Energy-efficient room air hygiene

When it comes to changing filters, ecological as well as economic aspects have to be taken into consideration

Around the world, rising energy prices and ambitious climate targets to promote CO_2 reduction are changing people's attitudes. The call for efficient and energy-saving products is only the logical consequence of this trend. Room air conditioning is affected by this development too. Particularly when it comes to filter media, for a long time now it has no longer been enough to simply take the number of particles held back into consideration. So, if they are to implement an overall system coordinated to utilisation, building services consultants should also take note of other criteria during the sizing process.

In commercial environments, between 10 and 20% of electrical energy is consumed in Europe for the purpose of powering fans in room air conditioning systems. This percentage is considerably higher in clean room production plants. Indeed, one third of the energy requirement alone is required to overcome the flow resistance of the filters used. It is for this precise reason that manufacturers are going to enormous lengths to make RAC systems more energy-efficient and to make significant energy savings by means of optimising filter media's and air passages' air flow and using intelligent air management systems. While it was previously only possible to assess filters based on how effectively they removed particles from the air (average number of particles held back) and not in terms of how energy-efficient they are in operation, the energy-related assessment is now receiving much more attention.

New Eurovent energy efficiency classification system

The new energy efficiency classification system pursuant to Eurovent 4/21 is now enabling users to compare the quality of filters with respect to their energy-related operating behaviour. To define the energy efficiency categories, only those energy requirements attributable to the filters' pressure losses are now being taken into consideration. If we were to assume that the volume flow rate required by the fan is constant, i.e. does not depend on the filter pressure loss, the energy requirement W attributable to the air filter can be calculated thus:

$$W = \frac{q_v \cdot \Delta p \cdot t}{\eta_{fan} \cdot 1{,}000}$$

The values defined for this evaluation procedure are:

q_v = 0.944 m^3/s (volume flow rate),
t = 6,000 h (operating time),
η_{Fan} = 0.50 (Eta – fan efficiency)
and the only variable value Δp = average differential pressure.

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The most important information on standards, guidelines, framework conditions and parameters.

Test standard EN 779:2012 Decisive measured values – energy efficiency category in the case of dust exposure pursuant to EN 779:2012	
Filter class – M5, M6	0 – 250 g
Filter class – F7, F8, F9	0 – 100 g

Test standard EN 779:2012	
Testing filters up to the final differential pressure	
Filter class – G1, G2, G3, G4	250 Pa
Filter class – M5, M6, F7, F8, F9	450 Pa

VDI 6022 Sheet 1 (5.4.8.) – Changing filters
Hygienic reasons
Economic optimisation
Achieving the intended final differential pressure
Defective filter

German Federal Environment Agency: annual average values for PM 10 dust	
Inner-city: Berlin city centre	32 µm/m3
Rural, peri-urban: Berlin Grunewald	21 µm/m3
Rural, remote: Thuringia	12 µm/m3

System operating time	
24 hours a day, seven days a week	8,760 h
14 hours a day, five days a week	3,354 h – reduction to 40% at weekends

Effective utilisation of the installed filter area
Optimum geometry (length and number of bags)
Dust holding capacity

Energy requirement / a in kWh pursuant to Eurovent
Based on measured values (0 – 250 g or 0 – 100 g)
Evaluation of the average differential pressure irrespective of the curve progression extending beyond this

W (in kWh) specifies the energy consumed in the time t (in h). Because the pressure loss during an air filter's operating time increases with dust storage, the integrally averaged pressure loss Δp (in Pa) is used in the equation – at the dust load defined depending on the filter class.

The size, which ultimately decides on the classification into the energy efficiency category, is the average differential pressure pursuant to Eurovent 4/21. The filters are loaded with a synthetic dust – the so-called ASHRAE dust – which is a standardised dust mixture simulating the composition of the external air's contamination, in order to practically identify the differential pressures. Initially, the differential pressure of a filter is measured during increasing loading until the prescribed final differential pressure pursuant to EN 779:2012 is reached. For the purpose of classification according to energy efficiency categories, the Group M filters' measured values will be evaluated with a dust load of up to 250 g, while the Group F filters' measured values will be evaluated with a dust load of up to 100 g. This roughly corresponds to the average dust absorption at an operating time of one year for the corresponding filter class or its typical particulate matter.
The increase in the differential pressure during a filter's operating time is practically simulated during this test sequence. The measurement results can be summarised as a curve (Figure 3).

Strict test procedure for M5 to F9 class filters

The Eurovent test procedure is strict. It therefore provides operators of ventilation and air conditioning systems with a maximum level of safety and reliability too. Filters of the M5 to F9 classes are examined in neutral, accredited test institutes. At the present time, these are VTT in Finland, SP in Sweden and Cetiat in France.

The notified bodies use standardised tests to check whether the manufacturers' information matches the catalogue data. The information is checked pursuant to EN 779:2012 with respect to filter class, initial differential pressure, initial efficiency and minimum efficiency, and also pursuant to Eurovent with respect to energy class and energy requirement (Figures 4 and 5).

The most important information about standards, guidelines, framework conditions and parameters at a glance:

Eurovent:
For the energy efficiency category, the measured values are decisive at a dust load pursuant to EN 779:2012 of
- 0 to 250 g: M5, M6 filter classes
- 0 to 100 g: F7, F8, F9 filter classes

EN 779:2012 – test standard:
Testing filters up to the final differential pressure
- 250 Pa: G1, G2, G3, G4 filter classes
- 450 Pa: M5, M6, F7, F8, F9 filter classes

VDI 6022 Sheet 1 (5.4.8.) – Changing filters:
- Hygienic reasons
- Economic optimisation
- Achieving the intended final differential pressure
- Defective filter

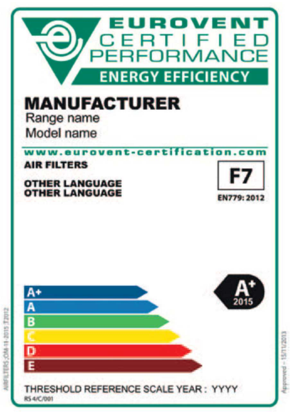

Figure 2: Eurovent energy efficiency label for air filters.

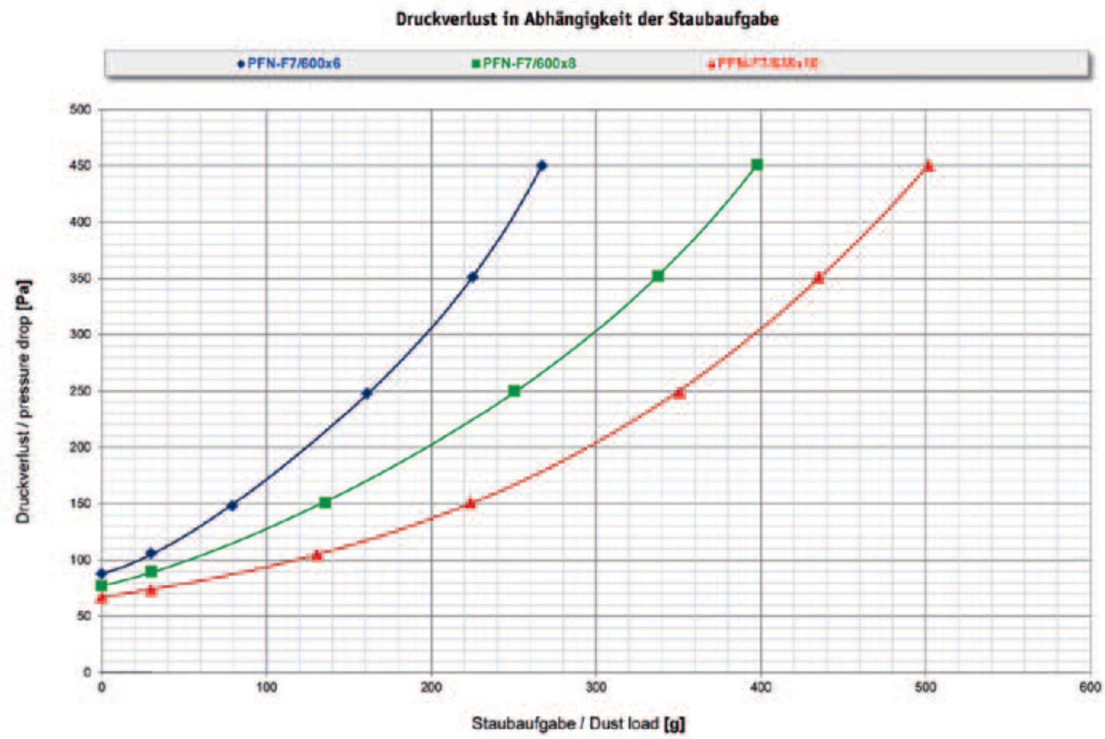

Figure 3: Differential pressure curve progression over the dust feed pursuant to DIN EN 779 for the three pocket filters listed.

Filterklasse nach EN779:2012					
	M5	M6	F7	F8	F9
Mindestwirkungsgrad	-	-	ME> 35%	ME> 55%	ME> 70%
Staubaufgabe	MM = 250 g ASHRAE		MF = 100 g ASHRAE		
A+	0 - 450	0 - 550	0 - 800	0 - 1000	0 - 1250
A	451 - 600	551 - 650	801 - 950	1001 - 1200	1251 - 1450
B	601 - 700	651 - 800	951 - 1200	1201 - 1500	1451 - 1900
C	701 - 950	801 - 1100	1201 - 1700	1501 - 2000	1901 - 2600
D	951 - 1200	1101 - 1400	1701 - 2200	2001 - 3000	2601 - 4000
E	>1201	>1401	>2201	>3001	>4001

Figure 4: Energy efficiency category limits for every filter class pursuant to DIN EN 779:2012 at 0.944 m³/s pursuant to EUROVENT RS 4/C/001-2015 – values in kWh/a.

Filter	PFN-F7/600x6	PFN-F7/600x8	PFN-F7/635x10
Energieklasse	C	B	A
Anschaffungs- und Einbaukosten	56,50 [€]	70,00 [€]	86,50 [€]
Wartungskosten	56,22 [€]	0,00 [€]	0,00 [€]
Entsorgungskosten	1,50 [€]	0,00 [€]	0,00 [€]
Energiekosten	86,80 [€]	69,98 [€]	55,71 [€]
1 Jahr	**201,02 [€]**	**139,98 [€]**	**142,21 [€]**
Anschaffungs- und Einbaukosten	56,50 [€]	70,00 [€]	86,50 [€]
Austauschkosten für 5 Jahre	333,19 [€]	274,68 [€]	254,15 [€]
Entsorgungskosten für 5 Jahre	9,00 [€]	6,00 [€]	4,50 [€]
Energiekosten für 5 Jahre	439,28 [€]	354,16 [€]	281,92 [€]
5 Jahre	**837,96 [€]**	**704,83 [€]**	**627,07 [€]**
Anschaffungs- und Einbaukosten	56,50 [€]	70,00 [€]	86,50 [€]
Austauschkosten für 10 Jahre	709,79 [€]	606,50 [€]	580,98 [€]
Entsorgungskosten für 10 Jahre	19,50 [€]	13,50 [€]	10,50 [€]
Energiekosten für 10 Jahre	891,97 [€]	719,13 [€]	572,46 [€]
10 Jahre	**1.677,76 [€]**	**1.409,13 [€]**	**1.250,44 [€]**

Figure 5: Sample values for lifecycle costs over one, five and ten years pursuant to the Eurovent Recommendation conc. “Calculating life cycle costs for air filters” issued 09/2005.

Influencing criteria for the filters’ energy requirement and energy efficiency category include e.g.:

1. **The average annual individual dust exposure**
   German Federal Environment Agency: annual average values for PM 10 dust exposure, e.g. -
   - Inner-city (Berlin city centre) 32 μm/m³.
   - Rural, peri-urban (Berlin Grunewald) 21 μm/m3.
   - Rural, remote (Thuringia) 12 μm/m³.

2. **The filters' system operating time and therefore loading time**
   - 24 hours a day, seven days a week: 8,760 h.
   - 14 hours a day, five days a week at 100%, reduction to 40% at weekends: 3,354 h.

3. **Effective utilisation of the installed filter area**
   - Optimum geometry (length and number of bags).
   - Quality and dust holding capacity of the fleece used.

Considering the LCC: the right filter for the respective application

In addition to assessing a filter with respect to its energy efficiency, economic efficiency is naturally in the operator's interest too. It in turn depends on the type of use, the prevalent dust loads and the operating hours (see Point 2). It is for this very reason that an LCC analysis tool, which makes it easier to choose the right filter for the type of application, has been developed. Practical parameters are included too:

- The dust holding capacity close to 100% of the dust exposure to be expected takes the utilisation of the entire dust holding capacity within the desired change interval into consideration.
- The definition of the final differential pressure in advance.
- Adaptation of the filter to local circumstances, such as the quality of the air to be filtered due to appropriate packaging (fleece, length, number of bags).

Less powerful filters with a lower level of energy efficiency can be used at less polluted air ratios (see Point 1). Conversely, increasing the number of bags can achieve the desired effect if the dust exposure is higher (see Point 3). The examination of the average differential pressure must, in this regard, be taken into consideration over the entire period of use. A standard C or B filter may be the suitable medium depending on the changeover time.

Figure 3 underlines the importance of assessing the relevant filters with respect to their pressure loss over the entire operating period, depending on their dust absorption for the defined differential pressure (250 Pa in our case). So, it may well be preferable to use a filter in energy efficiency category B over the supposedly more efficient filters in energy efficiency category A (filters are classified into energy efficiency categories by considering the dust feed from 0 to 100 g) at a higher, individual dust exposure (e.g. 200 g).

Summary

Due to the Eurovent energy efficiency classification and the LCC calculator, designers and users are being provided with basic information so they can take ecological as well as economic aspects into consideration when choosing filters. But specific influences – such as preliminary filtration or the specific dust exposure, as well as a filter's dust holding capacity and the desired default final differential pressure – must also be taken into consideration in addition to the evaluation according to Eurovent.

Eurovent does not make any provisions for preliminary filtration. In other words, irrespective of whether a filter is intended for the first or second filtration stage, at the F7 filter class, for instance, 0 to 100 g is relevant as the dust feed for classification into an energy efficiency category.

The energy efficiency category and annual energy requirement evaluation criteria must be finally applied if the configuration with respect to the…

1. …type of filter medium…
2. …length and number of bags…
3. …dust holding capacity…
4. …filter class…
5. …final differential pressure…
6. …dust exposure…
7. …change interval…

…is coordinated and there are several similar filters to choose from.

But when we focus on a filter's energy efficiency, one thing we must not forget is what we're actually using it for: to remove fine dust that is harmful to health and to thereby ensure a high and healthy room air quality.

Author: Dipl.-Ing. Thomas Klamp,
Head of Filter Technology, Trox GmbH

Pictures: TROX

www.troxtechnik.com

VIEWS AND VISIONS

IKZ-FACHPLANER: Mr Klamp, is the classification of filter media pursuant to Eurovent binding for all manufacturers, or is it a voluntary label?
Thomas Klamp: It is currently a voluntary label. At the present time, 24 companies are members of the Air Filter certification programme. The prerequisites for this include implementing a quality management system pursuant to ISO 9001, for instance, and accepting the rules and fees that have been set down.
IKZ-FACHPLANER: Can a building services consultant rely fully on the label's data?
Thomas Klamp: The performance details are checked by neutral test institutes – SP, VTT and Cetiat – as per the European EN 779:2012 standard. All the data is published in the Eurovent database and is accessible to all and sundry. There is a high level of transparency and comparability between filter manufacturers as a result of this. Also, the tests confirm the fact that the performance data does indeed match the catalogue data.
IKZ-FACHPLANER: Do the accredited test institutes regularly check the products even after the certification process is complete, so as to protect the quality and thus the label in the long term?
Thomas Klamp: Yes, Eurovent performs regular checks. One filter from four different product groups is examined by a neutral institute once per year. Once the filter in question has passed, the certification applies to the product range defined in the scope of application. The Certify All principle applies. In other words, if the four inspections were successful, all the filters supplied in the M5 to F9 range are certified. The certification is then valid for one year.
IKZ-FACHPLANER: And what about comparing rival products? Are there any special features that planners should bear in mind?
Thomas Klamp: The energy efficiency category criterion was created so that comparisons could be made. But the way of calculating a filter's LCC – Life Cycle Costs – allows for certain liberties which could lead to different results (such as the system operating time, the medium's dust holding capacity beyond the 0 to 100 g evaluation range, the differential pressure curve's progression and a filter's service life) depending on the dust exposure on site – and could do so individually according to the location and area. This also includes interest rates, cost changes for maintenance – such as staff, material and the time and effort required for maintenance – and disposal. Designers should therefore take note of what adjusting screws the individual manufacturer uses. With regard to the inspection certificates pursuant to EN 779, it must be noted that the filters can be compared at the same nominal volume flow rate.
IKZ-FACHPLANER: Is it even profitable to make efficiency-based comparisons? Just how much savings potential is there?
Thomas Klamp: The savings potential is definitely there. In principle, it all boils down to the quality of the material used. Savings of up to 50% can be made here. But, for many users, it is the investment costs that are decisive, so they don't even consider a high-quality material even if the saving more than compensates for this through energy conservation. It is also possible to make savings at comparable quality levels if a filter with the same dust holding capacities and investment costs has a more favourable pressure loss curve. In the end, any differential pressure savings made compared to another filter are profitable if everything else is identical. In this regard, it is possible to make estimated savings ranging from single to rather low double-digit percentage values. But precise details can only be provided in test facilities where two similar systems are equipped with different components.