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Air filters for general ventilation —

Part 3:
Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured

Filtres à air de ventilation générale —

Partie 3: Détermination de l'efficacité gravimétrique et de la résistance à l'écoulement de l'air par rapport à la quantité de poussière d'essai retenue

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 142, *Cleaning equipment for air and other gases*.

This first edition of ISO 16890-3, together with ISO 16890-1, ISO 16890-2 and ISO 16890-4, cancels and replaces ISO/TS 21220:2009, which has been technically revised.

ISO 16890 consists of the following parts, under the general title *Air filters for general ventilation*:

— *Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)*

— *Part 2: Measurement of fractional efficiency and air flow resistance*

— *Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured*

— *Part 4: Conditioning method to determine the minimum fractional test efficiency*

Introduction

The effects of particulate matter (PM) on human health have been extensively studied in the past decades. The results are that fine dust can be a serious health hazard, contributing to or even causing respiratory and cardiovascular diseases. Different classes of particulate matter can be defined according to the particle size range. The most important ones are PM_{10}, $PM_{2,5}$ and PM_1. The U.S. Environmental Protection Agency (EPA), the World Health Organization (WHO) and the European Union define PM_{10} as particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter. $PM_{2,5}$ and PM_1 are similarly defined. However, this definition is not precise if there is no further characterization of the sampling method and the sampling inlet with a clearly defined separation curve. In Europe, the reference method for the sampling and measurement of PM_{10} is described in EN 12341. The measurement principle is based on the collection on a filter of the PM_{10} fraction of ambient particulate matter and the gravimetric mass determination (see EU Council Directive 1999/30/EC of 22 April 1999).

As the precise definition of PM_{10}, $PM_{2,5}$ and PM_1 is quite complex and not simple to measure, public authorities, like the U.S. EPA or the German Federal Environmental Agency (Umweltbundesamt), increasingly use in their publications the more simple denotation of PM_{10} as being the particle size fraction less or equal to 10 µm. Since this deviation to the above mentioned complex “official” definition does not have a significant impact on a filter element’s particle removal efficiency, the ISO 16890 series refers to this simplified definition of PM_{10}, $PM_{2,5}$ and PM_1.

Particulate matter in the context of the ISO 16890 series describes a size fraction of the natural aerosol (liquid and solid particles) suspended in ambient air. The symbol ePM_x describes the efficiency of an air cleaning device to particles with an optical diameter between 0,3 µm and x µm. The following particle size ranges are used in the ISO 16890 series for the listed efficiency values.

Table 1 — Optical particle diameter size ranges for the definition of the efficiencies, ePM_x

Efficiency	Size range, µm
ePM_{10}	0,3 ≤ × ≤10
$ePM_{2,5}$	0,3 ≤ × ≤2,5
ePM_1	0,3 ≤ × ≤1

Air filters for general ventilation are widely used in heating, ventilation and air-conditioning applications of buildings. In this application, air filters significantly influence the indoor air quality and, hence, the health of people, by reducing the concentration of particulate matter. To enable design engineers and maintenance personnel to choose the correct filter types, there is an interest from international trade and manufacturing for a well-defined, common method of testing and classifying air filters according to their particle efficiencies, especially with respect to the removal of particulate matter. Current regional standards are applying totally different testing and classification methods, which do not allow any comparison with each other, and thus hinder global trade with common products. Additionally, the current industry standards have known limitations by generating results which often are far away from filter performance in service, i.e. overstating the particle removal efficiency of many products. With this new ISO 16890 series, a completely new approach for a classification system is adopted, which gives better and more meaningful results compared to the existing standards.

The ISO 16890 series describes the equipment, materials, technical specifications, requirements, qualifications and procedures to produce the laboratory performance data and efficiency classification based upon the measured fractional efficiency converted into a particulate matter efficiency (ePM) reporting system.

Air filter elements according to the ISO 16890 series are evaluated in the laboratory by their ability to remove aerosol particulate expressed as the efficiency values ePM_1, $ePM_{2,5}$ and ePM_{10}. The air filter elements can then be classified according to the procedures defined in ISO 16890-1. The particulate removal efficiency of the filter element is measured as a function of the particle size in the range of 0,3 µm to 10 µm of the unloaded and unconditioned filter element as per the procedures defined in ISO 16890-2. After the initial particulate removal efficiency testing, the air filter element is conditioned according to the procedures defined in ISO 16890-4 and the particulate removal efficiency is repeated on the conditioned filter element. This is done to provide information about the intensity of any electrostatic removal mechanism which may or may not be present with the filter element for test. The average efficiency of the filter is determined by calculating the mean between the initial efficiency and the conditioned efficiency for each size range. The average efficiency is used to calculate the $e\text{PM}_x$ efficiencies by weighting these values to the standardized and normalized particle size distribution of the related ambient aerosol fraction. When comparing filters tested in accordance with the ISO 16890 series, the fractional efficiency values shall always be compared among the same $e\text{PM}_x$ class (ex. $e\text{PM}_1$ of filter A with $e\text{PM}_1$ of filter B). The test dust capacity and the initial arrestance of a filter element are determined as per the test procedures defined in this part of ISO 16890.

Air filters for general ventilation —

Part 3:
Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured

1 Scope

This part of ISO 16890 specifies the test equipment and the test methods used for measuring the gravimetric efficiency and resistance to air flow of air filter for general ventilation.

It is intended for use in conjunction with ISO 16890-1, ISO 16890-2 and ISO 16890-4.

The test method described in this part of ISO 16890 is applicable for air flow rates between 0,25 m^3/s (900 m^3/h, 530 ft^3/min) and 1,5 m^3/s (5 400 m^3/h, 3 178 ft^3/min), referring to a test rig with a nominal face area of 610 mm × 610 mm (24 in × 24 in).

ISO 16890 (all parts) refers to particulate air filter elements for general ventilation having an $e\mathrm{PM}_1$ efficiency less than or equal to 99 % and an $e\mathrm{PM}_{10}$ efficiency greater than 20 % when tested as per the procedures defined within ISO 16890 (all parts).

Air filter elements outside of this aerosol fraction are evaluated by other applicable test methods. See ISO 29463 (all parts).

Filter elements used in portable room-air cleaners are excluded from the scope of this part of ISO 16890.

The performance results obtained in accordance with ISO 16890 (all parts) cannot by themselves be quantitatively applied to predict performance in service with regard to efficiency and lifetime.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15957, *Test dusts for evaluating air cleaning equipment*

ISO 16890-1, *Air filters for general ventilation — Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)*

ISO 16890-2:2016, *Air filters for general ventilation — Part 2: Measurement of fractional efficiency and resistance to air flow*

ISO 16890-4, *Air filters for general ventilation — Part 4: Conditioning method to determine the minimum fractional test efficiency*

ISO 29463-1, *High-efficiency filters and filter media for removing particles in air — Part 1: Classification, performance testing and marking*

ISO 29464, *Cleaning equipment for air and other gases — Terminology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 29464 and the following apply.

3.1 Air flow and resistance

3.1.1
air flow rate
volume of air passing through the filter per unit time

3.1.2
nominal air volume flow rate
air flow rate (3.1.1) specified by the manufacturer

3.1.3
filter face velocity
air flow rate (3.1.1) divided by the face area

Note 1 to entry: Filter face velocity is expressed in m/s.

3.1.4
resistance to air flow
difference in pressure between two points in an air flow system at specified conditions, especially when measured across the *filter element* (3.2.2)

Note 1 to entry: Resistance to air flow is measured in Pa.

3.1.5
recommended final resistance to air flow
maximum operating *resistance to air flow* (3.1.4) of the filter as recommended by the manufacturer

Note 1 to entry: Recommended final resistance to air flow is measured in Pa.

3.1.6
final resistance to air flow
resistance to air flow (3.1.4) up to which the filtration performance is measured to determine the *average arrestance* (3.3.3) and *test dust capacity* (3.3.4)

Note 1 to entry: Final differential pressure to air flow is measured in Pa.

3.1.7
initial resistance to air flow
resistance to air flow (3.1.4) of the clean filter operating at its test *air flow rate* (3.1.1)

Note 1 to entry: Initial resistance to air flow is measured in Pa.

3.1.8
test air
air to be used for testing purposes

3.2 Test device

3.2.1
test device
filter element (3.2.2) to be tested

3.2.2
filter element
structure made of the filtering material, its supports and its interfaces with the filter housing

3.2.3
upstream
U/S
region in a process system traversed by a flowing fluid before it enters that part of the *test device* (3.2.1)

3.2.4
downstream
D/S
area or region into which fluid flows on leaving the *test device* (3.2.1)

3.2.5
coarse filter
filtration device with particle removal efficiency <50 % in the PM_{10} particle range

3.2.6
fine filter
filtration device with particle removal efficiency ≥50 % in the PM_{10} particle range

3.2.7
final filter
air filter used to collect the *loading dust* (3.3.5) passing through or shedding from the filter under test

3.2.8
effective filter media area
area of the media contained in the filter and effectively passed by air during operation

Note 1 to entry: Effective filter media area is expressed in m^2.

3.2.9
filter media velocity
air flow rate (3.1.1) divided by the *effective filter media area* (3.2.8)

Note 1 to entry: Filter media velocity is expressed in m/s to an accuracy of three significant figures.

3.3 Gravimetric efficiency

3.3.1
arrestance
measure of the ability of a filter to remove a standard test dust from the air passing through it, under given operating conditions

Note 1 to entry: Arrestance is expressed as a weight percentage.

3.3.2
initial arrestance
value of *arrestance* (3.3.1) determined after the first loading cycle in a filter test

Note 1 to entry: Initial arrestance is expressed as a weight percentage.

3.3.3
average arrestance
ratio of the total amount of *loading dust* (3.3.5) retained by the filter to the total amount of dust fed up to final test pressure differential

3.3.4
test dust capacity
amount of *loading dust* (3.3.5) retained by the filter up to final pressure differential

Note 1 to entry: Test dust capacity is expressed in grams.

3.3.5
loading dust
synthetic dust formulated specifically for determination of the *test dust capacity* (3.3.4) and *arrestance* (3.3.1) of air filters

3.3.6
particle size
geometric diameter (equivalent spherical, optical or aerodynamic, depending on context) of the particles of an aerosol

3.4 Other terms

3.4.1
HEPA filter
filters with performance complying with requirements of filter class ISO 35H – ISO 45H as per ISO 29463-1

3.4.2
reference device
primary device possessing accurately known parameters used as a standard for calibrating secondary devices

3.4.3
filter face area
area of the inside section of the test duct immediately *upstream* (3.2.3) of the filter under test

Note 1 to entry: Nominal values 0,61 m × 0,61 m = 0,37 m^2.

4 Symbols and abbreviated terms

A	Arrestance, %
A_j	Arrestance in loading phase “j”, %
A_m	Average arrestance during test to final resistance to air flow, %
M_j	Mass of dust fed to the filter during loading phase “j”, g
mean	Mean value
m_d	Dust in duct after filter, g
m_j	Mass of dust passing the filter at the dust loading phase “j”, g
m_{tot}	Cumulative mass of dust fed to filter, g
m_1	Mass of final filter before dust increment, g
m_2	Mass of final filter after dust increment, g
p	Pressure, Pa
p_a	Absolute air pressure upstream of filter, kPa
p_{sf}	Air flow meter static pressure, kPa
q_m	Mass flow rate at air flow meter, kg/s
q_V	Air flow rate at filter, m^3/s
q_{Vf}	Air flow rate at air flow meter, m^3/s
t	Temperature upstream of filter, °C
t_f	Temperature at air flow meter, °C

ρ	Air density, kg/m^3
φ	Relative humidity upstream of filter, %
Δm	Dust increment, g
Δm_{ff}	Mass gain of final filter, g
Δp	Filter resistance to air flow, Pa
Δp_f	Differential pressure used for determination of air flow rate, Pa
$\Delta p_{1,20}$	Filter resistance to air flow at air density 1,20 kg/m^3, Pa
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
CEN	European Committee for Standardization
EN	European Norm
EUROVENT	European Committee of Air Handling and Refrigeration Equipment Manufacturers

5 General test device requirements

5.1 Test device requirements

The test device shall be designed or marked so as to prevent incorrect mounting. The test device shall be designed so that when correctly mounted in the ventilation duct, no air/dust leaks occur around the exterior filter frame and the duct sealing surfaces.

The complete test device (test device and frame) shall be made of material suitable to withstand normal usage and exposure to the range of temperature, humidity and corrosive environments likely to be encountered in service.

The complete test device shall be designed so that it will withstand mechanical constraints that are likely to be encountered during normal use. Dust or fibre released from the test device media by air flow through the test device shall not constitute a hazard or nuisance for the people (or devices) exposed to filtered air.

5.2 Test device preparation

The test device shall be mounted in accordance with the manufacturer's recommendations and after equilibration with the test air weighed to the nearest gram. Devices requiring external accessories shall be operated during the test with accessories having characteristics equivalent to those used in actual practice. The test device, including any normal mounting frame, shall be sealed into the test rig in a manner that prevents leakages. The tightness shall be checked by visual inspection and no visible leaks are acceptable. If for any reason dimensions do not allow testing of a test device under standard test conditions, assembly of two or more devices of the same type or model is permitted, provided no leaks occur in the resulting assembly. The operating conditions of such accessory equipment shall be recorded.