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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

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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 document 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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This document was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 195, *Cleaning equipment for air and other gases*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 16890-3:2016), which has been technically revised.

The main changes are as follows:

— the initial loading step has been revised from 30 g to 60 g throughout the document.

A list of all parts in the ISO 16890 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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. For the outdoor environment, the U.S. Environmental Protection Agency (EPA), the World Health Organization (WHO), the European Union, and other national agencies have established acceptable air quality standards according to concentrations of particulate matter classified per their aerodynamic sizes, defined as $PM_{2,5}$ and PM_{10}, and measured according to strict prescriptive methods and sampling times.

Since there is growing interest in relating indoor air quality to outdoors, the ISO 16890 series classifies ventilation filters according to their efficiencies measured with an optical diameter between 0,3 µm and *x* µm and relating the result to historic global average ambient PM concentrations. Although not exactly equivalent to filter performance of national ambient air quality standards at PM, the classification scheme presented in the ISO 16890 series yields a level of correspondence to the effectiveness of the filter for ambient particle concentrations. It is however recognized that the correspondence based on global averages may not be exactly the same at a specific location since local ambient particle concentration may be different than the global average.

The particle size ranges shown in Table 1 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}	$0,3 \le x \le 10$
$ePM_{2,5}$	$0,3 \le x \le 2,5$
ePM_1	$0,3 \le x \le 1$

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 the ISO 16890 series, a completely new approach for a classification system is adopted, which gives 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 (*e*PM) 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 ePM_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 need to always be compared among the same ePM_x class (e.g. ePM_1 of filter A with ePM_1 of filter B). The test dust capacity and the arrestance of a filter element are determined as per the test procedures defined in this document.

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

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 document 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 document 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).

This document refers to particulate air filter elements for general ventilation having an ePM_1 efficiency less than or equal to 99 % and an ePM_{10} efficiency greater than 20 % when tested as per the procedures defined in the ISO 16890 series.

NOTE The lower limit for this test procedure is set at a minimum ePM_{10} efficiency of 20 % since it is very difficult for a test filter element below this level to meet the statistical validity requirements of this procedure.

This document does not apply to filter elements used in portable room-air cleaners.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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 16890-2:2022, *Air filters for general ventilation — Part 2: Measurement of fractional efficiency and air flow resistance*

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 from air — Part 1: Classification, performance, testing and marking*

ISO 80000-1:2022, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Air flow and resistance

3.1.1
air flow rate
volume of air flowing through an air cleaner per unit time

[SOURCE: ISO 29464:2024, 3.1.29, modified — The preferred term "flow rate" has been removed.]

3.1.2
resistance to air flow
difference in absolute (static) 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 (inches of water).

[SOURCE: ISO 29464:2024, 3.1.43, modified — The admitted terms have been removed; "at specified conditions, especially when measured across the filter element" has been added.]

3.1.3
final resistance to air flow
resistance to air flow (3.1.2) up to which the filtration performance is measured to determine the *test dust capacity* (3.3.4)

Note 1 to entry: Final resistance to air flow is measured in Pa (inches of water).

[SOURCE: ISO 29464:2024, 3.2.141, modified – "for classification or other purposes" has been replaced with "to determine the test dust capacity".]

3.1.4
initial resistance to air flow
resistance to air flow (3.1.2) of the clean filter operating at its test *air flow rate* (3.1.1)

Note 1 to entry: Initial resistance to air flow is expressed in Pa (inches of water).

[SOURCE: ISO 29464:2024, 3.2.142]

3.1.5
test air
air being used for testing purposes

[SOURCE: ISO 29464:2024, 3.1.44]

3.2 Test device

3.2.1
test device
air cleaner that is being subjected to performance testing

[SOURCE: ISO 29464:2024, 3.1.45, modified — The preferred terms "device under test" and "DUT" have been removed.]

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

[SOURCE: ISO 29464:2024, 3.2.59]

3.2.3
upstream
U/S
area or region from which fluid flows as it enters an air cleaner

[SOURCE: ISO 29464:2024, 3.1.46, modified — "U/S" has been added as an admitted term.]

3.2.4
downstream
D/S
area or region into which fluid flows on leaving an air cleaner

[SOURCE: ISO 29464:2024, 3.1.16, modified — "D/S" has been added as an admitted term.]

3.2.5
final filter
air filter used to collect the *loading dust* (3.3.5) passing through or shedding from the filter under test

[SOURCE: ISO 29464:2024, 3.2.62]

3.2.6
effective filter medium area
area of the filter medium contained in the filter through which air passes during operation

Note 1 to entry: This excludes areas covered by sealant, spacers, struts, etc.

Note 2 to entry: Effective filter medium area is expressed in m^2 (ft^2).

[SOURCE: ISO 29464: 2024, 3.1.27]

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: This measure is expressed as a mass fraction.

[SOURCE: ISO 29464:2024, 3.2.15, modified — The preferred term "gravimetric arrestance" has been removed; "mass percentage" has been replaced by "mass fraction" in note 1 to entry.]

3.3.2
initial arrestance
ratio of the mass of a standard test dust retained by the filter to the mass of dust fed after the first increment of dust load

Note 1 to entry: This measure is expressed as a mass fraction.

Note 2 to entry: For example, see the procedure in ISO 29461-1 or this document.

[SOURCE: ISO 29464:2024, 3.2.17, modified — The preferred term "initial gravimetric arrestance" has been removed; "mass percentage" has been replaced by "mass fraction" in note 1 to entry; the reference to "ISO 16890-3" has been replaced by "this document" in note 2 to entry.]

3.3.3
total arrestance
value of *arrestance* (3.3.1) determined after the last loading cycle in a filter test

3.3.4
test dust capacity
TDC
total mass of *loading dust* (3.3.5) captured by an air-cleaning device up to the final test *resistance to air flow* (3.1.2)

[SOURCE: ISO 29464:2024, 3.2.23, modified — The preferred terms "dust holding capacity" and "DHC" and the admitted term "dust loading capacity" have been removed.]

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

[SOURCE: ISO 29464:2024, 3.2.45, modified — The preferred term "synthetic test dust" has been removed.]

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

[SOURCE: ISO 29464:2024, 3.2.116]

4 Symbols

A	Arrestance, %
A_j	Arrestance in loading phase “j”, %
A_t	Total arrestance during test to final resistance to air flow, %
M_j	Mass of dust fed to the filter during loading phase “j”, g
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

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 service. 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.

6 Loading dust

The loading dust as specified in ISO 15957 as L2 shall be used as a loading dust for reporting results. This procedure is applicable to loading a filtration device with other dust types mentioned in ISO 15957, but not for reporting results in accordance with this document.

7 Test equipment

7.1 Test rig

The test rig shall be as described in ISO 16890-2:2022, Clause 7. Parts not described in ISO 16890-2 and used in this document are described in 7.2 to 7.5.

7.2 Upstream mixing orifice

For all dust load measurements the upstream mixing orifice shall be installed.