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Particulate air filters for general ventilation — Determination of the filtration performance

Filtres à air de ventilation générale pour l'élimination des particules — Détermination des performances de filtration

Please see the administrative notes on page iii

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In accordance with the provisions of Council Resolution 15/1993, this document is **circulated in the English language only**.

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 21220 was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

Introduction

The procedures described in this International Standard have been developed from those given in EN 779 and ANSI/ASHRAE 52.2 and includes testing of performance of air filters mainly used in general ventilation applications.

Representative samples of particles upstream and downstream the filters are analysed by an optical particle counter (OPC) to provide filter particle size efficiency data.

Classification or rating of air filters is determined by national bodies or other associations and is not a part of this International Standard.

A brief principle description of the method is given in Annex C.

Initiatives to address certain filtration characteristics, such as the potential problems of particle re-entrainment, shedding and the in-service charge neutralization characteristics of certain types of media, have been included in Annexes A and B.

Certain types of filter media rely on electrostatic effects to achieve high efficiencies at low resistance to air flow. Exposure to some types of challenge, such as combustion particles or other fine particles, can inhibit such charges with the result that filter performance suffers. The normative test procedure, described in Annex A, provides techniques for identifying this type of behaviour. This procedure is used to determine whether the filter efficiency is dependent on the electrostatic removal mechanism and to provide quantitative information about the importance of the electrostatic removal. The procedure is selected because it is well established, reproducible, simple to perform, relatively quick and because an acceptable alternative procedure is not available.

In an ideal filtration process, each particle would be permanently arrested at the first contact with a filter fibre, but incoming particles can impact a captured particle and dislodge it into the air stream. Fibres or particles from the filter itself can also be released, due to mechanical forces. From the user's point of view, it can be important to know this; see Annex B.

Annexes A and D form a normative part of this International Standard.

Annexes B and C are for information only.

Particulate air filters for general ventilation — Determination of the filtration performance

1 Scope

This International Standard refers to particulate air filters for general ventilation. It describes testing methods and the test rig for measuring filter performance. The test rig is designed for an air flow rate 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).

This International Standard applies to air filters having an initial efficiency of less than 99 % with respect to 0,4 µm particles. Filters in the higher end and above 99 % initial efficiency are tested and classified according to other standards.

Two test methods are combined in this International Standard: a “fine method” for air filters in the higher efficiency range and a “coarse method” for lower efficiency filters. In either case, a flat sheet media sample or media pack sample from an identical filter shall be conditioned (discharged) to provide information about the intensity of the electrostatic removal mechanism.

After determination of its initial efficiency, the untreated filter is loaded with synthetic dust in one step until its final test-pressure drop is reached. Information on the loaded performance of the filter is then obtained.

The performance results obtained in accordance with this International Standard cannot, by themselves, be quantitatively applied to predict performance in service with regard to efficiency and lifetime. It is necessary to take into account other factors influencing performance, as described in Annexes A and B.

2 Normative references

The following referenced documents are indispensable for the application 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 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

3 Terms and definitions

3.1
arrestance
weighted (mass) removal of loading dust

3.2
average arrestance
ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to final test pressure drop

3.3
charged filter
filter in which the filter media is electrostatically charged or polarized

3.4
conditioned efficiency
efficiency of the conditioned filter media operating at an average media velocity corresponding to the test air flow rate in the filter

3.5
counting rate
number of counting events per unit of time

3.6
correlation ratio
ratio of downstream to upstream particle counts without the test filter in the test duct

3.7
DEHS
DES
liquid di(2-ethylhexyl)sebacate or bis(2-ethylhexyl)sebacate used for generating the DEHS test aerosol

See 9.2.1.

3.8
dust-holding capacity (deprecated)

See **test dust capacity** (3.35).

3.9
dust-loaded efficiency
efficiency of the filter operating at test flow rate and after dust loadings up to final test pressure drop

3.10
effective filtering area
area of filter medium in the filter that collects dust

3.11
efficiency

See **initial efficiency** (3.17), **conditioned efficiency** (3.4) or **dust-loaded efficiency** (3.9).

3.12
filter-face area
frontal face area of the filter including the header frame

NOTE The nominal values are 0,61 m × 0,61 m (24 in × 24 in).

3.13
filter-face velocity
air flow rate divided by the filter-face area

3.14
final filter
air filter used to collect the loading dust passing through or shedding from the filter under test

3.15
final pressure drop, recommended
maximum operating pressure drop of the filter as recommended by the manufacturer at rated air flow

3.16
final test pressure drop
pressure drop of the filter up to which the filtration performance is measured

3.17
initial efficiency
efficiency of the clean, untreated filter operating at the test air flow rate

3.18
initial pressure drop
pressure drop of the clean filter operating at the test air flow rate

3.19
isokinetic sampling
sampling of the air within a duct under conditions such that the probe inlet air velocity is the same as the velocity in the duct at the sampling point

3.20
KCl
solid KCl (potassium chloride) particles generated from an aqueous solution and used as test aerosol

3.21
loading dust
test dust specifically formulated for loading of the filter

NOTE Two types of loading dusts are used: ISO fine test dust is used for the loading of filters in accordance with the fine-dust method and ASHRAE dust is used for the filters tested in accordance with the coarse method.

3.22
mean diameter
geometric mean of the upper- and lower-limit diameters in a size range

3.23
medium velocity
air flow rate divided by the effective filtering area

NOTE The medium velocity is expressed to an accuracy of three significant figures.

3.24
minimum efficiency
lowest efficiency among the initial, conditioned or dust-loaded efficiencies

3.25
neutralization
bringing the aerosol to a Boltzmann charge equilibrium distribution with bipolar ions

3.26
particle bounce
behaviour of particles that impinge on the filter without being retained

3.27
particle size
equivalent optical diameter of a particle

3.28
particle-number concentration
number of particles per unit volume of the test air

3.29
penetration
ratio of the particle concentration downstream to that upstream of the filter

3.30
re-entrainment
releasing of particles previously collected on the filter into the air flow

3.31
shedding
releasing of particles into the air flow due to particle bounce and re-entrainment as well as the release of fibres or particulate matter from the filter or filtering material

3.32
synthetic test dust

See **loading dust** (3.21).

3.33
test air flow rate
volumetric rate of air flow through the filter under test

3.34
test aerosol
aerosol used for determining the efficiency of the filter

3.35
test dust capacity
TDC
amount of loading dust kept by the filter at final test pressure drop

4 Symbols and abbreviated terms

For the application of this International Standard, the following symbols and abbreviated terms apply.

A	Arrestance, expressed in percent
A_{m}	Average arrestance during test to final test pressure drop, expressed in percent
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
CL	Concentration limits of particle counter
C_{V}	Coefficient of variation
$C_{\mathrm{V},i}$	Coefficient of variation in size range, i
c	Subscript indicating that the sample is conditioned
$c_{\mathrm{mean},i}$	Mean of measuring points value for size range, i
CAS	Chemical Abstracts Service
CEN	European Committee for Standardization
d_i	Geometric mean of a size range, expressed in micrometres
d_{l}	Lower-limit diameter in a size range, expressed in micrometres
d_{u}	Upper-limit diameter in a size range, expressed in micrometres
DHC	Dust holding capacity, replaced by test dust capacity, TDC

$\bar{E}_i$	Average efficiency in a size range, i
$\bar{E}_{i,\mathrm{c}}$	Average efficiency of conditioned samples in size range, i
$\bar{E}_{i,\mathrm{c},s}$	Efficiency of conditioned sample "s" in size range, i
$\bar{E}_{i,\mathrm{u}}$	Average initial efficiency of untreated samples in size range, i
$\bar{E}_{i,\mathrm{u},s}$	Initial efficiency of untreated sample "s" in size range, i
EN	European Standard
EUROVENT	European Committee of Air Handling and Refrigeration Equipment Manufacturers
ISO	International Organization for Standardization
IPA	Isopropanol
i	Subscript indicating the size range
m	Mass passing filter, expressed in grams
m_d	Mass of dust downstream of the test filter, expressed in grams
m_tot	Cumulative mass of dust fed to filter, expressed in grams
m_1	Mass of final filter before dust increment, expressed in grams
m_2	Mass of final filter after dust increment, expressed in grams
N_u	Number of particles upstream of the filter
$N_{\mathrm{u},i}$	Number of particles in size range, i, upstream of the filter
N	Number of points
N_d	Number of particles downstream of the filter
$N_{\mathrm{d},i}$	Number of particles in size range, i, downstream of the filter
$\bar{N}_\mathrm{d}$	Average number of particles downstream of the filter
N_u	Number of particles upstream of the filter
$N_{\mathrm{u},i}$	Number of particles in size range, i, upstream of the filter
$\bar{N}_\mathrm{u}$	Average number of particles upstream of the filter
n	Exponent; see Annex D
OPC	Optical particle counter
p	Pressure, expressed in pascals [inches water, gauge (inWG)]
p_a	Absolute air pressure upstream of filter, expressed in kilopascals [inches water, gauge (inWG)]
p_c	Average pressure drop of conditioned samples
$p_{\mathrm{c},s}$	Pressure drop of conditioned sample "s"
p_sf	Air flow meter static pressure, expressed in kilopascals (pounds per square inch)
p_u	Average initial pressure drop of untreated samples
$p_{\mathrm{u},s}$	Pressure drop of untreated sample "s"
PAO	Polyalphaolefins
q_m	Mass flow rate at air flow meter, expressed in kilograms per second (pounds per second)
q_V	Air flow rate at filter, expressed in cubic metres per second (cubic feet per minute)
q_Vf	Air flow rate at air flow meter, expressed in cubic metres per second (cubic feet per minute)
R	Correlation ratio
R_i	Correlation ratio for size range, i
s	Subscript indicating sample number (1, 2, 3, ...)

T Temperature upstream of filter, expressed in degrees Celsius (degrees Fahrenheit)

T_f Temperature at air flow meter, expressed in degrees Celsius (degrees Fahrenheit)

$t_{\left(1-\frac{\alpha}{2}\right)}$ Distribution variable

TDC Test dust capacity, expressed in grams

U Uncertainty, expressed in percent

v_{mean} Mean value of velocity, expressed in metres per second (feet per minute)

δ Standard deviation

ν Number of degrees of freedom

ρ Air density, expressed in kilograms per cubic metre (pounds per cubic foot)

φ Relative humidity upstream of filter, expressed in percent

Δm Dust increment, expressed in grams

Δm_{ff} Mass gain of final filter, expressed in grams

Δp Filter pressure drop, expressed in pascals [inches water, gauge (inWG)]

Δp_f Air flow meter differential pressure, expressed in pascals [inches water, gauge (inWG)]

$\Delta p_{1,20}$ Filter pressure drop at air density 1,20 kg/m^3, expressed in pascals [inches water, gauge (inWG)]

5 Requirements

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

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

6 Classification/Rating

Filters are not classified or rated in this International Standard.

Many national and association bodies use 0,944 m^3/s (2 000 ft^3/min or 3 400 m^3/h) as nominal air flow for classification or rating of air filters that have a nominal face area of 0,61 m × 0,61 m (24 in × 24 in). It is, therefore, recommended to test filters at 0,944 m^3/s (if the manufacturer does not specify any other flow for another application). The air flow velocity associated with the volumetric flow is 2,54 m/s (500 ft/min).

7 Test rig and equipment

7.1 Test conditions

Room air or outdoor air may be used as the test air source. Relative humidity shall be less than 65 % for the KCl efficiency measurement and less than 75 % in other tests. The exhaust flow may be discharged outdoors, indoors or recirculated. Requirements of certain measuring equipment can impose limits on the temperature of the test air.

Filtration of the exhaust flow is recommended when test aerosol, loading dust or smell from the filter can be present.

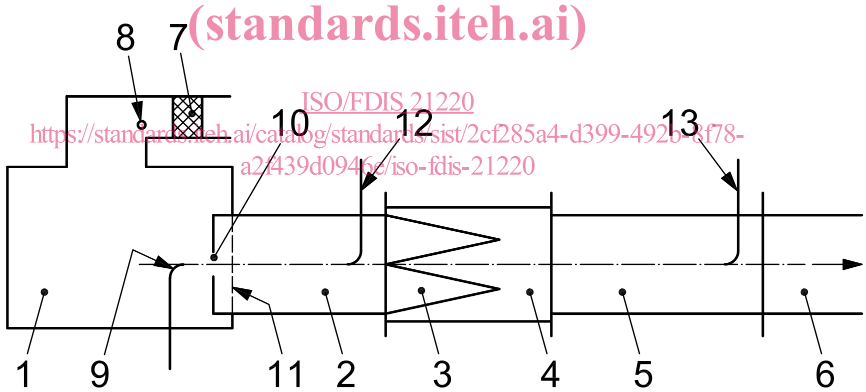
7.2 Test rig

The test rig (see Figure 1) consists of several square duct sections with 610 mm × 610 mm (24 in × 24 in) nominal inner dimensions except for the section where the filter is installed. This section has nominal inner dimensions between 616 mm (24,25 in) and 622 mm (24,50 in). The length of this duct section shall be at least 1,1 times the length of the filter, with a minimum length of 1 m (39,4 in).

The duct material shall be electrically conductive and electrically grounded, shall have a smooth interior finish and shall be sufficiently rigid to maintain its shape at the operating pressure. Smaller parts of the test duct may be made in glass or plastic to see the filter and equipment. Provision of windows to allow monitoring of test progress is desirable.

High-efficiency filters (Figure 1, key item 7) shall be placed upstream of the duct section 1 (Figure 1, key item 1), where the aerosol for efficiency testing is dispersed and mixed to create a uniform concentration upstream the filter.

The mixing orifice (Figure 1, key item 10) is located in the upstream part of duct section 2 (Figure 1, key item 2), in the centre of which is located the dust feeder discharge nozzle. Downstream of the dust feeder is a perforated plate (Figure 1, key item 11) intended to achieve a uniform dust distribution. In the last third of this duct section is the upstream aerosol sample head. For dust-loading tests, this sampling head shall be blanked off or removed.



Key

1	duct section 1 of the test rig (entry plenum)	8	inlet point for DEHS particles
2	duct section 2 of the test rig	9	dust injection nozzle
3	filter being tested	10	mixing orifice
4	duct section 3 including the filter to be tested	11	perforated plate
5	duct section 4 of the test rig	12	upstream sampling head
6	duct section 5 of the test rig	13	downstream sampling head
7	high-efficiency filter (at least 99,97 % on 0,3 µm particles)		

Figure 1 — Schematic diagram of the test rig

To avoid turbulence, the mixing orifice and the perforated plate should be removed during the efficiency test. To avoid systematic error, removal of these items during pressure-drop measurements is recommended.