REPORT

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Date 2017-02-13 | Reference 7P00438A |

Filtech Swiss
Via Pra Mag 9
6862 RANCATE-MENDRISIO
Schweiz

Testing of Air Filter according to ISO 16890:2016

(6 appendices)

A test according to ISO 16890:2016 was carried out by request from Filtech Swiss.

Tested item

Filtech Swiss, R05-50, a 592 mm x 592 mm x 25 mm, Panel filter.

Pictures can be found in appendix 5.

The item was sent to SP by Filtech Swiss and was received by SP on January 13, 2017.

The item was without visible defects.

Test method

The test was carried out according to standard ISO 16890:2016 "Air filters for general ventilation". The standard consists of four parts:

- *ISO 16890-1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)*

- *ISO 16890-2: Measurement of fractional efficiency and air flow resistance*

Measurements were performed with dual particle counters according to section 9.3.4 - Testing sequence for dual OPC testing.

- *ISO 16890-3: Determination of the gravimetric efficiency and the airflow resistance versus the mass of test dust captured*

- *ISO 16890-4: Conditioning method to determine the minimum fractional test efficiency*

Eight cabinets with a total surface area of 1.82 m^2 were placed in the chamber according to ISO 16890-4 section 7. The purity of the 2-propanol was 99.5 %. The test item was conditioned for 24.5 +/- 0.5 hours.

Efficiency at 50% nominal air flow was measured with DEHS in the range 0.3 – 1 µm.

Deviation from the standard:

Section 9.2.2 and 9.2.8, the evaporated amount of 2-propanol was not determined.
Section 7.3, the relative humidity (room air) was below 20 %.
Efficiency at 50% nominal air flow was measured at 700 m^3/h. ISO 16890 is applicable for air flow rates between 900 m^3/h and 5400 m^3/h.

Date and Place

The test was carried out at SP's laboratory of Energy and circular economy in Borås, Sweden on January 30 - February 10, 2017.

Tests according to ISO 16890-2 were carried out on January 30, 2017.
Tests according to ISO 16890-3 were carried out on February 10, 2017.
Tests according to ISO 16890-4 were carried out on February 10, 2017, conditioning procedure according to ISO 16890-4 was carried out on February 6-7, 2017.

Results

The results are presented in appendix 1-4 and are valid only for the item tested.

In appendix 1 a summary of the results are reported according ISO 16890-1. It also includes the fractional efficiencies and the calculation of PM-efficiencies.

In appendix 2 fractional efficiency and air flow resistance are reported according to ISO 16890-2.

In appendix 3 determination of the gravimetric efficiency (arrestance) and the air flow resistance versus the mass of test dust capture (test dust capacity) are reported according to ISO 16890-3.

In appendix 4 the minimum fractional efficiency is reported according to ISO 16890-4.

The measured particle concentrations are reported in appendix 2 and appendix 4. Table A6 (upstream count data), A7 (downstream count data) and A9 Uncertainty in ISO 16890-2 Annex A are reported.

Measurement equipment

- Pressure gauge Furness model 318, SP's inventory no. 901 568 (static P Filter)
- Pressure gauge Furness model 318, SP's inventory no. 901 569 (static P Flow)
- Pressure gauge Furness FC012, SP's inventory no. 201 691 (ΔP Filter)
- Pressure gauge Furness FC012, SP's inventory no. 201 690 (ΔP Flow)
- Particle counter TSI, OPS 3330, SP's inventory no. 902240
- Particle counter TSI, OPS 3330, SP's inventory no. 902241
- Barometer, Testo 511, SP's inventory no. 900 078
- Temperature and RH, Testo 635, SP's inventory no. 900 065
- Weighing scale, Mettler PC16, SP's inventory no. 202 741
- Flow meter, MFS-C-250, SP's inventory no. 202 742
- Temperature and RH, Tinytag, DIV 94 S
- Barometer, Druck PACE 1001, SP's inventory no. 902243

Uncertainty of measurement

The uncertainty of the Air flow is better than ± 5 %
The uncertainty of the Pressure Drop is better than ± 3 %
The uncertainty of the Temperature is better than ± 0.5 ºC
The uncertainty of the Relative Humidity is better than ± 2 % RH
The uncertainty of the Atmospheric Pressure is better than ± 1 mbar
The uncertainty of the Measured mass is better than ± 0.5 g

The uncertainty has been calculated according to EA-4/16 with a coverage factor k=2.

The uncertainty of the filtration efficiency according to ISO 16890:2016 is presented in appendices 2 and 4.

SP Technical Research Institute of Sweden
Energy and circular economy - Building Services Engineering

Performed by

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Appendices
1. Summary test report according to ISO 16890-1:2016
2. Test report according to ISO 16890-2:2016
3. Test report according to ISO 16890-3:2016
4. Test report according to ISO 16890-4:2016
5. Additional pictures of the test item.
6. The interpretation of test reports

Appendix 1

ISO 16890-1:2016 - Air Filter Test Results

Testing Organization:
SP Technical Research Institute of Sweden
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

GENERAL

Report no.: 7P00438A	Date of tests: 2017-01-30 - 2017-02-10	Date of report: 2017-02-13
Supervisor: UH		Device obtained (when and how obtained):
Test(s) requested by: Filtech Swiss		The device was sent and obtained on 2017-01-13

DEVICE TESTED

Model: R05-50		Manufacturer: Filtech Swiss	Construction: Panel filter
Article number: -	Type of medium: Synthetic	Net effective filtering area: 2.2 m^2	Filter dimensions (width x height x depth) 592x592x25 mm

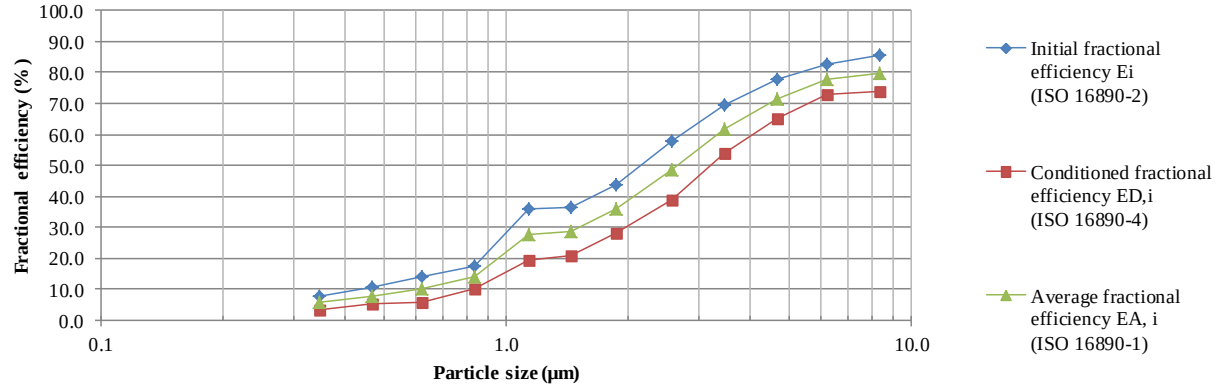
TEST DATA AND ATTACHED TEST REPORTS

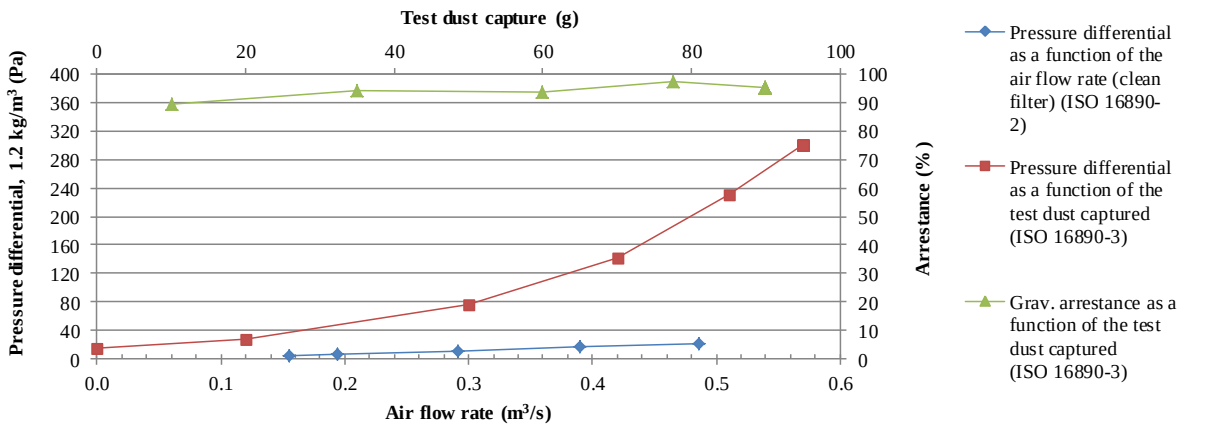
Test air flow rate: 0.389 m^3/s	Test aersole: KCl (1-10 µm) DEHS (0.3-1 µm)	Test report to ISO 16890-2	Report no. 7P00438A Appendix 2
		Test report to ISO 16890-3 (optional)	Report no. 7P00438A Appendix 3
		Test report to ISO 16890-4	Report no. 7P00438A Appendix 4

RESULTS

Initial pressure differential: 17 Pa	Initial grav. arrestance: 90 %	$ePM_{1,min}$ 6 %	$ePM_{2.5,min}$ 13 %		ISO rating (0.389 m^3/s)
Final test pressure differential: 300 Pa	Test dust capacity: 89 g	ePM_1 9 %	$ePM_{2.5}$ 18 %	ePM_{10} 51 %	**ISO ePM $_{10}$ 50 %**

Remarks:





NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

Appendix 1

ISO 16890-1:2016 - Fractional efficiency values

Testing organisation:	SP Technical Research Institute of Sweden	Report no:	7P00438A
Model:	R05-50	Manufacturer:	Filtech Swiss
Test air flow rate:	0.389 m^3/s	Date of report:	2017-02-13

i	d_i µm	d_{i+1} µm	$d_{a,i}$ µm	$\Delta ln\ d_i$ µm	E_i %	$E_{D,i}$ %	$E_{A,i}$ %
1	0.30	0.40	0.35	0.29	7.7	3.4	5.5
2	0.40	0.55	0.47	0.32	10.5	5.1	7.8
3	0.55	0.70	0.62	0.24	13.8	6.0	9.9
4	0.70	1.00	0.84	0.36	17.5	10.3	13.9
5	1.00	1.30	1.14	0.26	35.9	19.4	27.7
6	1.30	1.60	1.44	0.21	36.3	20.8	28.5
7	1.60	2.20	1.88	0.32	43.7	28.2	36.0
8	2.20	3.00	2.57	0.31	58.0	39.0	48.5
9	3.00	4.00	3.46	0.29	69.3	54.1	61.7
10	4.00	5.50	4.69	0.32	77.6	65.2	71.4
11	5.50	7.00	6.20	0.24	82.5	72.7	77.6
12	7.00	10.00	8.37	0.36	85.4	73.7	79.5

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

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

$\Delta \ln d_i$: Logarithmic width of a particle diameter size in range i; ln is the natural logaritm to the base of e, where e is an irrational and transcendetal constant approximately equal to 2.718281828, dimensionless

$\Delta \ln d_i = \ln (d_{i+1}/d_i)$

E_i: Initial fractional efficiency of partcile size range i of the untreated and unloaded filter element, %

$E_{D,i}$: Fractional efficiency of particle size range i of the filter element after an artifical conditioning step, %

$E_{A,i}$: Average fractional efficeincy $(E_i + E_{D,i})/2$ of particle size range i, %

Appendix 1

ISO 16890-1:2016 - Calculation of PM-efficiencies

Testing organisation:	SP Technical Research Institute of Sweden	Report no.:	7P00438A
Model:	R05-50	Manufacturer:	Filtech Swiss
Test air flow rate:	0.389 m^3/s	Date of report:	2017-02-13

i	$d_{a,i}$ µm	$\Delta ln\ d_i$ µm	urban distribution $q_{3u}(d_{a,i})$	$q_{3u}(d_{a,i}) \cdot \Delta ln\ d_i$	$E_{D,i} \cdot q_{3u}(d_{a,i}) \cdot \Delta ln\ d_i$	$E_{A,i} \cdot q_{3u}(d_{a,i}) \cdot \Delta ln\ d_i$	$ePM_{x,min}$ %	ePM_x %
1	0.35	0.29	0.226	0.065	0.221	0.36		
2	0.47	0.32	0.199	0.063	0.326	0.50		
3	0.62	0.24	0.158	0.038	0.228	0.38		
4	0.84	0.36	0.115	0.041	0.424	0.57	**$ePM_{1,min}$**	**ePM_1**
			∑ line 1-4	0.208	1.199	1.806	6	9
5	1.14	0.26	0.085	0.022	0.433	0.617		
6	1.44	0.21	0.076	0.016	0.328	0.451		
7	1.88	0.32	0.080	0.026	0.721	0.919		
8	2.57	0.31	0.100	0.031	1.206	1.502	**$ePM_{2.5,min}$**	**$ePM_{2.5}$**
			∑ line 1-8	0.302	3.889	5.295	13	18

i	$d_{a,i}$ µm	$\Delta ln\ d_i$ µm	rural distribution $q_{3u}(d_{a,i})$	$q_{3u}(d_{a,i}) \cdot \Delta ln\ d_i$		$E_{A,i} \cdot q_{3u}(d_{a,i}) \cdot \Delta ln\ d_i$		ePM_x %
1	0.35	0.29	0.094	0.027		0.150		
2	0.47	0.32	0.084	0.027		0.209		
3	0.62	0.24	0.074	0.018		0.177		
4	0.84	0.36	0.070	0.025		0.348		
5	1.14	0.26	0.076	0.020		0.554		
6	1.44	0.21	0.088	0.018		0.523		
7	1.88	0.32	0.108	0.034		1.238		
8	2.57	0.31	0.137	0.043		2.065		
9	3.46	0.29	0.167	0.048		2.967		
10	4.69	0.32	0.195	0.062		4.442		
11	6.20	0.24	0.217	0.052		4.057		
12	8.37	0.36	0.231	0.083		6.564		**ePM_{10}**
			∑ line 1-12	0.457		23.294		51

Appendix 2

ISO 16890-2:2016 - AIR FILTER TEST RESULTS SUMMARY

Testing Organization:
SP
Technical Research Institute of Sweden
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

GENERAL

Test ID: SP201701301	Date of test: 2017-01-30	Operator: UH

Particle counter information

Manufacturer:	Model:	Coincidence value (p/cm^3):	Air flow measurement:	Device obtained (when and how obtained):
TSI Gmbh	OPS 3330	300	Annubar, Micatrone Air flow sensor MFS-SS	The device was sent and obtained on 2017-01-13

DEVICE TESTED

Model:	Manufacturer:	Construction:
R05-50	Filtech Swiss	Panel filter

Article number:	Type of media:	Net effective media area (m^2)	Filter dimensions (width x height x depth)
-	Synthetic	2.2 m^2	592x592x25 mm

Filter/media electrostatic charge:	Media colour:	Media adhesive:
Yes	white	N/A

Device Condition: Clean / Initial

Other descriptive information:

TEST DATA SUMMARY

Test air flow rate:	Test air temperature:	Test air RH:	Test aersol:
0.389 m^3/s	20.6 - 21.3 ° C	49.1 - 51.8 %	DEHS (0.3-1 µm) KCl (1-10 µm)

RESULTS

Resistance to airflow (Pa)

Measured: 17 Pa
Rated initial: -
Rated Final: -

Test Device Photo

Fractional Efficiency (%)

Range (µm)	Measured Efficiency	Rated Efficiency	Upstream concentration (particles / dm^3)
0.30 - 0.40	8		14623
0.40 - 0.55	11		12755
0.55 - 0.70	14		8498
0.70 - 1.00	17		7986
1.00 - 1.30	36		5341
1.30 - 1.60	36		2933
1.60 - 2.20	44		12223
2.20 - 3.00	58		8091
3.00 - 4.00	69		3683
4.00 - 5.50	78		2011
5.50 - 7.00	83		623
7.00 - 10.00	85		580

Remarks:

NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

Appendix 2

ISO 16890-2:2016 - AIR FILTER TEST RESULTS DETAILS

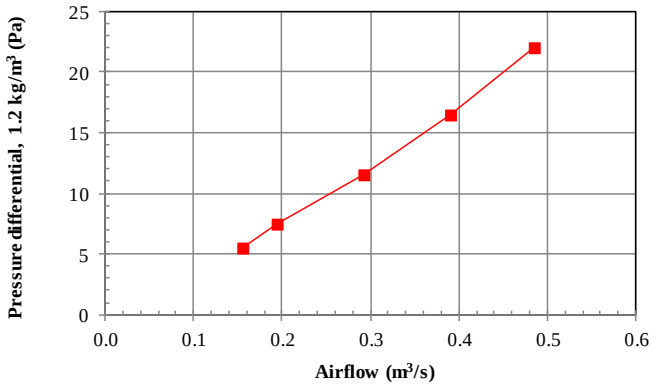
Testing Organization:
SP
Technical Research Institute of Sweden
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

Test ID: SP201701301 | Date of test: 2017-01-30 | Operator: UH

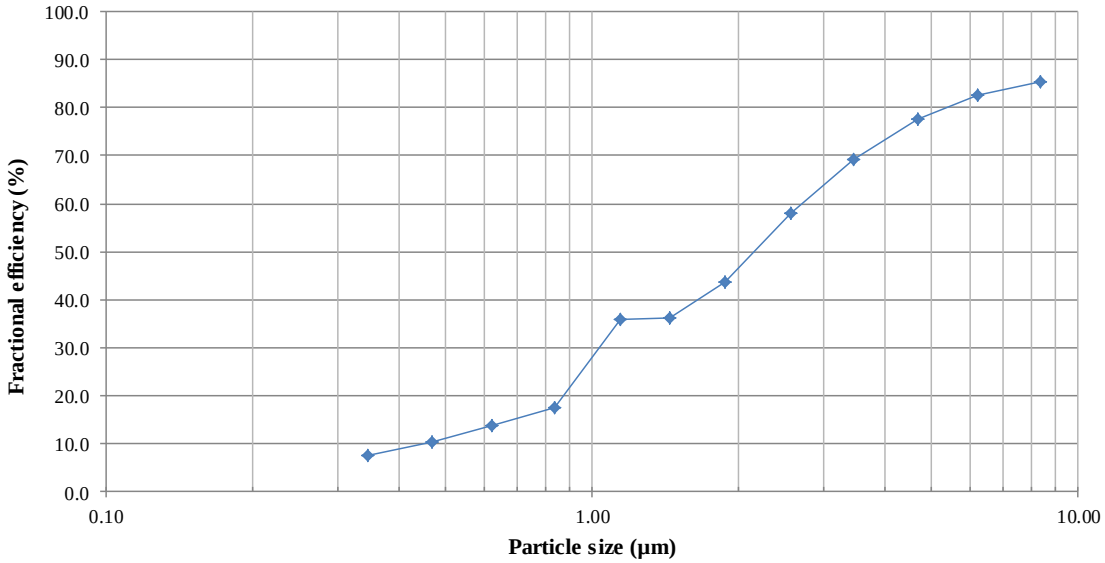
TEST DATA DETAILS

Resistance to Airflow 1.2 kg/m^3

% of rated airflow	Airflow (m^3/s)	Resistance to Airflow (Pa)
40%	0.155	6
50%	0.194	8
75%	0.292	12
100%	0.390	17
125%	0.486	22



Fractional Efficiency by Particle Size



NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

Appendix 2

Efficiency measurement

Upstream count data

OPC bin	$d_{a,i}$	Upstream efficiency count data					
	µm	1	2	3	4	5	$U_{e,tot}$
1	0.35	14749	14732	14361	14666	14607	**73115**
2	0.47	13151	12799	12524	12761	12541	**63776**
3	0.62	8840	8313	8343	8477	8516	**42489**
4	0.84	8102	8168	7886	7888	7884	**39928**
5	1.14	5409	5570	5212	5291	5223	**26705**
6	1.44	2990	3034	2917	2943	2782	**14666**
7	1.88	12425	12613	12232	11940	11904	**61114**
8	2.57	8271	8252	8145	7970	7815	**40453**
9	3.46	3767	3861	3670	3630	3488	**18416**
10	4.69	1970	2079	2050	1942	2014	**10055**
11	6.20	627	611	635	622	622	**3117**
12	8.37	588	606	589	558	559	**2900**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement

Downstream count data

OPC bin	$d_{a,i}$	Downstream efficiency count data					
	µm	1	2	3	4	5	$D_{e,tot}$
1	0.35	12586	12435	12306	12359	12237	**61923**
2	0.47	11394	10990	10964	11117	11165	**55630**
3	0.62	7448	7464	7407	7207	7238	**36764**
4	0.84	6676	6444	6360	6405	6585	**32470**
5	1.14	3719	3670	3564	3416	3426	**17795**
6	1.44	1711	1741	1707	1719	1652	**8530**
7	1.88	6580	6378	6215	6206	6074	**31453**
8	2.57	3294	3347	3184	3067	2978	**15870**
9	3.46	1118	1097	1127	1065	1034	**5441**
10	4.69	463	437	457	453	457	**2267**
11	6.20	141	128	109	117	131	**626**
12	8.37	133	116	122	121	126	**618**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement

Final results and uncertainty

OPC bin	$d_{a,i}$	Penetration data reduction			Uncertainty limits		Uncertainty	Efficiency
	µm	P_a	δ	e	Static	Dynamic	Pass/Fail	%
1	0.35	0.923	0.016	0.020	≤ 0.05	0.065	Pass	**7.7**
2	0.47	0.895	0.019	0.024	≤ 0.05	0.063	Pass	**10.5**
3	0.62	0.862	0.033	0.040	≤ 0.05	0.060	Pass	**13.8**
4	0.84	0.825	0.021	0.026	≤ 0.05	0.058	Pass	**17.5**
5	1.14	0.641	0.021	0.026	≤ 0.05	0.045	Pass	**35.9**
6	1.44	0.637	0.018	0.023	≤ 0.05	0.045	Pass	**36.3**
7	1.88	0.563	0.015	0.019	≤ 0.05	0.039	Pass	**43.7**
8	2.57	0.420	0.011	0.014	≤ 0.05	0.029	Pass	**58.0**
9	3.46	0.307	0.010	0.012	≤ 0.05	0.046	Pass	**69.3**
10	4.69	0.224	0.011	0.013	≤ 0.05	0.034	Pass	**77.6**
11	6.20	0.175	0.020	0.025	≤ 0.05	0.035	Pass	**82.5**
12	8.37	0.146	0.011	0.014	≤ 0.05	0.029	Pass	**85.4**

$d_{a,i}$:	Geometric mean diameter of a size range i, µm
P_a	the final penetration for a given particle size
δ	the standard deviation of the penetration for a given particle size
e	the uncertainty of the penetration for a given particle size

Appendix 3

ISO 16890-3:2016 - AIR FILTER TEST RESULTS SUMMARY					Testing Organization SP Technical Research Institute of Sweden Brinellgatan 4, 501 15 Borås, Swedan +460105165000
GENERAL					
Test ID: SP201701301		Date of test: 2017-02-10			Operator: UH
			Air flow measurement: Annubar, Micatrone Air flow sensor MFS-SS		Test sample obtained: The device was sent and obtained on 2017-01-13
DEVICE TESTED					
Model: R05-50		Manufacturer: Filtech Swiss			Construction: Panel filter
Article number: -	Type of media: Synthetic	Net effective media area (m^2) 2.2 m^2			Filter dimension (W x H x D) (mm) 592x592x25 mm
Filter/media electrostatic charge: Yes		Media colour: white			Media adhesive: N/A
Device Condition: Conditioned per ISO 16890-4					
Other descriptive information:					
TEST DATA SUMMARY					
Test air flow rate: 0.389 m^3/s	Test air temperature: 20.7 - 21 °C	Test air RH: 40 - 42.3 %			Loading dust: Particle Technology, ISO 121031 A2-fine
RESULTS					
Resistance to airflow			**Dust loading results**		
Measured: 16 Pa	Rated initial: - Pa		Initial arrestance (%)	Average arrestance(%)	Test dust capacity (g)
Final test pressure: 300 Pa	Rated Final: - Pa		90 %	93.7 %	89 g
Test Device Photo					
					
Remarks:					
NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.					

Appendix 3

ISO 16890-3:2016 - AIR FILTER TEST RESULTS DETAILS

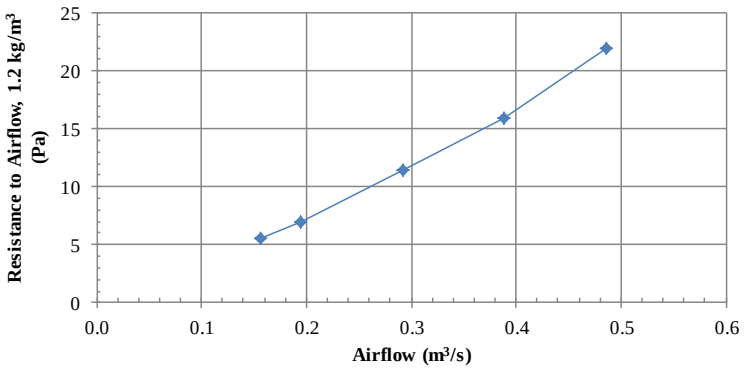
Testing Organization:
SP
Technical Research Institute of Sweden
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

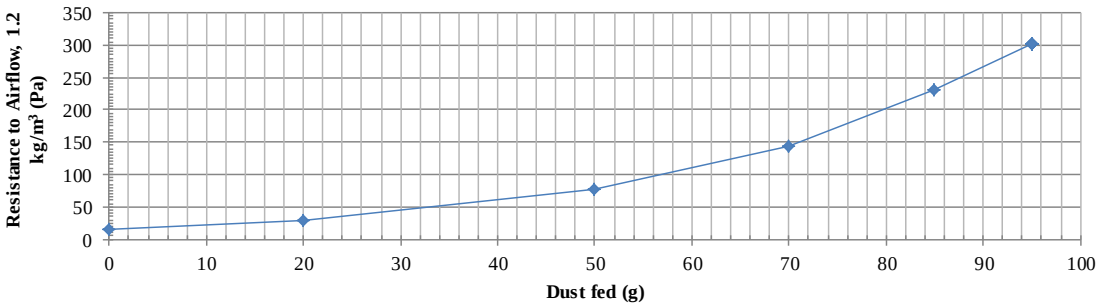
Test ID:	SP201701301	Date of test:	2017-02-10	Operator:	UH

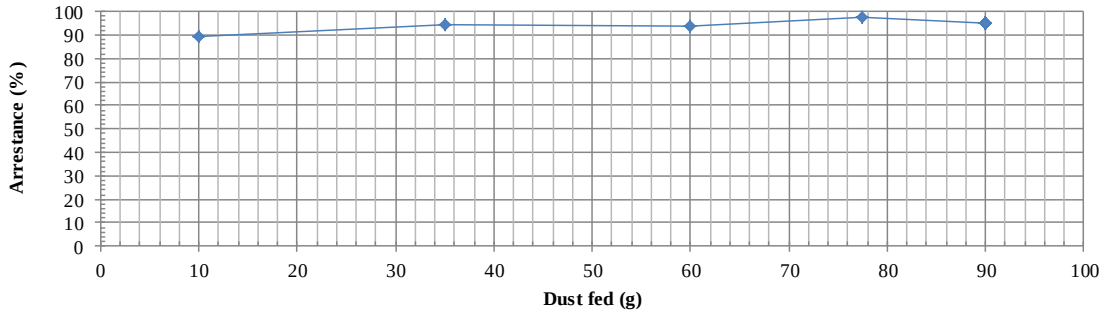
TEST DATA DETAILS

Resistance to Airflow 1.2 kg/m^3

% of rated airflow	Airflow (m^3/s)	Resistance to Airflow (Pa)
40%	0.157	5
50%	0.195	7
75%	0.292	11
100%	0.389	16
125%	0.487	22







NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

Appendix 3

ISO 16890-3:2016 -
Air flow rate and resistance to air flow after different dust loading phases

Test device:	R05-50
Test no.:	SP201701301
Test dust:	Particle Technology, ISO 121031 A2-fine, Batch nr: 9173
Air flow rate:	0.389 m^3/s

Date	Loaded dust	Air flow meter				Filter						
	m_{tot}	t_f	p_{sf}	Δp_f	q_m	t	ϕ	p_a	ρ	q_v	Δp	$\Delta p_{1.20}$
	g	°C	Pa	Pa	kg/s	°C	%	kPa	kg/m^3	m^3/s	Pa	Pa
	Clean filter											
2017-02-10	-	20.8	12	90	0.19	20.8	43.1	101.6	1.199	0.157	6	5
2017-02-10	-	20.9	17	90	0.23	20.9	43.4	101.6	1.198	0.195	7	7
2017-02-10	-	20.9	32	90	0.35	20.9	43.7	101.6	1.198	0.292	12	11
2017-02-10	-	20.9	52	90	0.47	20.9	42.3	101.6	1.199	0.389	16	16
2017-02-10	-	20.5	75	90	0.58	20.5	43.9	101.6	1.200	0.487	22	22
	Clean filter pressure drop is proportional to $(q_v)^n$, where n = 1.21											
	Dust loading phase											
2017-02-10	0	20.9	52	90	0.466	20.9	42.3	101.6	1.199	0.389	16	16
2017-02-10	20	20.8	62	90	0.467	20.8	40.8	101.6	1.199	0.389	28	28
2017-02-10	50	20.9	105	90	0.467	20.9	40.8	101.6	1.199	0.389	77	77
2017-02-10	70	21.0	164	90	0.467	21.0	42.2	101.7	1.199	0.389	143	143
2017-02-10	85	20.7	241	90	0.467	20.7	41.1	101.7	1.201	0.389	231	231
2017-02-10	95	20.9	301	90	0.467	20.9	40.0	101.8	1.201	0.389	302	301

Symbols and units

Δp_f	air flow meter differential pressure, Pa	q_m	mass flow rate, kg/s
m_{tot}	cumulative mass of dust fed to filter, g	q_v	air flow rate filter, m^3/s
Δp	measured filter pressure drop, Pa	t_f	temperature at air flow meter, °C
$\Delta p_{1.20}$	resistance to air flow at air density 1.20 kg/m^3, Pa	t	temperature upstream of filter, °C
p_a	absolute air pressure upstream of filter, kPa	ϕ	relative humidity upstream of the filter, %
p_{sf}	air flow meter static pressure, kPa	ρ	air density upstream of filter, kg/m^3

Appendix 3

ISO 16890-3:2016 -
Resistance to air flow and arrestance after different dust loading phases

Test device:	R05-50
Test no.:	SP201701301
Test dust:	Particle Technology, ISO 121031 A2-fine, Batch nr: 9173
Air flow rate:	0.389 m^3/s

Date	Δp_1 Pa	Δm g	m_{tot} g	Δp_2 Pa	m_1 g	m_2 g	Δm_{ff} g	m_d g	A_j %	A_m %
2017-02-10	16	20	20	28	2131.3	2133.3	2.0	0.1	89.5	89.5
2017-02-10	28	30	50	77	2133.3	2134.9	1.6	0.1	94.3	92.4
2017-02-10	77	20	70	143	2134.9	2136.1	1.2	0.1	93.5	92.7
2017-02-10	143	15	85	231	2136.1	2136.4	0.3	0.1	97.3	93.5
2017-02-10	231	10	95	301	2136.4	2136.8	0.4	0.1	95.0	93.7

Mass of tested device

Initial mass of tested device: 309.1 g

Final mass of tested device: 387 g

Test dust: Particle Technology, ISO 121031 A2-fine, Batch nr: 9173

Symbols and units

A_j	arrestance, %
A_m	average arrestance, %
Δm	dust increment, g
Δp_1	resistance to air flow before dust increment (air density 1.20 kg/m³), Pa
Δp_2	resistance to air flow after dust increment (air density 1.20 kg/m³), Pa
m_d	dust in duct after device, g
m_1	mass of final filter before dust increment, g
m_2	mass of final filter after dust increment, g
m_{tot}	cumulative mass of dust fed to filter, g
Δm_{ff}	mass gain of final filter, g

Appendix 4

ISO 16890-4:2016 - AIR FILTER TEST RESULTS SUMMARY

Testing Organization:
SP
Technical Research Institute of Sweden
Brinellgatan 4, 50115 Borås, Swedan
+460105165000

GENERAL

Test ID: SP201701301	Date of test: 2017-02-06 - 2017-02-07	Operator: UH

Particle counter information			Air flow measurement:	Device obtained (when and how obtained):
Manufacturer:	Model:	Coincidence value (p/cm^3):	Annubar, Micatrone	The device was sent and obtained on
TSI Gmbh	OPS 3330	300	Air flow sensor MFS-SS	2017-01-13

DEVICE TESTED

Model:		Manufacturer:	Construction:
R05-50		Filtech Swiss	Panel filter
Article number:	Type of media:	Net effective media area (m^2)	Filter dimensions (width x height x depth)
-	Synthetic	2.2 m^2	592x592x25 mm
Filter/media electrostatic charge:		Media colour:	Media adhesive:
Yes		white	N/A

Device Condition: Conditioned per ISO 16890-4

Other descriptive information:

TEST DATA SUMMARY

Test air flow rate:	Test air temperature:	Test air RH:	Test aersole:
0.389 m^3/s	20 - 20.9 ° C	42.3 - 45.9 %	DEHS (0.3-1 µm) KCl (1-10 µm)

RESULTS

Resistance to airflow (Pa)

Measured: 16 Pa
Rated initial: -
Rated Final: -

Test item photo

Fractional Efficiency (%)

Range (µm)	Measured Efficiency	Rated Efficiency	Upstream concentration (particles / dm^3)
0.30 - 0.40	3		15913
0.40 - 0.55	5		13969
0.55 - 0.70	6		9303
0.70 - 1.00	10		8847
1.00 - 1.30	19		5778
1.30 - 1.60	21		3162
1.60 - 2.20	28		12705
2.20 - 3.00	39		7943
3.00 - 4.00	54		3624
4.00 - 5.50	65		2143
5.50 - 7.00	73		680
7.00 - 10.00	74		656

Remarks:

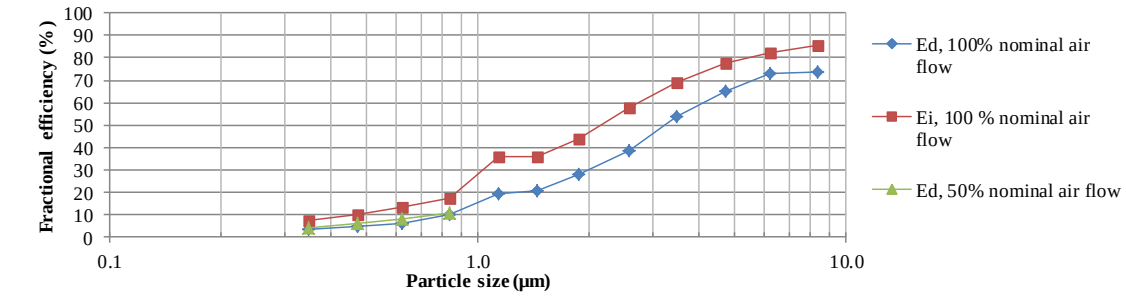
NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

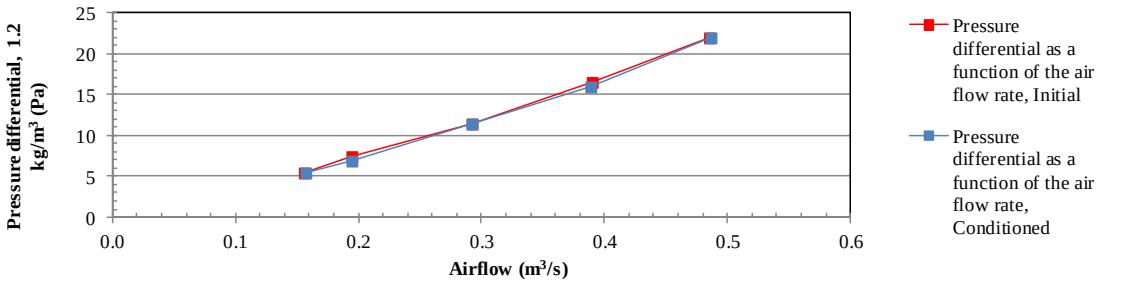
Appendix 4

ISO 16890-4:2016 - AIR FILTER TEST RESULTS DETAILS		**Testing Organization:** SP Technical Research Institute of Sweden Brinellgatan 4, 501 15 Borås, Swedan +460105165000
Test ID: SP201701301	Date of test: 2017-02-06 - 2017-02-07	Operator: UH

TEST DATA DETAILS

Resistance to Airflow, 1.2 kg/m³		**Fractional efficiency**			
Initial		Range (µm)	E_i, 100 % nominal air flow	E_d, 100% nominal air flow	E_d, 50% nominal air flow
Airflow (m³/s)	Resistance to Airflow (Pa)				
0.155	6	0.30 - 0.40	7.7	3.4	4.5
0.194	8	0.40 - 0.55	10.5	5.1	6.6
0.292	12	0.55 - 0.70	13.8	6.0	8.4
0.390	17	0.70 - 1.00	17.5	10.3	10.8
0.486	22	1.00 - 1.30	35.9	19.4	
Conditioned		1.30 - 1.60	36.3	20.8	
Airflow (m³/s)	Resistance to Airflow (Pa)	1.60 - 2.20	43.7	28.2	
0.157	5	2.20 - 3.00	58.0	39.0	
0.195	7	3.00 - 4.00	69.3	54.1	
0.292	11	4.00 - 5.50	77.6	65.2	
0.389	16	5.50 - 7.00	82.5	72.7	
0.487	22	7.00 - 10.00	85.4	73.7	





TEST CONDITIONS

Temperature in the chamber:	Relative humidity in the chamber:	Atmospheric pressure:
20.9 - 21.6 ° C	15.3 - 21.1 %	1003.1 - 1010.7 mbar

NOTE: The results of this test relate only to the test device in the condition stated herein. The performance results cannot by themselves be quantitatively applied to predict filtration performance in all "real life" environments.

Appendix 4

Efficiency measurement

Upstream count data

OPC bin	$d_{a,\,i}$	Upstream efficiency count data					
	µm	1	2	3	4	5	$U_{e,tot}$
1	0.35	15852	15931	15957	15961	15865	**79566**
2	0.47	13864	14212	13996	13859	13914	**69845**
3	0.62	9211	9369	9395	9278	9263	**46516**
4	0.84	8800	8936	8867	8823	8808	**44234**
5	1.14	5943	5849	5418	5770	5908	**28888**
6	1.44	3325	3289	2974	3031	3189	**15808**
7	1.88	12999	12943	12001	12670	12913	**63526**
8	2.57	8075	8153	7468	7958	8059	**39713**
9	3.46	3623	3632	3481	3616	3770	**18122**
10	4.69	2141	2176	2007	2172	2218	**10714**
11	6.20	674	685	648	676	717	**3400**
12	8.37	679	669	621	640	671	**3280**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement

Downstream count data

OPC bin	$d_{a,\,i}$	Downstream efficiency count data					
	µm	1	2	3	4	5	$D_{e,tot}$
1	0.35	14348	14661	14295	14073	14101	**71478**
2	0.47	12844	13162	13015	13036	12987	**65044**
3	0.62	8663	8945	8818	8689	8918	**44033**
4	0.84	8014	7820	8116	8049	7890	**39889**
5	1.14	4964	4832	4594	4577	4866	**23833**
6	1.44	2431	2307	2068	2306	2375	**11487**
7	1.88	8738	8684	7774	8345	8629	**42170**
8	2.57	4366	4486	4072	4388	4442	**21754**
9	3.46	1633	1600	1512	1583	1633	**7961**
10	4.69	793	758	717	757	690	**3715**
11	6.20	224	231	206	188	237	**1086**
12	8.37	240	271	244	242	221	**1218**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement

Final results and uncertainty

OPC bin	$d_{a,\,i}$	Penetration data reduction			Uncertainty limits		Uncertainty	Efficiency
	µm	P	δ	e	Static	Dynamic	Pass/Fail	%
1	0.35	0.966	0.022	0.027	≤ 0.05	0.068	Pass	**3.4**
2	0.47	0.949	0.017	0.021	≤ 0.05	0.066	Pass	**5.1**
3	0.62	0.940	0.015	0.019	≤ 0.05	0.066	Pass	**6.0**
4	0.84	0.897	0.018	0.022	≤ 0.05	0.063	Pass	**10.3**
5	1.14	0.806	0.024	0.030	≤ 0.05	0.056	Pass	**19.4**
6	1.44	0.792	0.041	0.051	≤ 0.05	0.055	Pass	**20.8**
7	1.88	0.718	0.016	0.020	≤ 0.05	0.050	Pass	**28.2**
8	2.57	0.610	0.017	0.021	≤ 0.05	0.043	Pass	**39.0**
9	3.46	0.459	0.013	0.016	≤ 0.05	0.069	Pass	**54.1**
10	4.69	0.348	0.033	0.041	≤ 0.05	0.052	Pass	**65.2**
11	6.20	0.273	0.025	0.031	≤ 0.05	0.055	Pass	**72.7**
12	8.37	0.263	0.025	0.032	≤ 0.05	0.053	Pass	**73.7**

$d_{a,\,i}$:	Geometric mean diameter of a size range i, µm
P_a	the final penetration for a given particle size
δ	the standard deviation of the penetration for a given particle size
e	the uncertainty of the penetration for a given particle size

Appendix 4

Efficiency measurement, 50% nominal air flow

Upstream count data

OPC bin	$d_{a,\,i}$	Upstream efficiency count data					
	µm	1	2	3	4	5	$U_{e,tot}$
1	0.35	15259	15333	15024	15245	15210	**76071**
2	0.47	13518	13801	13315	13583	13334	**67551**
3	0.62	9131	9115	9028	9240	9307	**45821**
4	0.84	8718	8747	8922	8971	8713	**44071**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement, 50% nominal air flow

Downstream count data

OPC bin	d_i	Downstream efficiency count data					
	µm	1	2	3	4	5	$D_{e,tot}$
1	0.35	14125	13509	13178	13387	13376	**67575**
2	0.47	13107	12232	12038	12334	12261	**61972**
3	0.62	8916	8279	8228	8385	8437	**42245**
4	0.84	8228	7776	7733	7996	7787	**39520**
Note: All data shown is the number of particle counts for 60 s							

Efficiency measurement, 50% nominal air flow

Final results and uncertainty

OPC bin	$d_{a,\,i}$	Penetration data reduction			Uncertainty limits		Uncertainty	Efficiency
	µm	P	δ	e	Static	Dynamic	Pass/Fail	%
1	0.35	0.955	0.027	0.033	≤ 0.05	0.067	Pass	**4.5**
2	0.47	0.934	0.036	0.044	≤ 0.05	0.065	Pass	**6.6**
3	0.62	0.916	0.032	0.040	≤ 0.05	0.064	Pass	**8.4**
4	0.84	0.892	0.029	0.036	≤ 0.05	0.062	Pass	**10.8**

$d_{a,\,i}$:	Geometric mean diameter of a size range i, µm
P_a	the final penetration for a given particle size
δ	the standard deviation of the penetration for a given particle size
e	the uncertainty of the penetration for a given particle size

Appendix 5

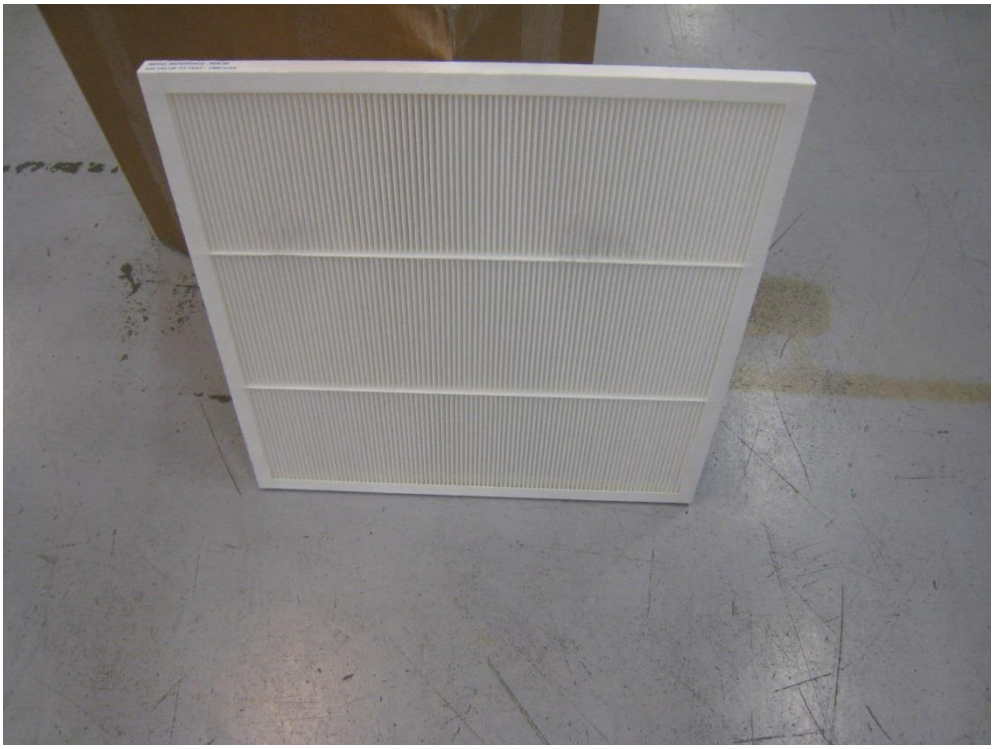


Fig 1. Overview of the test item.

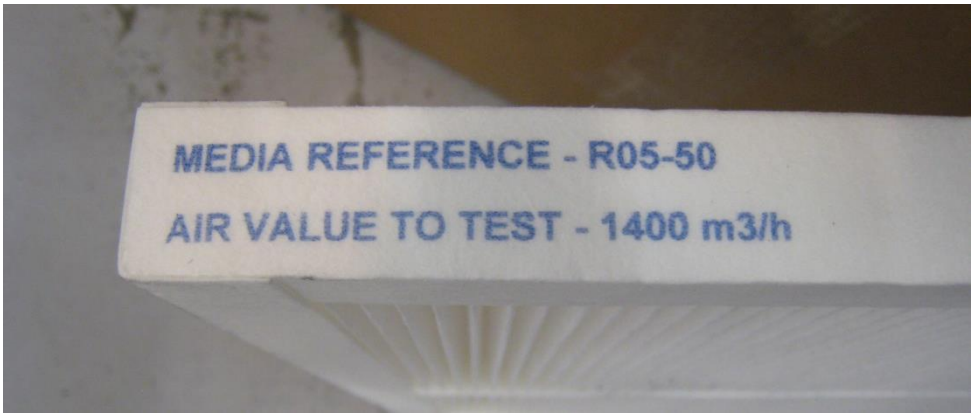


Fig 2. Label on the test item.

Appendix 6

The interpretation of test reports according to ISO 16890:2016

This brief review of the test procedures, including those for addressing the testing of electrostatic charged filters, is provided for those unfamiliar with the procedures of this series of ISO standards. It is intended to assist in understanding and interpreting the results in the test report/summary. (For further details of procedures the full ISO 16890 document series shall be consulted).

Air filters may rely on the effects of passive static electric charges on the fibres to achieve high efficiencies, particularly in the initial stages of their working life. Environmental factors encountered in service may affect the action of these electric charges so that the initial efficiency may drop substantially after an initial period of service. This could be offset or countered by an increase in efficiency ("mechanical efficiency") as dust deposits build up. The reported, untreated and conditioned (discharged) efficiency shows the extent of the electrical charge effect on initial performance and indicates the potential loss of particle removal efficiency when the charge effect is completely removed and when at the same time there is no compensating increase of the mechanical efficiency. These test results should not be assumed to represent the filter performance in all possible environmental conditions or to represent all possible "real life" behavior.