Air Handling Technology

VDMA Air Filter Information (2018-06)

DIN EN ISO 16890:2017: A step towards more practical relevance

Content

DIN EN ISO 16890:2017: A step towards more practical relevance

Particulate matter and its effects on health

Fine dust consists of the smallest solid and liquid particles, which are divided into different particle fractions. Particles with a diameter of up to 10 µm (PM_{10} / PM = particulate matter) are referred to as fine dust. Accordingly, the terms $PM_{2,5}$ and PM_1 particles up to diameters of 2,5 µm and 1 µm. In Germany there are over 300 measuring stations for fine dust concentrations. Current data can be viewed on the website of the Federal Environment Agency: http://www.umweltbundesamt.de/daten/luftbe- loadung/aktuelleluftdaten#stations.

Particles of the size around 3 µm to 10 µm are deposited mainly in the nose and throat area. If the diameter drops to 2,5 µm ($PM_{2,5}$), the particles are respirable. From a diameter around 1 µm (PM_1) or smaller, they can even enter the bloodstream via the alveoli. The health effects range from irritation and inflammation of the mucous membranes to damage to the pulmonary alveoli. The health effects range from irritation and inflammation of the mucous membranes to the damage of the pulmonary alveoli and the triggering of cardiovascular diseases. According to the WHO, permanent exposure to particulate matter ($PM_{2,5}$) can lead to arteriosclerosis. affects births and cause diseases of the respiratory tract. The German Federal Environment Agency estimates that approximately 47,000 deaths in Germany each year are caused by particulate matter.
The European Environment Agency estimates that approximately 500,000 premature deaths across Europe each year are caused by particulate matter.

Particulate matter can have natural and man-made (anthropogenic) causes. The latter is caused by combustion processes, road, air, sea and rail transport, among other things. Working with bulk materials, heating systems, power plants and agriculture also contributes to the pollution.

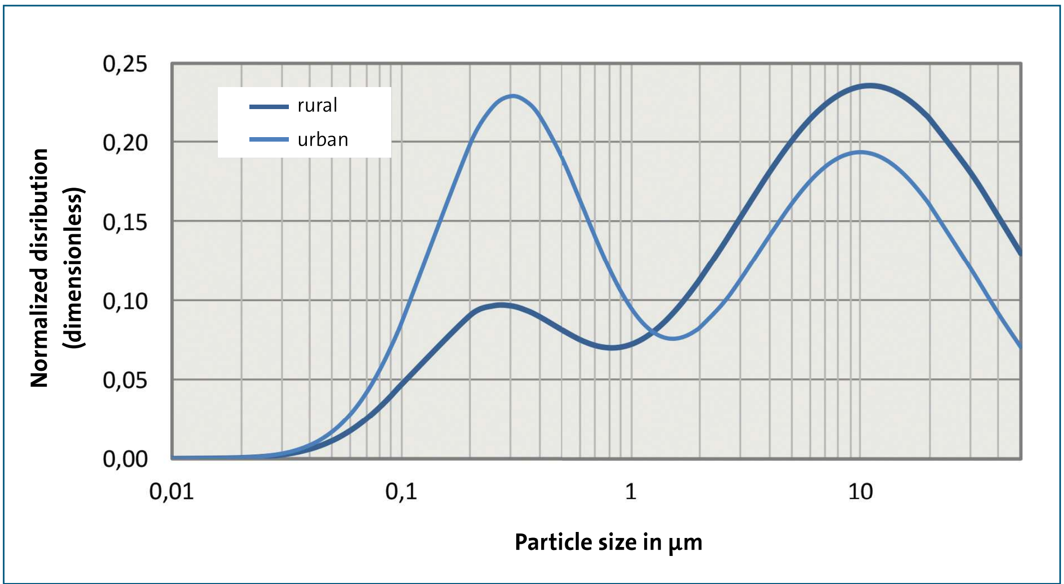

Figure 1:
Typical urban and rural particle size distribution according to DIN EN ISO 16890-1:2017 (Origin: Freudenberg Filtration Technologies SE & Co.KG, Weinheim)

The anthropogenic portion makes up the majority of particles in the air. In addition, there are gaseous pollutants from various sources, which can form fine dust through chemical reactions.

In addition to the various sources, the local fine dust concentration is influenced by relative humidity, temperature, wind conditions and other factors. Giving a statement about the particle distribution and concentration at a specific time and place is therefore often difficult to impossible. Nevertheless, DIN EN ISO 16890 attempts to evaluate filters with the aid of actually measured and then adjusted particle size distributions. Thus, a wide range of particle sizes is considered and a filter classification as close to reality as possible is achieved. The standard provides two size distributions (rural and urban) according to which the separation efficiency of the filters is evaluated (see Figure 1).

What changes with DIN EN ISO 16890?

In accordance with DIN EN 779:2012, the efficiency of an air filter was assessed as the mean value after several loading steps with a synthetic laboratory dust – the so-called ASHRAE dust – but only and exclusively for the particle size 0,4 µm. This means that the amount of test dust stored influences the measurement result. For example, if the filter absorbs a lot of dust and this load results in a sharp increase in efficiency, the average value is also high. In practice, on the other hand, the same filter usually behaves differently: its efficiency remains rather constant with the storage of atmospheric dust. It can even decrease slightly until, after some time, it finally increases less than the comparison with ASHRAE dust suggests. For this reason, the ISO standard evaluates the collection efficiency of a fine filter without dust loading in the laboratory. The DIN EN ISO 16890 represents the conditions in real operation in a more accurate way. Instead of taking only the particle size of 0,4 µm into account, now a broad spectrum between 0,3 µm and 10 µm is consulted, in order to achieve separation rates of fractional efficiencies for the fine dust fractions PM_{10}, $PM_{2,5}$ and PM_1.

Procedure of a filter testing according to DIN EN ISO 16890

According to the DIN EN ISO 16890 standard, the fractional efficiency of an untreated air filter in the particle size range from 0,3 µm to 10 µm is measured first. Then the complete filter element is exposed to an isopropanol vapour atmosphere for 24 hours in order to evaluate the influence of electrostatic mechanisms on the fractional efficiency. The fractional efficiency is measured again and the result is a particle size efficiency spectrum, that determines the minimum efficiency for the respective particle size ranges. The mean value of the untreated and the treated filter efficiency becomes the values ePM_1 for the particle size range up to 1 µm, $ePM_{2,5}$ for the particle size range up to 2,5 µm and ePM_{10} for the particle size range up to 10 µm. In addition, the minimum fractional efficiencies $ePM_{1,\,min}$ and $ePM_{2,5,\,min}$ are calculated only from the deposition curve measured after the isopropanol treatment.

Table 1
Filter groups

Group designation	Requirement			Class reporting value
	***e*PM$_{1, min}$**	***e*PM$_{2,5, min}$**	***e*PM$_{10}$**	
ISO Coarse	–	–	<50 %	Initial gravimetric arrestance
ISO *e*PM10	–	–	≥50 %	*e*PM$_{10}$
ISO *e*PM2,5	–	≥50 %	–	*e*PM$_{2,5}$
ISO *e*PM1	≥50 %	–	–	*e*PM$_{1}$

Origin: DIN EN ISO 16890-1:2017

Based on these fractional efficiencies, filters are divided into four groups. For the ISO *e*PM1 and ISO *e*PM2,5 groups, a filter must separate at least 50 % of the corresponding particle size range after discharge. The condition for the group ISO *e*PM10 is that the filter element has an average fractional efficiency (mean value of new condition and after IPA discharge) of at least 50 %. If, for example, a filter separates more than 50 % PM$_1$ fine dust after discharge, it may be classified as an ISO *e*PM1 filter. The respective mean values are then used for this purpose. For labelling, the respective average fractional efficiency is reported, rounded off in 5 % steps. In the future, we will speak of an ISO *e*PM1 55 % filter, for example. Classes in the actual sense of DIN EN 779 will therefore no longer exist. In addition, filters often fulfil the conditions for several classes. It is possible, for example, that a filter will achieve ISO *e*PM1 50 %, ISO *e*PM2,5 70 % and ISO *e*PM10 95 %. The manufacturer must then decide which specifications on his filter make sense.

In addition to the fine dust filters, the ISO standard also evaluates also coarse dust filters. These are referred to as ISO Coarse if they separate less than 50% of the PM$_{10}$ particles. ISO A2 (according to ISO 12103-1) is used as laboratory test dust for this purpose. Part 3 of DIN EN ISO 16890 describes a dust loading procedure which is necessary for the ISO Coarse group. Optionally, it can also be carried out for filters of the ISO *e*PM groups. The so-called gravimetric arrestance (dust retention) is measured and the dust holding capacity of the filter is evaluated. This measuring procedure is comparable to the predecessor standard DIN EN 779. The biggest difference is the use of the A2 test dust, which will lead to changed measuring results compared to measurements with ASHRAE dust. Furthermore, it is planned to include the data from this test in the evaluation of energy efficiency.

What are the advantages of DIN EN ISO 16890?

The filter groups ISO *e*PM10, ISO *e*PM2,5 and ISO *e*PM1 refer directly to the particles relevant to human health. This makes it easier to design filter systems in such a way that they meet the actual local air pollution requirements. The starting point for efficient system planning is now the local air quality, which can be determined, for example, from data from the official measuring stations. The local air quality determines the filter selection. An individual and coordinated design of the filters takes into account not only the health effects of fine dust in building ventilation, but also the application-related requirements of industrial process air. In addition to separation efficiency, energy efficiency and life cycle costs are important criteria for air filter selection.

How does the standard affect indoor air quality and hygiene?

Indoor air quality is significantly influenced by the quality and quantity of fresh air supplied, but also by various factors within the building, such as the type of use, the floor covering and the building materials used. With the performance data according to the DIN EN ISO 16890, a much more differentiated and precise filter design and assessment of supply air quality is possible. The direct reference of the ISO *e*PM groups to real particle separation makes the filter designation more descriptive and thus supports the constantly growing awareness of air quality in general. In this context, it can be assumed that the requirements placed on filters in general air conditioning systems will continue to rise.

Comparability of the evaluation scheme according to DIN EN ISO 16890 with the classification of DIN EN 779

The category in which the „old“ filters are classified (in) with the new ISO standard depends on their composition and must be determined individually for each filter. Due to the different measurement and evaluation procedures, the filter classes of DIN EN 779 cannot be directly incorporated into the evaluation scheme of the DIN EN ISO 16890 groups. For the selection of suitable air filters, the critical particle size range for the application must be determined. There is considerable public interest in a simple orientation aid ,in which the new filter groups can be traced back to the „old“ filter classes of DIN EN 779. The following table is largely based on measurement data provided by Eurovent and was developed by the VDMA Air Filter Working Group.

For example, most previous G3 filters will achieve separation values in the Coarse 45% to 65% range. F7 filters will achieve approximately efficiencies of $ePM_{2.5}$ 50% to 75 % and ePM_{1} to 40 % to 65 %. It should be noted that filters must reach at least 50% in an *e*PM group in order to obtain the ISO *e*PMx label according to the standard. Filters in the ISO *e*PM1 and ISO *e*PM2,5 groups must still achieve at least 50 % in their respective ISO *e*PM groups even in the electrostatically discharged state ($ePM_{x,\,min}$). In addition, each ISO *e*PM2,5 filter also achieves the coarser group ISO *e*PM10. The same applies to ISO *e*PM1 filters, which always reach the ISO *e*PM2,5 and ISO *e*PM10 groups.

Table 2

Guidance DIN EN 779 – DIN EN ISO 16890 by the VDMA

According to DIN EN 779	According to DIN EN ISO 16890			
	Coarse	ePM_{10}	$ePM_{2,5}$	ePM_1
G1	–	–	–	–
G2	**30% – 50%**	–	–	–
G3	**45% – 65%**	–	–	–
G4	**60% – 85%**	–	–	–
M5	**80% – 95%**	**40% – 70%**	10% – 45%	5% – 35%
M6	> 90%	**45% – 80%**	**20% – 50%**	10% – 40%
F7	> 95%	80% – 90%	**50% – 75%**	**40% – 65%**
F8	> 95%	90% – 100%	75% – 95%	**65% – 90%**
F9	> 95%	90% – 100%	85% – 95%	**80% – 90%**

M5 to F9 based on Eurovent Recommendation 4/23 (2017), the information is for guidance only and without guarantee.

The introduction of the new ISO standard has also resulted in changes to other regulations relating to filter classes in accordance with DIN EN 779.

Recommended use for ventilation and air-conditioning technology

Currently (December 2018), there are various recommendations for the use of ventilation and air-conditioning technology on a national and international level. These partly differ from each other and provide so for contradictory information on the market. In the following, the authors present the two most important recommendations. At the international level this is the Eurovent Recommendation 4/23. At the national level this is VDI 6022 Blatt 1:2018-01. The recommendation table in Eurovent 4/23 has been published as a replacement for the table in EN 16798-3 as long as the filter designations contained therein still refer to EN 779.

Both recommendations refer to the new classification according to DIN EN ISO 16890. In order to select the suitable filter or filters, the outside air quality is classified into three different groups using the PM particle concentrations. In addition, the desired supply air quality must be determined. Here VDI 6022 divides into three classes (very high, high, medium) without specifying these more precisely. Eurovent divides here into five classes, which are determined by PM values analogous to outdoor air. Both papers emphasise that the supply air quality must be better than the desired room air quality, as additional particle sources always exist in buildings.

Table 3

Recommended minimum efficiencies for filters according to Eurovent 4/23

Outdoor air quality	Supply air quality				
	SUP 1* $PM_{2,5} \leq 2{,}5$ or $PM_{10} \leq 5$	**SUP 2*** $PM_{2,5} \leq 5$ or $PM_{10} \leq 10$	**SUP 3**** $PM_{2,5} \leq 7{,}5$ or $PM_{10} \leq 15$	**SUP 4** $PM_{2,5} \leq 10$ or $PM_{10} \leq 20$	**SUP 5** $PM_{2,5} \leq 15$ or $PM_{10} \leq 30$
***e*PM-group**	***e*PM$_1$**	***e*PM$_1$**	***e*PM$_{2,5}$**	***e*PM$_{10}$**	***e*PM$_{10}$**
ODA 1 $PM_{2,5} \leq 10$ or $PM_{10} \leq 20$	70%	50%	50%	50%	50%
ODA 2 $PM_{2,5} \leq 15$ or $PM_{10} \leq 30$	80%	70%	70%	80%	50%
ODA 3 $PM_{2,5} > 15$ or $PM_{10} > 30$	90%	80%	80%	90%	80%

*Last filter stage must be at least ISO *e*PM1 50% .
** Last filter stage must be at least ISO *e*PM2,5 50%.

Classes of outdoor air

ODA 1 Outdoor air that is only temporarily dusty. Used when WHO Guidelines (2005) are met ($PM_{2,5} \leq 10$ µg/m³ and $PM_{10} \leq 20$ µg/m³).

ODA 2 Outdoor air with high dust concentrations. Used when WHO Guidelines (2005) are exceeded by a factor of up to 1,5 ($PM_{2,5} \leq 15$ µg/m³ and $PM_{10} \leq 30$ µg/m³).

ODA 3 Outdoor air with very high dust concentrations. Used when the WHO Guidelines (2005) are exceeded by more than a factor of 1.5 ($PM_{2,5} > 15$ µg/m³ and $PM_{10} > 30$ µg/m³).

Classes of supply air

SUP 1 Supply air with very low particle concentrations. The WHO Guidelines (2005) are undercut by a factor of 0,25 ($PM_{2,5} \leq 2{,}5$ µg/m³ and $PM_{10} \leq 5$ µg/m³).
Examples: Rooms with the highest hygienic requirements: Hospitals, pharmacy, electrical and optical industry, clean rooms.

SUP 2 Supply air with low particle concentrations. The WHO Guidelines (2005) are undercut by a factor of 0,5 ($PM_{2,5} \leq 5$ µg/m³ and $PM_{10} \leq 10$ µg/m³).
Examples: Rooms with permanent use: Nursery school, offices, hotels, residential buildings, meeting rooms, exhibition halls, conference rooms, theatres, cinemas, concert halls, food industry.

SUP 3 Supply air with average particle concentrations. The WHO Guidelines (2005) are undercut by a factor of 0,75 ($PM_{2,5} \leq 7{,}5$ µg/m³ and $PM_{10} \leq 15$ µg/m³).
Examples: Rooms with temporary use: Warehouses, shopping centers, washrooms, server rooms, copy rooms, food industry with low hygiene requirements.

SUP 4 Supply air with high particle concentrations. The WHO Guidelines (2005) are met ($PM_{2,5} \leq 10$ µg/m³ and $PM_{10} \leq 20$ µg/m³).
Examples: Rooms with a short useful life: Toilets, storage rooms, stairwells, areas of the automotive industry.

SUP 5 Supply air with very high particle concentrations. The WHO Guidelines (2005) are exceeded by a factor of 1,5 ($PM_{2,5} \leq 15$ µg/m³ und $PM_{10} \leq 30$ µg/m³).
Examples: Rooms with temporary use: waste management, computer centers, car parks, production in heavy industry.

Origin: Eurovent Recommendation 4/23 (2017)

Eurovent 4/23 (2017)

At international level, the Eurovent Association Working Group Filters prepared the recommendation in Table 3 for the future selection of indoor air filters in accordance with DIN EN ISO 16890. SUP (= supply air quality) refers to the supply air quality directly after the last filter stage. ODA (= outdoor air quality) stands for outdoor air quality. The subdivision into the categories ODA 1 to 3 and SUP 1 to 5 is based on World Health Organization guidelines on air pollution. Table 3 shows only particle concentrations in µg/m³, but not harmful gases. The suggested filter efficiencies are cumulative values; they can be achieved by one or more filter stages. For this reason, they are not directly DIN EN ISO 16890 groups, since they always refer to only one filter element.

For example, a shopping centre (SUP 3) in a rural area with clean air (ODA 1) should be equipped with a filter system. According to the table above, it is recommended that the PM2,5 size class be equipped with an efficiency of is separated by at least 50 %. The filter efficiencies in the table apply to single filters and multi-stage filter systems. If several filters are used, an overall efficiency must be calculated. This is done as shown in Table 3 in the calculation example.

VDI 6022 Blatt 1:2018-01

VDI 6022 Blatt 1:2018-01 defines the minimum requirements for air conditioning systems listed in Table 4 (Hygiene requirements for air conditioning systems and units):

Table 4

Recommended filter classes in VDI 6022-1:2018-01

Outdoor air quality according to VDI 6022 Blatt 1[a)]	SUP 1 (very high)	SUP 2 (high)	SUP 3 (medium)
AUL 1 (clean)	ISO *e*PM10 50% + ISO *e*PM1 50%	ISO *e*PM1 50%	ISO *e*PM1 50%
AUL 2 (unpolluted)	ISO *e*PM2,5 65% + ISO *e*PM1 50%	ISO *e*PM10 50% + ISO *e*PM1 50%	ISO *e*PM10 50% + ISO *e*PM1 50%
AUL 3 (highly polluted)	ISO *e*PM1 50% + ISO *e*PM1 80%	ISO *e*PM2,5 65% + ISO *e*PM1 50%	ISO *e*PM10 50% + ISO *e*PM1 50%

a) Definition identical with ODA 1 to ODA 3 according to DIN EN 16798-3 (see Eurovent)
Note: If there are high gaseous impurities (limit values according to Directive 2008/50/EG), a molecular filter must be provided between the first and second filter stage.

In addition, VDI 6022 requires at least the following air filter qualities and stages:

- Filtration of upstream of the air-handling unit (also fan) at least ISO *e*PM10 50 %
- Filtration of supply air (at least ISO *e*PM1 50 % for the last filter stage)
- Filtration of the secondary air as required, but at least ISO *e*PM10 50%
- Filtration of air upstream of the air-handling plenums in contact with fractions of outdoor air (at least ISO *e*PM1 80 %)
- In the case of a single-stage filter system, the filter must be at least Class ISO *e*PM1 50 %

Further recommendations for the use of air filters in comfort ventilation and air conditioning systems can be found in:

- VDI 3803 Blatt 4:2012 (Air-conditioning, system requirements - Air filter systems)
- DIN EN 16798-3:2017 (Energy performance of buildings – Ventilation for buildings – Part 3: For non-residential buildings – Performance requirements for ventilation and room-conditioning systems)

Who is responsible for implementing the current standard?

Every manufacturer must ensure that he places a safe product on the market. He must comply with the safety regulations of product liability. The requirements of the recognized rules of technology (e.g. DIN-/EN standards) are merely the lower limit for this. In this sense, all parties (manufacturers, dealers, consumers) who handle air filters are subject to certain security obligations. As an employer, an operator of air filters, for example, has a duty of care towards his employees. As an employer, he must provide his employee a safe work equipment. This obligation results, among other things, from the Ordinance on Industrial Safety and Health (§ 10) and the occupational health and safety regulations.

What is the legal relevance of DIN, EN or ISO standards?

DIN, EN or ISO standards are private technical regulations of a recommendatory nature. They only become binding standards if reference is made to them, e.g. in a contract between the parties or in laws and regulations. If, on the other hand, there is a lack of such an agreement, the service must comply with the recognised rules of technology upon acceptance. These rules may represent DIN, EN or ISO standards, but do not have to do so. These standards may become obsolete and (then) no longer represent the (current) rules of technology. Thus the standards, unless outdated, are regarded as recognized rules of technology even if they are not mentioned in a contract. However, compliance with the recognized rules of technology does not necessarily mean that the safety provisions of product liability are also met. These can go further in individual cases. The safety level of the product is then determined according to the objectively discernible or ascertainable state of the art of science and technology at the time of placing on the market.

What time horizont and transition periods are planned for the conversion from DIN EN 779 to DIN EN ISO 16890 series?

Both standards have a coexistence period until 30 June 2018, during which both standards are parallelly valid.

Can filters that have been tested and classified according to DIN EN 779:2012 still be used?

From the end of the coexistence period (from July 2018), only filters that have been tested and evaluated in accordance with DIN EN ISO 16890 may be used.

Under certain circumstances, filters according to DIN EN 779:2012 can be used if a safety risk can be completely excluded. The consequences described above apply with regard to product safety and product liability.

Calculation example for 2-stage filter systems according to DIN EN ISO 16890

With DIN EN ISO 16890 it is possible to calculate the corresponding supply air concentrations based on the fine dust concentrations PM_{10}, $PM_{2.5}$ and PM_1 in the outside air. This can be done for one filter stage as well as for multiple filter stages with some simplifying assumptions. The results of such a calculation can be used to estimate the supply air quality as a function of the outdoor air quality. Fig. 2 gives the following example the results of such a calculation for a typical urban outdoor air.

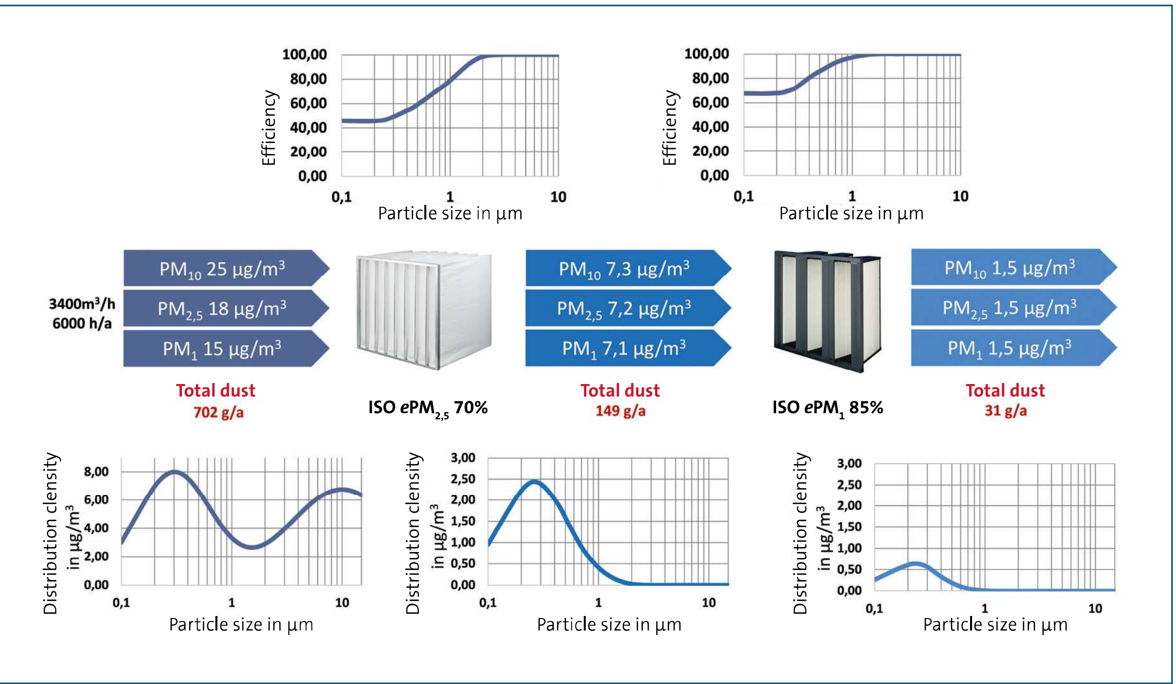

Figure 2:
Results of a calculation of the supply air concentrations according to DIN EN ISO 16890 as an example for a typical urban particle size distribution (Origin: Kalthoff Luftfilter und Filtermedien GmbH, Selm)

Legal indications

The VDMA Air Filter Information has been compiled by the Air Filter Working Group of the VDMA General Air Technology Association. The information serves only as a reference point and assistance for the application and implementation of the new air filter standard DIN EN ISO 16890 **„Air filters for general ventilation technology“.**

It should be expressly pointed out that the points and representations listed in each case can only represent individual examples and that there may be other methods and representations in this respect. The information does not claim to be exhaustive, nor does it claim to be an exact interpretation of the existing legal provisions. The paper must not replace the study of the relevant directives, laws and ordinances. Furthermore, the special features of the respective products in which the air filters are installed as well as their different application possibilities must be taken into account.

VDMA Air Filter Working Group

Leading German manufacturers of air filters work together in a working group under the umbrella of the VDMA. Regardless of their role as competitors on the market, the member companies address current and long-term problems and issues, discuss them and try to develop solutions and assistance.

Members of the Air Filter Working Group

AAF-Lufttechnik GmbH
AFPRO Filters GmbH
B&S Industrieservice GmbH
Camfil KG
DMT GmbH & Co. KG
EMW filtertechnik GmbH
Heinz Fischer KG
Freudenberg Filtration Technologies SE & Co. KG
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TROX GmbH
ts-systemfilter gmbh
Volz Luftfilter GmbH & Co. KG

Chair during the preparation of this document:
Kalthoff Luftfilter und Filtermedien GmbH

Air Conditioning and Ventilation Technology Department at VDMA

The specialist department looks after around 80 well-known manufacturers of ventilation systems, components and assemblies for domestic, commercial and industrial applications. In the DIN Standards Committee Mechanical Engineering (NAM), the specialist department manages the national mirror committees for air filters (CEN/TC 195 and ISO/TC 142), fans (CEN/TC 156/WG 17 and ISO/TC 117) and central air handling units (CEN/TC 156/WG 5).

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Annex

Overview of differences between DIN EN ISO 16890 and DIN EN 779

DIN EN ISO 16890	DIN EN 779
Test objective	
Classification in ISO *e*PM-Groups	Classification in filter classes G, M and F
Coarse dust filter: ISO *e*PM Coarse	G1 – G4
Medium dust filter: ISO *e*PM10	M5 – M6
Fine dust filter: ISO *e*PM2,5	M6 – F7
Fine dust filter: ISO *e*PM1	F7 – F9
Relevent filter characteristic	
Coarse dust filter: Grav. arrestance in relation to A2 test dust	Coarse dust filter: Medium grav. arrestance in relation to ASHRAE dust
Fine dust filter: Fractional efficiency in relation to ePM_x (0,3 µm – 10 µm)	Fine dust filter: Medium efficiency in relation to 0,4 µm particle
Test aerosols	
DEHS- and KCL-Aerosol	DEHS-Aerosol
Assessed filter condition	
New condition	New and dusted condition
New condition after IPA-treatment	New condition after IPA-treatment
IPA treatment	
Total filter element	Sample from filter medium
Steaming with IPA	Immersion in liquid IPA
Differential pressure	
Differential pressure curve at the filter element in % of the nominal volume flow	Differential pressure curve at the filter element in % of the nominal volume flow
Final differential pressure	
ISO Coarse: 200 Pa	G1 – G4: 250 Pa
ISO *e*PM1 up to *e*PM10: 300 Pa	M5 – F9: 450 Pa
Dust holding capacity	
Dusting with A2-Test-Dust (quartz dust)	Dusting with ASHRAE test dust (quartz dust, soot, cotton fibres)
Energy classidication	
Manufacturer-related label process	Manufacturer-related label process

Imprint

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Layout
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Print
h. reuffurth gmbh, Mühlheim am Main
www. reuffurth.net

Picture Sources
Cover Camfil KG, Reinfeld

Page 2 Freudenberg Filtration Technologies SE & Co.KG, Weinheim

Page 10 Kalthoff Luftfilter und Filtermedien GmbH, Selm

State
June 2018

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