*भारतीय मानक*

***Indian Standard***

**IS 17570 (Part 4) : 2024**
**ISO 16890-4 : 2022**

# सामान्य संवातन के लिए एयर फिल्टर

## भाग 4 न्यूनतम भिन्नात्मक परीक्षण दक्षता ज्ञात करने के लिए कंडीशनिंग पद्धति

*( पहला पुनरीक्षण )*

# Air Filters for General Ventilation

## Part 4 Conditioning Method to Determine the Minimum Fractional Test Efficiency

*( First Revision )*

ICS 91.140.30



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Refrigeration and Air Conditioning Sectional Committee, MED 03

NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical to ISO 16890 (Part 4) : 2022 ‘Air filters for general ventilation — Part 4: Conditioning method to determine the minimum fractional test efficiency’, issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on recommendation of the Refrigeration and Air Conditioning Sectional Committee and approval of the Mechanical Engineering Division Council.

This standard was first published in 2021. The first revision of the standard has been brought to adopt ISO 16890 (Part 4) : 2022 ‘Air filters for general ventilation — Part 4: Conditioning method to determine the minimum fractional test efficiency’.

This standard is one of the series of Indian Standards on air filters for general ventilation. The other parts in this series under the general title are as follows:

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

Part 2 Measurement of fractional efficiency and air flow resistance (ISO 16890-2 : 2016, MOD)

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

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminologies and conventions are, however, not identical to those used in Indian Standard. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear, referring to this standard, they should be read as ‘Indian Standard’; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

The Committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

| *International Standard* | *Title* |
|---|---|
| ISO 16890-2 : 2016 | Air filters for general ventilation — Part 2: Measurement of fractional efficiency and air flow resistance |

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded-off value should be the same as that of the specified value in this standard.

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# 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 |
|---|---|
| $ePM_{10}$ | $0,3 \leq x \leq 10$ |
| $ePM_{2,5}$ | $0,3 \leq x \leq 2,5$ |
| $ePM_1$ | $0,3 \leq x \leq 1$ |

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 $ePM_x$ 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 shall 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 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.

*Indian Standard*

# AIR FILTERS FOR GENERAL VENTILATION

## PART 4 CONDITIONING METHOD TO DETERMINE THE MINIMUM FRACTIONAL TEST EFFICIENCY

*( First Revision )*

## 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.

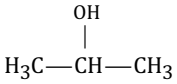
### 5.4 Conditioning cabinet requirements

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.

Dimensions in millimetres

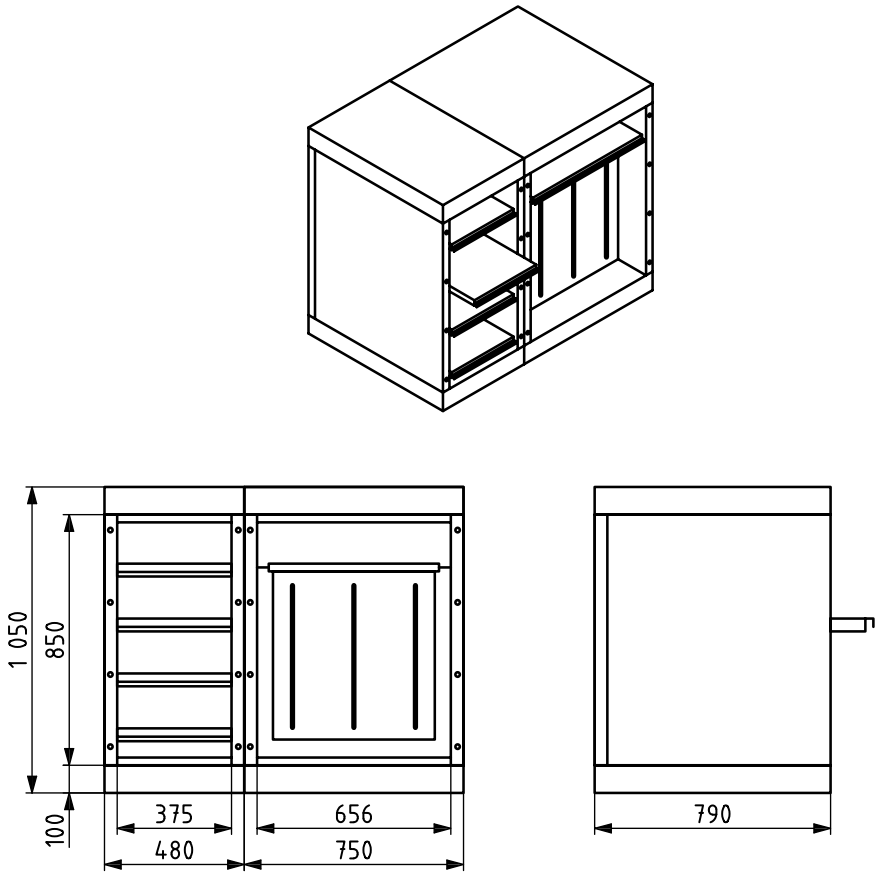



**Figure 1 — Conditioning cabinet schematic drawing**

To make sure that the air inside the conditioning cabinet is saturated with IPA very quickly, a total of at least 1 $dm^3$ (34 fl oz) liquid IPA shall be filled into the trays before starting the conditioning. The trays shall offer at least 1,0 $m^2$ (10.8 $ft^2$) free surface area for IPA evaporation. Each tray shall be filled with liquid IPA and covered before starting the conditioning procedure. The mixture of ambient air and IPA in the conditioning cabinet shall not interact with the ambient air (proper seal).

NOTE For 1 $dm^3$ of IPA the weight is equal to 786 g (27.7 oz).

The container with IPA shall not come into direct contact with sunlight or any other heat radiation that can alter the vapour characteristics significantly. Respecting these conditions and controlling the temperature and humidity within the specified ranges, there is no need for instrumentation to verify the IPA vapour concentration surrounding the test device as the air in the chamber is almost saturated with IPA vapour.

The trays with liquid IPA shall be uncovered and placed inside the filter housing. After closing the tray section door, wait for 30 min. Then open the filter section door and place the test device inside (upstream side towards IPA – vertical/horizontal).

Close the filter section door tightly. Once the conditioning time is reached, open the filter section door and immediately remove the test device. Finally, pull out the IPA trays, cover them and store them in the extraction hood.

## 7.3 Environment, temperature and relative humidity

The room air where the conditioning cabinet is installed shall be controlled at (25 ± 5) °C [(77 ± 9) °F], with a relative humidity of (40 ± 20) %. The room air temperature is especially sensitive to evaporation and diffusion processes within the conditioning cabinet, and shall be reported continuously or at least

hourly. The temperature measurement device shall be accurate to within ±1 °C (1.8 °F). The relative humidity measurement device shall be accurate to within ±2 %. The temperature and relative humidity measurement devices shall be calibrated yearly. More frequent calibration can be needed in places where the relative humidity changes significantly by season.

Standard climatic conditions for equilibration with room air shall be (23 ± 5) °C [(73 ± 9) °F] with a relative humidity of (45 ± 10) %.

## 8 Safety issues

This conditioning test requires the use of health hazard reagents (IPA). This document does not claim to treat all possible related health and safety issues.

It is in the responsibility of the user of this document to take suitable measures for the health and safety protection of staff before applying this method. Additionally, it is presupposed that the responsible user takes into consideration official and legal regulations. See Annex A for safety recommendations.

## 9 Test method

### 9.1 General

The described procedure is based on a standardized treatment with IPA to evaluate electrostatic influence on the fractional efficiency of a full-size filter.

The IPA test is made by first measuring the fractional efficiency of an untreated filter. Next, the test device is conditioned with IPA vapour. If IPA is reused, the IPA purity shall remain above 99,5 %. After the filter has been exposed to the IPA vapour, it is placed under standard climatic conditions for at least 30 min. Then the fractional efficiency measurements are repeated according to ISO 16890-2, using the same method and test aerosol as applied for the initial fractional efficiency test before conditioning. To verify that the sample is free from residual IPA, the sample is purged for 10 min with test air at (23 ± 5) °C [(73 ± 9) °F] and a relative humidity of (45 ± 10) % and the fractional efficiency test is repeated.

The IPA vapour treatment is made using the conditioning cabinet described in Clause 7. This system includes several trays/vessels for the liquid IPA. The filter shall be subjected to several additional tests and it is imperative that the filter be preserved in an undamaged, uncontaminated condition for the duration of the planned total test program.

### 9.2 Conditioning procedure

The conditioning procedure for the test device shall follow the listed steps.

a) Equilibrate the test device under standard climatic conditions for at least 30 min. Weigh the test device to the nearest gram and measure the initial fractional efficiency and the resistance to airflow values for the new untreated device according to ISO 16890-2 (if not yet done).

b) Fill the trays with IPA respecting the minimum requirement of Clause 7. Weigh each tray to the nearest gram (respecting safety issues according to Clause 8).

c) Place one IPA tray after the other inside the chamber and remove its cover. Close the tray section door and wait for 30 min.

d) Open the filter section door and immediately insert the test filter in place. Make sure that the filter is installed in a way that the levelling of the IPA concentration within the conditioning cabinet by diffusion is easily possible (no blockage). Close the filter section door and tighten the curl knobs.

e) Set the conditioning time on the timer to 24 h and start the conditioning procedure; test device exposed to saturated IPA vapour/air mixture at (25 ± 5) °C [(77 ± 9) °F] run for 24 h. Room climatic conditions including barometric pressure shall be reported (and controlled if necessary).

f) Once conditioning time is reached, open the filter section door and immediately remove the test filter. Close the filter section door and tighten the curl knobs.

g) Equilibrate the test device under standard climatic conditions for at least 30 min.

h) Pull out the IPA trays and place them covered inside the extraction hood. Weigh each tray to the nearest gram to determine the amount of IPA evaporated.

i) Weigh the filter to the nearest gram and measure the fractional efficiency and resistance to airflow according to ISO 16890-2. After purging for 10 min, the fractional efficiency test is repeated once more.

j) As an additional indication for full discharge by conditioning, a third fractional efficiency test at 50 % air flow rate shall be performed. When the efficiency curves show a variation > 5 percentage points for 0,4 µm, the same test device shall be conditioned for another 24 h. Repeat the same until the 0,4 µm efficiency measured at 100 % and 50 % air flow rate differs less than 5 percentage points. If the 5 percentage point criterion cannot be met then the filter is not classifiable per ISO 16890-1. The 50 % air flow efficiency shall be run according to ISO 16890-2 with the system airflow set to 50 % of the original airflow and shall use a particle counter correlation per ISO 16890-2 which shall be determined at 50 % of the original airflow. For this 50 % airflow efficiency, ISO 16890-2:2016, 9.2 is not required.

NOTE It is expected that the filter will discharge in one iteration but it can take more. If the discharge is not complete after five iterations, then it is unlikely the filter will ever discharge completely.

### 9.3 Repeat testing

A test including conditioning on a second new test device shall be done when one or more of the following criteria occurs:

a) the change in weight is more than ±1 % or exceeds the maximum of ±20 g (0.71 oz); or

b) the resistance to airflow has changed by more than ±10 % or exceeds ±10 Pa (0.04 inches $H_2O$); or

c) the fractional efficiency for 0,4 µm has changed more than ±5 % in measured efficiency percentage points after purging.

If the required accuracy in one or more of the criteria above cannot be met, the test shall be stopped to find out if the filter media or filter construction is affected by the IPA vapour or if the qualification test shows a mismatch of the test rigs and procedures.

## 10 Qualification

The temperature measuring and the relative humidity sensors shall be checked and calibrated a minimum of once a year.

All other instruments used in this method shall be calibrated and maintained according to the manufacturer's specifications.

Air tightness of the conditioning cabinet shall be checked by a leakage test on a regular basis, equivalent to the leak test described in ISO 16890-2. In order to avoid unnecessary spillage of IPA-vapour, to reduce explosion risk and exposure of persons to IPA-vapour, the cabinet shall be sealed such that an applied overpressure of 200 Pa (0.80 inches $H_2O$) will not drop more than 30 Pa (0.12 inches $H_2O$) in 1 min. This is what an airtight construction allows and this will lead to a maximum 30 g (1.06 oz) IPA loss during a 24 h conditioning cycle.

The conditioning cabinet owner/operator shall always have a qualification testing report available documenting the results of the latest qualification testing.

## 11 Reporting results

Test results shall be reported using the test report format of ISO 16890-2 for fractional efficiency and resistance to airflow, which includes information about the filter manufacturer, the filter model and description.

The following additional information about the conditions during conditioning and test data shall be reported:

a) range of room air temperature, relative humidity and barometric pressure during conditioning time with respect to the given limits;

b) purity of IPA liquid (min 99,5 %);

c) time of exposure/conditioning;

d) conditioning cabinet description including photos and/or drawings with information about the main dimensions, volume of the cabinet, the amount of IPA trays, evaporation surface (number and size of the trays) and amount of IPA filled into trays with respect to the minimum criteria of Clause 7;

e) test device weight before and after conditioning and the weight of the IPA trays before and after conditioning to determine the evaporated amount of IPA;

f) test device resistance to airflow at rated air flow rate before and after conditioning. Data values for resistance to airflow shall be reported as whole number values only (no decimal or fractions) when displayed in SI units (Pa) or to two decimal places in IP units (inches $H_2O$) (see ISO 16890-2);

g) test device fractional efficiency curve at rated air flow rate before and after conditioning including measurement at 50 % rated air flow rate after conditioning. All data values for fractional efficiency shall be reported as whole number values only (no decimal or fractions);

h) additional remarks.

# Annex A
(informative)

# Recommendations for health and safety aspects for the use of IPA

## A.1 Possible measures to deal with health and safety risks of IPA

Mixtures of air and IPA vapour form an explosion hazard within the explosion limits of IPA in air and IPA vapour/saturation air ratio (see Clause 6).

Due to a possible explosion hazard as a result of the mixture of air and IPA vapour around the conditioning cabinet, a declaration of an explosion zone can be required, which leads to numerous preventive actions, e.g. switching off every kind of ignition source, grounding the cabinet.

Due to the risk of explosion, all single parts of the conditioning cabinet should be grounded to prevent electrostatic charging of surfaces.

The conditioning cabinet itself should be placed under a local exhaust ventilation device such as a ventilation hood or similar to ventilate the area from IPA vapour during conditioning and especially when opening the doors of the cabinet.

When handling liquid IPA, it is important to wear personal protective equipment such as gloves and a protection mask to avoid inhaling the vapour. This should be respected for the entire operation. The MSDS should be respected and placed onto the conditioning cabinet.

Furthermore, the user of this document should be aware of national and local regulations referring to health and safety, such as maximum workplace concentration, to avoid health and safety problems when carrying out these tests.

The user of this document should be aware of safety measures, e.g. using explosion protected equipment (pump, valves), grounding all parts of the equipment, avoiding or reduction of non-groundable surfaces, taking into account local explosion safety rules and guidelines.

The user of this document should be aware of whether venting of the IPA-air mixture to the outside is allowed according to local rules and legislation. It is recommended that professionals are consulted for health and safety.

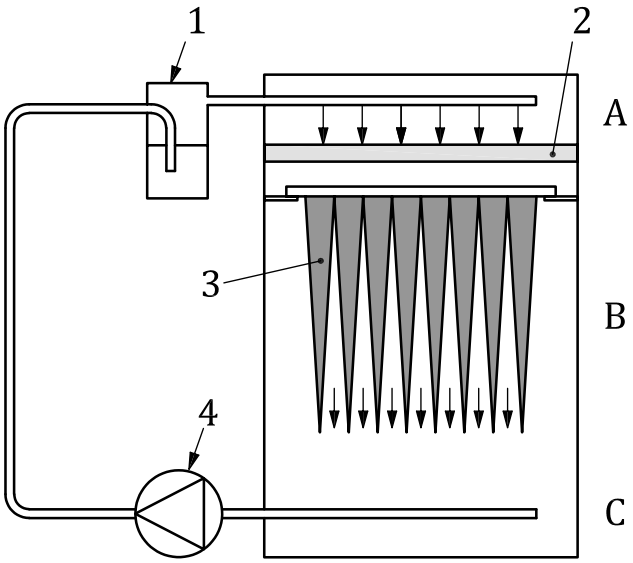
The filling of the trays should be done under an extraction hood.

## A.2 Alternative conditioning cabinet

An alternative conditioning cabinet design may be applied, if the user can attest that with the alternative design the same results are achieved as with use of the cabinet defined in this document (see Clause 7).

This can be an outcome of a detailed plan of measures for the health and safety protection of the staff. The following alternative was discussed in the working group.

The cabinet consists of three sections as described in Figure A.1.




**Key**

A distribution and droplet elimination section on top including minimum of three tubes with holes

B filter holding chamber in the middle

C collection section for recirculating air on the bottom

1 evaporator Laskin nozzle

2 filter media pad (at least 50 % $ePM_{10}$) between two metal grids

3 test device

4 compressor (explosion-proof, volume flow rate 25 $dm^3$/min)

**Figure A.1 — Schematic view of conditioning cabinet and IPA-vapour system**

The IPA-vapour atmosphere in this conditioning cabinet is created by recirculation of the air through three units with Laskin nozzles in liquid IPA. The air coming out of the Laskin units will be saturated with IPA and can additionally contain IPA aerosol. Any IPA aerosol will be caught by the filter media pad in the top section A of the cabinet and evaporate subsequently. The air in the cabinet will be saturated with IPA depending on the air exchange ratio in the cabinet. After an exposure time of 24 h, the air in the cabinet can be drained using the recirculation pump, which should have an air flow which will result in an air exchange rate in the cabinet of > 3,5 times the chamber volume per hour. After 30 min of recirculating fresh air, the IPA concentration in the cabinet and the test sample is so low that the cabinet can be opened without risk of explosion or health issues and the test sample can be measured without delay.

# Bibliography

[1] ISO 29461, *Air intake filter systems for rotary machinery — Test methods*

[2] ISO 29463 (all parts), *— High-efficiency filters and filter media for removing particles in air*

[3] ANSI/ASHRAE 52.2, *Method of testing general ventilation air-cleaning devices for removal efficiency by particle size*

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

[5] ISO 16890-3, *Air filters for general ventilation — Part 3: Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured*

[6] EN 12341, *Ambient air - standard gravimetric measurement method for the determination of the $PM_{10}$ or $PM_{2,5}$ mass concentration of suspended particulate matter*

[7] EU Council Directive 1999/30/EC of 22 April 1999 – *Relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air*

[8] ISO 29464:2017, *Cleaning of air and other gases — Terminology*

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