

BS EN 779:2012



BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 779:2012. It supersedes BS EN 779:2002 which is withdrawn.

BS EN 779:2012 provides a system of checking the filtration performance of air filters used in air conditioning systems. The use of this revised version of BS EN 779 will ensure a more rigorous check of the quality and performance of air filters used in air conditioning systems. This in turn will result in improved air quality in indoor working environments.

The test procedures used in this standard are based on established techniques developed over decades, but using modern digital instrumentation. The multiple mechanisms involved in air filtration are complex and difficult to model, and consequently the testing techniques themselves have also become complex.

A result of this is that the performance grading of air filters cannot be carried out reproducibly in terms of their effectiveness in the removal of atmospheric particulate air pollution. Tests using artificial (synthetic) particulate contamination are used to grade these filters.

The BS EN 779:2012 test system grades (ranks) air filters according to their particulate removal capability. This varies and may increase or decrease significantly during the lifetime of the filter. Users of this standard need to be aware that the term 'average efficiency', which occurs in the classification table and in other places, is a test parameter that relates only to tests using artificial test contamination in artificial test conditions. The value of this parameter obtained in the test procedures does not correspond with or relate directly to the installed performance of air filters in ventilation systems. This value cannot be used to estimate or predict the effectiveness of these filters in removing particulate atmospheric pollution.

Conversely, the 'minimum efficiency' is a minimum performance criterion. Under normal operating conditions the particulate removal capability of the filter will not fall below this value.

BSI experts, together with experts in CEN and ISO, are actively supporting an ISO project to develop new performance criteria for air filters for use in general ventilation. The new standard is scheduled for publication in 2015 and will rank filters in terms of their performance in the removal of particulate air pollution.

The UK participation in its preparation was entrusted to Technical Committee MCE/21/3, Air filters other than for air supply for I.C. engines and compressors.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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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 April 2011.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Foreword

This document (EN 779:2012) has been prepared by Technical Committee CEN/TC 195 “Air filters for general air cleaning”, the secretariat of which is held by UNI.

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 October 2012, and conflicting national standards shall be withdrawn at the latest by October 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 779:2002.

EN 779:2012 is based on the test method according to EN 779:2002. 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”).

Annexes A to D 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, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

General

The procedures described in this standard have been developed from those given in EN 779:2002. The basic design of test rig given in EN 779:2002 is retained. A challenge aerosol of DEHS (or equivalent) is dispersed evenly across the duct upstream of the filter being tested. Representative upstream and downstream air samples are analysed by an optical particle counter (OPC) to provide filter particle size efficiency data.

Classification

The EN 779:2002 classification system (comprising groups F and G filters) has been changed to three groups (F-, M- and G-filters).

Filters found to have an average efficiency value of less than 40 % of 0,4 μm particles will be allocated to group G and the efficiency reported as "< 40 %". The classification of G filters (G1 - G4) is based on their average arrestance with the loading dust.

Filters found to have an average efficiency value from 40 % to less than 80 % of 0,4 μm particles will be allocated to group M (M5, M6) and the classification is based on their average efficiency (0,4 μm). The filter classes F5 and F6 have changed to M5 and M6, but with same requirements, as in the old classification system.

Filters found to have an average efficiency of 80 % or more of 0,4 μm particles will be allocated to group F (F7-F9) and the classification is based on their average efficiency (0,4 μm) as in the old system and the minimum efficiency during the test.

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 EN 779:2002 and Eurovent 4/9 test method so that much suitable equipment already exists.
- Liquid aerosols is easy to generate in the concentrations, size range and degree of consistency required.
- Undiluted DEHS is used to give a non charged aerosol.
- 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 non-spherical salt and test dusts.

Filtration characteristics

Initiatives to address the potential problems of particle re-entrainment and shedding from filters have been included in Annex A.

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.

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 discharge test procedure described 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.

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 shall be 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 test dust 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 shall be tested at an air flow rate between 0,24 m^3/s (850 m^3/h) and 1,5 m^3/s (5400 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 (informative).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 5167-1:2003, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements (ISO 5167-1:2003)*

ISO 2854:1976, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 12103-1:1997, *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*

3 Terms and definitions

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

3.1

arrestance

weighed (mass) removal of loading dust

3.2

average arrestance - A_m

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

Note 1 to entry: Average arrestance is used for classification of G-filters.

3.3

average efficiency - E_m

weighted average of the efficiencies of 0,4 μm particles for the different specified dust loading levels up to final test pressure drop

Note 1 to entry: Average efficiency is used for classification of M and F-filters.

3.4

average efficiency - $E_{i,j}$

average efficiency for a size range "i" at different dust loading intervals "j"

3.5

average discharged efficiency - $\bar{E}_{D,i}$

average efficiency for a size range "i" after discharging filter samples

3.6

average untreated efficiency - $\bar{E}_{U,i}$

average efficiency for a size range "i" of untreated filter samples

3.7

charged filter

filter which is electrostatically charged or polarised

3.8

coarse filter

filter classified in one of the classes G1 to G4

3.9

counting rate

number of counting events per unit of time

3.10

DEHS

liquid (DiEthylHexylSebacate) for generating the test aerosol

3.11

discharged efficiency

efficiency of filter media after having been discharged by isopropanol

3.12

test dust capacity

amount of loading dust retained by the filter up to final test pressure drop

3.13

efficiency

see initial efficiency, discharged efficiency, minimum efficiency and average efficiencies

3.14

face area

area of the inside section of the test duct immediately upstream of the filter under test

Note 1 to entry: Nominal values $0,61 \text{ m} \times 0,61 \text{ m} = 0,372 \text{ m}^2$.

3.15

face velocity

air flow rate divided by the face area

3.16

final filter

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

3.17

final pressure drop - recommended

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

3.18

final test pressure drop

pressure drop up to which the filtration performance is measured for classification purposes



3.19

fine filter

filter classified in one of the classes F7 to F9

3.20

HEPA filter

High Efficiency Particulate Air filter, classes H13 to H14 according to EN 1822-1

3.21

initial arrestance

arrestance of the first 30 g loading dust increment

3.22

initial efficiency

efficiency of the clean filter operating at the test air flow rate

Note 1 to entry: For each size range of selected particles.

3.23

initial pressure drop

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

3.24

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

3.25

loading dust

same as synthetic dust

3.26

mean diameter

geometric average of the size range diameter

3.27

media velocity

air flow rate divided by the net effective filtering area

Note 1 to entry: Expressed in m/s to an accuracy of three significant figures.

3.28

medium filter

filter classified in one of the classes M5 or M6

3.29

minimum efficiency

lowest efficiency among the discharged efficiency, initial efficiency and the lowest efficiency throughout the loading procedure of the test

Note 1 to entry: Minimum efficiency is used for classification of F-filters.

3.30

net effective filtering area

area of filter medium in the filter which collects dust

3.31

particle bounce

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

3.32

particle size

equivalent optical diameter of a particle

3.33

particle number concentration

number of particles per unit of volume of the test air

3.34

penetration

ratio of the particle concentration downstream to upstream of the filter

3.35

re-entrainment

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

3.36

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

3.37

synthetic dust

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

3.38

test aerosol

aerosol used for determining the efficiency of the filter

3.39

test air flow rate

volumetric air flow rate through the filter under test

Note 1 to entry: Expressed in m^3/s for a reference air density of $1,20 \text{ kg}/\text{m}^3$.

3.40

test air

air to be used for testing purposes

3.41

test dust capacity

amount of loading test dust kept by filter up to final test pressure drop

3.42

ULPA-Filter

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

3.43

untreated efficiency

efficiency of untreated filter samples

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 test 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 (deprecated). see <i>TDC</i>
d_i	Size range diameter or mean diameter in a size range "i", μm
d_l	Lower border diameter in a size range, μm
d_u	Upper border diameter in a size range, μm
E_i	Average initial efficiency of size range "i", %
$E_{i,j}$	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 test pressure drop, %
E_m	Average efficiency of 0,4 μm particles during test up to final test pressure drop (used for classification), %
$\bar{E}$	Average efficiency, %
$\bar{E}_{D,i}$	Average efficiency of conditioned (discharged) media samples for size range "i"
$\bar{E}_{D,s,i}$	Average efficiency of conditioned (discharged) media sample "s" and for size range "i"
$\bar{E}_{U,i}$	Average efficiency of untreated media samples for size range "i"
$\bar{E}_{U,s,i}$	Average efficiency of untreated media sample "s" and for size range "i"
F7 to F9	Fine filter classes
G1 to G4	Coarse filter classes
M5, M6	Medium filter classes
M_j	Mass of dust fed to the filter during loading phase "j", g
<i>mean</i>	Mean value
<i>mean_i</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
$p_{D,s}$	Pressure drop of conditioned (discharged) sample "s"
p_{sf}	Air flow meter static pressure, kPa
$p_{U,s}$	Pressure drop of untreated sample "s"
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
s	Subscript indicating sample number (1, 2, 3, ...)
t	Temperature upstream of filter, °C
t_f	Temperature at air flow meter, °C
$t(1 - \frac{\alpha}{2})$	Distribution variable
TDC	Test dust capacity, g
U	Uncertainty, % units
δ	Standard deviation
δ_i	Standard deviation for size range "i"
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 Service
CEN	European Committee for Standardization
EN	European Norm
EUROVENT	European Committee of Air Handling and Refrigeration Equipment Manufacturers
ISO	International Organization for Standardization

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 average efficiency or average 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 test pressure drop for Coarse (G) filters;
- 450 Pa maximum final test pressure drop for Medium (M) and Fine (F) filters.

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

Filters tested at airflows and final test pressure drops different from those above shall be classified according to Table 1, and 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 ¹⁾

Group	Class	Final test pressure drop Pa	Average arrestance (A_m) of synthetic dust %	Average efficiency (E_m) of 0,4 µm particles %	Minimum Efficiency ^a of 0,4 µm particles %
Coarse	G1	250	$50 \leq A_m < 65$	-	-
	G2	250	$65 \leq A_m < 80$	-	-
	G3	250	$80 \leq A_m < 90$	-	-
	G4	250	$90 \leq A_m$	-	-
Medium	M5	450	-	$40 \leq E_m < 60$	-
	M6	450	-	$60 \leq E_m < 80$	-
Fine	F7	450	-	$80 \leq E_m < 90$	35
	F8	450	-	$90 \leq E_m < 95$	55
	F9	450	-	$95 \leq E_m$	70

^a Minimum efficiency is the lowest efficiency among the initial efficiency, discharged efficiency and the lowest efficiency throughout the loading procedure of the test.

1) 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.

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 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 × 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.

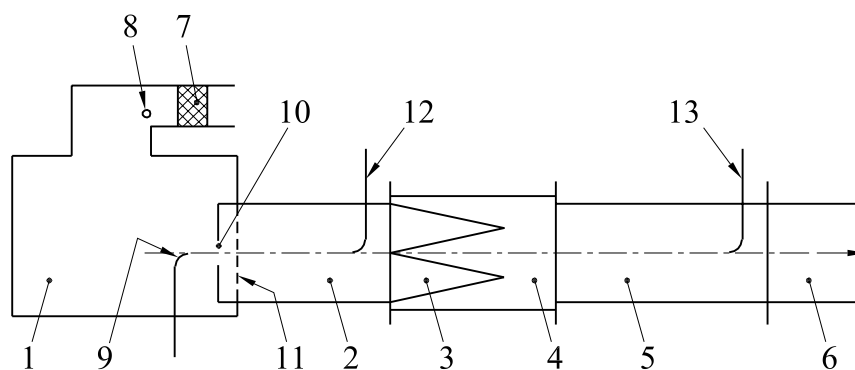
Section 5 may be used for both efficiency and arrestance measurements and is fitted with a final filter for the arrestance test and with the downstream sampling head for the efficiency test. Section 5 could also be duplicated, allowing one part to be used for arrestance test and the other for the efficiency 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 | 8 Inlet point for DEHS particles |
| 2 Duct section of the test rig | 9 Dust injection nozzle |
| 3 Filter to be tested | 10 Mixing orifice |
| 4 Duct section including the filter to be tested | 11 Perforated plate |
| 5 Duct section of the test rig | 12 Upstream sampling head |
| 6 Duct section of the test rig | 13 Downstream sampling head |
| 7 HEPA-Filter (at least H13) | |

Figure 1 — Schematic diagram of the test rig

Dimensions in millimetres

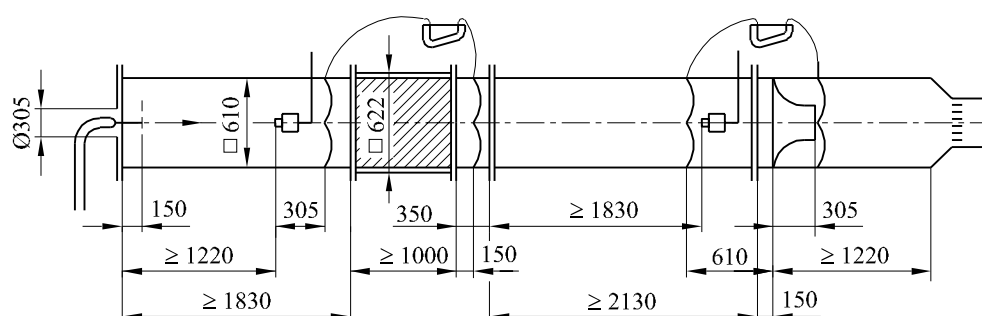
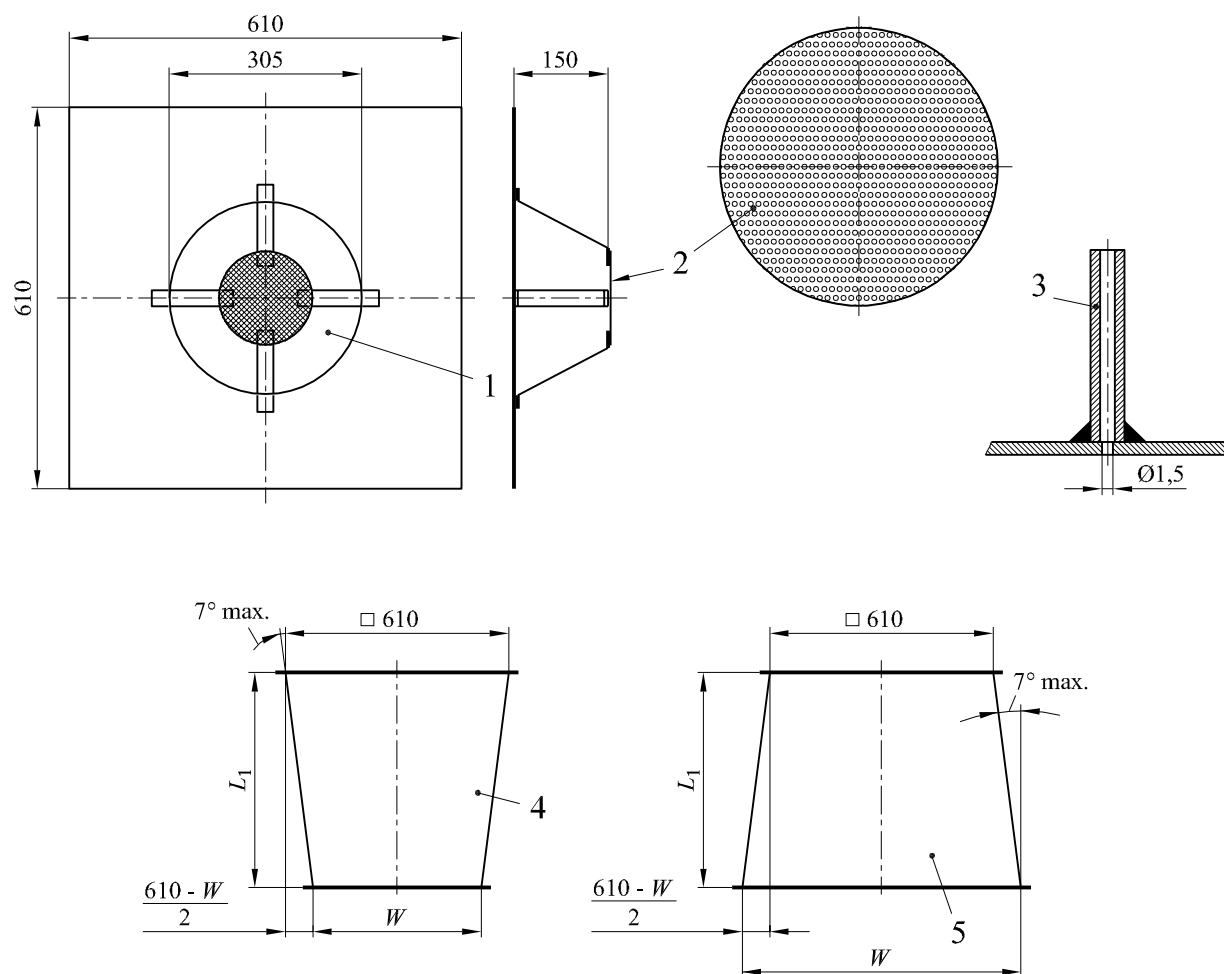


Figure 2 — Dimensions of the test rig

Dimensions in millimetres



Key

- 1 Mixing orifice
- 2 Perforated plate with $\varnothing 152 \text{ mm} \pm 2 \text{ mm}$ and 40 % open area
- 3 Pressure tap
- 4 Transition duct - test filter smaller than duct
- 5 Transition duct - test filter larger than duct

Figure 3 — Details of test duct components

7.3 Aerosol generation – DEHS Test Aerosol

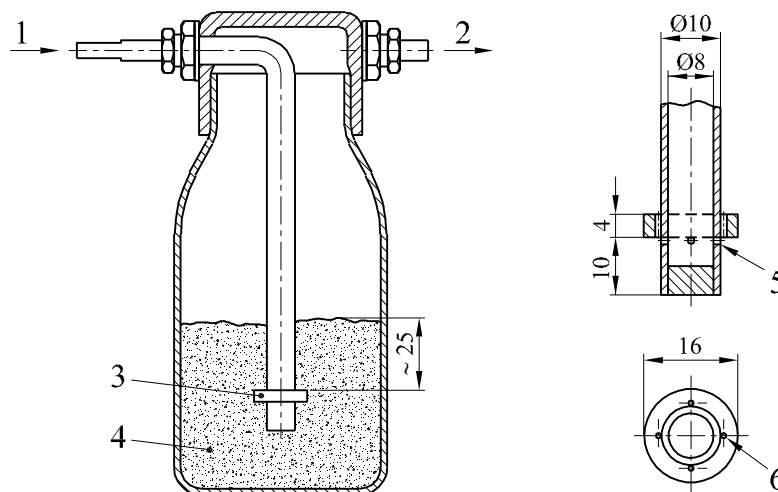
The test aerosol described shall consist of untreated and undiluted DEHS. Any other aerosol proven to give equivalent performance may be used. Test aerosol of DEHS (DiEthylHexylSebacate) produced by a Laskin nozzle is widely used in performance testing of HEPA and ULPA filters.

Figure 4 gives an example of a system for generating the aerosol. It consists of a small container with DEHS liquid and a Laskin nozzle. The aerosol is generated by feeding compressed particle-free air through the Laskin nozzle. The atomised droplets are then directly introduced into the test rig. The pressure and air flow to the nozzle are varied according to the test flow and the required aerosol concentration. For a test flow of $0,944 \text{ m}^3/\text{s}$ the pressure is about 17 kPa, corresponding to an air flow of about $0,39 \text{ dm}^3/\text{s}$ ($1,4 \text{ m}^3/\text{h}$) through the nozzle.

Any other generator capable of producing uncharged droplets in sufficient concentrations in the size range of $0,2 \mu\text{m}$ to $3,0 \mu\text{m}$ can be used.

Before testing, regulate the upstream concentration to reach steady state and to have a concentration below the coincidence level of the particle counter.

Dimensions in millimetres



Key

- 1 Particle-free air (pressure about 17 kPa)
- 2 Aerosol to test rig
- 3 Laskin nozzle
- 4 Test aerosol (for instance DEHS)
- 5 Four $\varnothing$ 1,0 mm holes 90° apart top edge of holes and just touching the bottom of the collar
- 6 Four $\varnothing$ 2,0 mm holes next to tube in line with radial holes

Figure 4 — DEHS particle generation system

7.4 Aerosol sampling system

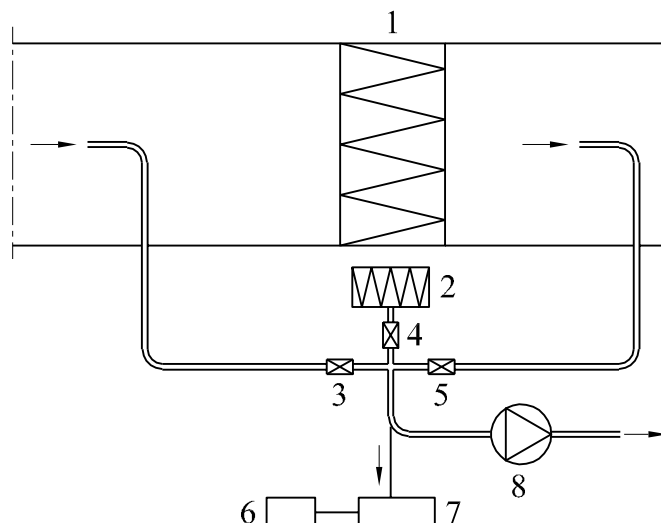
Two rigid sample lines of equal length and equivalent geometry (bends and straight lengths) shall connect the upstream and downstream sampling heads to the particle counter (see Figure 5). The sample tubes shall be electrically conducting or have a high dielectric constant and have a smooth inside surface (steel, tygon, etc).

Tapered sampling probes are placed in the centre of the upstream and downstream measuring sections. The sampling heads shall be centrally located with the inlet tip facing the inlet of the rig parallel to the air flow. The sampling shall be isokinetic within 10 % at a test flow rate of $0,944 \text{ m}^3/\text{s}$. Isokinetic sampling is also recommended at other test flows.

Three one-way valves make it possible to sample the aerosol upstream or downstream of the filter under test, or to have a "blank" suction through a HEPA filter. These valves shall be of a straight-through design. Due to possible particle losses from the sampling system, the first measurement after a valve is switched should be ignored.

The flow rate can be maintained by the pump in the counter in the case of a particle counter with a high flow rate (e.g. $0,47 \text{ dm}^3/\text{s}$) or by an auxiliary pump in the case of a counter with smaller sample flow rates. The exhaust line shall then be fitted with an isokinetic sampling nozzle directly connected to the particle counter to achieve isokinetic conditions within a tolerance of $\pm 10 \%$.

Particle losses will occur in the test duct, aerosol transport lines and particle counter. Minimisation of particle losses is desirable because a smaller number of counted particles will mean larger statistical errors and thus less accurate results. The influence of particle losses on the result is minimised if the upstream and downstream sampling losses are made as near equal as possible.



Key

- 1 Filter
- 2 HEPA filter (clean air)
- 3 Valve, upstream
- 4 Valve, clean air
- 5 Valve, downstream
- 6 Computer
- 7 Particle counter
- 8 Pump

Figure 5 — Schematic diagram of the aerosol sampling system

7.5 Flow measurement

Flow measurement shall be made by standardised flow measuring devices in accordance with EN ISO 5167-1. Examples are orifice plates, nozzles, Venturi tubes, etc.

The uncertainty of measurement shall not exceed 5 % of the measured value at 95 % confidence level.

7.6 Particle counter

This method requires the use of an optical particle counter (OPC) having a particle size range of at least 0,2 µm to 3,0 µm. The counting efficiency of the OPC shall be ≥ 50 % for 0,2 µm particles. The size range should be divided into at least five size classes, the boundaries of which should be approximately equidistant on a logarithmic scale.

Clause 8 contains further information and details about the calibration and operation of OPCs, which have to be used for this test.

7.7 Differential pressure measuring equipment

Measurements of pressure drop shall be taken between measuring points located in the duct wall as shown in Figure 2. Each measuring point shall comprise four interconnected static taps equally distributed around the periphery of the duct cross section.

The pressure measuring equipment used shall be capable of measuring pressure differences with an accuracy of ± 2 Pa in the range of 0 Pa to 70 Pa. Above 70 Pa, the accuracy shall be ± 3 % of the measured value.

7.8 Dust feeder

Any dust feeder can be chosen as long as it gives the same test result as the dust feeder described below. The purpose of the dust feeder is to supply the synthetic dust to the filter under test at a constant rate over the test

period. A certain mass of dust previously weighed is loaded into the mobile dust feeder tray. The tray moves at a uniform speed and the dust is taken up by a paddle wheel and carried to the slot of the dust pickup tube of the ejector.

The ejector disperses the dust with compressed air and directs it into the test rig through the dust feed tube. The dust injection nozzle shall be positioned at the entrance of duct section 2 in Figure 1 and be collinear with the duct centre line.

The compressed air shall be dry, clean and free from oil.

The general design of the dust feeder and its critical dimensions are given in Figure 6 and Figure 7. The angle between the dust pickup tube and dust feed trough is 90° in the figure but could be less in real application.

Backflow of air through the pickup tube from the positive duct pressure shall be prevented when the feeder is not in use.

The degree of dust dispersion by the feeder is dependent on the characteristics of the compressed air, the geometry of the aspirator assembly and the rate of air flow through the aspirator. The aspirator venturi is subject to wear from the aspirated dust and will become enlarged with use. Its dimension shall be monitored periodically to ensure that the tolerances shown in Figure 7 are met.

The gauge pressure on the air line to the Venturi corresponding to an air flow of the dust-feeder pipe of $6,8 \text{ l/s} \pm 0,2 \text{ l/s}$ shall be measured periodically for different pressure drops in the duct. See 8.11.