Status of Air filter energy performance and product characteristics

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ABSTRACT

Throughout the certification process of air filters, the major technical characteristics are evaluating. Both theoretical models and experimental methods, proves some relationships between the parameters and the performance of product. In this article we present the statistical analysis of certified products according to EN ISO16890:2016. A sample of 1800 certified products by Eurovent Certita Certification is analysed to highlight products characteristics based on quantitative approach. The results could be useful for manufactures to find out the important characteristics and their relationships in terms of product performance and certification process.

KEYWORDS

Air Filter, Fin Qir Filter; Product Characteristics, Energy Efficiency, Certification

1 INTRODUCTION

Nowadays, the quality of indoor and outdoor air is an important topic anywhere in the world and especially indoor air that is typically two to five times more polluted than outdoor air (United States Environmental Protection Agency). Thus, air filters could perform an important function in commercial and institutional facilities to remove respirable particles such as microorganisms, dust and allergens from the breathing air. In fact, air filters provide the primary protection for building occupants and HVAC equipment against air pollutants (Filtration + Separation - the online magazine).
When considering different types of air filters, it is important to look at the performance of the filter. According to EN ISO16890:2016, there are three major components to filter performance; (1) Efficiency that presents the percentage of airborne particulate the filter will remove, (2) Dust-Holding Capacity, which presents the amount of dust the filter will hold before being changed and (3) The resistance to airflow, measured in inches of water gage (Pa), of the filter.
The efficiency depends on several factors such as pore size, fiber size, mat thickness, filter density, size and density of the entrained particle, and the velocity of air movement through the filter. The most effective filters depend primarily on the retention of particles through the sieve action of small pores developed through compaction or other processes, or through the interception of the particles by a mat of fine fibers as the result of either a diffusion or impaction mechanism. In most cases combinations of the above are operating (Lockhart Jr. et al., 1964).
Throughout the certification process, the major technical characteristics of air filters such as initial pressure drops, basic design, depth/length, face dimensions, filter Media, nominal airflow rate and particulate matter efficiency (ePMx) are evaluating. Both theoretical models and experimental methods, proves some relationships between these parameters and the performance of product. For instance, decreasing fibre charge density, filter thickness and

packing density, increases aerosol penetration through the electret filter media. However, these studies are of a limited significance for the relationships between these parameters and the results of the air filters standards. In this article we discuss the relationships between all those parameters with the air filter classes according to EN ISO16890:2016. A sample of 1800 products will be analysed based on quantitative approach and the result could be useful for manufactures to find out the important characteristics and their relationships in terms of product performance and certification process.

2 PARTICULATE MATTER EFFICIENCY

Years ago, it was difficult for end users to choose the right filtration solution for a given environmental situation. But, the new global standard for general filtration solve this because ISO 16890 directly links the outdoor air pollution measurements PM_1, $PM_{2.5}$ and PM_{10} to the filtration removal efficiency of air filters, which called particulate matter efficiency (ePMx) (Sundvik A., 2017). Particulate matter in the context of the EN ISO 16890 series describes a size fraction of the natural aerosol (liquid and solid particles) suspended in ambient air. The symbol ePMx describes the efficiency of an air cleaning device to particles with an optical diameter between 0,3 µm and x µm. In simple terms, this means that a filter rated ePM_1[60%] removes 60% or more of the particulates in the PM_1 range. In other words, the filter provides 60% protection against PM_1 air pollution. Different classes of particulate matter can be defined according to the particle size range. The most important ones are PM_1, $PM_{2.5}$ and PM_{10}.
As the precise definition of PM_1, $PM_{2.5}$ and PM_{10} are quite complex and not simple to measure, public authorities, like the U.S. EPA or the German Federal Environmental Agency, increasingly use in their publications the simpler denotation of PM_{10} as being the particle size fraction less or equal to 10 µm. Since this deviation is complex, the EN ISO 16890 series refers to this simplified definition of PM_1, $PM_{2.5}$ and PM_{10}. The following particle size ranges are used in the EN ISO 16890 series for the listed efficiency values.

Table 1: Optical particle diameter size ranges for the definition of the efficiencies, ePMx

Efficiency	Size Range, µm
ePM_{10}	$0{,}3 \leq x \leq 10$
$ePM_{2,5}$	$0{,}3 \leq x \leq 2{,}5$
ePM_1	$0{,}3 \leq x \leq 1$

The average and minimum efficiency values are both used to classify a product. To classify a filter as an ePM_1 or $ePM_{2.5}$ product, the minimum efficiency must be above 50%. If the minimum efficiency is above 50%, the reported efficiency value will be the average efficiency value between the minimum and virgin efficiency. For ePM_{10}, there is no threshold demand for minimum efficiency, but the average efficiency has to stay above 50%. If a filter's efficiency drops below 50% on ePM_{10}, it will be classified as a "coarse" filter and only dust arrestance in percent [%] is reported:

Table 2: Filter Groups

Group Designation	Requirement			Class Reporting Value
	$ePM_{1,\,min}$	$ePM_{2,5,\,min}$	ePM_{10}	
ISO Coarse	–	–	< 50%	Initial grav. Arrestance
ISO ePM_{10}	–	–	≥ 50%	ePM_{10}
ISO $ePM_{2,5}$	–	≥ 50%	–	$ePM_{2,5}$
ISO ePM_1	≥ 50%	–	–	ePM_1

3 EUROVENT FINE FILTER CERTIFICATION PROGRAM

As an independent institution the Eurovent Certification Company has developed an international certification program for fine filters (https://www.eurovent-certification.com/fr). The evaluation and classification of fine filters is based on the EN ISO 168900:2016 test standard. Viledon fine filters are all certified by Eurovent, giving users complete peace of mind. The aim of this guideline is to assess the yearly energy consumption based on a laboratory test procedure which can be the basis for an energy efficiency classification, to give the user of air filters guidance for the filter selection.
This Certification Program applies to Air Filter elements rated and sold as ISO PM_1, $PM_{2.5}$ and PM_{10} according to EN ISO 16890-1:2016, referring to a front frame size of 592x592mm according to standard EN 15805:2010 and with a nominal airflow between 0.24 and 1.5 m³/s. When a company joins the program, all relevant ISO ePM_1, ISO $ePM_{2.5}$ and ISO ePM_{10} air filter elements shall be certified". As manufacturers may produce a large number of filters with different length/depth there is an acceptance criteria for the declaration of filters belonging to the same filter family as already certified filters with the same nominal airflow and with different length/depth of the overall filter element within an acceptance criteria of +/- 10% or 50 mm (whatever is the smaller). Outside of this acceptance criteria the filters shall be declared.

Table 2: Filter Groups

M_X = 200 g (AC Fine)	**AEC in kWh/y FOR ePM1**					
	ePM_1 and $ePM_{1,\,min} \geq 50\%$					
	A+	A	B	C	D	E
50% & 55%	800	900	1050	1400	2000	>2000
60% & 65%	850	950	1100	1450	2050	>2050
70% & 75%	950	1100	1250	1550	2150	>2150
80% & 85%	1050	1250	1450	1800	2400	>2400
> 90%	1200	1400	1550	1900	2500	>2500

M_X = 250 g (AC Fine)	**AEC in kWh/y FOR ePM2.5**					
	$ePM_{2.5}$ and $ePM_{2.5,\,min} \geq 50\%$					
	A+	A	B	C	D	E
50% & 55%	700	800	950	1300	1900	>1900
60% & 65%	750	850	1000	1350	1950	>1950
70% & 75%	800	900	1050	1400	2000	>2000
80% & 85%	900	1000	1200	1500	2100	>2100
> 90%	1000	1100	1300	1600	2200	>2200

M_X = 400 g (AC Fine)	**AEC in kWh/y FOR ePM10**					
	$ePM_{10} \geq 50\%$					
	A+	A	B	C	D	E
50% & 55%	450	550	650	750	1100	>1100
60% & 65%	500	600	700	850	1200	>1200
70% & 75%	600	700	800	900	1300	>1300
80% & 85%	700	800	900	1000	1400	>1400
> 90%	800	900	1050	1400	1500	>1500

Each filter family should include the information about; Model, product category (e.g. Bag, V-type), filter media, number of pockets, filter depth, face dimensions, nominal flow rate, initial pressure drop at nominal air flow rate, ePMx, ePMx min, Eurovent Energy Efficiency Class according to RS 4/C/001 2 (Table 3), annual Energy Consumption according to Eurovent Document 4/21 and filter frame material.
The Annual Energy Consumption calculated using the method described in Eurovent Document 4/21 - 2018 shall be compared to the class limits defined in the table below for the different energy efficiency classes to classify the filter under concern, depending of its filter class to EN ISO 16890:2016. For instance, if a declared value for ePM_1 is 66% and the measured value is 59%, the status will be "Passed", but if the declared value is 54% and measured one is 48%, then the status will be "Failed" and product will be rerated in group $ePM_{2,5}$.

4 RESULTS

In this research work, a mathematical analysis is implemented about existing data on Eurovent website [8]. The data is collected for 1800 certified air filters from 22 different manufactures. In this section the results are presented in two section; (1) the statistical analysis about product characteristics and (2) analysis on the energy efficiency of air filters.

4.1 Filter Media

Filter media are the granular filtering materials which are installed in the filters and Their function are to retain the suspended solids during the filtration process. Based on our statistical analyis, the major material of certified products is Glass with 63,16% and later Synthetic with 31,09% is the most used material through different models (Figure 1). There are other minor materials like combination of carbon with glass or synthetic that are used in the structure of less than 7% of filters.

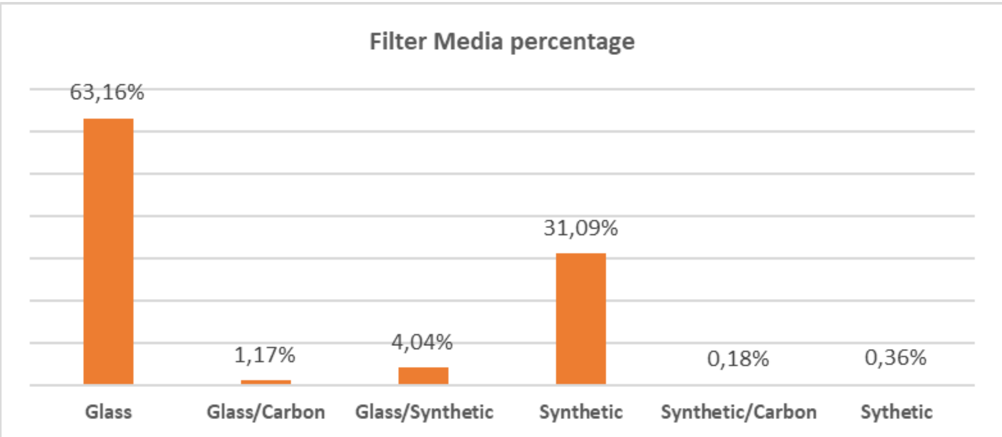

Figure 1: Filter Media percentage

4.2 Design Type

Several types of air filters are common in commercial HVAC systems; (1) Bag filter or named Glass or synthetic media bags which are made in a metal, plastic or wooden frame, (2) Pleated filter which are deep pleated filters in a metal, plastic, aluminum, MDF or wooden frame (> 150 mm depth), (3) V-type filters that are rigid filters with media pleats in a Vshaped design. 1, 2, 3, 4 … V´s, (4) Panel filter is a type of filter made in glass media pleat or synthetic media pleat in a cardboard, plastic or metal frame. <150 mm depth and (5) Filter mats that are manufactured from silicon- and PVC-free Polyester (PES) or Polyethylene terephthalate (PET) non-woven materials. Through our existing analysis, Bag filter is the major design type (60,65%) and later the V-type with 18,69% and Panel filters with 16,53% are the most designed filters.

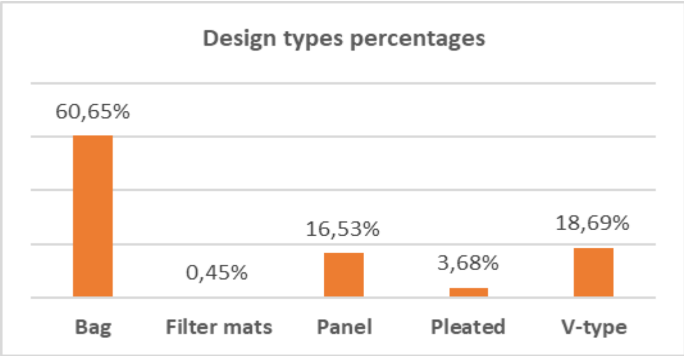

Figure 2: Design Types percentage

4.3 Depth/Length

This parameter corresponds to the Depth or Length of air filters in mm with the frame (complete filter), which are only calculated for bag, Panel, V-type and Pleated. In our analysis we define seven different categories (Figure 3) for existing certified product that start from the range {0 - 100} mm up to {600 - 700} mm. The study presents the range {500-600} mm as the major group with 23,8% and later the ranges {600 - 700} mm and {200 – 300} mm with 20,7% as the second most range groups. The minimum range belongs to {100 – 200} mm and {400 – 500} mm. Very small percentages of declared filters do not include their depth sizes which are presented as NA.

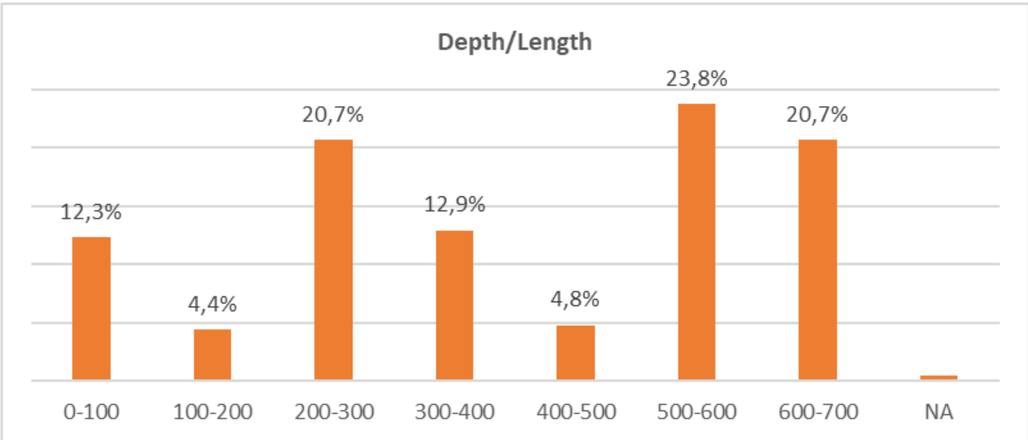

Figure 3. Depth/Length categories percentage

4.4 Number of Bags

Nowadays there are different types of air filters and one of the parameters that makes the filters different is the number of bags to for the clarification/filtration of fluids. Our analysis (Figure 4) proves that 33,50% of the air filters in HVAC systems are including eight filters. In second level there are certified filters with ten bags (26%), which is not far in terms of quantity with eight bags. Later there are filters with four (15,86%) and six bags (11,86%). The minor quantity of bags through these kinds of filter include five (0,42%) and seven bags (0,08%).

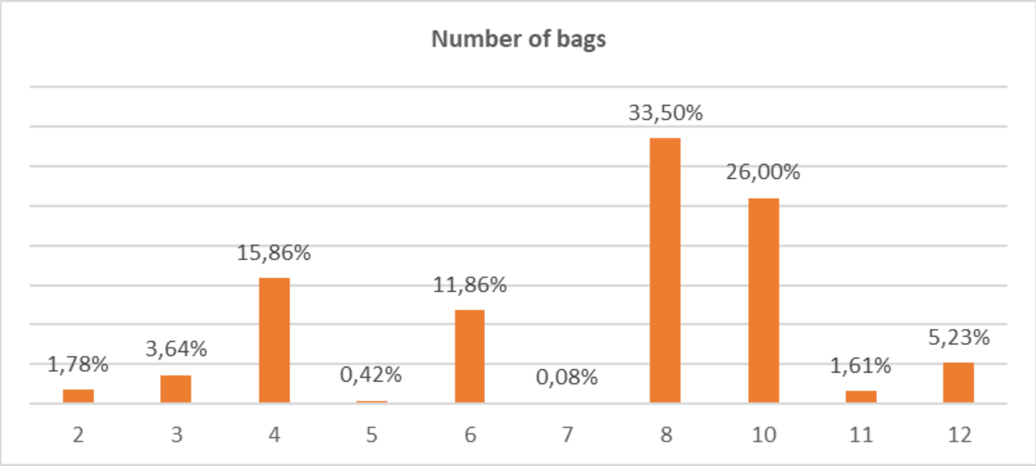

Figure 4. Number of bags percentage in certified filters

4.5 Eurovent Energy efficiency classes

Eurovent Energy Efficiency Class according to RS 4/C/001 2 (Table 3), annual Energy Consumption according to Eurovent Document 4/21 and filter frame material, shows that 24%, 23,8 and 22,8% of filters as the received Energy class C, D and E. Unfortunately, a minor percent of filters (3,1%) received energy class A+ that could motivate other manufactures to improve their quality of manufacturing (Figure 5).

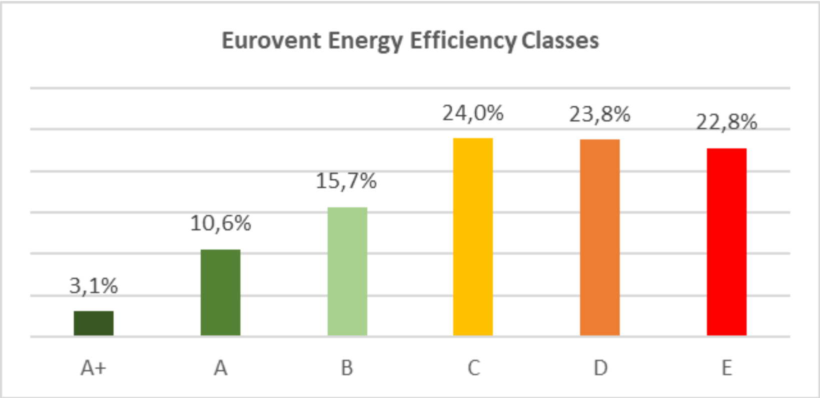

Figure 5. Eurovent energy efficiency class percentage

Particulate matter in the context of the EN ISO 16890 series describes a size fraction of the natural aerosol (liquid and solid particles) suspended in ambient air. Since this deviation is complex, the EN ISO 16890 series refers to this simplified definition of ISO ePM_1, $ePM_{2.5}$ and ePM_{10}. The following figure (Figure 6) describes the relation between ISO Class rating according to EN ISO16890: 2016 and Eurovent energy efficiency classes. Based on this figure, ISO ePM_1 is as the major percentage (56,2%) of certified products that includes 15,8% as C class, 13,6% as D class, 9,3% and 9,2% as E and B classes, 6,3% as A Class and only 2% as A+. Later, 30,6% of certified products considered as ISO ePM_{10} and in this category, 10,5% of products received class E as the major class, 6,4% class D, 5,6% class B, 4,5% class C and few percentages (2,6% and 0,9%) classes A and A+. Minor percentages of certified products contain ISO $ePM_{2.5}$ with 13,1% and in this category classes C, D and E are the major classes.

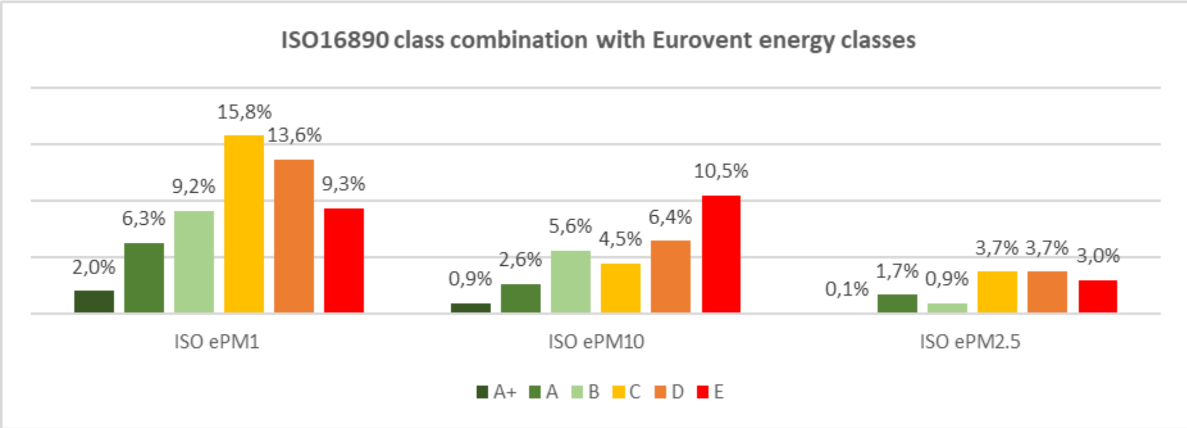

Figure 6. ISO Class rating acc. to EN ISO16890: 2016 and Eurovent energy efficiency class percentage

5 CONCLUSIONS

The objective of this article is to present some results from analyzed data that exists on Eurovent website. A part of these results is about product characteristics in terms of their structure that could give an overview to manufactures about the major physical parameters of existing certified products in the market. And other part is about the certification process and status with a comparison between Eurovent certification program and EN ISO 168900:2016.

The results above prove that only a minor portion of certified air filters have proper energy performance and the rest are certified as Classes C, D and E. As this product is applying in different HVAC products, and could have important impact in final energy performances. Therefore, needs more efforts and attention from manufactures to work on the improvement of their products. In the next article, the correlation between energy performance and product characteristics will be presented.

6 REFERENCES

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