Media used for the testing according to procedures A and C of DIN EN ISO 846:2019

Procedure	Medium	According to passage
C	Incomplete agar medium	5.2.3.4

Test specimens for procedure A are incubated in petri dishes without agar medium placed in a box providing a relative humidity >95 %.

Test conditions, duration and temperature of testing

Polished stainless steel disks were used as negative controls for procedure A.

Test duration for testing was 28 days for procedures A and C. The testing was performed at a temperature of 29±1 °C for both procedures.

3 Results

All of the test specimens were evaluated visually and by light microscopy after the test period (Tables 4 and 5).

None of the three negative controls (polished stainless steel disks) showed growth (growth rating: 0).

Table 4: Results of the testing of the filter medium of the **particle filter Nissan 272774BR1A** according to procedures A and C of the DIN EN ISO 846:2019

Material		procedure A	
		single values	Mean value
Particle filter Nissan 272774BR1A, filter medium	**Group I** inoculated	0,0,0,0,0	**0**
	Group S sterile	0,0,0	0
		procedure C	
Particle filter Nissan 272774BR1A filter, medium	**Group I** inoculated	0,0,0,0,0	0
	Group S sterile	0,0,0	0

Procedure A
0 = No growth apparent on the test specimen surface, even under the microscope with a magnification of about 50x.
1a = No growth visible to the naked eye, but microscopically detectable covering up to 25 % of the surface
1b = No growth visible to the naked eye, but microscopically detectable covering up to 50 % of the surface
1c = No growth visible to the naked eye, but microscopically detectable covering more than 50 % of the surface
2 = Growth visible to the naked eye covering up to 25 % of the surface
3 = Growth visible to the naked eye covering up to 50 % of the surface
4 = Considerable growth covering more than 50 % of the surface
5 = Heavy growth covering the surface completely
Procedure C
0 = no bacterial growth
+ = bacterial growth
* = weak growth of fungi

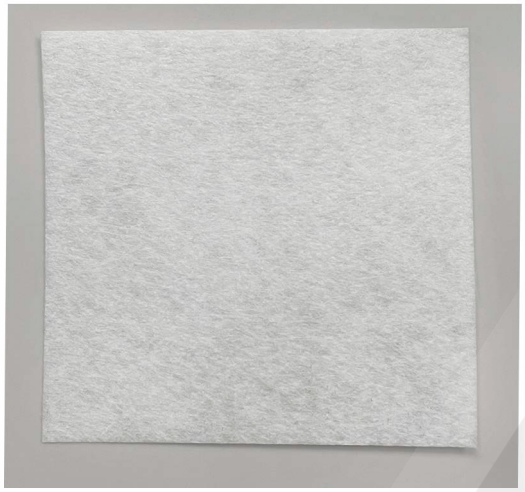


Fig. 1: Procedure A: **Particle filter Nissan 272774BR1A, filter medium;** test specimen at the end of the test period (example);rating: 0

Table 5: Results of the testing of the frame material + adhesive of the **particle filter Nissan 272774BR1A** according to procedures A and C of the DIN EN ISO 846:2019

Material		procedure A	
		single values	Mean value
Particle filter Nissan 272774BR1A, frame + adhesive	**Group I** inoculated	0,0,0,0,0	**0**
	Group S sterile	0,0,0	0
		procedure C	
Particle filter Nissan 272774BR1A, frame + adhesive	**Group I** inoculated	0*,0*,0*,0*,0	0
	Group S sterile	0*,0*,0*	0

For legend see Table 4

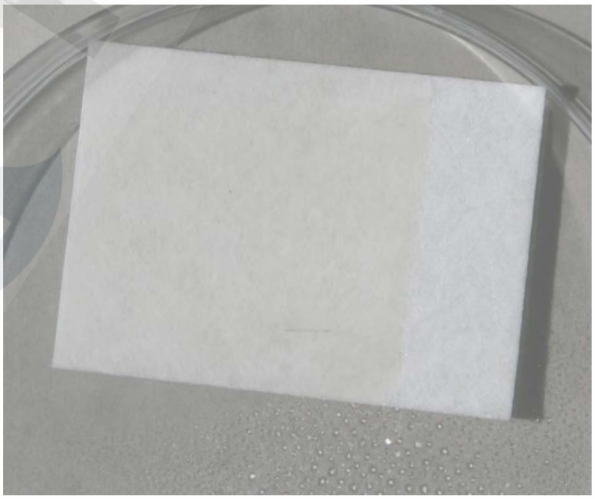


Fig. 2: Procedure A: **Particle filter Nissan 272774BR1A, frame + adhesive;** test specimen at the end of the test period (example); rating: 0

Evaluation of the results[1]

Table 6: Evaluation of the results for the tested material

Material	Procedure A Basic resistance against fungal growth in absence of organic contamination		Procedure C Resistance against bacteria	
	Growth intensity	**Evaluation of the material**	**Result**	**Evaluation of the material**
Particle filter Nissan 272774BR1A, filter medium	0	The material contains no nutrients for the growth of fungi; it is "inert" or "fungistatic".	0 No growth	The material contains no nutrients for the growth of bacteria.
Particle filter Nissan 272774BR1A, frame + adhesive	0	The material contains no nutrients for the growth of fungi; it is "inert" or "fungistatic".	0 No growth	The material contains no nutrients for the growth of bacteria.

[1] The following interpretations are not accredited by the DAkkS. They are not based on the requirements of DIN EN ISO/IEC 17025.