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Air filters for general ventilation —

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

Filtres à air de ventilation générale —

Partie 4: Méthode de conditionnement afin de déterminer l'efficacité spectrale minimum d'essai

Reference number
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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

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 16890-4:2016), which has been technically revised.

The main changes are as follows:

— in 7.2 the dimensions of the conditioning cabinet are indicated in a more flexible way. This change does not affect the test, however, it does make the procedure more reasonable for the users;

— 9.1 has been reworded to remove duplicate information and some parts have been moved to a new subclause 9.3;

— in 9.2 a sentence has been added to make the proper procedure clear to the users.

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. Different classes of PM 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 (EU) define PM_{10} as PM 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 PM and the gravimetric mass determination (see Reference [7]).

As the precise definition of PM_{10}, $PM_{2,5}$ and PM_1 is quite complex and not easy to measure, public authorities, such as the U.S. EPA or the German Federal Environmental Agency (Umweltbundesamt), increasingly use in their publications the simpler denotation of PM_{10} as being the particle size fraction less than 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.

PM 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 as shown in Table 1.

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 PM. 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 PM. Current regional standards are applying completely 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 show better filtration performance than the 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 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 PM 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 this document 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 can possibly 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 (e.g. $e\text{PM}_1$ 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 ISO 16890-3.

The results from this document can also be used by other standards that define or classify the fractional efficiency in the size range of 0,3 µm to 10 µm when electrostatic removal mechanism is an important factor to consider, for example ISO 29461.

The performance results obtained in accordance with the 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 4:
Conditioning method to determine the minimum fractional test efficiency

1 Scope

This document establishes a conditioning method to determine the minimum fractional test efficiency.

It is intended to be used in conjunction with ISO 16890-1, ISO 16890-2 and ISO 16890-3, and provides the related test requirements for the test device and conditioning cabinet as well as the conditioning procedure to follow.

The conditioning method described in this document is referring to a test device with a nominal face area of 610 mm × 610 mm (24 inches × 24 inches).

This document refers to particulate air filter elements for general ventilation having an $e\text{PM}_1$ efficiency less than or equal to 99 % and an $e\text{PM}_{10}$ efficiency greater than 20 % when tested according to the procedures defined within the ISO 16890 series.

NOTE The lower limit for this test procedure is set at a minimum $e\text{PM}_{10}$ efficiency of 20 % since it will be very difficult for a test filter element below this level to meet the statistical validity requirements of this procedure.

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

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

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
minimum fractional test efficiency
fractional efficiency measured according to ISO 16890-2 after applying the conditioning method defined in this document

[SOURCE: ISO 29464:2017, 3.2.108]

4 Symbols and abbreviated terms

IPA	isopropyl alcohol (isopropanol)
MSDS	material safety data sheet

5 General conditioning test requirements

5.1 General

The conditioning procedure is used to determine the minimum fractional test efficiency and to test whether the filter fractional efficiency is dependent on the electrostatic removal mechanism. This is accomplished by measuring the removal efficiency of an untreated filter and the corresponding efficiency after conditioning.

Many types of air filters rely to different extents on the effects of passive electrostatic charges on the fibres to achieve higher particle removal efficiencies, particularly in the initial stages of their working life, at low resistance to airflow.

Exposure to some types of challenges, such as combustion particles, fine particles or oil mist in service can affect the action of these electric charges so that the initial efficiency can drop substantially after an initial period of service. This drop in the fractional efficiency can be reduced by a slight increase in mechanical efficiency from the collection of particles in the filtration media. The amount of the drop and the amount of the increase can vary by filter type, service location and atmospheric air conditions.

The procedure described in this document indirectly but quantitatively shows the extent of the electrostatic charge effect on the initial performance on a full-size filter (measured according to ISO 16890-2). It indicates the level of efficiency obtainable with the charge effect removed [or minimized by isopropyl alcohol (IPA, commonly known as isopropanol or 2-propanol) vapour conditioning] and with no increase in mechanical efficiency. It should not be assumed that the measured conditioned ("discharged") efficiency always represents real life behaviour. The treatment of a filter as described in this document can affect the structure of the fibre matrix or chemically affect the fibres or even fully destroy the filter medium. Hence, this procedure shall not be applicable to all types of filters. If degradation shows a visual, physical change or a resistance to airflow change of more than 10 % and a minimum 10 Pa change, this document is not applicable and the filter shall not be classified according to ISO 16890-1.

5.2 Test device requirements

The test device shall be designed or marked so as to prevent incorrect mounting. The complete test device (filter 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.

5.3 Test device selection

The test device shall be mounted in accordance with the manufacturer's specifications and, after equilibration to standard climatic conditions, weighed to the nearest gram. Before starting the conditioning, the initial resistance to airflow and initial fractional efficiency shall be determined according to the measurement procedure described in ISO 16890-2.

The test device shall be a full-size filter element with a nominal face dimension of 610 mm × 610 mm (24 inches × 24 inches) with a maximum length (depth) of 760 mm (29.9 inches). If for any reason, dimensions do not allow conditioning of a test device under standard test conditions, assembly of two or more smaller devices of the same type or model is permitted, provided no leaks occur in the resulting assembly. For filters with a higher length or depth, the conditioning cabinet described in 7.1 can be scaled accordingly. The operating conditions of such accessory equipment shall be recorded.

5.4 Conditioning cabinet requirements

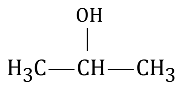
Critical dimensions and arrangements of the conditioning cabinet are shown in Figure 1 and Figure A.1 and are intended to help construct a conditioning cabinet to meet the performance requirements of this document. All dimensions shown are mandatory unless otherwise indicated. Units shown are in mm (inches) unless otherwise indicated.

The design of equipment not specified (including but not limited to the holding frame, IPA trays, conditioning cabinet surroundings and auxiliaries) is discretionary, but the equipment shall have adequate capacity to meet the performance and health and safety requirements described in Clause 8.

6 Conditioning materials

The liquid for the conditioning step to discharge filter media and equalize electrostatic surface charges on the filter fibres is IPA. IPA is placed inside the conditioning cabinet to evaporate until the equilibrium of IPA vapour in ambient air is reached so that liquid IPA will not be in contact with the filter media. Refer to Clause 8 for safety issues.

Isopropanol (IPA) – formula: C_3H_8O



Isopropanol properties:

Density	785,5 kg/m^3 (49 lb/ft^3)
Molecular weight	60,09 g/mol
Melting point	185 K
Boiling point	355 K
Flash point	285 K
Ignition temperature	698 K
Vapour pressure	0,059 7 bar [a] (at 298 K)/0,043 2 bar (at 293 K)/0,081 4 bar (at 303 K)

To be calculated as follows:

$$\log_{10}(P) = A - \frac{B}{T + C}$$

where

P is pressure (bar)

T is temperature (K)

A is 4,577 95

B is 1 221,423

C is −87,474

NOTE 1 bar = 100 kPa.

Explosion limits (in air)	Lower concentration limit 2 % (vol.), upper concentration limit 12 % (vol.) both at 293 K
CAS Registry Number® [b]	67-63-0

[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

[b] CAS Registry Number® is a trademark of CAS corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

For the conditioning test, IPA shall have a purity of minimum 99,5 %.

7 Conditioning cabinet

7.1 General

The conditioning cabinet shall consist of a filter holding chamber and one or two IPA tray holding chambers. Each chamber may have separate doors for service. The filter holding chamber shall allow the installation of a full-size filter (the test device) in a way that the filter does not touch the conditioning cabinet walls and allows air/vapour to pass around freely by diffusion. There shall be an open-air passage between the IPA tray holding chamber and the filter holding chamber to guarantee that the mixture of air and IPA vapour can equilibrate in the whole conditioning cabinet volume as easily as possible. To make sure that test devices with non-rigid, self-supporting structures, such as bag filters, are installed in the proper way and offer the full media surface to the air/vapour mixture, the filter holding frame is in a horizontal position and the test device is hanging vertically (dust air side of the filter to the top, clean air side to the bottom of the chamber).

7.2 Conditioning cabinet dimensions and construction materials

The conditioning cabinet shall be made of stainless or galvanized steel. IPA vapour is denser than air and can stratify within the chamber, possibly causing all areas of the filter not to be subjected to the concentration of IPA vapour. Therefore, the positioning of several IPA trays inside the IPA holding chamber of the cabinet is adjacent to the filter holding chamber, so that an equal distribution of IPA vapour within the cabinet is achieved quickly.

The conditioning cabinet shall be capable of containing a full-size filter with face dimensions of 610 mm × 610 mm (24 inches × 24 inches). The maximum length/depth of the test device shall be 760 mm (29.9 inches). To allow the air to pass freely around the test device by diffusion, the outer filter holding chamber volume shall be between 0,45 m^3 (15.9 ft^3) and 0,65 m^3 (23.0 ft^3). The filter holding chamber recommended dimensions are 750 mm × 750 mm × 850 mm (29.5 inches × 29.5 inches × 33.5 inches).

Figure 1 shows the recommended size and dimensions of the conditioning cabinet.