



Lindbergs Ventilation AB
Västkustvägen 400
254 77 FLENINGE

Long term test of Air Filter according to SP Method 1937

(3 appendices)

At the request of Lindbergs Ventilation AB, SP has carried out a test of an air filter to evaluate the long term performance of the filtration efficiency. The long term test have been carried out as a part of P-marking of air filters according to SP's certification rules CR 055 "Certification rules for air filter".

Tested item

Lindbergs Ventilation AB, F6 Microglas, art.nr 600150M10, 592 mm x 592 mm x 500 mm, 10 pocket air filter with glass media (UPF).

The item was sent to SP by Lindbergs Ventilation AB and was received by SP on March 29, 2012.

The item was without visible defects.

Date and Place

The test was carried out at SP's laboratory of Energy Technology in Borås, Sweden on March 30, 2012 – October 4, 2012.

Test method

The test was carried out according to SP Method 1937. The filter was weighed before and after the test. Initially, filtration efficiency and pressure drop were measured in an indoor test rig as specified in EN 779. After that, the filter was installed in a continuously running test rig with outdoor air for six months. Adjustment of the nominal air flow through the filter was done regularly. Filtration efficiency and pressure drop were measured in the EN779 test rig every second month during this 6 months period.

The filtration efficiency was determined by measuring the particle concentration. The particle concentration was measured upstream and downstream the filter with an optical particle counter. A polydisperse aerosol of DEHS was generated by a laskin nozzle. The static pressure was measured upstream and downstream the filter to get the pressure drop.

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Results

The tested filter has fulfilled the requirements regarding long-term performance for a filter of class M6 (see appendix 2) during the entire test period.

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

Measurement equipment

| | |
|----------------------------------|----------------------------|
| • Pressure gauge Furness FC016 | SP's inventory no. 202 587 |
| • Pressure gauge Furness FC016 | SP's inventory no. 202 588 |
| • Pressure gauge Furness FC012 | SP's inventory no. 201 691 |
| • Pressure gauge Furness FC012 | SP's inventory no. 201 690 |
| • Pressure gauge Furness FC012 | SP's inventory no. 202 747 |
| • Particle counter Las-X II | SP's inventory no. 701 378 |
| • Auto sampler | SP's inventory no. 201 455 |
| • Barometer, Druck DPI 260 | SP's inventory no. 201 637 |
| • 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. 202 192 |
| • Flow meter, MFS-C-315 | SP's inventory no. 202 193 |
| • Flow meter, MFS-C-400 | SP's inventory no. 202 718 |
| • Kr-85 Aerosol Neutralizer, TSI | SP's inventory no. 202 635 |

Uncertainty of measurement

The uncertainty of the Airflow is better than $\pm 5\%$

The uncertainty of the Pressure Drop is better than $\pm 3\%$

The uncertainty of the Temperature is better than $\pm 0.5\text{ }^\circ\text{C}$

The uncertainty of the Relative Humidity is better than $\pm 4\%$ RH

The uncertainty of the Atmospheric Pressure is better than $\pm 2\text{ mbar}$

The uncertainty of the Measured mass is better than $\pm 0.5\text{ g}$

The statistical uncertainty of the filtration efficiency is presented in appendix 1.

SP Technical Research Institute of Sweden Energy Technology - Combustion and Aerosol Technology

Performed by

Examined by

Christian Mossberg

Marie Rönnbäck

Appendices

1. Test results
2. Limit values
3. Picture of tested item

Appendix 1

Testing organisation: SP Technical Research Institute of Sweden

Report no.: PX23030A

SP Method 1937 AIR FILTER RESULTS

GENERAL

| | | |
|---|---------------------------------------|----------------|
| Test no.: 201203301 | Date of test: 2012-03-30 - 2012-10-04 | Supervisor: CM |
| Test requested by: Lindbergs Ventilation AB | Device receiving date | |
| Device delivered by: Lindbergs Ventilation AB | 2012-03-29 | |

DEVICE TESTED

| | | |
|--|---|---|
| Model: F6 Microglas, art.nr 600150M10 | Manufacturer: Lindbergs Ventilation AB | Construction: Pocket filter, 10 pockets |
| Type of media: Glass UPF | Net effective filtering area: 6.0 m ² | Filter dimensions (width x height x depth): 592 mm x 592 mm x 500 mm |

TEST DATA

| | | | | |
|--|--------------------------------------|---|-----------------------|--|
| Test air flow rate: 0.944 m ³ /s | Test air temperature: 25 to 29 °C | Test air relative humidity: 17 to 46 % | Test aerosol: DEHS | |
|--|--------------------------------------|---|-----------------------|--|

RESULTS

| | | | | |
|---|---|---|---|---------------------------------|
| Initial, efficiency 0.4 µm: 21.2 % | 2 months, efficiency 0.4 µm: 17.7 % | 4 months, efficiency 0.4 µm: 16.8 % | 6 months, efficiency 0.4 µm: 17.1 % | Initial pressure drop: 66 Pa |
| Initial, efficiency 0.87 µm: 44.7 % | 2 months, efficiency 0.87 µm: 37.1 % | 4 months, efficiency 0.87 µm: 34.1 % | 6 months, efficiency 0.87 µm: 32.8 % | Increase in weight: 173.8 g |
| Note: The performance results are only valid for the tested item and cannot by themselves be quantitatively applied to predict efficiency and lifetime in service | | | | |

Appendix 1

SP Method 1937 - Efficiency

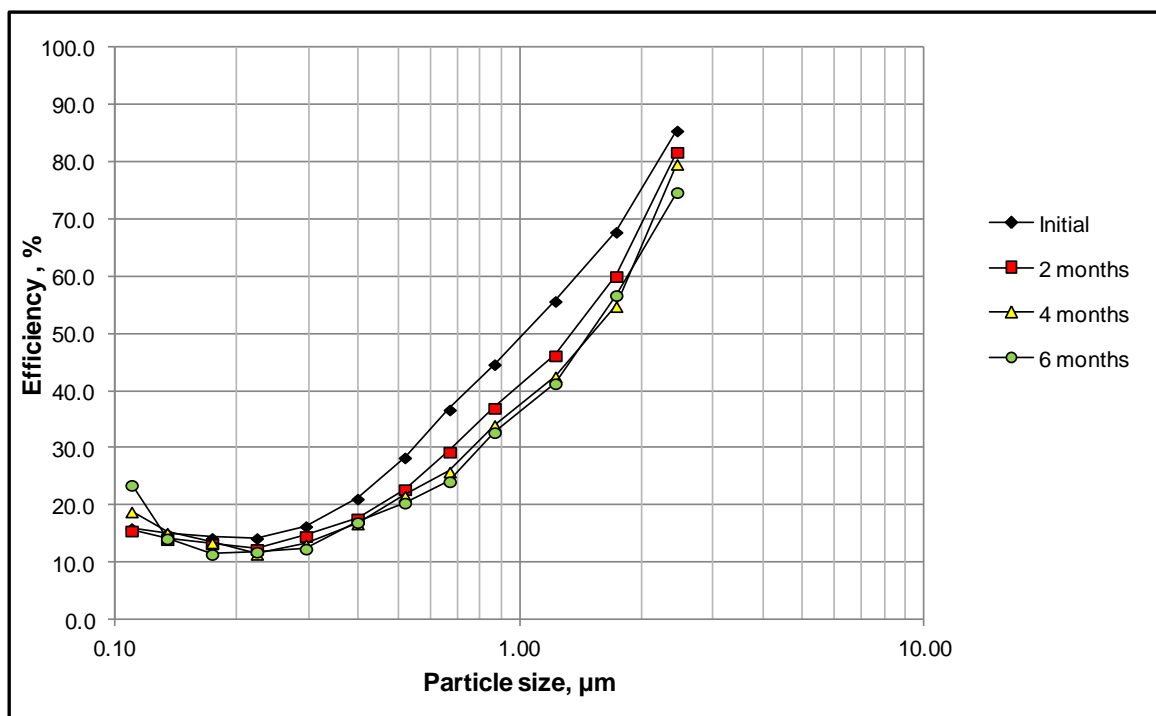
Air filter: F6 Microglas, art.nr 600150M10

Test aerosol: DEHS

Air flow rate: 0.944 m³/s

| Particle size | | Efficiency % | | | |
|----------------|------------|---------------------------------|-----------------------------------|------------------------------------|------------------------------------|
| Interval µm | Mean µm | Initial 2012-03-30 0 days | 2 months 2012-06-01 63 days | 4 months 2012-07-31 123 days | 6 months 2012-10-04 188 days |
| 0.10 - 0.12 | 0.11 | 16.0 ± 8.7 | 15.6 ± 9.0 | 18.9 ± 3.9 | 23.6 ± 4.8 |
| 0.12 - 0.15 | 0.13 | 15.1 ± 1.3 | 14.1 ± 1.6 | 15.2 ± 2.0 | 14.2 ± 1.8 |
| 0.15 - 0.20 | 0.17 | 14.3 ± 1.3 | 13.3 ± 1.4 | 13.5 ± 2.1 | 11.5 ± 1.2 |
| 0.20 - 0.25 | 0.22 | 14.3 ± 1.6 | 12.4 ± 1.7 | 11.5 ± 1.3 | 11.9 ± 1.8 |
| 0.25 - 0.35 | 0.30 | 16.4 ± 1.2 | 14.6 ± 1.1 | 13.2 ± 1.1 | 12.4 ± 1.7 |
| 0.35 - 0.45 | 0.40 | 21.2 ± 1.0 | 17.7 ± 1.7 | 16.8 ± 1.6 | 17.1 ± 2.0 |
| 0.45 - 0.60 | 0.52 | 28.4 ± 1.2 | 22.8 ± 1.6 | 21.7 ± 1.2 | 20.5 ± 0.9 |
| 0.60 - 0.75 | 0.67 | 36.8 ± 2.2 | 29.4 ± 2.3 | 25.9 ± 1.8 | 24.2 ± 2.2 |
| 0.75 - 1.00 | 0.87 | 44.7 ± 1.7 | 37.1 ± 3.3 | 34.1 ± 2.0 | 32.8 ± 2.6 |
| 1.00 - 1.50 | 1.22 | 55.7 ± 1.8 | 46.2 ± 3.6 | 42.6 ± 3.8 | 41.4 ± 4.8 |
| 1.50 - 2.00 | 1.73 | 67.8 ± 1.8 | 60.1 ± 2.4 | 54.8 ± 2.0 | 56.8 ± 1.7 |
| 2.00 - 3.00 | 2.45 | 85.6 ± 1.7 | 81.8 ± 2.6 | 79.7 ± 3.2 | 74.8 ± 2.7 |

Note. The uncertainty of the measured efficiencies is reported on a 95 % confidence level.



Appendix 1

SP Method 1937 - Air flow rate and pressure drop

Air filter: F6 Microglas, art.nr 600150M10

Air flow rate: 0.944 m³/s

| Date | Air flow meter | | | | Filter | | | | | | |
|---|----------------------|-----------------------|-----------------------|------------------------|---------|--------|-----------------------|------------------------|-------------------------------------|----------|--------------------------|
| | t _f °C | p _{st} Pa | dp _f Pa | q _m kg/s | t °C | φ % | p _a kPa | ρ kg/m ³ | q _v m ³ /s | Δp Pa | Δp _{1.20} Pa |
| Initial | | | | | | | | | | | |
| 2012-03-30 | 25.8 | 38 | 32 | 0.27 | 25.8 | 17.0 | 98.4 | 1.144 | 0.238 | 10 | 10 |
| 2012-03-30 | 26.0 | 97 | 125 | 0.54 | 26.0 | 17.0 | 98.4 | 1.144 | 0.472 | 24 | 24 |
| 2012-03-30 | 26.0 | 177 | 280 | 0.81 | 26.0 | 17.1 | 98.5 | 1.145 | 0.709 | 43 | 43 |
| 2012-03-30 | 25.3 | 279 | 495 | 1.08 | 25.3 | 17.7 | 98.6 | 1.148 | 0.944 | 66 | 66 |
| 2012-03-30 | 25.9 | 380 | 770 | 1.35 | 25.9 | 17.2 | 98.7 | 1.147 | 1.180 | 93 | 94 |
| Clean filter pressure drop is proportional to (q _v) ⁿ , where n = 1.3873 | | | | | | | | | | | |
| 2 months | | | | | | | | | | | |
| 2012-06-01 | 25.6 | 38 | 32 | 0.27 | 25.6 | 26.2 | 98.3 | 1.143 | 0.238 | 9 | 9 |
| 2012-06-01 | 25.8 | 96 | 125 | 0.54 | 25.8 | 26.2 | 98.4 | 1.143 | 0.473 | 23 | 23 |
| 2012-06-01 | 25.7 | 175 | 280 | 0.81 | 25.7 | 26.4 | 98.5 | 1.144 | 0.710 | 42 | 42 |
| 2012-06-01 | 24.8 | 276 | 495 | 1.08 | 24.8 | 27.4 | 98.6 | 1.148 | 0.944 | 65 | 66 |
| 2012-06-01 | 25.6 | 381 | 770 | 1.35 | 25.6 | 26.6 | 98.7 | 1.147 | 1.181 | 93 | 94 |
| Filter pressure drop is proportional to (q _v) ⁿ , where n = 1.4531 | | | | | | | | | | | |
| 4 months | | | | | | | | | | | |
| 2012-07-31 | 25.5 | 35 | 31 | 0.27 | 25.5 | 43.9 | 99.3 | 1.152 | 0.233 | 8 | 8 |
| 2012-07-31 | 25.6 | 94 | 126 | 0.54 | 25.6 | 44.0 | 99.3 | 1.152 | 0.473 | 22 | 22 |
| 2012-07-31 | 25.3 | 173 | 282 | 0.82 | 25.3 | 45.1 | 99.4 | 1.154 | 0.709 | 40 | 40 |
| 2012-07-31 | 24.8 | 275 | 499 | 1.09 | 24.8 | 45.7 | 99.5 | 1.157 | 0.944 | 63 | 63 |
| 2012-07-31 | 25.9 | 376 | 774 | 1.36 | 25.9 | 44.0 | 99.6 | 1.154 | 1.180 | 90 | 91 |
| Filter pressure drop is proportional to (q _v) ⁿ , where n = 1.48955 | | | | | | | | | | | |
| 6 months | | | | | | | | | | | |
| 04/10/2012 | 28.4 | 47 | 12 | 0.27 | 28.4 | 31.0 | 98.2 | 1.129 | 0.236 | 9 | 9 |
| 04/10/2012 | 28.6 | 128 | 47 | 0.53 | 28.6 | 30.9 | 98.2 | 1.129 | 0.474 | 23 | 23 |
| 04/10/2012 | 28.6 | 233 | 106 | 0.80 | 28.6 | 31.1 | 98.3 | 1.130 | 0.708 | 41 | 41 |
| 04/10/2012 | 28.1 | 369 | 191 | 1.07 | 28.1 | 31.5 | 98.4 | 1.133 | 0.945 | 63 | 64 |
| 04/10/2012 | 28.3 | 535 | 299 | 1.34 | 28.3 | 31.3 | 98.6 | 1.134 | 1.181 | 90 | 91 |
| Filter pressure drop is proportional to (q _v) ⁿ , where n = 1.4603 | | | | | | | | | | | |

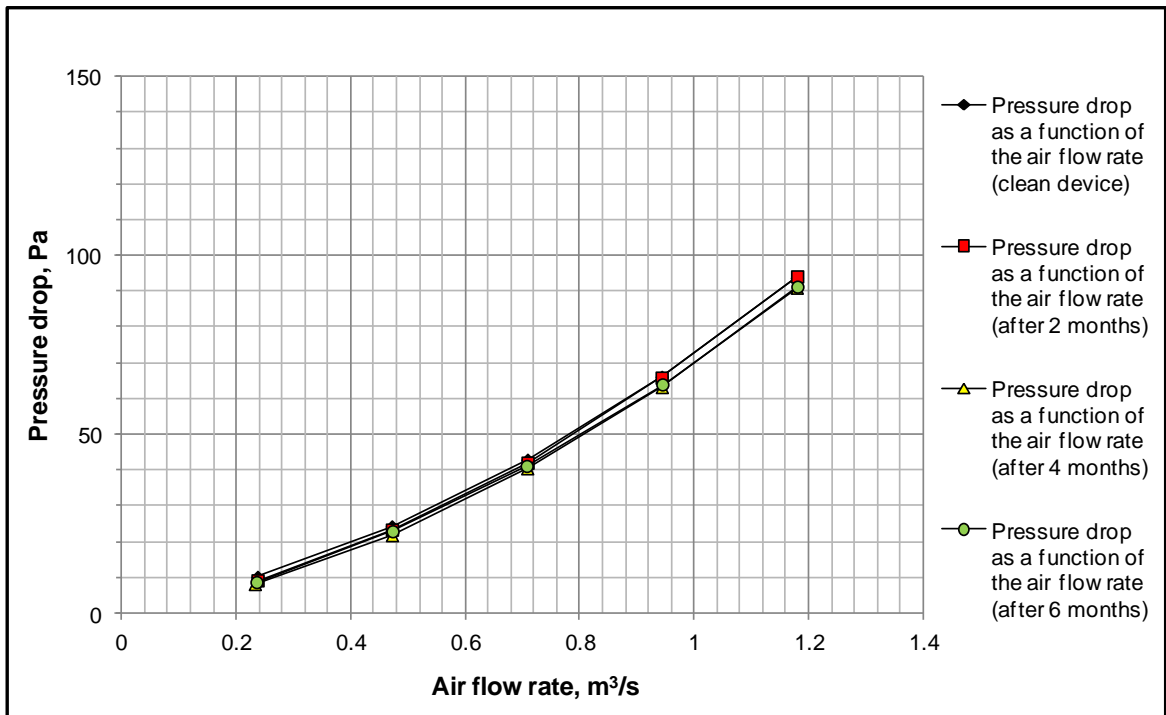
Symbols and units

| | | | |
|--------------------|---|----------------|---|
| dp _f | air flow meter differential pressure, Pa | q _m | mass flow rate, kg/s |
| Δp | measured filter pressure drop, Pa | q _v | air flow rate filter, m ³ /s |
| Δp _{1.20} | filter pressure drop at air density 1.20 kg/m ³ , Pa | t _f | temperature at air flow meter, °C |
| p _a | absolute air pressure upstream of filter, kPa | t | temperature upstream of filter, °C |
| p _{st} | air flow meter static pressure, kPa | φ | relative humidity upstream of the filter, % |
| | | ρ | air density upstream of filter, kg/m ³ |

Mass of tested item:

| | | |
|----------------------------|--------------|----------|
| Clean filter: | 2 697.3 | g |
| After complete test: | 2 871.1 | g |
| Increase in weight: | 173.8 | g |

Appendix 1



SP Method 1937 - Air flow rate, outdoor rig

Air filter: F6 Microglas, art.nr 600150M10
 Rig No.: 2
 Air flow rate: 0.944 m³/s

| Date | t | φ | p _{atm} | q |
|------------|------|------|------------------|-------|
| | °C | % | kPa | m³/s |
| 2012-04-02 | 3.1 | 27.0 | 98.0 | 0.945 |
| 2012-05-16 | 13.4 | 65.0 | 98.9 | 0.947 |
| 2012-05-08 | 20.7 | 44.0 | 98.5 | 0.948 |
| 2012-07-06 | 19.8 | 77.9 | 99.5 | 0.946 |
| 2012-08-02 | 25.7 | 49.1 | 99.5 | 0.945 |
| 2012-09-06 | 14.8 | 50.4 | 99.8 | 0.945 |
| | | | | |
| | | | | |
| | | | | |

Symbols and units

- t temperature, °C
- φ relative humidity, %
- p_{atm} atmospheric pressure, kPa
- q air flow rate, m³/s

Appendix 2

Limit values

For the filter to be considered as fulfilling the requirements for P-marked air filters as specified in SPs certification rules CR055 “Certification rules for air filter”, the filtration efficiency must exceed the following limit values (see Table 1) at every measurement. On comparison of the measured value against the limit value, the statistical uncertainty and a method error are considered. This is described in SP-method 1937.

Table 1. Limit values

| Filter class according to EN779 | Minimum filtration efficiency at long-term test according to SP Method 1937 | |
|---------------------------------|---|---------|
| | 0,4 µm | 0,87 µm |
| M5 | 2 % | 8 % |
| M6 | 12 % | 25 % |
| F7 | 50 % | 70 % |
| F8 | 70 % | 85 % |
| F9 | 80 % | 90 % |

Appendix 3

