

SLOVENSKI STANDARD

SIST EN 779:2004

01-maj-2004

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SIST EN 779:2000

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

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

Partikel-Luftfilter für die allgemeine Raumluftechnik - Bestimmung der Filterleistung

Filtres a air de ventilation général pour l'élimination des particules - Détermination des performances de filtration

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Ta slovenski standard je istoveten z: EN 779:2002

ICS:

91.140.30 Ú!^: !æ^çæ} ã Á|ã æ \ã Ventilation and air-conditioning
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English version

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

Partikel-Luftfilter für die allgemeine Raumluftechnik - Bestimmung der Filterleistung

This European Standard was approved by CEN on 14 September 2002.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 779:2002) has been prepared by Technical Committee CEN/TC 195 "Air filters for general air cleaning", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2003, and conflicting national standards shall be withdrawn at the latest by May 2003.

This European Standard deals with the performance testing of particulate air filters for general ventilation and supersedes EN 779:1993, which describes an obsolete test method.

EN 779 is based on the test method according to Eurovent 4/9:1997. In addition, it contains extensive test rig qualification procedures together with procedures which give some information regarding the real life behaviour of particulate air filters (see "Introduction").

Annex A is normative. Annexes B to E are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

General

The procedures described in this standard have been developed from those given in EN 779:1993 and Eurovent 4/9:1997. The basic design of test rig given in EN 779:1993 is retained with the exception of the “dust-spot” atmospheric aerosol opacity test equipment. Instead, a challenge aerosol of DEHS (or equivalent) is dispersed evenly across the duct upstream of the filter being tested. Representative upstream and downstream samples are analysed by an optical particle counter (OPC) to provide filter particle size efficiency data.

Classification

The EN 779:1993 classification system (comprising groups F and G filters) has been retained; classification is now determined from the average filtration efficiency with respect to liquid DEHS particles of 0,4 µm diameter. Classification of F filters is based on performance with respect to 0,4 µm particles because of practical evidence that the EN 779:1993 classification based on the “dust-spot” opacity test is very closely matched. Filters found to have an average efficiency value of less than 40 % will be allocated to group G and the efficiency reported as “< 40 %”. The classification of G filters is based on their average arrestance with the loading dust.

Test aerosol

A challenge aerosol of DEHS (or equivalent) was chosen for the efficiency test for the following reasons:

- experience has already been gained by users of the Eurovent 4/9 test method so that much suitable equipment already exists;
- liquid aerosols are easy to generate in the concentrations, size range and degree of consistency required;
- the DEHS could be used as a neutral test aerosol without charge or be charged to the Boltzmann equilibrium charge level. In this standard the aerosol should be brought to the Boltzmann charge distribution;
- spherical latex particles are used to calibrate particle counters. The determination of the particle size of spherical liquid particles using optical particle counters is more accurate than would be the case with solid particles of nonspherical salt and test dusts.

The aerosol should be brought to the Boltzmann charge distribution to represent the charge distribution of aged ambient atmospheric aerosol.

Filtration characteristics

Initiatives to address the potential problems of particle re-entrainment, shedding and the in-service charge neutralisation 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 in normal atmospheric air or oil mist, may neutralise such charges with the result that filter performance suffers. It is important that the users are aware of the potential for performance degradation when loss of charge occurs. It is also important that means be available for identifying cases where the potential exists. 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.

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

know this, but such behaviour would probably not be detected by a particle counter system according to this standard.

1 Scope

This European Standard refers to particulate air filters for general ventilation. These filters are classified according to their performance as measured in this test procedure.

This European Standard contains requirements to be met by particulate air filters. It describes testing methods and the test rig for measuring filter performance.

In order to obtain results for comparison and classification purposes, particulate air filters are tested against two synthetic aerosols, a fine aerosol for measurement of filtration efficiency as a function of particle size within a particle size range 0,2 μm to 3,0 μm , and a coarse one for obtaining information about dust holding capacity and, in the case of coarse filters, filtration efficiency with respect to coarse loading dust (arrestance).

This European Standard applies to air filters having an initial efficiency of less than 98 % with respect to 0,4 μm particles. Filters should be tested at an air flow rate between 0,24 m^3/s (850 m^3/h) and 1,5 m^3/s (5 400 m^3/h).

The performance results obtained in accordance with this standard cannot by themselves be quantitatively applied to predict performance in service with regard to efficiency and lifetime. Other factors influencing performance to be taken into account are described in annex A (normative) and annex B (informative).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1822-1, *High efficiency air filters (HEPA and ULPA) - Part 1: Classification, performance testing, marking.*

EN ISO 5167-1:1995, *Measurement of fluid flow by means of pressure differential devices - Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full (ISO 5167-1:1991).*

ISO 2854, *Statistical interpretation of data - Techniques of estimation and tests relating to means and variances.*

ISO 12103-1, *Road vehicles - Test dust for filter evaluation - Part 1: Arizona test dust.*

3 Terms and definitions

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

3.1 arrestance

weighted (mass) removal of loading dust (expressed in %)

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 pressure drop. Average arrestance is used for classification of G-filters (expressed in %)

3.3 average efficiency - E_m

weighted average of the efficiencies for the different specified dust loading levels up to final pressure drop. Average efficiency is used for classification of F-filters (expressed in %)

3.4**average efficiency - $E_{i,j}$**

average efficiency for a size range "i" at different dust loading intervals "j" (expressed in %)

3.5**charged filter**

filter which is electrostatically charged or polarised

3.6**coarse filter**

filter classified in one of the classes G1 to G4

3.7**counting rate**

number of counting events per unit of time

3.8**DEHS**

liquid (DiEthylHexylSebacate) for generating the test aerosol

3.9**dust holding capacity**

amount of loading dust retained by the filter up to final pressure drop (expressed in grams)

3.10**face area**

area of the inside section of the test duct immediately upstream of the filter under test (nominal values $0,61 \text{ m} \times 0,61 \text{ m} = 0,37 \text{ m}^2$)

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3.11**face velocity**

air flow rate divided by the face area (expressed in m/s)

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3.12**final filter**

air filter used to collect the loading dust passing the filter under test

3.13**final pressure drop - recommended**

maximum operating pressure drop of the filter as recommended by the manufacturer at rated air flow (expressed in Pa)

3.14**final pressure drop**

pressure drop up to which the filtration performance is measured for classification purposes (expressed in Pa)

3.15**fine filter**

filter classified in one of the classes F5 to F9

3.16**HEPA filter**

High Efficiency Particulate Air Filter, classes H10 to H14 according to EN 1822-1. A filter intended to purify the air upstream of the test circuit

3.17**ULPA filter**

Ultra Low Penetration Air Filter, classes U15 to U17 according to EN 1822-1

3.18

initial arresstance

arresstance of the first 30 g loading dust increment (expressed in %)

3.19

initial efficiency

efficiency of the clean filter operating at the test air flow rate (expressed in % for each size range of selected particles)

3.20

initial pressure drop

pressure drop of the clean filter operating at its test air flow rate (expressed in Pa)

3.21

isokinetic sampling

sampling of the air within a duct such the probe inlet air velocity is the same as the velocity in the duct at the sampling point

3.22

loading dust

synthetic test dust specifically formulated for determining the dust holding capacity and arresstance of the filter

3.23

mean diameter

geometric average of the size range diameter (expressed in μm)

3.24

media velocity

air flow rate divided by the net effective filtering area (expressed in m/s to an accuracy of three significant figures)

3.25

net effective filtering area

area of filter medium in the filter which collects dust (expressed in m^2)

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3.26

neutralisation

bringing the aerosol to a Boltzmann charge distribution (same amount of positive as negative ions in the aerosol)

3.27

particle bounce

it describes the behaviour of particles that impinge on the filter without being retained

3.28

particle size

equivalent optical diameter of a particle

3.29

particle number concentration

number of particles per unit of volume of the test air

3.30

penetration

ratio of the particle concentration downstream to upstream of the filter (expressed in %)

3.31

re-entrainment

releasing to the air flow of particles previously collected on the filter

3.32**shedding**

releasing to the air flow of particles due to particle bounce and re-entrainment effects, and to the release of fibres or particulate matter from the filter or filtering material

3.33**synthetic test dust**

dust specifically formulated for determining the dust holding capacity and arrestance of the filter

3.34**test air flow rate**

volumetric rate of air flow through the filter under test (expressed in m^3/s for a reference air density of $1,20 \text{ kg/m}^3$)

3.35**test aerosol**

aerosol used for determining the efficiency of the filter

3.36**test air**

air to be used for testing purposes

4 Symbols and abbreviated terms

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

A	Arrestance
A_j	Arrestance in loading phase "j", %
A_m	Average arrestance during test to final pressure drop, %
CL	Concentration limits of particle counter
CV	Coefficient of variation
CV_i	Coefficient of variation in size range "i"
DHC	Dust holding capacity, g
d_i	Size range diameter or mean diameter, μm
d_l	Lower border diameter in a size range, μm
d_u	Upper border diameter in a size range, μm
E_i	Initial efficiency, %
$E_{i,j}$	The average efficiency for size range "i" after dust loading phase "j", %
$E_{m,i}$	Average efficiency of size range "i" during test up to final pressure drop, %
E_m	Average efficiency of $0,4 \mu\text{m}$ particles during test up to final pressure drop (used for classification), %
\bar{E}	Average efficiency, %
F5 to F9	Fine filter classes
G1 to G4	Coarse filter classes
M_j	Mass of dust fed to the filter during loading phase "j", g
<i>mean</i>	Mean value
$mean_i$	Mean value in size range "i"
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
N_i	Number of particles in size range "i" upstream of the filter
n	Number of points
n_i	Number of particles in size range "i" downstream of the filter
OPC	Optical particle counter
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
$t(1 - \frac{\alpha}{2})$	Distribution variable
U	Uncertainty, % units
δ	Standard deviation
ν	Number of degrees of freedom
ρ	Air density of air, kg/m ³
ϕ	Relative humidity upstream of filter, %
Δm	Dust increment, g
Δm_{ff}	Mass gain of final filter, g
Δp	Filter pressure drop, Pa
Δp_f	Air flow meter differential pressure, Pa
$\Delta p_{1,20}$	Filter pressure drop 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
CAS	Chemical Abstracts
CEN	European Committee for Standardisation
EN	European Standard
EUROVENT	European Committee of Air Handling and Refrigeration Equipment Manufacturers
ISO	International Standards Organisation

NORDTEST Organisation for common test recommendations in Nordic countries

VTT Technical Research Centre of Finland

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 leak occurs at the sealing edge.

The complete filter (filter and frame) shall be made of material suitable to withstand normal usage and exposures to those temperatures, humidities and corrosive environments that are likely to be encountered.

The complete filter shall be designed so that it will withstand mechanical constraints that are likely to be encountered during normal use. Dust or fibres 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

Filters are classified according to their efficiency (arrestance) under the following test conditions:

- the air flow shall be 0,944 m³/s (3 400 m³/h) if the manufacturer does not specify any rated air flow rate;
- 250 Pa maximum final pressure drop for Coarse (G) filters;
- 450 Pa maximum final pressure drop for Fine (F) filters.

If the filters are tested at 0,944 m³/s and at maximum final pressure drops, they are classified according to Table 1. For instance G3, F7.

Filters tested at airflows and final pressure drops different from those above shall be classified according to Table 1. The classification shall be qualified by test conditions in parentheses, e.g. G4 (0,7 m³/s, 200 Pa), F7 (1,25 m³/s).

Table 1 — Classification of air filters according to EN 779

Class	Final pressure drop Pa	Average arrestance (A_m) of synthetic dust %	Average efficiency (E_m) of 0,4 μm particles %
G1	250	$50 \leq A_m < 65$	-
G2	250	$65 \leq A_m < 80$	-
G3	250	$80 \leq A_m < 90$	-
G4	250	$90 \leq A_m$	-
F5	450	-	$40 \leq E_m < 60$
F6	450	-	$60 \leq E_m < 80$
F7	450	-	$80 \leq E_m < 90$
F8	450	-	$90 \leq E_m < 95$
F9	450	-	$95 \leq E_m$

NOTE The characteristics of atmospheric dust vary widely in comparison with those of the synthetic loading dust used in the tests. Because of this the test results do not provide a basis for predicting either operational performance or life. Loss of media charge or shedding of particles or fibres can also adversely affect efficiency (see annexes A and B).

7 Test rig and equipment

7.1 Test conditions

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Room air or outdoor air may be used as the test air source. Relative humidity shall be less than 75 %. The exhaust flow may be discharged outdoors, indoors or recirculated. Requirements of certain measuring equipment may impose limits on the temperature of the test air.

Filtration of the exhaust flow is recommended when test aerosol and loading dust may be present.

7.2 Test rig

The test rig (see Figure 1) consists of several square duct sections with 610 mm \times 610 mm nominal inner dimensions except for the section where the filter is installed. This section has nominal inner dimensions between 616 mm and 622 mm. 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.

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

HEPA filters may be placed upstream of section 1, in which the aerosol for efficiency testing is dispersed and mixed to create a uniform concentration upstream the filter.

Section 2 includes in the upstream section the mixing orifice (10) in the centre of which the dust feeder discharge nozzle is located. Downstream of the dust feeder is a perforated plate (11) intended to achieve a uniform dust distribution. In the last third of this duct is the upstream aerosol sampling head. For arrestance tests, this sampling head shall be blanked off or removed.

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.

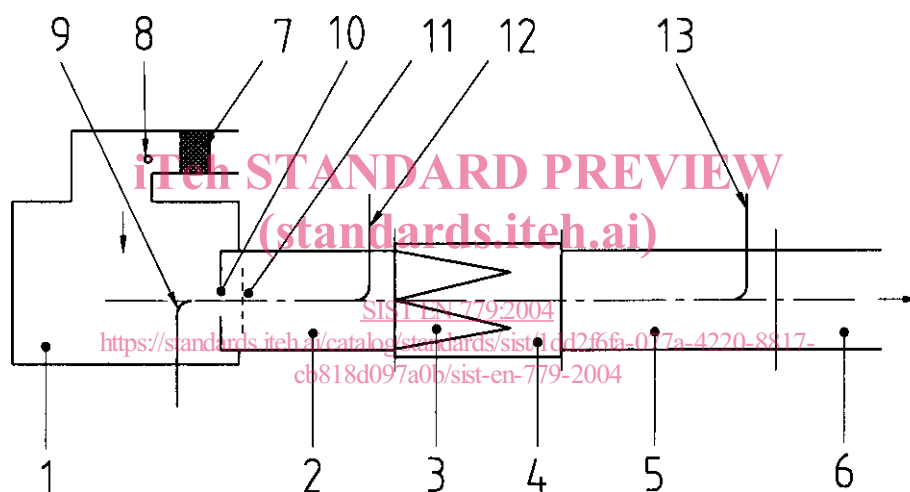
Section 5 may be used for both efficiency and arrestance measurements and is fitted with a final filter for the arrestance test and with the downstream sampling head for the efficiency test. Section 5 could also be duplicated, allowing one part to be used for arrestance test and the other for the efficiency test.

The test rig can be operated either in both negative or positive pressure. In the case of positive pressure operation (i.e. the fan upstream the test rig), the test aerosol and loading dust could leak into the laboratory, while at negative pressure particles could leak into the test system and affect the number of measured particles.

The dimensions of the test rig and the position of the pressure taps are shown in Figure 2.

The pressure drop of the tested filter shall be measured using static pressure taps located as shown in Figure 2. Pressure taps shall be provided at four points over the periphery of the duct and connected together by a ring line.

Section 6 is fitted with a standardised air flow measuring device. If an alternative air flow measurement device is used, this section can be shortened.



Key

- 1 Duct section of the test rig
- 2 Duct section of the test rig
- 3 Filter to be tested
- 4 Duct section including the filter to be tested
- 5 Duct section of the test rig
- 6 Duct section of the test rig
- 7 HEPA filter (at least H13)
- 8 Inlet point for DEHS particles
- 9 Dust injection nozzle
- 10 Mixing orifice
- 11 Perforated plate
- 12 Upstream sampling head
- 13 Downstream sampling head

Figure 1 — Schematic diagram of the test rig