REPORT

Issued by an Accredited Testing Laboratory

Contact person RISE
Christian Mossberg
Division Built Environment
+46 10 516 59 13
christian.mossberg@ri.se

Date
2020-12-15

Reference
2P07180A-rev1-01

Filtex AB
Box 55
511 21 KINNA

Testing of Air Filter according to ISO 16890:2016

(7 appendices)

This is an additional report to 2P07180A-rev1, dated 2020-10-22.

According to Kalthoff Luftfilter und Filtermedien GmbH and Filtex AB the tested model is also manufactured by Filtex AB with model name Ecopac EM515.000.06. The tested model and manufacturer has been replaced with Ecopac EM515.000.06 and Filtex AB in all relevant sections in the report.

A test according to ISO 16890:2016 was carried out by request from Kalthoff Luftfilter und Filtermedien GmbH.

Tested item

Filtex AB, Ecopac EM515.000.06, a 592 mm x 592 mm x 600 mm, 6 pocket air filter.

Pictures can be found in appendix 5.

The item was sent to RISE by Kalthoff Luftfilter und Filtermedien GmbH and was received on September 24, 2020.

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

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Testing
ISO/IEC 17025

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.

Deviations from the standard:

Section 9.2.2 and 9.2.8, the evaporated amount of 2-propanol was not determined.

Additional to the test:

An energy calculation was performed according to Eurovent 4/21-2019 “Energy efficiency evaluation of air filters for general ventilation purposes”, Fourth edition”.

Date and Place

The test was carried out at RISE’s laboratory of Ventilation and Air Treatment in Borås, Sweden on October 07 – October 16, 2020.

Tests according to ISO 16890-2 were carried out on October 07, 2020.
Tests according to ISO 16890-3 were carried out on October 15-16, 2020.
Tests according to ISO 16890-4 were carried out on October 14, 2020, conditioning procedure according to ISO 16890-4 was carried out on October 13-14, 2020.

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.

In appendix 7 the energy calculation according to Eurovent 4/21-2019 is reported.

Measurement equipment

- Pressure gauge Furness model 318, RISE's inventory no. 901 568
- Pressure gauge Furness model 318, RISE's inventory no. 901 569
- Pressure gauge Furness FC012, RISE's inventory no. 201 691
- Pressure gauge Furness FC012, RISE's inventory no. BX70943
- Particle counter TSI, OPS 3330, RISE's inventory no. 902240
- Particle counter TSI, OPS 3330, RISE's inventory no. 902241
- Barometer, Testo 511, RISE's inventory no. 900 078
- Temperature and RH, Testo 635, RISE's inventory no. 900 065
- Weighing scale, Mettler PBK785, RISE's inventory no. BX81958
- Flow meter, MFS-C-250, RISE's inventory no. 202 742
- Temperature and RH, Tinytag, DIV 94 S
- Barometer, Druck PACE 1001, RISE'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.

RISE Research Institutes of Sweden AB
Department Energy and Resources - Ventilation and Air Treatment

Performed by

Signed by: Christian Mossberg
Reason: I am the author of this document
Date & Time: 2020-12-16 10:48:28 +01:00

Christian Mossberg

Examined by

Signed by: Tobias Eriksson
Reason: I have reviewed this document
Date & Time: 2020-12-16 10:04:42 +01:00

Tobias Eriksson

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
7. Energy calculation according to Eurovent 4/21-2019

Appendix 1

ISO 16890-1:2016 - Air Filter Test Results

Testing Organization:
RISE Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

GENERAL

Report no.: 2P07180A-rev1-01	Date of tests: 2020-10-07 - 2020-10-16	Date of report: 2020-12-15
Supervisor: CM		Device obtained (when and how obtained):
Test(s) requested by: Kalthoff Luftfilter und Filtermedien GmbH		The device was sent and obtained on 2020-09-24

DEVICE TESTED

Model: Ecopac EM515.000.06		Manufacturer: Filtex AB	Construction: Pocket filter, 6 Pockets
Article number: -	Type of medium: Synthetic	Net effective filtering area: 4.3 m^2	Filter dimensions (width x height x depth) 592x592x600 mm

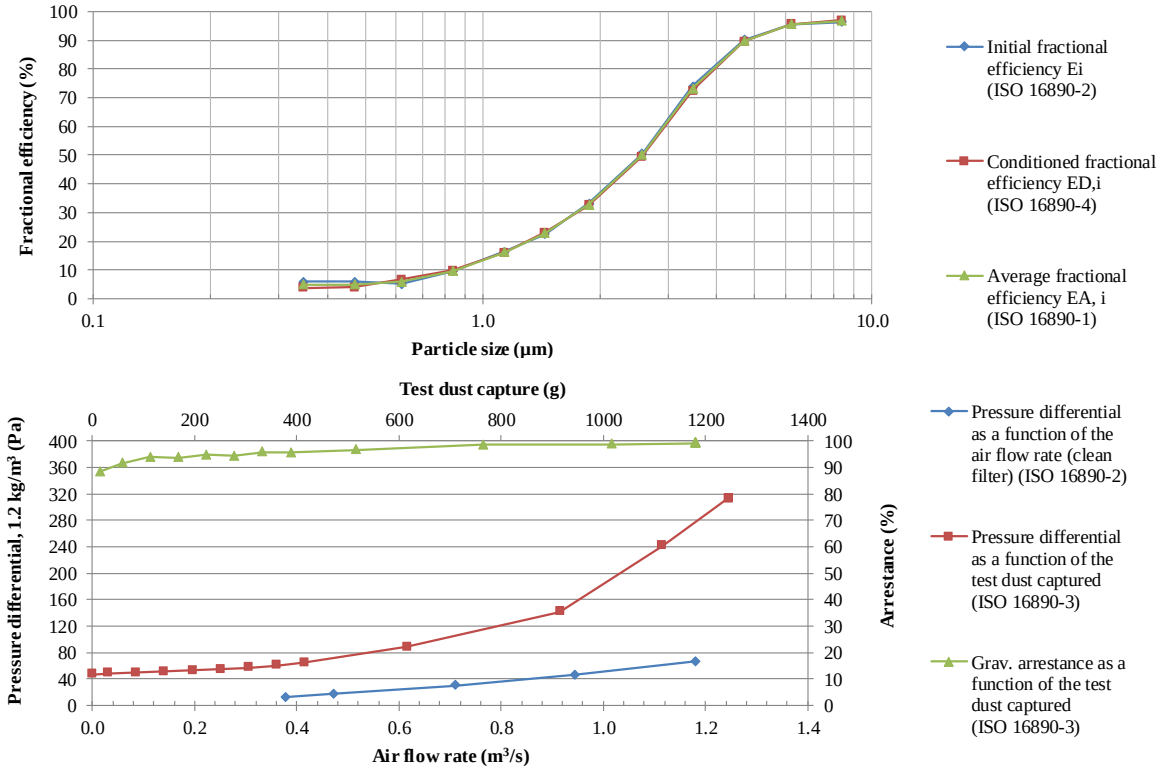
TEST DATA AND ATTACHED TEST REPORTS

Test air flow rate: 0.944 m^3/s	Test aersole: KCl (1-10 µm)	Test report to ISO 16890-2	Report no. 2P07180A-rev1-01 Appendix 2
	DEHS (0.3-1 µm)	Test report to ISO 16890-3	Report no. 2P07180A-rev1-01 Appendix 3
		Test report to ISO 16890-4	Report no. 2P07180A-rev1-01 Appendix 4

RESULTS

Initial pressure differential: 46 Pa	Initial grav. arrestance: 88 %	$ePM_{1,\ min}$ 6 %	$ePM_{2.5,\ min}$ 14 %	$ePM_{10,\ min}$ 58 %	ISO rating
Final test pressure differential: 300 Pa	Test dust capacity: 1181 g	ePM_1 6 %	$ePM_{2.5}$ 14 %	ePM_{10} 58 %	**ISO ePM $_{10}$ 55 %**

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:	RISE Research Institutes of Sweden AB			Report no:	2P07180A-rev1-01	
Model:	Ecopac EM515.000.06			Manufacturer:	Filtex AB	
Test air flow rate:	0.944 m^3/s			Date of report:	2020-12-15	

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	5.9	3.8	4.9
2	0.40	0.55	0.47	0.32	5.9	4.0	5.0
3	0.55	0.70	0.62	0.24	5.2	6.6	5.9
4	0.70	1.00	0.84	0.36	9.6	9.7	9.7
5	1.00	1.30	1.14	0.26	16.3	16.1	16.2
6	1.30	1.60	1.44	0.21	22.4	23.1	22.8
7	1.60	2.20	1.88	0.32	33.1	32.5	32.8
8	2.20	3.00	2.57	0.31	50.5	49.5	50.0
9	3.00	4.00	3.46	0.29	74.0	72.4	73.2
10	4.00	5.50	4.69	0.32	90.1	89.6	89.8
11	5.50	7.00	6.20	0.24	95.7	95.7	95.7
12	7.00	10.00	8.37	0.36	96.5	97.0	96.7

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:	RISE Research Institutes of Sweden AB	Report no.:	2P07180A-rev1-01
Model:	Ecopac EM515.000.06	Manufacturer:	Filtex AB
Test air flow rate:	0.944 m^3/s	Date of report:	2020-12-15

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	0.250	0.32		
2	0.47	0.32	0.199	0.063	0.254	0.31		
3	0.62	0.24	0.158	0.038	0.253	0.23		
4	0.84	0.36	0.115	0.041	0.400	0.40	**$ePM_{1,min}$**	**ePM_1**
			∑ line 1-4	0.208	1.157	1.253	6	6
5	1.14	0.26	0.085	0.022	0.359	0.362		
6	1.44	0.21	0.076	0.016	0.366	0.360		
7	1.88	0.32	0.080	0.026	0.831	0.838		
8	2.57	0.31	0.100	0.031	1.534	1.549	**$ePM_{2.5,min}$**	**$ePM_{2.5}$**
			∑ line 1-8	0.302	4.247	4.362	14	14

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	0.104	0.131		
2	0.47	0.32	0.084	0.027	0.107	0.132		
3	0.62	0.24	0.074	0.018	0.119	0.106		
4	0.84	0.36	0.070	0.025	0.243	0.242		
5	1.14	0.26	0.076	0.020	0.322	0.325		
6	1.44	0.21	0.088	0.018	0.424	0.417		
7	1.88	0.32	0.108	0.034	1.119	1.129		
8	2.57	0.31	0.137	0.043	2.109	2.129		
9	3.46	0.29	0.167	0.048	3.480	3.520		
10	4.69	0.32	0.195	0.062	5.575	5.591		
11	6.20	0.24	0.217	0.052	5.000	5.001		
12	8.37	0.36	0.231	0.083	8.005	7.984	**$ePM_{10,min}$**	**ePM_{10}**
			∑ line 1-12	0.457	26.607	26.708	58	58

Appendix 2

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

Testing Organization:
RISE
Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

GENERAL

Test ID: SP202010071	Date of test: 2020-10-07	Operator: CM

Particle counter information			Air flow measurement:	Device obtained (when and how obtained):
Manufacturer: TSI Gmbh	Model: OPS 3330	Coincidence value (p/cm^3): 300	Annubar, Micatrone Air flow sensor MFS-SS	The device was sent and obtained on 2020-09-24

DEVICE TESTED

Model: Ecopac EM515.000.06	Manufacturer: Filtex AB	Construction: Pocket filter, 6 Pockets

Article number: -	Type of media: Synthetic	Net effective media area (m^2) 4.3 m^2	Filter dimensions (width x height x depth) 592x592x600 mm

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

Device Condition: Clean / Initial

Other descriptive information:	Mass of test item (initial): 3126.8 g

TEST DATA SUMMARY

Test air flow rate: 0.944 m^3/s	Test air temperature: 22.1 - 22.8 ° C	Test air RH: 44.7 - 47 %	Test aersol: DEHS (0.3-1 µm) KCl (1-10 µm)

RESULTS

Resistance to airflow (Pa)

Measured: 46 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	6		16604
0.40 - 0.55	6		13317
0.55 - 0.70	5		7814
0.70 - 1.00	10		7329
1.00 - 1.30	16		11439
1.30 - 1.60	22		9457
1.60 - 2.20	33		13067
2.20 - 3.00	51		8188
3.00 - 4.00	74		5187
4.00 - 5.50	90		2107
5.50 - 7.00	96		364
7.00 - 10.00	96		175

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

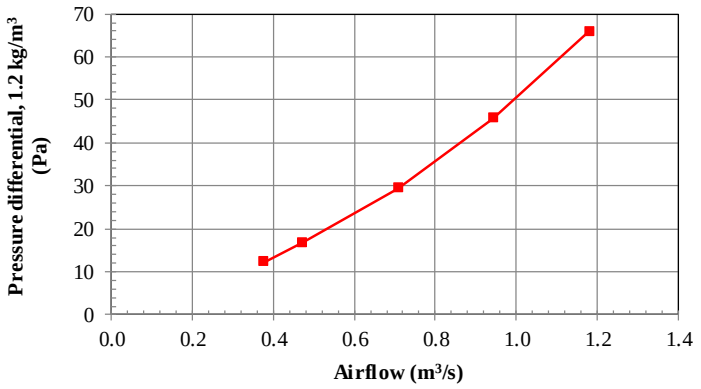
Testing Organization:
RISE
Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

Test ID: SP202010071 | Date of test: 2020-10-07 | Operator: CM

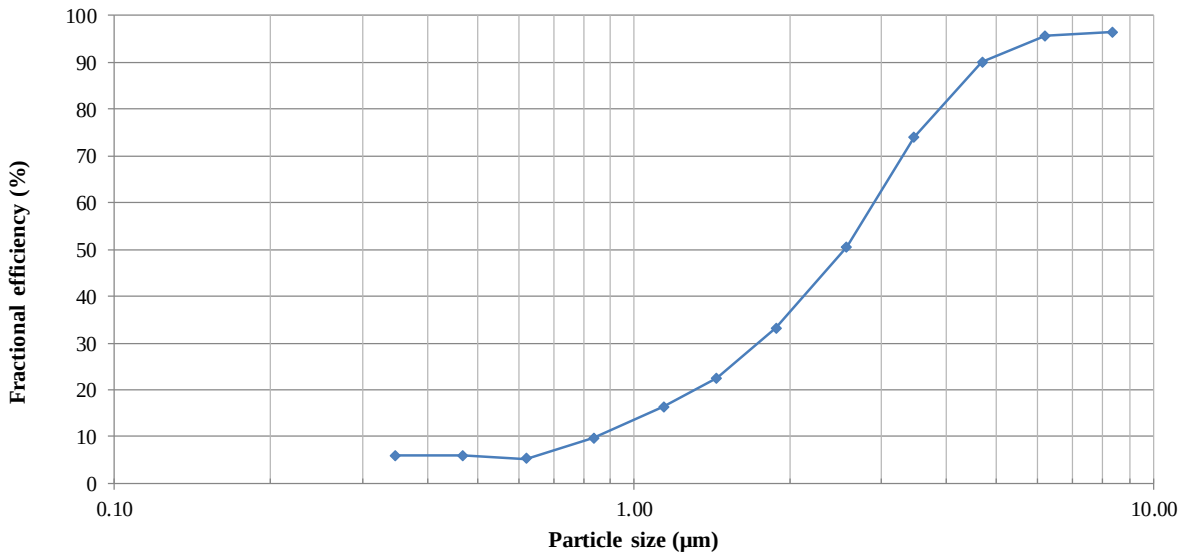
TEST DATA DETAILS

Resistance to Airflow 1.2 kg/m³

% of rated airflow	Airflow (m^3/s)	Resistance to Airflow (Pa)
40%	0.377	12
50%	0.472	17
75%	0.709	29
100%	0.944	46
125%	1.180	66



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	16526	16348	16815	16700	16631	**83020**
2	0.47	13202	13228	13467	13249	13440	**66586**
3	0.62	7683	7755	7868	7945	7818	**39069**
4	0.84	7280	7084	7439	7294	7549	**36646**
5	1.14	11776	11621	11340	11124	11333	**57194**
6	1.44	9688	9621	9501	9253	9220	**47283**
7	1.88	13202	13164	13054	12877	13037	**65334**
8	2.57	8358	8395	8162	7980	8044	**40939**
9	3.46	5188	5207	5365	5159	5016	**25935**
10	4.69	2189	2107	2208	2097	1936	**10537**
11	6.20	378	383	365	391	303	**1820**
12	8.37	191	172	185	167	162	**877**
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	15535	15828	16122	15778	15750	**79013**
2	0.47	13083	13093	13159	13208	13207	**65750**
3	0.62	7335	7385	7450	7174	7301	**36645**
4	0.84	6175	6019	6340	6225	6371	**31130**
5	1.14	8084	7948	7821	7771	7781	**39405**
6	1.44	7541	7320	7228	7241	7299	**36629**
7	1.88	8832	8536	8758	8586	8732	**43444**
8	2.57	4218	4199	4271	4250	4179	**21117**
9	3.46	1382	1371	1326	1333	1289	**6701**
10	4.69	202	208	202	185	162	**959**
11	6.20	12	14	16	10	18	**70**
12	8.37	9	5	5	8	6	**33**
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	0.941	0.021	0.026	≤ 0.05	0.066	Pass	**5.9**
2	0.47	0.941	0.014	0.017	≤ 0.05	0.066	Pass	**5.9**
3	0.62	0.948	0.030	0.037	≤ 0.05	0.066	Pass	**5.2**
4	0.84	0.904	0.030	0.038	≤ 0.05	0.063	Pass	**9.6**
5	1.14	0.837	0.014	0.017	≤ 0.05	0.059	Pass	**16.3**
6	1.44	0.776	0.019	0.023	≤ 0.05	0.054	Pass	**22.4**
7	1.88	0.669	0.012	0.015	≤ 0.05	0.047	Pass	**33.1**
8	2.57	0.495	0.015	0.018	≤ 0.05	0.035	Pass	**50.5**
9	3.46	0.260	0.010	0.013	≤ 0.05	0.039	Pass	**74.0**
10	4.69	0.099	0.006	0.008	≤ 0.05	0.015	Pass	**90.1**
11	6.20	0.043	0.015	0.018	≤ 0.05	0.009	Pass	**95.7**
12	8.37	0.035	0.010	0.012	≤ 0.05	0.007	Pass	**96.5**

$d_{a,i}$: 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 RISE Research Institutes of Sweden AB Brinellgatan 4, 501 15 Borås, Swedan +460105165000
GENERAL					
Test ID: SP202010071		Date of test:	2020-10-15 - 2020-10-16		Operator: IS / CM
			Air flow measurement: Annubar, Micatrone Air flow sensor MFS-SS		Test sample obtained: The device was sent and obtained on 2020-09-24
DEVICE TESTED					
Model: Ecopac EM515.000.06			Manufacturer: Filtex AB		Construction: Pocket filter, 6 Pockets
Article number: -	Type of media: Synthetic		Net effective media area (m^2) 4.3 m^2		Filter dimension (width x height x depth) 592x592x600 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: 0.944 m^3/s	Test air temperature: 19 - 19.5 °C		Test air RH: 41.5 - 46.1 %		Loading dust: Particle Technology, ISO 121031 A2-fine
RESULTS					
Resistance to airflow			**Dust loading results**		
Measured: 46 Pa	Rated initial:	- Pa	Initial arrestance (%)	Average arrestance(%)	Test dust capacity (g)
Final test pressure: 300 Pa	Rated Final:	- Pa	88 %	96.7 %	1181 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

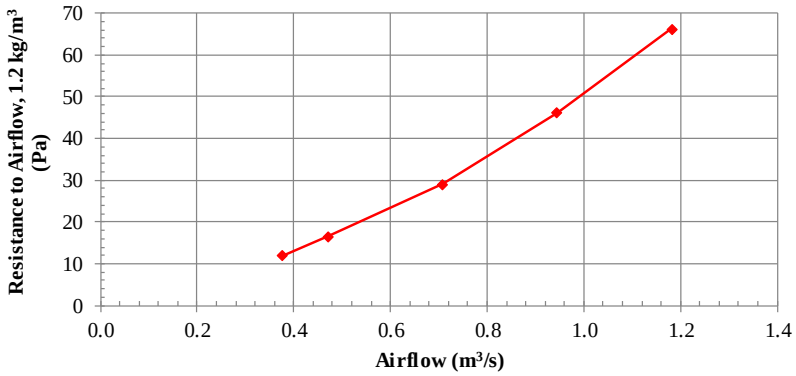
Testing Organization:
RISE
Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

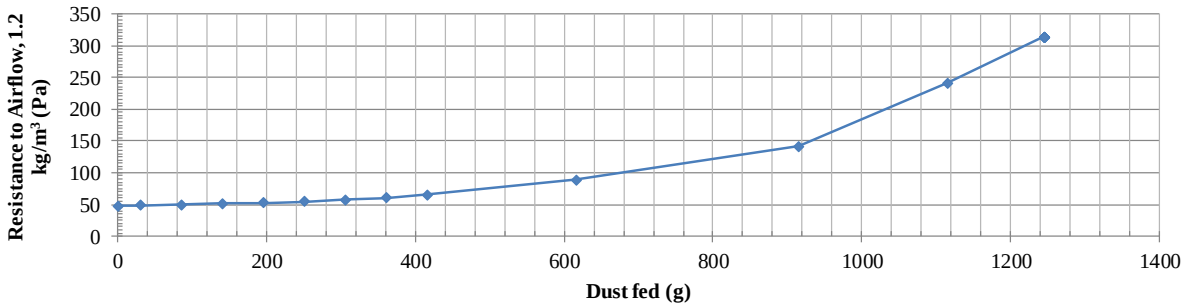
Test ID:	SP202010071	Date of test:	2020-10-15 - 2020-10-16	Operator:	IS / CM

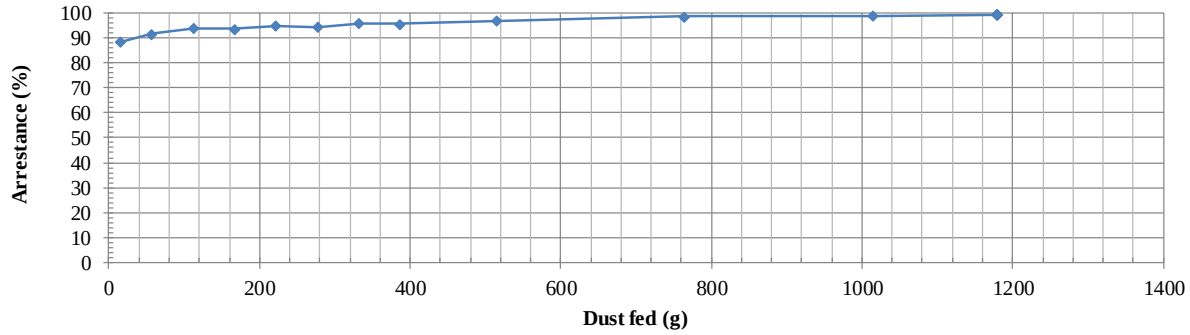
TEST DATA DETAILS

Resistance to Airflow 1.2 kg/m^3

% of rated airflow	Airflow (m^3/s)	Resistance to Airflow (Pa)
40%	0.377	12
50%	0.472	17
75%	0.708	29
100%	0.944	46
125%	1.182	66







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:	Ecopac EM515.000.06
Test no.:	SP202010071
Test dust:	Particle Technology, ISO 121031 A2-fine, Batch nr: 9838
Air flow rate:	0.944 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											
2020-10-14	-	22.0	64	84	0.45	22.0	45.4	100.4	1.179	0.377	12	12
2020-10-14	-	22.3	94	130	0.56	22.3	46.2	100.4	1.178	0.472	17	17
2020-10-14	-	22.4	187	288	0.83	22.4	46.6	100.4	1.178	0.708	29	29
2020-10-14	-	22.4	306	507	1.11	22.4	40.9	100.5	1.179	0.944	46	46
2020-10-14	-	22.1	433	788	1.40	22.1	40.2	100.5	1.181	1.182	66	66
	Clean filter pressure drop is proportional to $(q_v)^n$, where n = 1.49											
	Dust loading phase											
2020-10-15	0	19.5	183	512	1.124	19.5	41.5	100.3	1.190	0.944	47	47
2020-10-15	30	19.1	191	512	1.125	19.1	43.4	100.3	1.191	0.944	48	48
2020-10-15	85	19.1	188	512	1.125	19.1	44.2	100.3	1.191	0.944	50	50
2020-10-15	140	19.4	193	512	1.124	19.4	44.0	100.3	1.190	0.945	51	51
2020-10-15	195	19.2	192	512	1.124	19.2	43.9	100.3	1.191	0.944	53	53
2020-10-15	250	19.4	200	512	1.124	19.4	42.1	100.3	1.190	0.945	55	55
2020-10-15	305	19.5	197	512	1.124	19.5	44.5	100.3	1.189	0.945	57	57
2020-10-15	360	19.5	201	512	1.124	19.5	42.4	100.3	1.190	0.945	60	60
2020-10-15	415	19.4	208	512	1.124	19.4	42.2	100.3	1.190	0.944	65	65
2020-10-15	615	19.2	219	512	1.124	19.2	46.1	100.3	1.191	0.944	88	88
2020-10-15	915	19.5	265	512	1.124	19.5	42.3	100.4	1.190	0.944	141	141
2020-10-16	1115	19.1	355	512	1.125	19.1	41.9	100.4	1.192	0.944	240	241
2020-10-16	1245	19.0	398	512	1.126	19.0	42.2	100.4	1.193	0.943	312	313

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:	Ecopac EM515.000.06
Test no.:	SP202010071
Test dust:	Particle Technology, ISO 121031 A2-fine, Batch nr: 9838
Air flow rate:	0.944 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 %
2020-10-15	47	30	30	48	2371.7	2375.2	3.5	0.0	88.3	88.3
2020-10-15	48	55	85	50	2375.2	2379.8	4.6	0.0	91.6	90.5
2020-10-15	50	55	140	51	2379.8	2383.2	3.4	0.0	93.8	91.8
2020-10-15	51	55	195	53	2383.2	2386.7	3.5	0.0	93.6	92.3
2020-10-15	53	55	250	55	2386.7	2389.6	2.9	0.0	94.7	92.8
2020-10-15	55	55	305	57	2389.6	2392.7	3.1	0.0	94.4	93.1
2020-10-15	57	55	360	60	2392.7	2395.0	2.3	0.0	95.8	93.5
2020-10-15	60	55	415	65	2395.0	2397.5	2.5	0.0	95.5	93.8
2020-10-15	65	200	615	88	2397.5	2404.2	6.7	0.0	96.7	94.7
2020-10-15	88	300	915	141	2404.2	2408.9	4.7	0.0	98.4	95.9
2020-10-16	141	200	1115	241	2408.9	2411.3	2.4	0.0	98.8	96.4
2020-10-16	241	130	1245	313	2411.3	2412.4	1.1	0.0	99.2	96.7

Mass of tested device

Initial mass of tested device: 3127.3 g

Final mass of tested device: 4295.5 g

Test dust: Particle Technology, ISO 121031 A2-fine, Batch nr: 9838

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:
RISE
Research Institutes of Sweden AB
Brinellgatan 4, 50115 Borås, Swedan
+460105165000

GENERAL

Test ID: SP202010071	Date of test: 2020-10-14	Operator: CM

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	2020-09-24

DEVICE TESTED

Model:		Manufacturer:	Construction:
Ecopac EM515.000.06		Filtex AB	Pocket filter, 6 Pockets
Article number:	Type of media:	Net effective media area (m^2)	Filter dimensions (width x height x depth)
-	Synthetic	4.3 m^2	592x592x600 mm
Filter/media electrostatic charge:		Media colour:	Media adhesive:
Yes		white	N/A

Device Condition: Conditioned per ISO 16890-4

Other descriptive information:	Mass of test item before / after discharge proceudre and before measurement: 3126.3 g / 3129.5 g / 3128.3 g

TEST DATA SUMMARY

Test air flow rate:	Test air temperature:	Test air RH:	Test aersole:
0.944 m^3/s	22 - 22.7 ° C	40.2 - 46.6 %	DEHS (0.3-1 µm) KCl (1-10 µm)

RESULTS

Resistance to airflow (Pa)				Fractional Efficiency (%)			
Measured:	46 Pa	Rated initial:	-	Range (µm)	Measured Efficiency	Rated Efficiency	Upstream concentration (particles / dm^3)
		Rated Final:	-				
Test item photo				0.30 - 0.40	4		18265
				0.40 - 0.55	4		14432
				0.55 - 0.70	7		8534
				0.70 - 1.00	10		7798
				1.00 - 1.30	16		12552
				1.30 - 1.60	23		10609
				1.60 - 2.20	33		14850
				2.20 - 3.00	50		9593
				3.00 - 4.00	72		6200
				4.00 - 5.50	90		2817
				5.50 - 7.00	96		575
				7.00 - 10.00	97		347

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

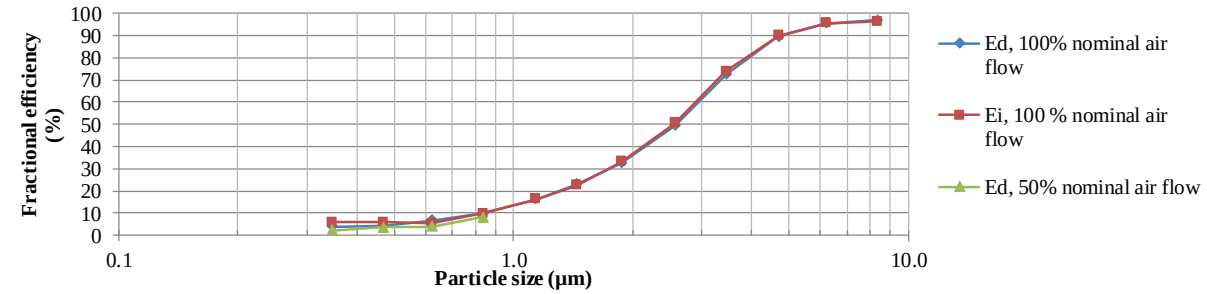
ISO 16890-4:2016 - AIR FILTER TEST RESULTS DETAILS

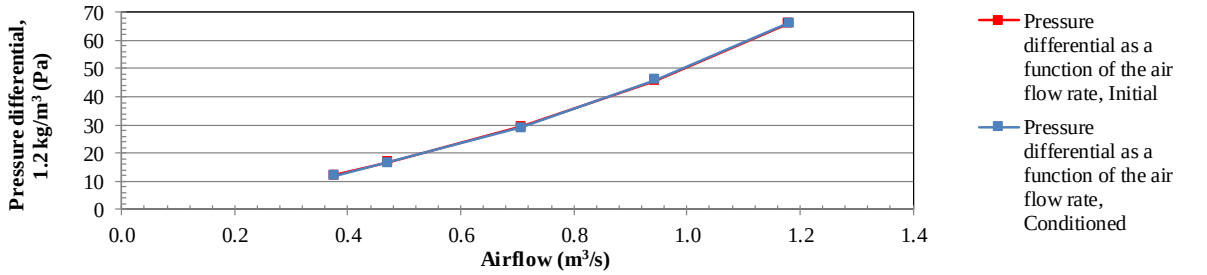
Testing Organization:
RISE
Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

Test ID: SP202010071 | Date of test: 2020-10-14 | Operator: CM

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 (m^3/s)	Resistance to Airflow (Pa)				
0.377	12	0.30 - 0.40	5.9	3.8	2.3
0.472	17	0.40 - 0.55	5.9	4.0	3.6
0.709	29	0.55 - 0.70	5.2	6.6	3.9
0.944	46	0.70 - 1.00	9.6	9.7	8.1
1.180	66	1.00 - 1.30	16.3	16.1	
Conditioned		1.30 - 1.60	22.4	23.1	
Airflow (m^3/s)	Resistance to Airflow (Pa)	1.60 - 2.20	33.1	32.5	
0.377	12	2.20 - 3.00	50.5	49.5	
0.472	17	3.00 - 4.00	74.0	72.4	
0.708	29	4.00 - 5.50	90.1	89.6	
0.944	46	5.50 - 7.00	95.7	95.7	
1.182	66	7.00 - 10.00	96.5	97.0	





CONDITIONING PROCEDURE

Date:	Temperature in the chamber:	Relative humidity in the chamber:	Atmospheric pressure:
2020-10-13 - 2020-10-14	21.6 - 22.7 ° C	29.3 - 35.6 %	995.8 - 1003.8 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	17758	18098	18197	18742	18529	**91324**
2	0.47	14026	14521	14408	14451	14754	**72160**
3	0.62	8434	8481	8560	8554	8640	**42669**
4	0.84	7743	7824	7686	7846	7889	**38988**
5	1.14	12865	12803	12395	11952	12744	**62759**
6	1.44	10854	10930	10221	10250	10790	**53045**
7	1.88	14955	14945	14599	14530	15223	**74252**
8	2.57	9706	9662	9425	9325	9846	**47964**
9	3.46	6348	6286	6039	6074	6251	**30998**
10	4.69	2950	2877	2800	2715	2742	**14084**
11	6.20	594	613	535	578	556	**2876**
12	8.37	385	384	322	329	314	**1734**
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	17096	17428	17342	17500	17379	**86745**
2	0.47	14229	14565	14372	14475	14278	**71919**
3	0.62	7611	7901	7759	7739	7986	**38996**
4	0.84	6347	6573	6504	6421	6610	**32455**
5	1.14	9147	9145	8656	8458	8906	**44312**
6	1.44	8430	8513	8121	8073	8388	**41525**
7	1.88	10148	10135	9930	9585	10541	**50339**
8	2.57	4953	5069	5078	4979	5249	**25328**
9	3.46	1739	1810	1714	1774	1788	**8825**
10	4.69	290	323	293	292	262	**1460**
11	6.20	29	28	24	25	18	**124**
12	8.37	14	12	12	8	11	**57**
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	0.962	0.016	0.020	≤ 0.05	0.067	Pass	**3.8**
2	0.47	0.960	0.020	0.025	≤ 0.05	0.067	Pass	**4.0**
3	0.62	0.934	0.016	0.019	≤ 0.05	0.065	Pass	**6.6**
4	0.84	0.903	0.021	0.026	≤ 0.05	0.063	Pass	**9.7**
5	1.14	0.839	0.023	0.028	≤ 0.05	0.059	Pass	**16.1**
6	1.44	0.769	0.015	0.018	≤ 0.05	0.054	Pass	**23.1**
7	1.88	0.675	0.015	0.019	≤ 0.05	0.047	Pass	**32.5**
8	2.57	0.505	0.016	0.020	≤ 0.05	0.035	Pass	**49.5**
9	3.46	0.276	0.007	0.009	≤ 0.05	0.041	Pass	**72.4**
10	4.69	0.104	0.008	0.009	≤ 0.05	0.016	Pass	**89.6**
11	6.20	0.043	0.008	0.010	≤ 0.05	0.009	Pass	**95.7**
12	8.37	0.030	0.006	0.007	≤ 0.05	0.006	Pass	**97.0**

$d_{a,i}$:	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	16099	15534	15551	15424	15460	**78068**
2	0.47	13023	12831	12740	12910	12914	**64418**
3	0.62	8013	7668	7883	7770	7834	**39168**
4	0.84	7553	7371	7327	7427	7583	**37261**
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	15483	14976	14979	14938	15019	**75395**
2	0.47	13012	12920	12694	12776	13074	**64476**
3	0.62	7418	7219	7408	7361	7432	**36838**
4	0.84	6287	6328	6310	6354	6309	**31588**
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	0.977	0.009	0.011	≤ 0.05	0.068	Pass	**2.3**
2	0.47	0.964	0.014	0.017	≤ 0.05	0.067	Pass	**3.6**
3	0.62	0.961	0.012	0.015	≤ 0.05	0.067	Pass	**3.9**
4	0.84	0.919	0.022	0.028	≤ 0.05	0.064	Pass	**8.1**

$d_{a,i}$:	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

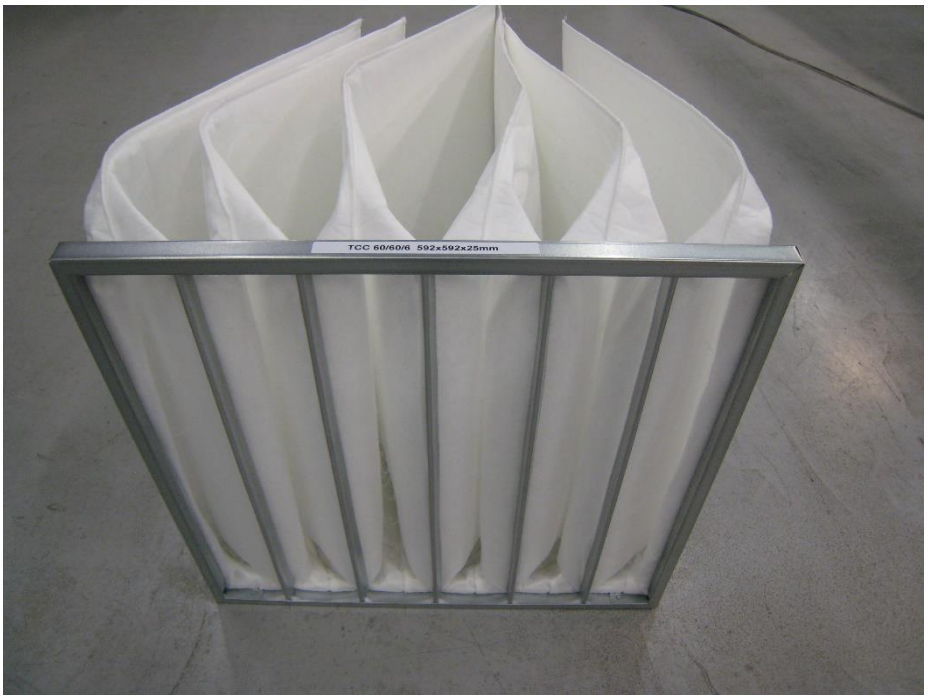


Fig 1. Overview of the test item.

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" behaviour.

Appendix 7

Eurovent 4/21 - 2019
Energy efficiency evaluation of air filters for general ventilation purposes

Testing Organization:
Research Institutes of Sweden AB
Brinellgatan 4, 501 15 Borås, Swedan
+460105165000

Test ID: SP202010071 | Date of test: 2020-10-15 | Operator: IS / CM

DEVICE TESTED

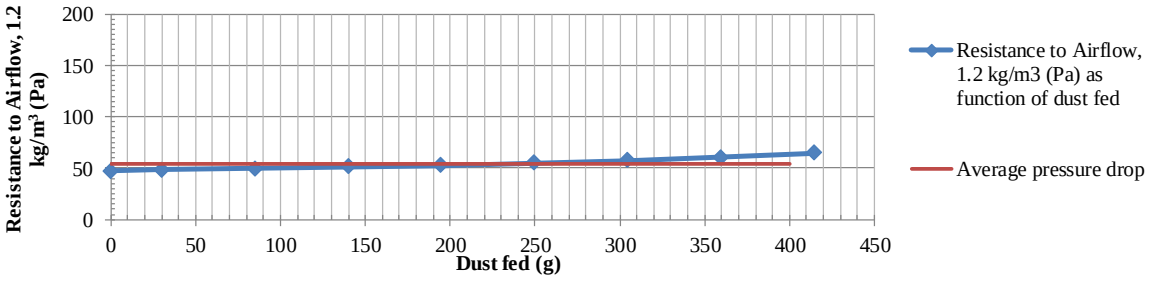
Model:	Manufacturer:	Construction:
Ecopac EM515.000.06	Filtex AB	Pocket filter, 6 Pockets

Article number:	Type of medium:	Net effective filtering area:	Filter dimensions (width x height x depth)
-	Synthetic	4.3 m^2	592x592x600 mm

TEST DATA DETAILS

i	$m_{i,}$	Δp_i	$\Delta p_{i,a}$	Δm_i
	g	**Pa**	**Pa**	**g**
0	0	47.2		
1	30	48.2	47.7	30
2	85	49.7	48.9	55
3	140	51.2	50.4	55
4	195	52.7	51.9	55
5	250	54.7	53.7	55
6	305	57.2	56.0	55
7	360	60.2	58.7	55
8	415	64.7	62.5	55
	M_x	Δp_x	$\Delta p_{n,a}$	Δm_n
	g	**Pa**	**Pa**	**g**
	400	63.5	61.9	40

i number of the dust loading step
$m_{i,}$ total amount of dust fed to the air filter after the dust loading step *i*
Δp_i pressure drop of the air filter after dust loading step *i*
$\Delta p_{i,a}$ average of the pressure drops of the air filter measured before and after the dust loading step *i*
Δm_i dust increment fed to the air filter during loading step *i*
n total number of dust loading steps to feed the amount of test dust M_x to the air filter ($n \geq 8$)



RESULTS

ISO group	PM10	Δp_a, Average pressure drop	**53.7 Pa**
Amount of dust fed, M_x	400	Yearly energy consumption, W	**609 kWh**

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.