Eurovent Industry Recommendation / Code of Good Practice

EUROVENT

EUROPE'S INDUSTRY ASSOCIATION FOR **INDOOR CLIMATE, PROCESS COOLING,** AND **FOOD COLD CHAIN** TECHNOLOGIES

Eurovent 4/21 - 2016

Energy Efficiency Evaluation of Air Filters for General Ventilation Purposes

Second 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.

Important remarks

The first edition of Eurovent 4/21 (2014), which relates to the long-established EN 779 standard, will remain valid until 31 December 2017 in order to allow for a sufficient transition time towards the new ISO standard.

Throughout 2017, participants in the 'Eurovent Certified Performance' programme for air filters, which is run independently by Eurovent Certita Certification, are going to evaluate their products according to EN ISO 16890 making use of Eurovent 4/21 (2016). The updated 'Eurovent Certified Performance' energy classes and values are then going to be published on www.eurovent-certification.com as of January 2018.

Modifications

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

Modifications as against	Key changes
1st edition	Implementation of ISO 16890 classification and testing methods in place of EN 779.
2nd edition	Present document

Preface

In a nutshell

The purpose of this recommendation is to

- Define energy efficiency of air filters for general ventilation purposes,
- Define energy efficiency evaluation methods,
- Implement the ISO 16890 classification and testing methods in place of EN 779.

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. For a detailed list of members, visit www.eurovent.eu.

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 the end of this document.

The Eurovent Association does not grant any certification based on this document. All certification-related issues are managed by the association's independent subunit Eurovent Certita Certification in Paris (www.eurovent-certification.com).

Contents

1. Background

In the context of increasing energy prices and the imperative of reducing CO_2 emissions, the energy consumption related to air filters has become the focus of attention. Air filters used for general ventilation are tested and classified according to their particle efficiencies, especially with respect to the removal of particulate matter, in accordance with the ISO 16890 series of standards.

The aim of this guideline is to define a method of air filter classification with regard to energy-efficient operation, to give the user of air filters guidance for the filter selection. It has to be noted that to reduce the energy consumption by using more energy efficient filters requires that the speed of the fan can be adjusted to supply a constant air volume flow rate. If the fan is operated at a fixed speed, lowering the (average) pressure drop of the air filters will result in an increased air volume flow rate. In the worst case, this may even result in a situation where the fan is operated in a region with lower efficiency resulting in an increased overall energy consumption.

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 yearly energy consumption calculated in this document can only be used as an indicator for the classification system and relates only to the contribution of the air filters involved. The yearly energy consumption in an individual, actual application may differ from this significantly.

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 is increasing. 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. As a laboratory test method, the average pressure drop is determined from a loading of the filter according to ISO 16890-3 using a synthetic test dust specified in ISO 15957 as L2 (AC Fine).

According to this guideline fine dust filters are rated with an efficiency $e\text{PM}_{10} \geq 50\%$.

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):

$$W = \frac{q_{\text{V}} \cdot \overline{\Delta p} \cdot t}{\eta \cdot 1000} \qquad \text{(1a)}$$

Where we define: q_V = 0.944 m³/s, t = 6000 h/a and η = 0.50

As given above, the volume flow rate is considered to be fixed at 0.944 m³/s (3400 m³/h). This corresponds in a real air handling unit to a fan with variable speed drive controlled to run at fixed volume flow. Additionally, the fan efficiency is defined to 0.50, which can be considered as a typical average efficiency of a fan in an air handling unit.

With the constant values given above, the only variable in Eq. (1a) is the average pressure drop and hence, it can be written as Eq. (1b).

$$W = 11.33 \frac{\text{kWh / a}}{\text{Pa}} \cdot \overline{\Delta p} \qquad (1b)$$

3. Energy efficiency evaluation

As a measure for the energy efficiency of an air filter, a key energy performance number (*kep*) is defined in Eq. (2).

$$kep = \frac{-\log(1 - e\,\text{PM}_x)}{\overline{\Delta p} - C_x} \cdot 100\,\text{Pa} \qquad (2)$$

In Eq. (2), the efficiency $e\text{PM}_x$ corresponds to the rated efficiency defined in ISO 16890-1, which is the efficiency value rounded downwards to the nearest multiple of 5%points.

The *kep* number follows the well-known α or 100γ values, typically used to describe the relation of filtration efficiency and pressure drop of filter media, which can be derived from the physics of filtration.

$$\alpha \text{ or } 100\gamma = \frac{-\log(1 - E)}{\Delta p} \cdot 100\,\text{Pa} \qquad (3)$$

In Eq. (3), E is the efficiency of a filter medium and Δp its pressure drop. The constant C_x in Eq. (2) considers the fact, that the relation in Eq. (3) is strictly only valid for filter media and that due to the three-dimensional flow pattern, the pressure drop of a three dimensional filter element typically is larger than the contribution of the filter medium.

In principal, three different *kep* values could be calculated for the three different particular matter size ranges. Nevertheless, in this document only one individual *kep* value is defined depending on the ISO group classification of the respective air filter. In case the air filter is classified as ISO ePM1, $e\text{PM}_1$ and C_1 shall be used in Eq. (2), in case it is classified as ISO ePM2,5, $e\text{PM}_{2,5}$ and $C_{2,5}$ is used and in case it is classified as ISO ePM10, $e\text{PM}_{10}$ and C_{10} is used.

The rating shall be carried out for a full size filter element (face dimension 592 mm x 592 mm to EN 15805) as described below

1.) Carry out a full test to the ISO 16890 series of standards at a flow rate q_V = 0.944 m³/s and determine the $e\text{PM}_x$ efficiencies and the ISO ePMx 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 or to the final pressure drop (300 Pa), whichever comes first. During the course of dust loading, the pressure drop curve vs. 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). In the first step, 30 g of dust shall be fed to the filter or an amount of dust that results in 10 Pa pressure drop increase, whichever comes first. 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.

Table 1: Total amount of dust fed and constant C

ISO group	ISO ePM1	ISO ePM2,5	ISO ePM10
Amount of dust fed M_x	300 g	400 g	700 g
Constant C_x	35 Pa	35 Pa	25 Pa

If the final pressure drop of 300 Pa is reached at a lower amount of dust as specified in Table 1, the dust feeding procedure can be stopped and the *kep* value shall be defined to 0 (*kep* = 0).

ISO 16890-3 defines to load the test filter up to the final pressure drop (300 Pa). In case the final pressure drop is not reached before the total amount of dust M_x given in Table 1 is fed to the test filter, the loading procedure can be continued to achieve a full ISO 16890-3 test, but the additional dust loading data are not used in this EUROVENT document.

3.) Calculate the average pressure drop by using Eq. (4) from the *n*+1 data points pressure drop vs. mass of dust fed.

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

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

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

$$\overline{\Delta p} = \frac{1}{M_x} \cdot \sum_{i=1}^{n} \overline{\Delta p_i} \cdot \Delta m_i$$

4.) Calculate the key energy performance number *kep* according to Eq. (2) using the rated efficiency values (rounded downwards to the nearest multiple of 5% points).

5.) Calculate the yearly energy consumption *W* related to the filter using Eq. (1)

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

4. Symbols

ePM_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 prEN 16798-3:2014, chapter 7.5
i	Number of the dust loading step
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 in g fed to the test filter in accordance with ISO 16890-3 and 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, m³/s
t	Time of operation in h. For an air filter during a period of one year, a total operating time of 6000 h is assumed.
W	Yearly energy consumption, kWh

5. Example

As an example, the calculation method is shown based on test results for a pocket filter rated as ISO ePM2,5 60% at 0.944 m³/s according to EN ISO 16890.

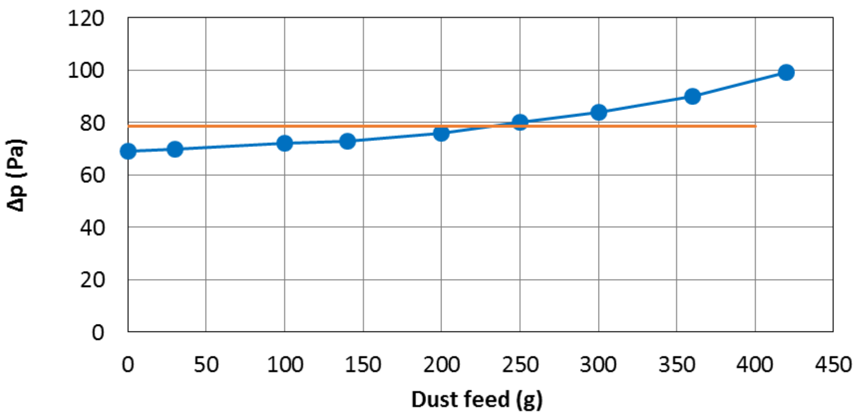

Figure 1: Pressure drop as a function of the dust loading at 0.944 m³/s according to EN ISO 16890-3. The red line marks the average pressure drop.

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

Step	Dust feed m_i in g	Pressure drop Δp_i in Pa	Dust increment Δm_i in g	Av. Pressure drop $\overline{\Delta p_i}$ in Pa
0	0	69		
1	30	70	30	69
2	100	72	70	71
3	140	73	40	73
4	200	76	60	75
5	250	80	50	78
6	300	84	50	82
7	360	90	60	87
8	420	99	40	93

According to Table 1, the total amount of dust $M_{2,5} = 400\,\mathrm{g}$ and using Eq. (4) with the data given in Table 2, the average pressure drop calculates to $\overline{\Delta p} = 78.41\,\mathrm{Pa}$.

With this average pressure drop, the Key Energy Performance number calculates to (see Eq. (2)):

$$kep = \frac{-\log(1-0.6)}{78.41\,\mathrm{Pa} - 35\,\mathrm{Pa}} \cdot 100\,\mathrm{Pa} = 0.92$$

and the yearly energy consumption is $W = 888\,\mathrm{kWh/a}$.

6. Literature

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About Eurovent

We are Europe's Industry Association for Indoor Climate, Process Cooling, and Food Cold Chain Technologies – thinking beyond 'HVAC&R'

Eurovent is Europe's Industry Association for Indoor Climate, Process Cooling, and Food Cold Chain Technologies. Its members from throughout Europe, the Middle East and Africa represent more than 1.000 companies, the majority small and medium-sized manufacturers. Based on objective and verifiable data, these account for a combined annual turnover of more than 30bn Euros, employing around 150.000 people within the association's geographic area. This makes Eurovent one of the largest cross-regional industry committees of its kind. The organisation's activities are based on highly valued democratic decision-making principles, ensuring a level-playing field for the entire industry independent from organisation sizes or membership fees.

Eurovent's roots date back to 1958. Over the years, the Brussels-based organisation has become a well-respected and known stakeholder that builds bridges between manufacturers it represents, associations, legislators and standardisation bodies on a national, regional and international level. While Eurovent strongly supports energy-efficient and sustainable technologies, it advocates a holistic approach that also integrates health, life and work quality as well as safety aspects. Eurovent holds in-depth relations with partner associations around the globe. It is a founding member of the ICARHMA network, supporter of REHVA, and contributor to various EU and UN initiatives.

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