From EN 779 to ISO 16890: a new worldwide reference test method for general ventilation filters

Alain Ginestet[1]

1 CETIAT
Centre Technique des Industries Aérauliques et Thermiques
Domaine scientifique de la Doua, 25 avenue des Arts
69100 Villeurbanne, FRANCE
**Corresponding author: alain.ginestet@cetiat.fr*

ABSTRACT

For testing of general ventilation filters, a completely new standard is now available and is going to replace EN 779 (2012) since the parts 1 to 4 of ISO 16890 (2017) have been adopted in August 2016 and published in 2017 at both international and European levels. With this new standard, the fractional efficiency of the new and the conditioned (24 hours to isopropanol vapour) filters is measured between 0.3 and 10 µm. The 2 fractional efficiency curves are combined to 2 different reference particle size distributions in order to obtain the efficiencies of the filter with reference to ePM_1, $ePM_{2.5}$ and ePM_{10}. This paper presents the content of the new ISO 16890 and highlights the main differences between EN 779 and ISO 16890. The adoption of the new ISO 16890 standard has a great impact on the filtration and ventilation industries.

KEYWORDS

General ventilation filter, air filter testing, EN ISO 16890, EN 779, filter classification

1 INTRODUCTION

The reference standard for testing general ventilation filters (Figure 1) in Europe is EN 779 (2012).

a) b)

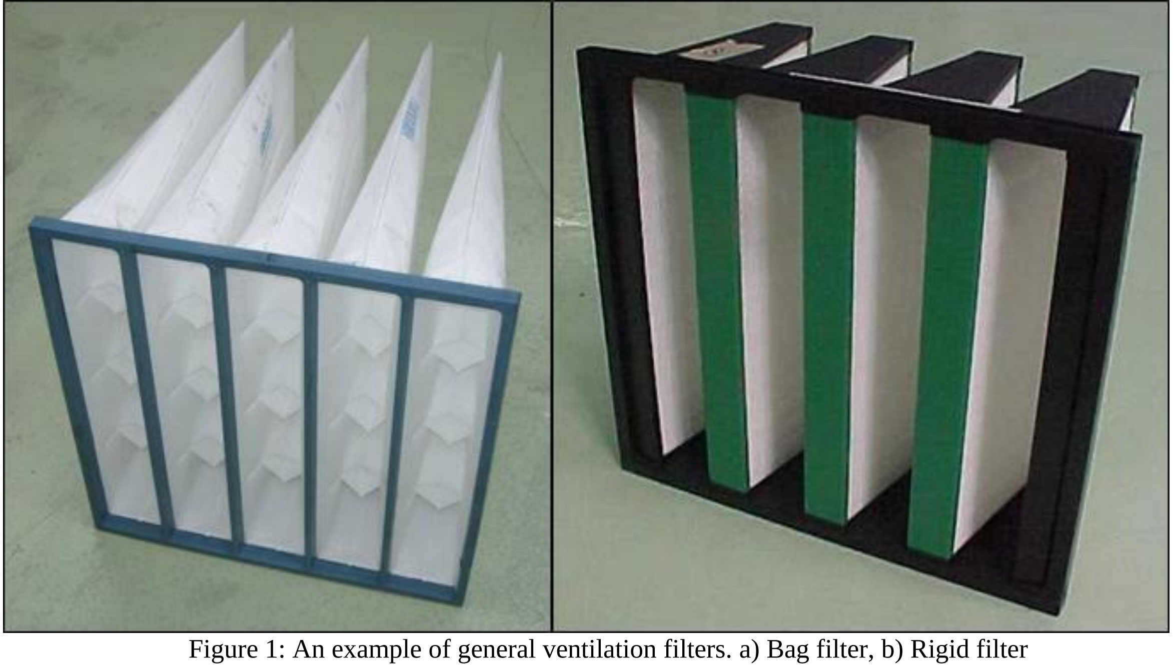

Figure 1: An example of general ventilation filters. a) Bag filter, b) Rigid filter

A completely new standard is now available and is going to replace EN 779 since the parts 1 to 4 of ISO 16890 standard (2017a, 2017b, 2017c, 2017d) have been adopted in August 2016 and published in 2017. Because this standard has also been adopted in Europe at the same time (2 votes in parallel according to the Vienna agreement), this ISO standard is also an EN standard and applies automatically in Europe in place of the existing EN 779 by mid-2018.

If the same parameters are measured with the use of both EN 779 and ISO 16890 standards – pressure drop as function of air flow, pressure drop as function of loading with an artificial dust, fractional efficiency, gravimetric efficiency, test dust holding capacity – there are some differences (test aerosol, loading dust, final pressure drop, etc.) and the filter ranking systems are completely different. So the objective of this paper is to present the content of the new standard and to explain the main differences between EN 779 and ISO 16890. The new filter ranking system is especially highlighted.

2 EN ISO 16890 VS. EN 779

The ISO 16890 standard is applicable for an air flow rate between 900 m^3/h and 5400 m^3/h referring to a test rig with a nominal face area of 610 mm x 610 mm. The test rig used for filter testing according to ISO 16890 is the same as that used for filter testing according to EN 779 except of minor changes which are not described here (mainly a closer control of the temperature and the humidity of the test air and the use of an aerosol mixing device upstream of the downstream aerosol sampling line). The main differences between the ISO 16890 and EN 779 standard are listed in Table 1.

For both standards a test begins with the determination of the initial pressure drop / air flow characteristic and the resistance to air flow of the tested filter is measured at 50%, 75%, 100% and 125% of the rated air volume flow rate. The resistance to air flow data are corrected to an air density of 1.20 kg/m^3.

For both standards the initial fractional efficiency (efficiency by particle size) of the tested filter is measured. Two different test aerosols are used with the ISO 16890 (DEHS (DiEthylHexylSebacate) liquid phase aerosol between 0.3 and 1.0 µm and KCl (Potassium chloride) solid phase aerosol between 1.0 and 10 µm) while DEHS (between 0.2 and 3.0 µm) only is used with EN 779. In ISO 16890 standard data are corrected with a correlation ratio which represents the efficiency measured with no filter within the test rig.

The choice of 2 different test aerosols has been driven by the need for an easy way to produce and to measure test aerosol for the fine particle size range (DEHS under 1 µm) and the importance to highlight the bouncing effects which concern the coarse particle size range (KCl over 1 µm).

Then the filter under test (ISO 16890) is conditioned for 24 hours within a chamber which air is saturated by isopropanol (IPA) vapours. This conditioning step is intended to completely remove the electrostatic charge of the filter medium (if any) with no compensating increase in mechanical efficiency (in EN 779 this conditioning step consists in the immersion for 2 minutes of flat filter sample media in liquid IPA). After this conditioning step the fractional efficiency of the tested filter is measured again on DEHS and KCl aerosols and this value is called the minimum efficiency of the filter. For each particle size (0.3 to 10 µm) the average efficiency is calculated taking into account the initial and the conditioned (minimum) values.
To evaluate the air filters according to their ePM efficiencies (efficiencies with respect to particulate matter fractions), standardized volume distribution functions of the particle sizes

are used which globally represent the average ambient air of urban and rural areas (Table 2). So the efficiency of the filter is calculated on ePM_1, $ePM_{2.5}$ and ePM_{10} from the average fractional efficiencies and the 2 different standardized particle size distributions. The filters belong to a group depending on the values of the minimum efficiency on ePM except for ePM_{10} and coarse filter groups (Table 3). The ePM efficiency of the filter is the average of the initial (ePM_1, ini, $ePM_{2.5}$, ini, ePM_{10}, ini) and the minimum (ePM_1, min, $ePM_{2.5}$, min, ePM_{10}, min) efficiencies. The efficiency reported value (ePM_1, $ePM_{2.5}$, ePM_{10}) is rounded downwards to the nearest multiple of 5% (Table 3). If the filter cannot belong to an ePM group then its initial gravimetric efficiency measured with the ISO 15957 L2 synthetic dust (Table 1) is used to express its performance (Table 3).

Finally, the loading curve of the filter under test is established. It consists in loading the filter with ISO 15957 L2 test dust (2015) (upstream concentration 140 mg/m³) step by step, at constant air flow rate, until its pressure drop reaches 200 Pa ($ePM_{10} \geq 50$ %) or 300 Pa ($ePM_{10} < 50$ %). The initial gravimetric efficiency as well as those after each loading steps are measured. The average test dust holding capacity is calculated.

Table 1: Main differences between EN 779 and ISO 16890 standards

	EN 779	**ISO 16890**
Test aerosol	DEHS (0.2 to 3 µm)	DEHS (0.3 to 1 µm) KCl (1 to 10 µm)
Loading dust	ASHRAE dust	ISO 15957 (2015) L2 dust
Final pressure drop	250 Pa (G) 450 Pa (M, F)	200 Pa ($ePM_{10} < 50$ %) 300 Pa ($ePM_{10} \geq 50$ %)
Filter conditioning	IPA liquid / filter media	IPA vapour / full size filter
Filter classification / ranking	G, M and F groups	ePM group, coarse

Table 2: Particle parameters for ePM calculations

	Reference particle size distribution	Test aerosol	Particle size range
ePM_1	Urban	DEHS	0.3 – 1 µm
$ePM_{2.5}$	Urban	DEHS	0.3 – 1 µm
		KCl	1 – 2.5 µm
ePM_{10}	Rural	DEHS	0.3 – 1 µm
		KCl	1 – 10 µm
Coarse	Initial gravimetric efficiency on ISO 15957 L2 dust		

Table 3: Filter groups according to ISO 16890

Group designation	Requirement			Efficiency reported value
	ePM_1, min	$ePM_{2.5}$, min	ePM_{10}	
ISO coarse	-	-	< 50 %	Initial gravimetric arrestance
ISO ePM_{10}	-	-	≥ 50 %	ePM_{10}
ISO $ePM_{2.5}$	-	≥ 50 %		$ePM_{2.5}$
ISO ePM_1	≥ 50 %	-		ePM_1

An example of ISO 16890 test results is given in Figure 2 while an example of calculation and efficiency reported value is given in Table 4. In this example the filter is electrostatically charged (electret medium) and the minimum fractional efficiency (obtained after the conditioning step with isopropanol vapours) is for this reason much lower than the initial fractional efficiency. The ePM_1, min value is lower than 50 % (49.5 %) and for this reason the filter does not belong to the ePM_1 group; it belongs to the $ePM_{2.5}$ group because the $ePM_{2.5}$, min efficiency is greater than 50 % (60.7 %). The $ePM_{2.5}$ efficiency equals 79.1 % (average of 60.7 % and 97.5 %) and so it is rounded to 75 % and this filter is declared 75 % $ePM_{2.5}$.

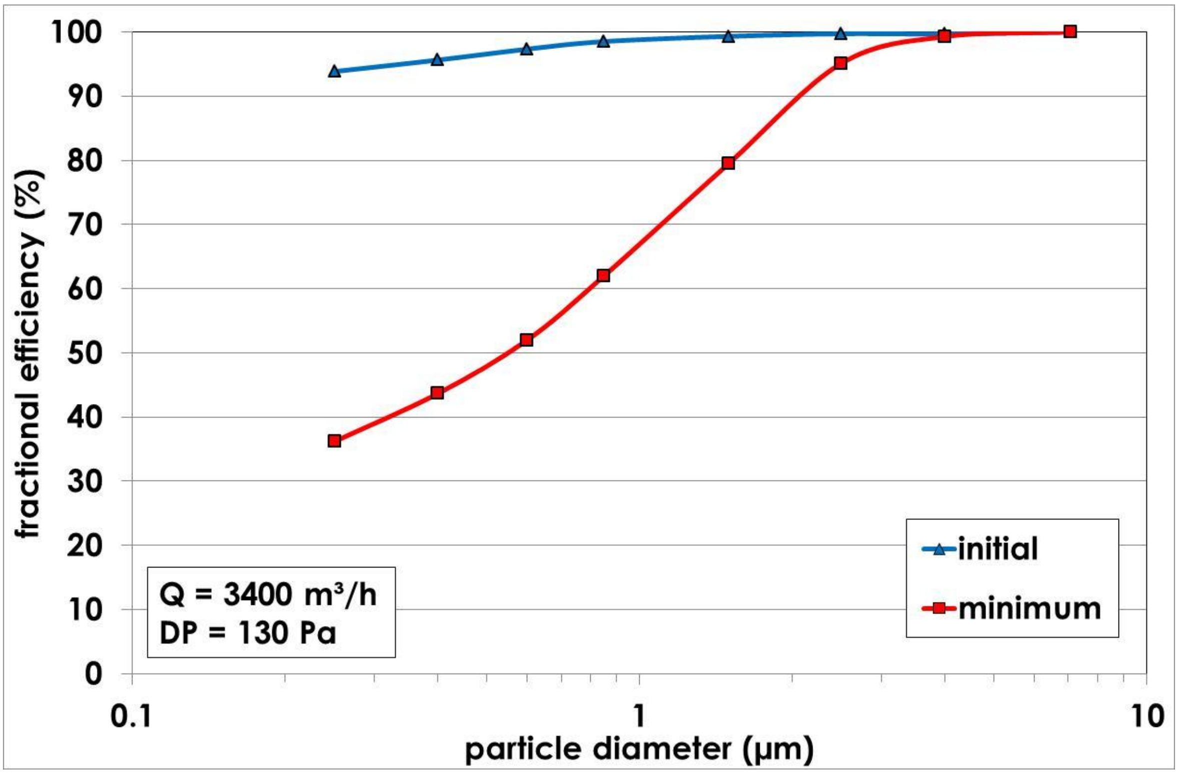

Figure 2: ISO 16890 fractional efficiency test results

Table 4: ePM values associated to test results presented in Figure 2

Calculated efficiency		ePM_1 (%)	$ePM_{2.5}$ (%)	ePM_{10} (%)
ePM_1, ini (%)	96.7	73.1		
ePM_1, min (%)	49.5			
$ePM_{2.5}$, ini (%)	97.5		79.1	
$ePM_{2.5}$, min (%)	60.7			
ePM_{10}, ini (%)	99.2			92.6
ePM_{10}, min (%)	86.1			

3 DISCUSSION

The adoption of the ISO 16890 standard in 2016 represents a major change for general ventilation filters evaluation. The test method is not so different compared to that used in EN 779 but the use of the test results for filter ranking and/or classification is completely different. In ISO 16890 the efficiencies on ePM are calculated and the initial and conditioned (minimum) fractional efficiency values only are considered, combined to standardized particle size distributions. In EN 779, the class of the filters (groups M and F) depends on the average efficiency at 0.4 µm which takes into account the initial efficiency at 0.4 µm as well as those obtained after each loading phase with the ASHRAE synthetic dust. For EN 779, F group also takes into account the minimum efficiency at 0.4 µm which is basically that obtained after the conditioning step with liquid IPA on the flat filter medium samples. Also, the loading dusts and the final pressure drop are different (see Table 1). For these reasons, there is no automatic link between the values obtained with the 2 standards.

But it is possible to use the EN 779 data to calculate the ePM_1 and $ePM_{2.5}$ efficiencies if we assume that the conditioned efficiencies obtained on the occasion of EN 779 testing represent the conditioned efficiencies of the full size filters that would be obtained according to the ISO 16890. Then it is possible to compare the average efficiency at 0.4 µm (EN 779) and that on ePM_1 (ISO 16890) and examples for at least 50 filters are given in Figure 3.

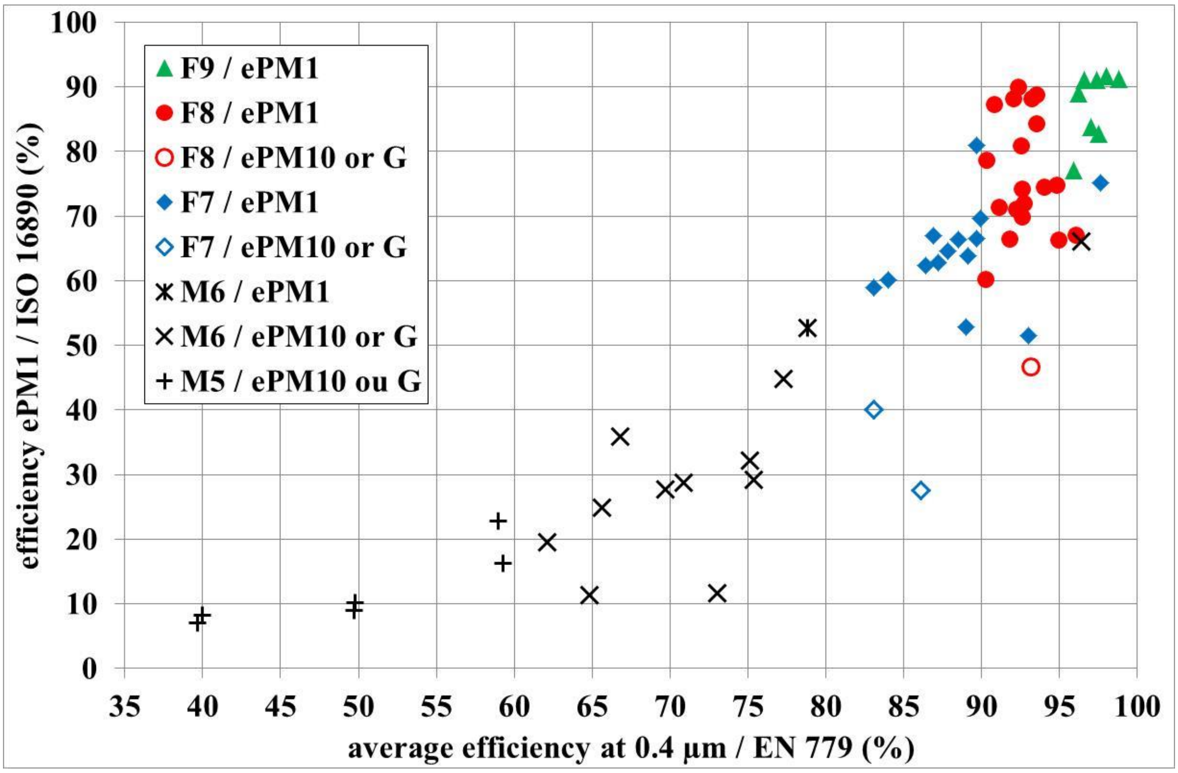

Figure 3: ePM_1 efficiency vs. average efficiency at 0.4 µm

It appears that F9 filters would correspond to ePM_1 filters with values mainly over 80 %, F8 filters would correspond to ePM_1 filters with values mainly between 60 % and 90 %, F7 filters would correspond to ePM_1 filters with values mainly between 50 % and 70 %; M6 and M5 filters would correspond to ePM_{10} or coarse filters. Some few F8 and F7 filters would not correspond to ePM_1 filters and then would become ePM_{10} or coarse filters (no calculation are available with reference to ePM_{10} because EN 779 testing do not provides fractional efficiency data over 3 µm); this trend concern electret filters as well as filters with a low initial efficiency and fast increase of the efficiency during loading. Surprisingly with this sample, no filter would correspond to $ePM_{2.5}$.

Because of the differences between the 2 loading dusts, it is expected that the dust holding capacity with the ISO 16890 standard would probably be 3 to 5 times higher than that with EN 779 (at the same final pressure drop).

4 CONCLUSIONS

The adoption of the ISO 16890 standard in 2016 is of a great importance because this standard is also an EN standard and is going to replace the EN 779 by mid-2018 (EN 779 and ISO 16890 are used in parallel until mid-2018). The filter ranking system based on ePM is completely new and differs from that of EN 779 so that there is no automatic link between the efficiencies expressed according to the 2 standards. But the use of EN 779 data can help to imagine how the filters classified according to EN 779 could be efficient on ePM according to ISO 16890. Nevertheless, filter manufacturers, ventilation system manufacturers will probably need time to switch from a standard to the other, to adopt an other way to express and to deal with the performances of general ventilation filters according to ISO 16890. Also, many documents (standards, regulations, call for tenders, specifications, etc.) and activities (certification programs) referring to EN 779 must now be updated to refer to ISO 16890. For example, the energy classification system developed within the Eurovent Certification Scheme (ECP), which is now a reference in the industry, is being to change to take into account the new ISO 16890 standard.

Even if changes are often difficult to accept and to manage, it can be considered that the new filter ranking system will be easier to understand because the efficiency of filters is expressed according to ePM fraction which is a concept probably easier to understand than the average efficiency at 0.4 µm.

5 ACKNOWLEDGEMENTS

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