Eurovent Industry Recommendation / Code of Good Practice

Eurovent 4/25 - 2023

Energy consumption evaluation of air filters for general ventilation in NRVUs in the context of Ecodesign

First Edition

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Document history

This Eurovent Industry Recommendation / Code of Good Practice supersedes all of its previous editions, which automatically become obsolete with the publication of this document.

Modifications

This Eurovent publication was modified as against previous editions in the following manner:

Modifications as against	Key changes
1st edition	Present document

Preface

In a nutshell

The purpose of this document is to:

- **Define a method to rate the energy consumption of air filters for general ventilation of any size and at the actual air flow rate**
- **Provide a conformity assessment tool applicable to the anticipated future Ecodesign requirements for filters in non-residential ventilation units**
- **Implement the EN ISO 16890 classification and testing method accordingly**

Authors

This document was published by the Eurovent Association and was prepared in a joint effort by participants of the Product Group 'Air Filters' (PG-FIL), which represents a vast majority of all manufacturers of these products active on the EMEA market.

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Adoption

It has been approved and adopted through a formal voting procedure by Europe's national Member Associations from 20+ European countries, which ensures a wide-ranging representativeness based on democratic decision-making procedures. More information on these members can be found at www.eurovent.eu.

Important remarks

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Contents

1. Introduction

In the context of the imperative to reduce energy consumption and CO_2 emissions, which is the subject of the Ecodesign Directive, the energy consumption related to air filters is in the focus of attention.

The Commission Regulation (EU) 1253/2014, which implements the Ecodesign Directive with regard to requirements for ventilation units, addresses energy consumption of air filters by their initial pressure drop. This approach is suitable to assess a clean filter but is insufficient to consider the actual average pressure drop of the filter during its service life, which is an essential feature impacting energy consumption.

The energy consumption of air filters can be determined as a function of the volume flow rate, the fan efficiency, the operation time, and the average pressure drop. Due to the dust loading during operation, the pressure drop of an air filter increases over time. The related energy consumption during a certain period of time can be calculated from the integral average of the pressure drop over this period of time.

The aim of this guideline is to assess the Annual Energy Consumption (AEC) based on a laboratory test procedure, which determines the average pressure drop from a loading of the filter according to EN ISO 16890-3 using a synthetic test dust specified in EN ISO 15975 as L2 (AC Fine). The amount of test dust load was determined based on a representative ambient dust concentration, and the defined air flow rate and operating time.

This methodology has been successfully applied for several years in the well-established Eurovent Recommendation 4/21, which is the basis for an energy classification to give the user of air filters guidance for the filter selection. However, this recommendation was primarily developed for energy rating and performance comparison of filters with face dimensions of 592 mm x 592 mm at a standard reference air flow rate of 0,944 m^3/s (3.400 m^3/h).

The guidelines in this document are built on Eurovent 4/21 but extend its scope in order to provide the energy efficiency assessment of any filter installed in the ventilation unit and operating under its actual nominal flow rate. For the consistency of assessment, a fixed fan efficiency and operating time are also assumed.

It also has to be noted that the method provided in this document is based on laboratory test data with standardised test conditions, which may differ significantly from the individual application in a building ventilation unit. Hence, the average yearly energy consumption calculated in this document can be used as a rough estimation and relates only to the contribution of the air filters involved. The actual yearly energy consumption in an individual, actual application may differ from this significantly.

According to this guideline fine dust filters are rated with an efficiency $e\text{PM}_{10} \geq 50\%$ and a respective face velocity higher than 1,2 m/s. Filters operating at face velocity of 1,2 m/s or less, are not rated due to a very low air resistance, not relevant to the energy consumption.

1.1 Draft proposal for new Ecodesign requirements for filters in ventilation units

The ongoing review of Regulation (EU) 1253/2014 is considering introducing the annual energy consumption (AEC) limit for filters in non-residential ventilation units. AEC is proposed to be determined according to the original methodology of Eurovent 4/21. The procedure would require that the filter manufacturer declares for each filter at which volume flowrate the minimum AEC-requirements are met and the NRVU manufacturer states that the nominal flow rate is not higher than this volume flowrate. This proposal, if adopted, will provide for the actual energy consumption of filters to be included in the assessment, both those supplied with the unit and replacement filters.

The comprehensive methodology set out in this document could be applied to assess compliance.

2. Energy consumption related to air filters

The energy consumption of a fan in an air handling unit can be evaluated as a function of the volume flow rate supplied by the fan, the fan efficiency, the operation time, and the difference of the total pressure (static plus dynamic pressure) after the fan and the static pressure of the ambient air (assuming that the fan sucks in air from a static reservoir). Typically, the volume flow rate supplied by the fan and the pressure difference the fan has to overcome are related to each other by the characteristic fan curve. The efficiency of the fan is a function of the fan speed. The actual fan efficiency also strongly depends on the design and the layout of the fan and can be in the best case as high as 0,80 or even higher, and in the worst case as low as 0,25 or even lower.

The portion of the total yearly energy consumption which is related to the filters' pressure drop can be calculated using Eq. (1):

$$W = \frac{q_V \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000} \quad (1)$$

Where:

W	-	Annual energy consumption of the filter (AEC) in kWh/a
q_v	-	Air volume flow rate in m^3/s
t	-	Annual operating time, h/a
η	-	Fan efficiency, -
$\overline{\Delta p}$	-	Average pressure drop, Pa

For consistency and comparability of the assessment outcomes, we define t = 6.000 h/a and η = 0,5

1.2 Procedure for full-size filters (592 x 592 mm)

The rating shall be carried out for a full-size filter element (face dimension 592 mm x 592 mm according to EN 15805) as described below. The filter face velocity has to be above 1,2 m/s.

1. Carry out a full test according to the ISO 16890 series of standards at nominal volume flow rate and determine the *e*PM_x efficiencies and the ISO *e*PM_x group as described in ISO 16890-1.
2. Load the filter with ISO L2 dust (AC Fine) according to the procedure described in ISO 16890-3, feeding the total amount of dust given in Table 1 (rounded up to 10 g) or to the final pressure drop (300 Pa), whichever comes first. During the course of dust loading, the pressure drop curve versus dust fed shall be recorded with at least nine data points (m_i, Δp_i) including the initial data point (m_0 = 0 g, Δp_0) (minimum of eight loading steps). For the last loading step, the total amount of dust fed m_n ($n \geq 8$) shall be equal or slightly larger than the amount of dust given in Table 1. The additional dust loading increments should give a smooth curve pressure drop versus dust fed. The total

amount of dust that shall be fed to the filter is defined in Table 1, depending on the ISO classification.

ISO group	ISO ePM1	ISO ePM2,5	ISO ePM10
Amount of dust fed M_x for the flow rate q_V (m³/s)	$\frac{q_V}{0.944} \cdot 200$ g	$\frac{q_V}{0.944} \cdot 250$ g	$\frac{q_V}{0.944} \cdot 400$ g

Table 1: Dust concentration used for Eq. (1)

If the final pressure drop of 300 Pa is reached at a lower amount of dust as specified in Table 1, the Ecodesign AEC limit cannot be met and the procedure can be stopped.

Otherwise, proceed to point 3.

3. Calculate the average pressure drop by using Eq. (2) from the n+1 data points pressure drop versus mass of dust fed.

$\overline{\Delta p_i} = 0{,}5 \cdot (\Delta p_i + \Delta p_{i-1})$ where $i = 1 \dots n-1$

$\overline{\Delta p_n} = \Delta p_{n-1} + 0{,}5 \cdot \frac{\Delta p_n - \Delta p_{n-1}}{m_n - m_{n-1}} \cdot (M_x - m_{n-1})$ where $m_{n-1} < M_x$ and $m_n \geq M_x$

$\Delta m_i = m_i - m_{i-1}$ and $\Delta m_n = M_x - m_{n-1}$

$$\overline{\Delta p} = \frac{1}{M_X} * \sum_{i=1}^{n} \overline{\Delta p_i} * \Delta m_i \qquad (2)$$

4. Calculate the annal energy consumption W related to the filter using Eq. (1).

All data used for the energy efficiency evaluation (ePM$_x$ efficiency, ISO ePM$_x$ rating, and pressure drop curve) shall result from the same filter specimen.

1.3 Procedure for filters of standard dimensions other than 592 x 592 mm

Annual energy consumption of filters with standard face dimensions according to EN 15805, but different than 592 mm x 592 mm, which include:

490 x 592, 592 x 490, 287 x 592, 592 x 287, 287 x 490, 287 x 490, 490 x 287, 287 x 287 mm

can be estimated based on a full-size filter (592 mm x 592 mm) of the same filter family. After carrying out a test with a full-size filter, the annual energy consumption of a different filter size in the same filter family can be calculated using Eq. (3):

$$W(act) = W \cdot \frac{q_V(act)}{q_V} \qquad (3)$$

Where $W(act)$ is the energy consumption and $q_v(act)$ the volume flow rate of the filter under consideration. W is the energy consumption and q_v the volume flow rate of the tested 592 mm x 592 mm filter.

Filter family

Filters are part of the same filter family under the following conditions drawn on EPC 11 FIL – 04-2020 'Technical certification rules of the Eurovent Certified Performance Mark – Air Filters':

- The same filter material

- The same basic construction (e.g. bag, V-type, etc.)
- the same face velocity: rated airflow / min. net filter area (does not have to be published); the airflow rate shall be adapted to the face area with acceptance criteria of +/- 10%
- The same length/depth of the overall filter element with acceptance criteria of +/- 10% or 50 mm whatever is the smaller
- For Bag and V-Type filters, the same ratio of filter medium area to front face area with acceptance criteria of +/- 10%
- Same initial pressure drop with acceptance criteria of +/- 10%
- The same ePMx group
- The same ISO efficiency rating
- Published data available about: Basic construction, filter media, filter class available via internet or other published sales brochures

1.4 Procedure for filters of non-standard dimensions

To estimate the annual energy consumption of filters with face dimension other than specified in EN 15805, the filter family approach as described in paragraph 1.3 can also be applied. However, each non-standard sized filter must have a reference 592x592 mm filter model for prior determination of its AEC. Alternatively, the annual energy consumption of a non-standard filter can be directly determined as described in paragraph 1.2, on a test rig adapted to its dimensions and at its air flow rate and a corresponding dust load.

3. Commentary on implementation in the context of expected new Ecodesign requirements

EN ISO 16890 specifies testing of filters for airflow rates between 900 m³/h (0,25 m³/s) and 5.400 m³/h (1,5 m³/s), referring to a test rig with a nominal face area of 610 mm × 610 mm (for 592 mm x 592 mm filters).

According to Eurovent Recommendation 4/21, the energy efficiency of filters is determined for 592x592 mm filters at airflow of 3.400 m³/h, which relates to a face velocity of 2,7 m/s. Testing at 3.400 m³/h is the Eurovent standard, but it is commonly followed by non-certified manufacturers in providing technical data for their filters.

The draft new Ecodesign requirements for the maximum annual energy consumption (AEC) of a filter relate to an actual nominal flow rate of the ventilation unit and the filter face dimensions of 592 mm x 592 mm. In practice, after introducing the current Ecodesign requirements for NRVUs, 592 mm x 592 mm size filters operate at considerably lower face velocities (around 2 m/s). This means that all filters for which the annual energy consumption determined at 3.400 m³/h is lower that the AEC limit, would also meet the Ecodesign requirements at lower airflow rates.

However, if a filter does not meet the AEC limit at 3.400 m³/h and is intended to be installed in a VU operating at lower nominal flow rate, the methodology presented here allows to demonstrate its compliance with the Ecodesign requirements at an actual nominal flow rate. The same applies to conformity assessment for filters with other standard or customised dimensions.

It must also be noted that the presented proposal would not entail any additional burden and costs on manufacturers required to declare the maximum air flow rate of their products at which the AEC limit is met. This is because the supplier would have to carry out a single test, either

- For a filter size of 592 mm x 592 mm at 3.400 m^3/h
- For a filter size of 592 mm x 592 mm at a flow rate that meets the AEC limit
- For any customised filter size at a flow rate that meets the AEC limit

4. Symbols

$e\mathrm{PM}_x$	Rated efficiency as defined in ISO 16890-1 (values rounded downwards to the nearest multiple of 5% points)	
η	Efficiency of a fan for the transmission of electrical energy into energy content of the air flow field	
	As a representative average value for the different installations and operating conditions η is assumed to equal to 0,50	
	The total fan efficiency used in this document corresponds to η_{tot} as defined in EN 16798-3:2017, chapter 9.5	
i	Number of the dust loading steps	
m_i	Total amount of dust fed to an air filter after the dust loading step i	[g]
Δm_i	Dust increment fed to an air filter during loading step i	[g]
M_x	Amount of L2 dust fed to the test filter in accordance with ISO 16890-3	[g]
	Used to calculate the average pressure drop	
	M_x represents one of the three values M_{10}, $M_{2,5}$, and M_1 defined in Table 1	
n	Total number of dust loading steps used to feed the amount of test dust M_x to the air filter ($n \geq 8$)	
Δp_0	Initial pressure drop of an air filter	[Pa]
Δp_i	Pressure drop of an air filter after dust loading step i	[Pa]
$\overline{\Delta p_i}$	Average of the pressure drops of an air filter measured before and after the dust loading step i	
$\overline{\Delta p}$	Average pressure drop of an air filter	[Pa]
q_V	Air volume flow rate at filter	[m^3/s]
$q_V(act)$	Air volume flow rate at filter with face dimension other than 592 mm x 592 mm used to calculate $W(act)$ according to paragraph 2.2	[m^3/s]
t	Time of operation	[h]
	For an air filter during a period of one year, a total operating time of 6.000h is assumed	
W	Yearly energy consumption	[kWh]
$W(act)$	Yearly energy consumption of a filter with face dimensions other than 592 mm x 592 mm calculated according to Annex 1	[kWh]

5. Example

As an example, the calculation method is shown based on test results for a panel filter rated as ISO *e*PM_1 50% at 0,277 m³/s according to EN ISO 16890.

The Dimensions of the filter for width x height x depth are 592 mm x 287 mm x 50 mm. According to Annex 2 this filter could be calculated with a test filter in the same filter family. In this case a filter with dimensions 592 mm x 592 mm x 50 mm and an accordingly fitted volume flow rate of 0,556 m³/s.

According to Table 1 the total amount of dust is 120 g.

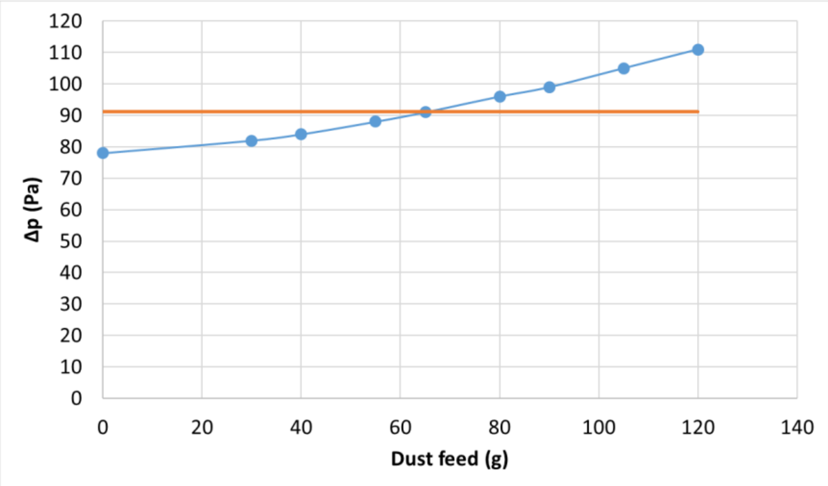

Figure 1: Pressure drop as a function of the dust loading at 0,944 m³/s according to EN ISO 16890-3

The red line marks the average pressure drop.

Step	Dust feed m_i [g]	Pressure drop Δp_i [Pa]	Dust increment Δm_i [g]	Av. pressure drop $\overline{\Delta p_i}$ [Pa]
0	0	78		
1	30	82	30	68,5
2	40	84	10	69,5
3	55	88	15	70,5
4	65	91	10	72,5
5	80	96	15	75
6	90	99	10	77
7	105	105	15	79
8	120	111	15	82

Table 2: Test data for the pressure drop according to EN ISO 16890-3 as a function of the AC Fine dust feed

By using Eq. (3) with the data given in Table 2, the average pressure drop calculates to $\overline{\Delta p}$ = 91,2 Pa and the yearly energy consumption to W = 609 kWh/a.

6. Literature

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[5] EN 15805:2009: Particulate air filters for general ventilation. Standardized dimensions, 2009

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