Determination of the filtration performance of air filter UAB FIBERTON 592x592x48 according to EN ISO 16890:2016

Requested by

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Order ref.

Q3JAPT230002-02, dated 16.1.2023

Contact person

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Assignment **Determination of the filtration performance of air filter UAB FIBERTON 592x592x48 according to EN ISO 16890:2016**

Sample details The customer delivered two air filters, from which one was randomly selected for tests, which is detailed in Appendix 1.

The sample were received 19.1.2023.
The measurements were made 25.1. - 6.2.2023.

Methods The tests were made according to EN ISO 16890:2016 standard series /1, 2, 3 and 4/

The filter discharging treatment were made by exposing it to isopropanol vapor. The purity of the isopropanol used in the test was ≥99.5 %.

The air flow rates were measured with a calibrated orifice plate with corner pressure tappings.

The instruments used in the measurements are presented in Appendix 8.

FINAS Finnish Accreditation Service has accredited our laboratory (T001, Appendix 1.08, Eurofins Expert Services Oy) to perform measurements according to EN ISO 16890:2016 standard series.

Results A summary of the test results, fractional efficiency values and calculation of the particulate matter efficiencies (ePM) are presented in Appendix 1. The test dust capacity has been interpolated/extrapolated to the final pressure drop.

Initial and conditioned fractional efficiency measurement results are presented in accordance with EN ISO 16890-2:2016 and EN ISO 16890-4:2016 in Appendix 2.

Dust loading and pressure drop measurement results are presented in accordance with EN ISO 16890-3:2016 in Appendix 3.

Test aerosol particle numbers measured in determination of initial fractional efficiency is presented in Appendix 4 and for conditioned fractional efficiency in Appendix 5.

The net effective filtering area 5.6 m² was calculated using the following measured approximate dimensions: pleat depth 42 mm, pleat tip width 1 mm pleat width 590 mm, number of pleats per filter pack 110, number of packs in the filter 1.

Normalized downstream particle size distributions and measured efficiencies in standardized environments are presented in Appendix 6.

The EN ISO 16890-1:2016 guideline for interpretation of test reports is presented in Appendix 7.

The measurements have been made so that the accuracy demands set in the standard ISO 16890-2 are fulfilled, i.e. pressure difference accuracy ±2 Pa in the range 0 - 70 Pa, above 70 Pa 3 % of the measured value, uncertainty of air flow rate ≤ 5 % at a 95 % confidence level.

The results are only valid for the tested filter sample.

References

/1/ EN ISO 16890-1:2016. Air filters for general ventilation - Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)

/2/ EN ISO 16890-2:2022. Air filters for general ventilation - Part 2: Measurement of fractional efficiency and air flow resistance

/3/ EN ISO 16890-3:2016. Air filters for general ventilation - Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured

/4/ EN ISO 16890-4:2022. Air filters for general ventilation - Part 4: Conditioning method to determine the minimum fractional test efficiency

Espoo, 7.2.2023

Antti Korhonen
Expert

Appendices 8

Distribution Customer, electronically approved

EN ISO 16890-1:2016 Air Filter Test Results

GENERAL

Test no.:	224772	Device receiving date:	19.1.2023	
Test requested by:	Fiberton Ltd	Date of test:	25.1. - 6.2.2023	
Device delivered by:	Fiberton Ltd	Operator: RB	Supervisor: AK	

DEVICE TESTED

Model		Manufacturer	Construction
UAB FIBERTON 592x592x48		Filberton Ltd	Panel
Type of medium	Net effective filtering area	Filter dimensions (width × height × depth)	
Synthetic	5.6 m²	592 mm x 592 mm x 48 mm	

TEST DATA

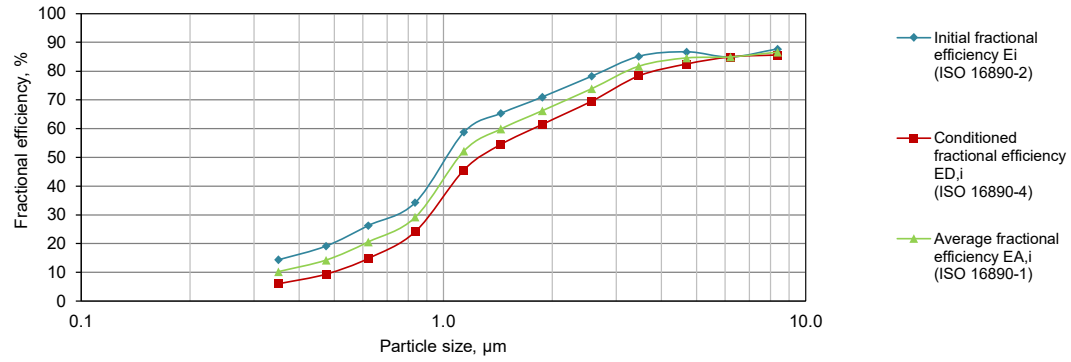
Test air flow rate	Test air temperature	Test air relative humidity	Test aerosol	Loading dust
0.944 m³/s	20 - 23 °C	41 - 52 %	DEHS and KCl	ISO 12103 A2 Fine

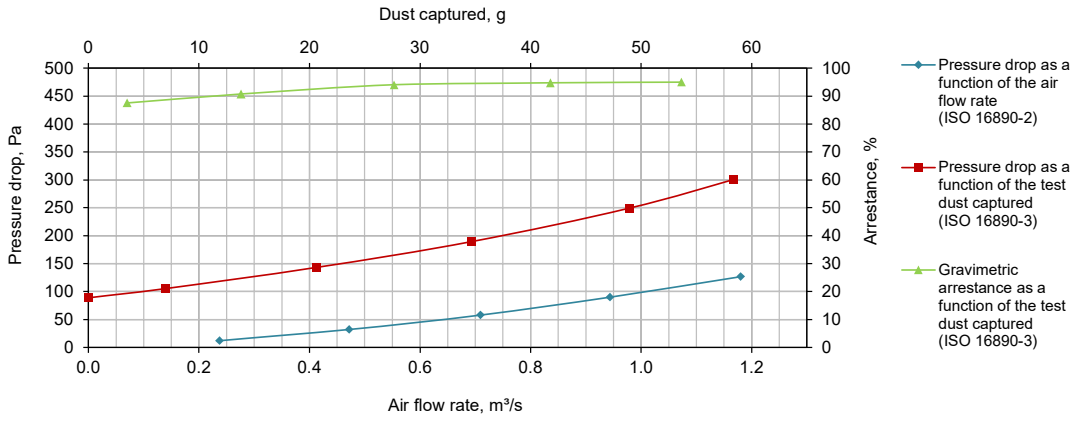
CONDITIONING ENVIRONMENT

Time of conditioning	Room temperature	Room relative humidity	Barometric pressure	Evaporated IPA amount
24 h	17 - 18 °C	39 - 46 %	97.7 - 99.3 kPa	292.5 g

RESULTS

Initial pressure drop	Initial grav. arrestance (5 g)	$ePM_{1,min}$	$ePM_{2.5,min}$	ISO rating
90 Pa	87 %	12 %	27 %	
Final test pressure drop	**Test dust capacity**	**ePM_1**	**$ePM_{2.5}$**	**ePM_{10}**
300 Pa	58 g	17 %	32 %	66 %
Remarks: -				**ISO ePM_{10} 65 %**





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

Fractional efficiency values
EN ISO 16890-1,2,4:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

Particle size				Fractional efficiency		
OPC Bin, *i*	Δd_i µm	$\overline{d}_i$ µm	$\Delta \ln d_i$ µm	E_i %	$E_{D,i}$ %	$E_{A,i}$ %
1	0.30 - 0.41	0.35	0.31237	14	6	10
2	0.41 - 0.55	0.47	0.29376	19	9	14
3	0.55 - 0.70	0.62	0.24116	26	15	21
4	0.70 - 1.00	0.84	0.35667	34	24	29
5	1.00 - 1.30	1.14	0.26236	59	46	52
6	1.30 - 1.60	1.44	0.20764	65	55	60
7	1.60 - 2.20	1.88	0.31845	71	61	66
8	2.20 - 3.00	2.57	0.31015	78	70	74
9	3.00 - 4.00	3.46	0.28768	85	78	82
10	4.00 - 5.50	4.69	0.31845	87	83	85
11	5.50 - 7.00	6.20	0.24116	85	85	85
12	7.00 - 10.00	8.37	0.35667	88	86	87

Symbols and units

Δd_i	Particle size range i, µm
$\overline{d}_i$	Geometric mean diameter of a size range i, µm
$\Delta \ln d_i$	Logarithmic width of particle diameter size range *i*
E_i	Initial fractional efficiency of particle 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 artificial conditioning step, %
$E_{A,i}$	Average fractional efficiency of particle size range *i*, %

Calculation of the particulate matter efficiencies (*e*PM)
EN ISO 16890-1:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

Particle size				Urban size distribution					
OPC Bin, i	Δd_i µm	$\bar{d}_i$ µm	$\Delta \ln d_i$ µm	$q_{3u}(\bar{d}_i)$	$q_{3u}(\bar{d}_i)$ * $\Delta \ln d_i$	$E_{D,i}$*$q_{3u}(\bar{d}_i)$ *$\Delta \ln d_i$	$E_{A,i}$*$q_{3u}(\bar{d}_i)$ *$\Delta \ln d_i$	$e\mathrm{PM}_{x,\,min}$ %	$e\mathrm{PM}_x$ %
1	0.30 - 0.41	0.35	0.31237	0.225685	0.070498	0.004218	0.007193		
2	0.41 - 0.55	0.47	0.29376	0.197321	0.057965	0.005423	0.008269		
3	0.55 - 0.70	0.62	0.24116	0.158372	0.038193	0.005665	0.007854		
4	0.70 - 1.00	0.84	0.35667	0.115223	0.041097	0.009912	0.012008	**$e\mathrm{PM}_{1,\,min}$**	**$e\mathrm{PM}_1$**
				Σ line 1-4	**0.207754**	**0.025219**	**0.035325**	**12**	**17**
5	1.00 - 1.30	1.14	0.26236	0.085032	0.022309	0.010176	0.011642		
6	1.30 - 1.60	1.44	0.20764	0.076177	0.015817	0.008624	0.009480		
7	1.60 - 2.20	1.88	0.31845	0.080218	0.025546	0.015709	0.016918		
8	2.20 - 3.00	2.57	0.31015	0.099839	0.030966	0.021543	0.022890	**$e\mathrm{PM}_{2.5,\,min}$**	**$e\mathrm{PM}_{2.5}$**
				Σ line 1-8	**0.302392**	**0.081270**	**0.096255**	**27**	**32**

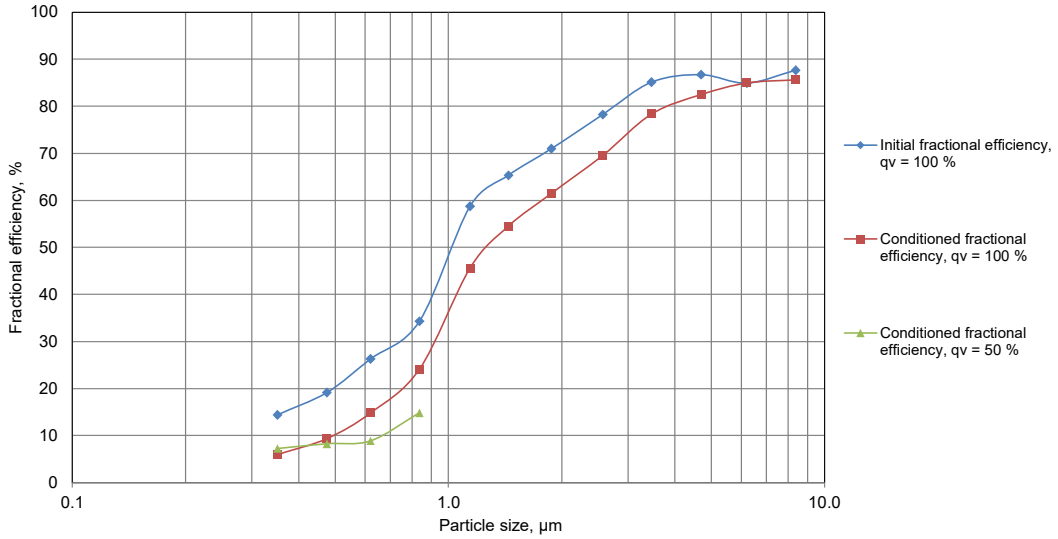
Particle size				Rural size distribution					
OPC Bin, i	Δd_i µm	$\bar{d}_i$ µm	$\Delta \ln d_i$ µm	$q_{3r}(\bar{d}_i)$	$q_{3r}(\bar{d}_i)$ * $\Delta \ln d_i$		$E_{A,i}$*$q_{3r}(\bar{d}_i)$ *$\Delta \ln d_i$		$e\mathrm{PM}_x$ %
1	0.30 - 0.41	0.35	0.31237	0.093806	0.029303		0.002990		
2	0.41 - 0.55	0.47	0.29376	0.083478	0.024522		0.003498		
3	0.55 - 0.70	0.62	0.24116	0.074324	0.017924		0.003686		
4	0.70 - 1.00	0.84	0.35667	0.070137	0.025016		0.007310		
5	1.00 - 1.30	1.14	0.26236	0.076281	0.020013		0.010444		
6	1.30 - 1.60	1.44	0.20764	0.088326	0.018340		0.010992		
7	1.60 - 2.20	1.88	0.31845	0.108042	0.034406		0.022786		
8	2.20 - 3.00	2.57	0.31015	0.137262	0.042573		0.031470		
9	3.00 - 4.00	3.46	0.28768	0.167084	0.048067		0.039293		
10	4.00 - 5.50	4.69	0.31845	0.195424	0.062233		0.052653		
11	5.50 - 7.00	6.20	0.24116	0.216707	0.052261		0.044391		
12	7.00 - 10.00	8.37	0.35667	0.231428	0.082545		0.071526		**$e\mathrm{PM}_{10}$**
				Σ line 1-12	**0.457204**		**0.301038**		**66**

Symbols and units

Δd_i	Particle size range i, µm
$\bar{d}_i$	Geometric mean diameter of a size range i, µm
$\Delta \ln d_i$	Logarithmic width of particle diameter size range i
$q_{3u}(\bar{d}_i)$	Discrete urban particle volume distribution, dimensionless
$q_{3r}(\bar{d}_i)$	Discrete rural particle volume distribution, dimensionless
$E_{D,i}$	Fractional efficiency of particle size range i of the filter element after an artificial conditioning step, %
$E_{A,i}$	Average fractional efficiency of particle size range i, %
$e\mathrm{PM}_{x,\,min}$	Minimum particulate matter efficiency value of the conditioned filter, %
$e\mathrm{PM}_x$	Particulate matter efficiency, %

Initial and conditioned fractional efficiency
EN ISO 16890-2,4:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s



Particle size		Fractional efficiency and upstream concentration					
Δd_i	d_i	Initial, q_V = 100 %		Conditioned, q_V = 100 %		Conditioned, q_V = 50 %	
µm	µm	%	#/dm³	%	#/dm³	%	#/dm³
0.30 - 0.41	0.35	14.4	39 396	6.0	38 663	7.3	30 351
0.41 - 0.55	0.47	19.2	24 172	9.4	23 548	8.3	19 042
0.55 - 0.70	0.62	26.3	15 179	14.8	14 806	8.9	12 155
0.70 - 1.00	0.84	34.3	15 477	24.1	15 294	14.9	13 242
1.00 - 1.30	1.14	58.8	5 683	45.6	4 890		
1.30 - 1.60	1.44	65.4	5 256	54.5	4 517		
1.60 - 2.20	1.88	71.0	6 595	61.5	5 743		
2.20 - 3.00	2.57	78.3	4 156	69.6	3 696		
3.00 - 4.00	3.46	85.1	2 985	78.4	2 634		
4.00 - 5.50	4.69	86.7	1 509	82.5	1 257		
5.50 - 7.00	6.20	84.9	372	85.0	342		
7.00 - 10.00	8.37	87.7	309	85.6	302		
DEHS concentration		111 880		109 656			
KCl concentration		122 782		106 080			
Pressure drop		90 Pa		89 Pa			
Device mass		1589 g		1589 g			

Particle counter coincidence value is 250 000 #/dm³

Symbols and units

Δd_i	Particle size range, µm
$\bar{d}_i$	Geometric mean diameter of a size range i, µm
q_V	Air flow rate at filter

Air flow rate and pressure drop after different dust loading phases
EN ISO 16890-2,3:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Air flow rate: 0.944 m³/s

Date	Loaded dust	Calibrated orifice plate [1]				Filter							% of rated air flow
	m_{tot} g	t_f °C	p_{sf} kPa	Δp_f Pa	q_m kg/s	t °C	φ %	p_a kPa	ρ kg/m³	q_V m³/s	Δp Pa	$\Delta p_{1.20}$ Pa	
Clean Filter													
25.1.2023	-	19.7	-0.173	1705	1.414	21.1	44.5	101.6	1.198	1.180	127	127	125 %
"	-	19.1	-0.125	1089	1.135	19.9	48.8	101.6	1.203	0.944	90	90	100 %
"	-	18.8	-0.087	612	0.854	19.6	50.3	101.6	1.204	0.709	58	58	75 %
"	-	19.7	-0.054	268	0.567	19.8	52.1	101.6	1.203	0.472	32	32	50 %
"	-	20.4	-0.030	67	0.285	20.1	51.4	101.6	1.202	0.237	12	12	25 %
Clean filter pressure drop is proportional to $(q_V)^n$, where n = 1.454													
Conditioned filter													
31.1.2023	-	22.0	-0.124	1058	1.100	22.3	41.3	99.3	1.165	0.944	88	89	100 %
"	-	22.3	-0.055	259	0.549	22.5	41.1	99.3	1.165	0.472	31	32	50 %
Dust loading phase													
6.2.2023	8	20.7	-0.257	1111	1.152	20.7	43.2	103.3	1.221	0.944	107	106	
"	23	20.1	-0.298	1114	1.155	20.3	44.6	103.4	1.223	0.945	144	143	
"	38	21.5	-0.342	1106	1.147	21.6	43.3	103.4	1.217	0.943	191	190	
"	53	20.1	-0.401	1104	1.149	21.1	41.1	103.4	1.219	0.943	251	249	
"	63	19.6	-0.451	1110	1.152	20.5	43.8	103.3	1.221	0.944	303	301	

Symbols and units

m_{tot}	Cumulative mass of dust fed to filter, g	t_f	Temperature at air flow meter, °C
p_a	Absolute air pressure upstream of filter, kPa	ρ	Air density upstream of filter, kg/m³
p_{sf}	Air flow meter static pressure, kPa	φ	Relative humidity upstream of filter, %
q_m	Mass flow rate, kg/s	Δp	Measured filter pressure drop, Pa
q_V	Air flow rate at filter, m³/s	Δp_f	Air flow meter differential pressure, Pa
t	Temperature upstream of filter, °C	$\Delta p_{1.20}$	Filter pressure drop at air density 1.20 kg/m³, Pa

[1] Orifice plate dimensions

Duct dimensions:	610 mm x 610 mm
Orifice diameter:	216 mm

Pressure drop and arrestance after different dust loading phases
EN ISO 16890-3:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Air flow rate: 0.944 m³/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	Δm_c g	$m_{c,tot}$ g	A %	A_m %
6.2.2023	89	8	8	106	2549.9	2550.9	1.0	0.0	7	7	87.5	-
"	106	15	23	143	2550.9	2552.3	1.4	0.0	14	21	90.7	-
"	143	15	38	190	2552.3	2553.2	0.9	0.0	14	35	94.0	-
"	190	15	53	249	2553.2	2554.0	0.8	0.0	14	49	94.7	-
"	249	10	63	301	2554.0	2554.5	0.5	0.0	10	58	95.0	92.7

Mass of tested device

Initial mass of tested device: 1588.9 g
Final mass of tested device: 1647.1 g

Symbols and units

A	Arrestance, %	Δm	Dust increment, g
A_m	Average arrestance, %	Δm_{ff}	Mass gain of final filter, g
m_d	Dust in duct after device, g	Δm_c	Captured dust increment, g
m_{tot}	Cumulative mass of dust fed to filter, g	$m_{c,tot}$	Cumulative mass of captured dust, g
m_1	Mass of final filter before dust increment, g	Δp_1	Pressure drop before dust increment (air density 1.20 kg/m³), Pa
m_2	Mass of final filter after dust increment, g	Δp_2	Pressure drop after dust increment (air density 1.20 kg/m³), Pa

Loading dust

Type: ISO 12103 A2 Fine
Manufactured by: Particle Technology Ltd
Batch no.: 10207 18/03/22

Correlation data for initial efficiency
EN ISO 16890-2:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

OPC Bin, i	$\bar{d}_i$ µm	Initial and final background					
		$U_{B,c,b}$	$U_{B,c,f}$	**$U_{B,c}$**	$D_{B,c,b}$	$D_{B,c,f}$	**$D_{B,c}$**
1	0.35	1	0	**0.5**	0	1	**0.5**
2	0.47	0	0	**0**	0	0	**0**
3	0.62	1	0	**0.5**	0	1	**0.5**
4	0.84	0	0	**0**	0	0	**0**
5	1.14	0	0	**0**	0	0	**0**
6	1.44	0	0	**0**	0	0	**0**
7	1.88	0	0	**0**	0	0	**0**
8	2.57	0	0	**0**	0	0	**0**
9	3.46	0	0	**0**	0	1	**0.5**
10	4.69	0	0	**0**	0	0	**0**
11	6.20	0	0	**0**	0	0	**0**
12	8.37	0	0	**0**	0	0	**0**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Upstream correlation (five measurements)						Downstream correlation (five measurements)					
		1	2	3	4	5	**$U_{c,tot}$**	1	2	3	4	5	**$D_{c,tot}$**
1	0.35	39781	39243	39996	39934	40167	**199121**	38160	37706	37847	37764	38114	**189591**
2	0.47	24894	24030	24393	24241	24401	**121959**	25487	25617	25865	25258	25793	**128020**
3	0.62	15526	15014	15373	15135	15340	**76388**	15609	15557	15647	15807	15880	**78500**
4	0.84	15879	15645	15748	15753	16037	**79062**	15666	15431	15609	15641	15732	**78079**
5	1.14	5534	5432	5449	5441	5429	**27285**	5491	5544	5496	5468	5436	**27435**
6	1.44	5110	5135	5152	5171	5070	**25638**	4570	4595	4763	4718	4585	**23231**
7	1.88	6473	6395	6501	6492	6391	**32252**	6465	6295	6577	6250	6336	**31923**
8	2.57	4070	4093	4140	4161	4077	**20541**	4430	4237	4400	4385	4261	**21713**
9	3.46	2852	2830	2874	2858	2783	**14197**	2984	3016	3036	2874	3010	**14920**
10	4.69	1497	1517	1452	1440	1533	**7439**	1516	1643	1555	1625	1582	**7921**
11	6.20	387	389	375	388	360	**1899**	395	373	381	385	393	**1927**
12	8.37	338	355	302	322	321	**1638**	334	369	372	306	323	**1704**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Correlation ratios (five measurements)							Uncertainty limits		
		R_1	R_2	R_3	R_4	R_5	**R_{avg}**	Pass/Fail	δ_c	e_c	Pass/Fail
1	0.35	0.959	0.961	0.946	0.946	0.949	**0.952**	Pass	0.0073	0.0091	Pass
2	0.47	1.024	1.066	1.060	1.042	1.057	**1.050**	Pass	0.0171	0.0212	Pass
3	0.62	1.005	1.036	1.018	1.044	1.035	**1.028**	Pass	0.0158	0.0197	Pass
4	0.84	0.987	0.986	0.991	0.993	0.981	**0.988**	Pass	0.0047	0.0058	Pass
5	1.14	0.992	1.021	1.009	1.005	1.001	**1.006**	Pass	0.0104	0.0129	Pass
6	1.44	0.894	0.895	0.924	0.912	0.904	**0.906**	Pass	0.0127	0.0158	Pass
7	1.88	0.999	0.984	1.012	0.963	0.991	**0.990**	Pass	0.0182	0.0226	Pass
8	2.57	1.088	1.035	1.063	1.054	1.045	**1.057**	Pass	0.0203	0.0252	Pass
9	3.46	1.046	1.066	1.056	1.006	1.082	**1.051**	Pass	0.0286	0.0355	Pass
10	4.69	1.013	1.083	1.071	1.128	1.032	**1.065**	Pass	0.0453	0.0563	Pass
11	6.20	1.021	0.959	1.016	0.992	1.092	**1.016**	Pass	0.0489	0.0607	Pass
12	8.37	0.988	1.039	1.232	0.950	1.006	**1.043**	Pass	0.1102	0.1368	Pass

Symbols and units

$\bar{d}_i$	Geometric mean diameter of a size range i, µm	$D_{B,c}$	Downstream background count average for correlation
$U_{B,c,b}$	Upstream begining background count for correlation	$U_{c,tot}$	Total upstream particle counts
$U_{B,c,f}$	Upstream final background count	$D_{c,tot}$	Total downstream particle counts
$U_{B,c}$	Upstream background count average for correlation	R_{avg}	Average correlation ratio
$D_{B,c,b}$	Downstream begining background count for correlation	δ_c	Standard deviation of the correlation values
$D_{B,c,f}$	Downstream final background count	e_c	Uncertainty at 95 % confidence interval for correlation values

Initial efficiency data
EN ISO 16890-2:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

OPC Bin, i	$\bar{d}_i$ µm	Initial and final background					
		$U_{B,e,b}$	$U_{B,e,f}$	**$U_{B,e}$**	$D_{B,e,b}$	$D_{B,e,f}$	**$D_{B,e}$**
1	0.35	1	1	**1**	1	1	**1**
2	0.47	0	0	**0**	0	0	**0**
3	0.62	0	0	**0**	0	0	**0**
4	0.84	2	1	**1.5**	1	0	**0.5**
5	1.14	0	0	**0**	0	0	**0**
6	1.44	0	0	**0**	0	0	**0**
7	1.88	0	0	**0**	0	0	**0**
8	2.57	0	0	**0**	0	0	**0**
9	3.46	0	0	**0**	0	2	**1**
10	4.69	0	0	**0**	0	0	**0**
11	6.20	0	0	**0**	0	0	**0**
12	8.37	0	0	**0**	0	0	**0**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Upstream efficiency (five measurements)						Downstream efficiency (five measurements)					
		1	2	3	4	5	**$U_{e,tot}$**	1	2	3	4	5	**$D_{e,tot}$**
1	0.35	39579	39305	39277	39217	39602	**196980**	32167	32004	32322	32131	31879	**160503**
2	0.47	24208	24187	24135	24211	24118	**120859**	20521	20495	20627	20613	20297	**102553**
3	0.62	15168	15257	15199	15130	15140	**75894**	11562	11601	11331	11518	11479	**57491**
4	0.84	15429	15365	15524	15680	15388	**77386**	9928	9944	10152	10153	10019	**50196**
5	1.14	5439	5572	5623	5898	5881	**28413**	2280	2276	2332	2484	2412	**11784**
6	1.44	5004	5189	5339	5480	5269	**26281**	1597	1682	1629	1700	1639	**8247**
7	1.88	6427	6554	6525	6655	6815	**32976**	1831	1907	1842	1949	1950	**9479**
8	2.57	4024	4070	4095	4224	4366	**20779**	959	960	917	945	990	**4771**
9	3.46	2968	2911	3003	2927	3114	**14923**	460	489	486	463	433	**2331**
10	4.69	1507	1475	1549	1506	1508	**7545**	202	235	216	197	218	**1068**
11	6.20	407	352	380	353	367	**1859**	57	74	49	38	66	**284**
12	8.37	304	281	307	311	344	**1547**	32	49	45	34	37	**197**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Observed penetration (five measurements)						
		P_{o1}	P_{o2}	P_{o3}	P_{o4}	P_{o5}	**P_o**	δ_o
1	0.35	0.813	0.814	0.823	0.819	0.805	**0.815**	0.007
2	0.47	0.848	0.847	0.855	0.851	0.842	**0.849**	0.005
3	0.62	0.762	0.760	0.746	0.761	0.758	**0.758**	0.007
4	0.84	0.643	0.647	0.654	0.648	0.651	**0.649**	0.004
5	1.14	0.419	0.408	0.415	0.421	0.410	**0.415**	0.006
6	1.44	0.319	0.324	0.305	0.310	0.311	**0.314**	0.008
7	1.88	0.285	0.291	0.282	0.293	0.286	**0.287**	0.004
8	2.57	0.238	0.236	0.224	0.224	0.227	**0.230**	0.007
9	3.46	0.155	0.168	0.162	0.158	0.139	**0.156**	0.011
10	4.69	0.134	0.159	0.139	0.131	0.145	**0.142**	0.011
11	6.20	0.140	0.210	0.129	0.108	0.180	**0.153**	0.041
12	8.37	0.105	0.174	0.147	0.109	0.108	**0.129**	0.031

OPC Bin, i	$\bar{d}_i$ µm	Penetration data reduction			Uncertainty limits			Efficiency
		P	δ	e	Static	Dynamic	Pass/Fail	**%**
1	0.35	0.856	0.010	0.012	0.05	0.060	Pass	**14.4**
2	0.47	0.808	0.014	0.017	0.05	0.057	Pass	**19.2**
3	0.62	0.737	0.013	0.016	0.05	0.052	Pass	**26.3**
4	0.84	0.657	0.005	0.006	0.05	0.046	Pass	**34.3**
5	1.14	0.412	0.007	0.009	0.05	0.029	Pass	**58.8**
6	1.44	0.346	0.010	0.012	0.05	0.024	Pass	**65.4**
7	1.88	0.290	0.007	0.009	0.05	0.020	Pass	**71.0**
8	2.57	0.217	0.008	0.010	0.05	0.015	Pass	**78.3**
9	3.46	0.149	0.011	0.014	0.05	0.022	Pass	**85.1**
10	4.69	0.133	0.012	0.015	0.05	0.020	Pass	**86.7**
11	6.20	0.151	0.041	0.051	0.05	0.030	Pass	**84.9**
12	8.37	0.123	0.032	0.040	0.05	0.025	Pass	**87.7**

Symbols and units

$\bar{d}_i$	Geometric mean diameter of a size range i, µm	$U_{e,tot}$	Total upstream particle counts
$U_{B,e,b}$	Upstream begining background count for penetration	$D_{e,tot}$	Total downstream particle counts
$U_{B,e,f}$	Upstream final background count	P_o	Observed penetration, -
$U_{B,e}$	Upstream background count average for penetration	P	Penetration, -
$D_{B,e,b}$	Downstream begining background count for penetration	δ_o	Standard deviation of the observed penetration
$D_{B,e,f}$	Downstream final background count	δ	Standard deviation of the penetration
$D_{B,e}$	Downstream background count average for penetration	e	Uncertainty at 95 % confidence interval for penetration values

Correlation data for conditioned efficiency
EN ISO 16890-2:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

OPC Bin, i	$\bar{d}_i$ µm	Initial and final background					
		$U_{B,c,b}$	$U_{B,c,f}$	**$U_{B,c}$**	$D_{B,c,b}$	$D_{B,c,f}$	**$D_{B,c}$**
1	0.35	1	0	**0.5**	0	0	**0**
2	0.47	0	0	**0**	0	0	**0**
3	0.62	0	0	**0**	0	0	**0**
4	0.84	0	0	**0**	0	0	**0**
5	1.14	0	0	**0**	0	0	**0**
6	1.44	1	0	**0.5**	0	0	**0**
7	1.88	0	0	**0**	1	0	**0.5**
8	2.57	0	0	**0**	0	0	**0**
9	3.46	0	0	**0**	0	0	**0**
10	4.69	0	0	**0**	1	0	**0.5**
11	6.20	0	0	**0**	0	0	**0**
12	8.37	0	0	**0**	0	0	**0**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Upstream correlation (five measurements)						Downstream correlation (five measurements)					
		1	2	3	4	5	**$U_{c,tot}$**	1	2	3	4	5	**$D_{c,tot}$**
1	0.35	38905	38496	38935	38496	38081	**192913**	36626	36167	36231	36352	35828	**181204**
2	0.47	23856	23507	23668	23595	23417	**118043**	25044	24396	24996	24970	24598	**124004**
3	0.62	14818	14707	14945	15014	14779	**74263**	15220	14901	15290	15359	15122	**75892**
4	0.84	15450	15295	15207	15493	15158	**76603**	15550	15241	15326	15354	15437	**76908**
5	1.14	4941	4998	5316	5374	5302	**25931**	4957	5094	5102	5144	5267	**25564**
6	1.44	4448	4608	4702	4887	4878	**23523**	4232	4193	4412	4372	4565	**21774**
7	1.88	5650	5821	5861	6127	6196	**29655**	5695	5768	6058	6212	6183	**29916**
8	2.57	3675	3724	3794	3887	4029	**19109**	3772	3888	4055	4154	4100	**19969**
9	3.46	2554	2589	2524	2662	2725	**13054**	2555	2689	2797	2804	2858	**13703**
10	4.69	1190	1263	1327	1304	1292	**6376**	1333	1455	1365	1502	1369	**7024**
11	6.20	305	331	344	299	331	**1610**	347	366	335	357	331	**1736**
12	8.37	232	258	231	276	265	**1262**	283	275	248	270	259	**1335**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Correlation ratios (five measurements)							Uncertainty limits		
		R_1	R_2	R_3	R_4	R_5	**R_{avg}**	Pass/Fail	δ_c	e_c	Pass/Fail
1	0.35	0.941	0.940	0.931	0.944	0.941	**0.939**	Pass	0.0052	0.0065	Pass
2	0.47	1.050	1.038	1.056	1.058	1.050	**1.050**	Pass	0.0080	0.0099	Pass
3	0.62	1.027	1.013	1.023	1.023	1.023	**1.022**	Pass	0.0052	0.0064	Pass
4	0.84	1.006	0.996	1.008	0.991	1.018	**1.004**	Pass	0.0106	0.0132	Pass
5	1.14	1.003	1.019	0.960	0.957	0.993	**0.987**	Pass	0.0273	0.0338	Pass
6	1.44	0.951	0.910	0.938	0.895	0.936	**0.926**	Pass	0.0231	0.0287	Pass
7	1.88	1.008	0.991	1.034	1.014	0.998	**1.009**	Pass	0.0164	0.0204	Pass
8	2.57	1.026	1.044	1.069	1.069	1.018	**1.045**	Pass	0.0236	0.0293	Pass
9	3.46	1.000	1.039	1.108	1.053	1.049	**1.050**	Pass	0.0387	0.0480	Pass
10	4.69	1.120	1.152	1.029	1.152	1.060	**1.102**	Pass	0.0559	0.0694	Pass
11	6.20	1.138	1.106	0.974	1.194	1.000	**1.082**	Pass	0.0930	0.1155	Pass
12	8.37	1.220	1.066	1.074	0.978	0.977	**1.063**	Pass	0.0990	0.1229	Pass

Symbols and units

$\bar{d}_i$	Geometric mean diameter of a size range i, µm	$D_{B,c}$	Downstream background count average for correlation
$U_{B,c,b}$	Upstream begining background count for correlation	$U_{c,tot}$	Total upstream particle counts
$U_{B,c,f}$	Upstream final background count	$D_{c,tot}$	Total of the downstream particle counts
$U_{B,c}$	Upstream background count average for correlation	R_{avg}	Average correlation ratio
$D_{B,c,b}$	Downstream begining background count for correlation	δ_c	Standard deviation of the correlation values
$D_{B,c,f}$	Downstream final background count	e_c	Uncertainty at 95 % confidence interval for correlation values

Conditioned efficiency data
EN ISO 16890-2:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

OPC Bin, i	$\bar{d}_i$ µm	Initial and final background					
		$U_{B,e,b}$	$U_{B,e,f}$	**$U_{B,e}$**	$D_{B,e,b}$	$D_{B,e,f}$	**$D_{B,e}$**
1	0.35	0	0	**0**	1	1	**1**
2	0.47	0	0	**0**	0	0	**0**
3	0.62	0	0	**0**	0	0	**0**
4	0.84	0	0	**0**	0	0	**0**
5	1.14	0	0	**0**	0	0	**0**
6	1.44	0	1	**0.5**	0	0	**0**
7	1.88	0	0	**0**	0	0	**0**
8	2.57	0	0	**0**	0	0	**0**
9	3.46	0	0	**0**	0	0	**0**
10	4.69	0	0	**0**	0	0	**0**
11	6.20	0	0	**0**	0	0	**0**
12	8.37	0	0	**0**	0	0	**0**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Upstream efficiency (five measurements)						Downstream efficiency (five measurements)					
		1	2	3	4	5	**$U_{e,tot}$**	1	2	3	4	5	**$D_{e,tot}$**
1	0.35	38433	38812	38700	38803	38566	**193314**	33665	34243	34205	34513	34096	**170722**
2	0.47	23262	23597	23657	23627	23598	**117741**	22248	22571	22242	22562	22488	**112111**
3	0.62	14805	14747	14771	15124	14581	**74028**	12878	12901	12857	12923	12862	**64421**
4	0.84	15286	15461	15080	15353	15290	**76470**	11451	11539	11720	11757	11789	**58256**
5	1.14	4766	4910	4768	4923	5085	**24452**	2509	2727	2612	2599	2671	**13118**
6	1.44	4384	4539	4442	4591	4627	**22583**	1789	1979	1951	1876	1915	**9510**
7	1.88	5648	5753	5760	5792	5762	**28715**	2284	2211	2227	2195	2236	**11153**
8	2.57	3552	3726	3762	3753	3688	**18481**	1161	1156	1192	1166	1200	**5875**
9	3.46	2543	2711	2623	2714	2581	**13172**	573	626	565	595	631	**2990**
10	4.69	1219	1269	1302	1268	1227	**6285**	248	255	231	236	241	**1211**
11	6.20	334	348	334	332	364	**1712**	55	55	60	53	55	**278**
12	8.37	307	312	325	288	276	**1508**	59	54	42	41	35	**231**

All data shown is the number of particle counts for 60 seconds

OPC Bin, i	$\bar{d}_i$ µm	Observed penetration (five measurements)						
		P_{o1}	P_{o2}	P_{o3}	P_{o4}	P_{o5}	**P_o**	δ_o
1	0.35	0.876	0.882	0.884	0.889	0.884	**0.883**	0.005
2	0.47	0.956	0.957	0.940	0.955	0.953	**0.952**	0.007
3	0.62	0.870	0.875	0.870	0.854	0.882	**0.870**	0.010
4	0.84	0.749	0.746	0.777	0.766	0.771	**0.762**	0.014
5	1.14	0.526	0.555	0.548	0.528	0.525	**0.537**	0.014
6	1.44	0.408	0.436	0.439	0.409	0.414	**0.421**	0.015
7	1.88	0.404	0.384	0.387	0.379	0.388	**0.388**	0.010
8	2.57	0.327	0.310	0.317	0.311	0.325	**0.318**	0.008
9	3.46	0.225	0.231	0.215	0.219	0.244	**0.227**	0.011
10	4.69	0.203	0.201	0.177	0.186	0.196	**0.193**	0.011
11	6.20	0.165	0.158	0.180	0.160	0.151	**0.163**	0.011
12	8.37	0.192	0.173	0.129	0.142	0.127	**0.153**	0.029

OPC Bin, i	$\bar{d}_i$ µm	Penetration data reduction			Uncertainty limits			Efficiency
		P	δ	e	Static	Dynamic	Pass/Fail	%
1	0.35	0.940	0.007	0.009	0.05	0.066	Pass	**6.0**
2	0.47	0.906	0.009	0.012	0.05	0.063	Pass	**9.4**
3	0.62	0.852	0.011	0.013	0.05	0.060	Pass	**14.8**
4	0.84	0.759	0.016	0.020	0.05	0.053	Pass	**24.1**
5	1.14	0.544	0.021	0.026	0.05	0.038	Pass	**45.6**
6	1.44	0.455	0.020	0.025	0.05	0.032	Pass	**54.5**
7	1.88	0.385	0.011	0.014	0.05	0.027	Pass	**61.5**
8	2.57	0.304	0.010	0.013	0.05	0.021	Pass	**69.6**
9	3.46	0.216	0.013	0.017	0.05	0.032	Pass	**78.4**
10	4.69	0.175	0.013	0.016	0.05	0.026	Pass	**82.5**
11	6.20	0.150	0.016	0.020	0.05	0.030	Pass	**85.0**
12	8.37	0.144	0.030	0.037	0.05	0.029	Pass	**85.6**

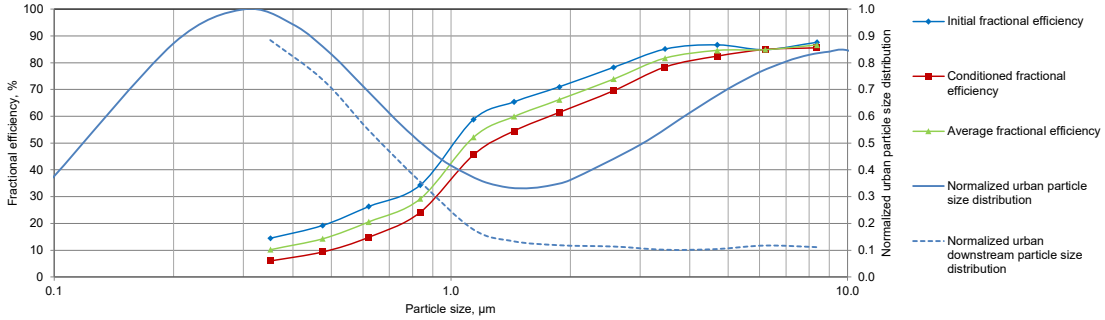
Symbols and units

$\bar{d}_i$	Geometric mean diameter of a size range i, µm	$U_{e,tot}$	Total upstream particle counts
$U_{B,e,b}$	Upstream begining background count for penetration	$D_{e,tot}$	Total downstream particle counts
$U_{B,e,f}$	Upstream final background count	P_o	Observed penetration, -
$U_{B,e}$	Upstream background count average for penetration	P	Penetration, -
$D_{B,e,b}$	Downstream begining background count for penetration	δ_o	Standard deviation of the observed penetration
$D_{B,e,f}$	Downstream final background count	δ	Standard deviation of the penetration
$D_{B,e}$	Downstream background count average for penetration	e	Uncertainty at 95 % confidence interval for penetration values

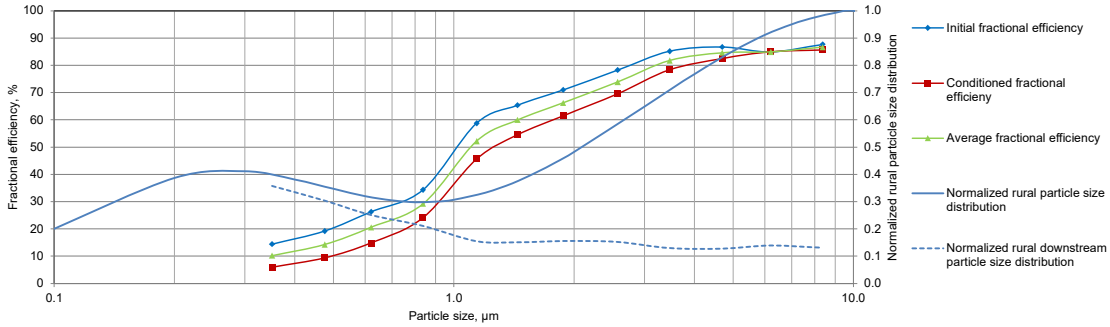
Normalized downstream particle size distribution and measured efficiencies
EN ISO 16890-1,2,4:2016

Air filter: UAB FIBERTON 592x592x48
Test no.: 224772
Test aerosols: DEHS (0.3 - 1 µm) and KCl (1 - 10 µm)
Air flow rate: 0.944 m³/s

Filtration performance in standardized urban environment used for ePM_1 and $ePM_{2.5}$ classification



Filtration performance in standardized rural environment used for ePM_{10} classification



Particle size			Urban size distribution					Rural size distribution			Fractional efficiency		
Δd_i µm	$\overline{d}_i$ µm	$\Delta \ln d_i$ µm	$q_{3u}(\overline{d}_i)$	$q_{3u}(\overline{d}_i)^*$ $\Delta \ln d_i$	$E_i{}^*q_{3u}(\overline{d}_i)$ $^*\Delta \ln d_i$	$E_{D,i}{}^*q_{3u}(\overline{d}_i)$ $^*\Delta \ln d_i$	$E_{A,i}{}^*q_{3u}(\overline{d}_i)$ $^*\Delta \ln d_i$	$q_{3r}(\overline{d}_i)$	$q_{3r}(\overline{d}_i)^*$ $^*\Delta \ln d_i$	$E_{A,i}{}^*q_{3r}(\overline{d}_i)$ $^*\Delta \ln d_i$	Initial, E_i %	Conditioned $E_{D,i}$ %	Average $E_{A,i}$ %
0.30 - 0.41	0.35	0.31237	0.22568	0.070498	0.010169	0.004218	0.007193	0.093806	0.029303	0.002990	14	6	10
0.41 - 0.55	0.47	0.29376	0.19732	0.057965	0.011115	0.005423	0.008269	0.083478	0.024522	0.003498	19	9	14
0.55 - 0.70	0.62	0.24116	0.15837	0.038193	0.010043	0.005665	0.007854	0.074324	0.017924	0.003686	26	15	21
0.70 - 1.00	0.84	0.35667	0.11522	0.041097	0.014105	0.009912	0.012008	0.070137	0.025016	0.007310	34	24	29
1.00 - 1.30	1.14	0.26236	0.08503	0.022309	0.013108	0.010176	0.011642	0.076281	0.020013	0.010444	59	46	52
1.30 - 1.60	1.44	0.20764	0.07618	0.015817	0.010337	0.008624	0.009480	0.088326	0.018340	0.010992	65	55	60
1.60 - 2.20	1.88	0.31845	0.08022	0.025546	0.018127	0.015709	0.016918	0.108042	0.034406	0.022786	71	61	66
2.20 - 3.00	2.57	0.31015	0.09984	0.030966	0.024236	0.021543	0.022890	0.137262	0.042573	0.031470	78	70	74
3.00 - 4.00	3.46	0.28768	0.12688	0.036500	0.031069	0.028605	0.029837	0.167084	0.048067	0.039293	85	78	82
4.00 - 5.50	4.69	0.31845	0.15556	0.049537	0.042952	0.040871	0.041911	0.195424	0.062233	0.052653	87	83	85
5.50 - 7.00	6.20	0.24116	0.17757	0.042823	0.036359	0.036388	0.036373	0.216707	0.052261	0.044391	85	85	85
7.00 - 10.00	8.37	0.35667	0.19157	0.068329	0.059904	0.058511	0.059208	0.231428	0.082545	0.071526	88	86	87

Particulate matter efficiencies		
$ePM_{1,\ ini}$	$ePM_{1,\ min}$	ePM_1
22 %	12 %	17 %
		-
$ePM_{2.5,\ ini}$	$ePM_{2.5,\ min}$	$ePM_{2.5}$
37 %	27 %	32 %
		-
$ePM_{10,\ ini}$	$ePM_{10,\ min}$	ePM_{10}
69 %	63 %	66 %
		ISO ePM_{10} 65 %

Symbols and units

Δd_i	Particle size range, µm
$\overline{d}_i$	Geometric mean diameter of a size range i, µm
$\Delta \ln d_i$	Logarithmic width of particle diameter size range i
$q_{3u}(\overline{d}_i)$	Discrete urban particle volume distribution, dimensionless
$q_{3r}(\overline{d}_i)$	Discrete rural particle volume distribution, dimensionless
E_i	Initial fractional efficiency of particle 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 artificial conditioning step, %
$E_{A,i}$	Average fractional efficiency of particle size range i, %
$ePM_{x,\ ini}$	Initial particulate matter efficiency value of the clean filter, %
$ePM_{x,\ min}$	Minimum particulate matter efficiency value of the conditioned filter, %
ePM_x	Particulate matter efficiency, %

The interpretation of test reports
ISO 16890-1:2016

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.

Instruments used in the test				
Instrument	Type code	Serial number	Calibration date	Used
Micromanometer	Furness C012	209103	15.7.2022	X
	Furness C012	1211165	15.7.2022	X
	Micatrone MF-PD	32760-068	15.7.2022	X
Barometer	Vaisala PTB330	F4340001	18.7.2022	X
Hygrometer	Vaisala HMT333	D3940024	8.12.2022	X
Temperature meter	Agilent 34970A	MY44034623	3.10.2022	X
Balance	Precisa XB10200D-IP65	5300037	11.1.2022	X
	DFWATEX2GD-1	93411584	11.1.2022	X
Particle counter	TSI 3330	3330152501	11.1.2022	X
	TSI 3330	3330160801	12.1.2022	X
DEHS aerosol generator	ISO 16890-2:2016	-	-	X
KCl aerosol generator	TSI 8108	8108153201	-	X
Dust feeder	TOPAS SAG 440	440 13 03 406	3.10.2022	X
Orifice plate	Ø 216 mm / (610 x 610) mm	-	7.12.2020	X
	Ø 272 mm / (610 x 610) mm	-	7.12.2020	-
	Ø 90 mm / (610 x 610) mm	-	7.12.2020	-