BRITISH STANDARD

BS EN 1822-1:1998

High efficiency air filters (HEPA and ULPA) —

Part 1: Classification, performance testing, marking

The European Standard EN 1822-1:1998 has the status of a British Standard

ICS 23.120

National foreword

This British Standard is the English language version of EN 1822-1:1998.

The UK participation in its preparation was entrusted by Technical Committee MCE/21, Filters for gases and liquids, to Subcommittee MCE/21/3, Air filters other than for air supply for IC engines and compressors, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 12, an inside back cover and a back cover.

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EUROPEAN STANDARD

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EN 1822-1

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ICS 23.120

Descriptors: air filters, cleaning equipment for gases, ventilation, air conditioning, definitions, classifications, specifications, tests, aerosols, test conditions, effectiveness

English version

High efficiency air filters (HEPA and ULPA) — Part 1: Classification, performance testing, marking

Filtres à air à très haute efficacité et filtres à air à très faible pénétration (HEPA et ULPA) — Partie 1: Classification, essais de performance et marquage

Schwebstoffilter (HEPA und ULPA) — Teil 1: Klassifikation, Leistungsprüfung, Kennzeichnung

This European Standard was approved by CEN on 6 March 1998.

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 Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization

Comité Européen de Normalisation

Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 1822-1:1998 E

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 195, Air filters for general air cleaning, the secretariat of which is held by DIN.

It is dealing with the performance testing of high efficiency particulate air filters (HEPA) and ultra low penetration air filters (ULPA).

The complete European Standard *High efficiency air filters (HEPA and ULPA)* will consist of the following parts:

- Part 1 *Classification, performance testing, marking*
- Part 2 *Aerosol production, measuring equipment, particle counting statistics*
- Part 3 *Testing flat sheet filter media*
- Part 4 *Determining leakage of filter elements (Scan method)*
- Part 5 *Determining the efficiency of filter elements*

As decided by CEN/TC 195, this European Standard is based on particle counting methods which actually cover most needs of different applications. The difference between this European Standard and previous national standards lies in the technique used for the determination of the overall efficiency. Instead of mass relationships, this new technique is based on particle counting at the most penetrating particle size (MPPS; range: 0,15 to 0,30 µm). It also allows ultra low penetration air filters to be tested, which is not possible with the previous test methods because of their inadequate sensitivity.

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 1998, and conflicting national standards shall be withdrawn at the latest by October 1998.

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, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This European Standard applies to high efficiency particulate and ultra low penetration air filters (HEPA and ULPA) used in the field of ventilation and air conditioning and for technical processes, e.g. for clean room technology or applications in the nuclear and pharmaceutical industry.

It establishes a procedure for the determination of the efficiency on the basis of a particle counting method using a liquid test aerosol, and allows a standardized classification of these filters in terms of their efficiency.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. Theses 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.

EN 1822-2, *High efficiency air filters (HEPA and ULPA) — Part 2: Aerosol production, measuring equipment, particle counting statistics.*

EN 1882-3, *High efficiency air filters (HEPA and ULPA) — Part 3: Testing flat sheet filter media.*

prEN 1882-4, *High efficiency air filters (HEPA and ULPA) — Part 4: Determining leakage of filter elements (Scan method).*

prEN 1882-5, *High efficiency air filters (HEPA and ULPA) — Part 5: Determining the efficiency of filter elements.*

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

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply.

3.1.1

filter medium

flat sheet filter material, unfolded

3.1.2

folded pack

a pack of the filter medium formed by uniform individual folds

3.1.3

filter element (filter)

a folded pack enclosed by a frame

3.1.4

penetration

the ratio of the particle number concentration downstream of the filter to the concentration upstream

3.1.5

efficiency

the ratio of the number of particles held back by the filter to the number of the particles impinging on the filter

3.1.6

particle size efficiency

the efficiency for a specific particle diameter. The efficiency plotted as a function of the particle diameter gives the efficiency curve

3.1.7

minimum filter efficiency

the minimum of the efficiency curve under given operating conditions of the filter (see **3.1.24**)

3.1.8

overall efficiency

the efficiency, averaged over the whole superficial face area of a filter element under given operating conditions of the filter

3.1.9

local efficiency

the efficiency at a specific point of the filter element under given operating conditions of the filter

3.1.10

nominal air volume flow rate

the air volume flow rate for which the filter element to be tested is specified

3.1.11

filter face area

the cross-sectional area of the filter element including the frame

3.1.12

superficial face area

the cross-sectional area of the filter element which is passed by the air flow

3.1.13

effective filter medium area

the effective cross-sectional area of the filter medium in the filter element (without adhesive areas, struts etc.) which is passed by the air flow

3.1.14

nominal filter medium face velocity

the nominal air volume flow rate divided by the effective filter medium area

3.1.15

leak

a point in the filter element at which the local efficiency falls below a given limit value

3.1.16

particle number concentration

the number of particles per unit volume of the carrier gas (air)

3.1.17

counting rate

the number of counting events per unit time

3.1.18

particle size

the geometrical diameter of the particles of the test aerosol

3.1.19

mean particle diameter

median value of the particle number distribution of the test aerosol

3.1.20

monodisperse

an aerosol is referred to as monodisperse when the width of its distribution function, described by the geometric standard deviation, is less than $\sigma_g = 1{,}15$. Aerosols whose distribution has a geometric standard deviation between $\sigma_g = 1{,}15$ and $\sigma_g = 1{,}5$ are referred to as quasi-monodisperse

3.1.21

polydisperse

an aerosol is referred to as polydisperse if its distribution shows a geometric standard deviation of $\sigma_g > 1{,}5$

3.1.22

HEPA filter

high efficiency particulate air filter, classes H 10 to H 14 (see Table 1)

3.1.23

ULPA filter

ultra low penetration air filter, classes U 15 to U 17 (see Table 1)

3.1.24

most penetrating particle size (MPPS)

the particle size at which the minimum of the particle size efficiency curve occurs (see **3.1.7**)

3.2 Symbols and abbreviations

For the purposes of this standard, the following symbols and abbreviations apply.

d_p	Particle diameter
E	Efficiency
P	Penetration
p	Pressure
RH	Relative humidity
T	Temperature
σ_g	Geometric standard deviation
CNC	Condensation nucleus counter
DEHS	Sebacic acid-bis (2-ethyl hexyl-) ester (trivial name: di-ethyl-hexyl-sebacate)
DMA	Differential electric mobility analyser
DMPS	Differential mobility particle sizer
DOP	Phthalic acid-bis (2-ethyl hexyl-) ester (trivial name: di-octyl-phthalate)
MPPS	Most penetrating particle size
OPC	Optical particle counter

4 Classification

Filter elements are classified in groups and classes according to their filtration performance (efficiency or penetration).

4.1 Groups of filters

According to this standard, filter elements fall into one of the following groups:

— group H: HEPA filters;

— group U: ULPA filters.

4.2 Classes of filters

Filter elements of group H and U are classified according to their performance (see **5.5**).

Group H filters are subdivided in five classes:

— H 10

— H 11

— H 12

— H 13

— H 14

Group U filters are subdivided in three classes:

— U 15

— U 16

— U 17

5 Requirements

5.1 General

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

The filter element shall be designed so that when correctly mounted in the ventilation duct, no leak occurs at the sealing edge.

If, for any reason, dimensions do not allow testing of a filter under standard test conditions, assembly of two or more filters of the same type or model is permitted, provided no leaks occur in the resulting filter.

5.2 Material

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

The filter element 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 the air flow through the filter element shall not constitute a hazard or nuisance for the people (or devices) exposed to filtered air.

5.3 Nominal air volume flow rate

The filter element shall be tested at its nominal air volume flow rate for which the filter has been designed by the manufacturer.

5.4 Pressure difference

The pressure difference across the filter element is recorded at the norminal air volume flow rate.

5.5 Filtration performance

The filtration performance is expressed by the efficiency or penetration.

After testing in accordance with clause **6**, filter elements are classified according to Table 1.

6 Test methods

6.1 Test rigs

The test rigs are described in detail in EN 1822-3, prEN 1822-4 and prEN 1822-5. The individual methods of measurement and the measuring instruments are described in EN 1822-2.

6.2 Test conditions

The air in the test channel used for testing shall comply with the following requirements:

Temperature: 23 °C ± 5 °C

Relative humidity < 75 %

The temperature and relative humidity shall remain constant over a longer period of time.

The cleanliness of the test air shall be ensured by appropriate pre-filtering, so that in operation without addition of aerosol the particle number concentration measured with the particle counting method is less than 350 000 m^{-3}. The test specimen shall have the same temperature as the test air.

6.3 Test aerosols

For the testing of HEPA and ULPA filters in accordance with this standard, a liquid particle test aerosol shall be used. Possible substances include but are not limited to DEHS, DOP, paraffin oil (low viscosity). For further details see **4.1** of EN 1822-2:1998.

NOTE The use of alternative materials for challenge aerosols may also be agreed between supplier and purchaser when the materials specified in this standard are unacceptable.

The concentration and the size distribution of the aerosol shall be constant over time. For the leakage testing and the efficiency test of the filter element the mean particle diameter of the test aerosol shall correspond to the most penetrating particle size (MPPS) for the filter medium.

6.4 Survey of test procedures

The complete testing procedure for HEPA and ULPA filters in accordance with this standard consists of three steps, each of which may be implemented as an independent test.

Table 1 — Classification of HEPA and ULPA filters

Filter class	Overall value		Local value[1) 2)]	
	Efficiency (%)	Penetration (%)	Efficiency (%)	Penetration (%)
H 10	85	15	—	—
H 11	95	5	—	—
H 12	99,5	0,5	—	—
H 13	99,95	0,05	99,75	0,25
H 14	99,995	0,005	99,975	0,025
U 15	99,999 5	0,000 5	99,997 5	0,002 5
U 16	99,999 95	0,000 05	99,999 75	0,000 25
U 17	99,999 995	0,000 005	99,999 9	0,000 1

1) See **6.5.2** and prEN 1822-4.

2) Local values lower than those given in the Table may be agreed between supplier and purchaser.

6.4.1 ***Step 1***

Firstly the efficiency of test samples of the filter medium shall be determined for a range of particle sizes at the nominal filter medium velocity. From the efficiency vs particle size curve the most penetrating particle size (MPPS) shall be determined, for which the filtration efficiency of the filter medium is at a minimum.

See **6.5.1**.

6.4.2 ***Step 2***

The filter element is tested at nominal air volume flow rate for freedom from leaks using a test aerosol with a mean particle size which corresponds to the MPPS.

See **6.5.2**.

6.4.3 ***Step 3***

Using the same test aerosol, again at the nominal air volume flow rate, the overall efficiency of the filter element is determined.

See **6.5.3**.

6.4.4 On the basis of the values determined for the local efficiency (leakage test) and the overall efficiency, the filter can be assigned to a filter class as specified in **5.5**. This assignment is only valid if the fixed test conditions are met.

In all three procedural steps it is permissible to use either a monodisperse or a polydisperse test aerosol. The particle counting method used may be a total count method (CNC) or a method involving particle size analysis (OPC).

Since total count particle counting methods provide no information about the particle size, they may only be used to determine the efficiency in procedural step 1 with monodisperse test aerosols of a known particle size.

For the determination of the minimum efficiency of the sheet filter medium (see **6.4.1**) the test method using a monodisperse test aerosol has to be considered as the reference test method. Care has to be taken for the correlation with the reference test method if using a polydisperse aerosol.

6.5 Test procedures

6.5.1 ***Testing sheet filter media***

6.5.1.1 *Test samples*

The testing procedure requires at least five sheet samples of the filter material.

The test samples shall be free of folds, creases, holes and other irregularities. The test samples shall have a minimum size of 200 mm × 200 mm.

6.5.1.2 *Test apparatus*

The arrangement of the test apparatus is shown in Figure 1. An aerosol is produced in the aerosol generator, then passed through a conditioner (for example to evaporate a solvent) and neutralized, before being brought together with the particle-free mixing air to the test filter mounting assembly.

Upstream and downstream from the test filter mounting assembly there are sampling points from which a part of the flow is led to the particle counter. The upstream sampling point is connected with a dilution circuit to adjust the high particle concentration to the measuring range of the particle counter.

When using the total count counting method (CNC) a differential electric mobility analyser (DMA) is included before the aerosol neutralizer to separate out a (quasi-) monodisperse fraction of the required particle size from the initial polydisperse aerosol.

If a counting method with particle size analysis (OPC) is used, then the size distribution of a polydisperse aerosol can be measured before and after the test specimen.

Instead of using a single particle counter, which measures the unfiltered and filtered gases consecutively, it is also permissible to use two particle counters of equal optical design for both measurements.

After the downstream sampling point the test aerosol is led through an exhaust filter and extracted by a pump. The apparatus is completed by devices to measure the gas parameters, the drop of pressure across the test specimen, and to measure and regulate the air volume flow rate.

The measurement data are recorded and evaluated by a computer.

The test apparatus can also be operated in an overpressure mode. In this case the extraction pump is not required, and the mixing air is supplied from a compressed air line. If so desired, the measurement and regulation of the air volume flow rate can then be carried out on the upstream side.

The test rig is described in detail in EN 1822-3. The individual methods of measurement are described in EN 1822-2.

6.5.1.3 *Measurement procedure*

The test sample shall be mounted in a test filter holding assembly with a cylindrical cross-section giving an exposed area of 100 cm^2 and subjected to a flow of test air at the nominal filter medium face velocity.

The test aerosol shall be added to the test air flow at a uniform rate. In order to establish the particle size vs penetration relationship the values for at least six logarithmically, approximately equidistant points shall be determined on the efficiency vs particle size curve.

By means of the DMA at least six quasi-monodisperse test aerosols shall be produced with the appropriate median values of the particle diameter and their concentrations determined upstream and downstream from the test sample. As an alternative procedure, the size distribution of a polydisperse aerosol may be determined upstream and downstream from the test sample in at least six size classes.

In each case it shall be ensured that the measuring range or the range of produced particle sizes envelopes the minimum of the efficiency curve.

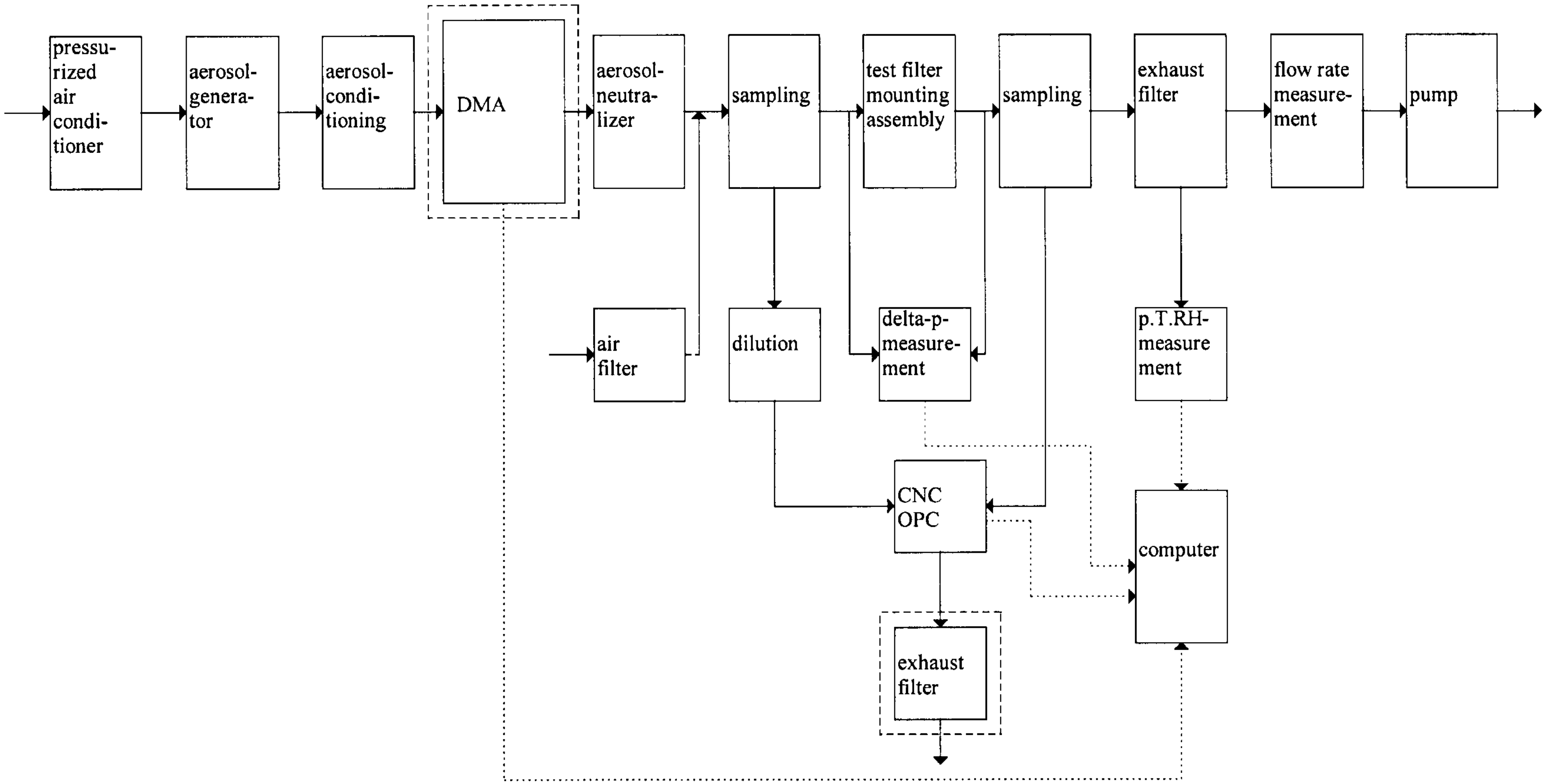

Figure 1 — Arrangement of apparatus for testing the filter medium

6.5.1.4 *Evaluation of test results*

From the measurements on the five test samples the particle size vs efficiency relationship shall be represented graphically (see Figure 2 by way of an example) and the position and value of the minimum efficiency shall be determined.

Arithmetic mean values shall be determined for:

- — the minimum efficiency
- — the particle size at the minimum efficiency (MPPS)
- — the pressure difference.

The particle size at the MPPS shall subsequently be used as the mean size of the test aerosol in the filter element leakage test (see **6.5.2**) and in the efficiency test (see **6.5.3**).

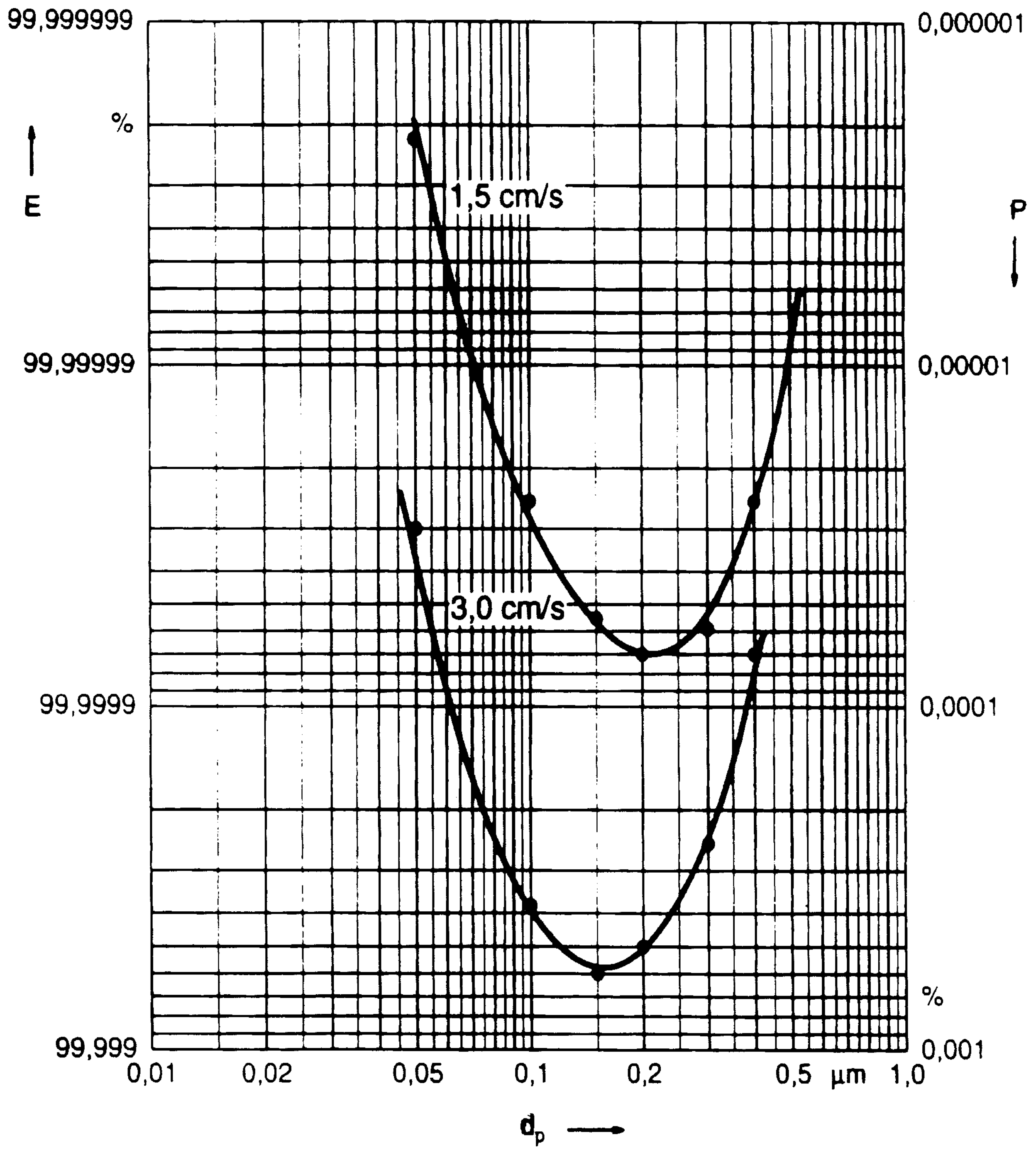

Figure 2 — Particle size efficiency *E* and penetration *P* of an ultra low penetration air (ULPA) filter medium as function of the particle diameter d_p for two different filter medium velocities (example)

6.5.2 ***Leakage test of the filter element***

The leakage test serves to test the filter element for local penetration values (see Table 1). The basis for this test is the particle counting scan method. However for classes H 13 and H 14 the oil thread test (see prEN 1822-4) may be used alternatively. The oil thread test shall also be used for filter shapes for which the scan method cannot be applied.

6.5.2.1 *Test specimen*

For the leakage testing a filter element is required which can be sealed into the test rig and subjected to a flow in accordance with the requirements.

6.5.2.2 *Test apparatus*

The arrangement of the individual components of the test apparatus for the scan test is shown in Figure 3. The prefiltered test air is drawn in by a fan and passed through a secondary filter (see **6.2**). The volume flow rate shall be registered by a standardized measuring device according to EN ISO 5167-1, or some other volume flow rate measuring device which can be calibrated, and shall be kept constant by a flow rate controller.

The neutralized test aerosol shall be introduced into the channel downstream from the volume flow rate measuring device and shall be distributed equally over the cross-section of the channel. Before the test filter mounting assembly a part of the flow shall be taken and led via a dilution circuit to the particle counting equipment (CNC or OPC). The size distribution of the test aerosol can optionally be controlled by a so-called DMPS system (see EN 1822-2).

Behind the test filter there is a scanning device with one or more mechanically moveable probes, with which the entire surface of the filter can be traversed. The probes shall be connected to the particle counters, where necessary via a device to adapt the volume flow rate. The test aerosol may be introduced upstream from the volume flow measuring device, if there are no disturbances of the measurement.

The measurements for the gas parameters, the pressure drop across the filter, the position of the probe and the particle counting rates shall be recorded and processed by a computer.

The individual components of the test rig are described in detail in prEN 1822-4. The individual methods of measurement are described in EN 1822-2 .

6.5.2.3 *Measurement procedure*

During the course of the leakage test the test specimen shall be subjected to the nominal air flow rate. The test aerosol, whose mean diameter shall correspond to the MPPS of the filter medium (see **6.5.1.4**), shall be distributed homogeneously over the entire test cross-section.

On the downstream side of the filter element being tested the particle concentration shall be sampled by means of one or more test air sampling probes which shall be moved at a defined rate. The particle concentration shall be compared with the concentration applied on the upstream side.

In the scanning operation the entire surface of the filter element shall be covered in overlapping tracks.

6.5.2.4 *Evaluation of test results*

From the test parameters of the leakage test (see prEN 1822-4) and from the permissible local value of the efficiency (see Table 1) and taking statistical relationships into account (see EN 1822-2) it is possible to give a limit value for the particle counting rate, above which there is a leak.

If the limit value is not exceeded at any point on the filter surface then the filter has passed the leakage test.

6.5.3 ***Efficiency test of the filter element***

The overall efficiency of the complete filter element can be determined by one of the following methods:

— by measuring of the average particle concentration on the upstream and downstream sides of the filter with stationary sampling probes (static measuring method);

— by the continuous measurement of the particle concentration on the upstream and downstream sides of the filter in the course of the leakage test, with a stationary sampling probe on the upstream side and a scanning sampling probe on the downstream side which moves over the entire filter element (scan method).

6.5.3.1 *Efficiency test using the static measuring method*

6.5.3.1.1 *Test specimen*

The test specimen used shall be the filter element tested for leakage in accordance with **6.5.2**.

6.5.3.1.2 *Test apparatus*

The test to determine the overall efficiency of the filter element shall be carried out in a test apparatus (see Figure 4) which is largely identical with the test apparatus used for the leakage test. The test filter mounting assembly is followed by a section which mixes the aerosol on the downstream side evenly over the whole cross section of the channel. This is followed by a stationary sampler and an exhaust filter. The downstream sample flow is also led to a particle counter.

The test procedure is described in detail in prEN 1822-5. The individual methods of measurement are described in EN 1822-2.

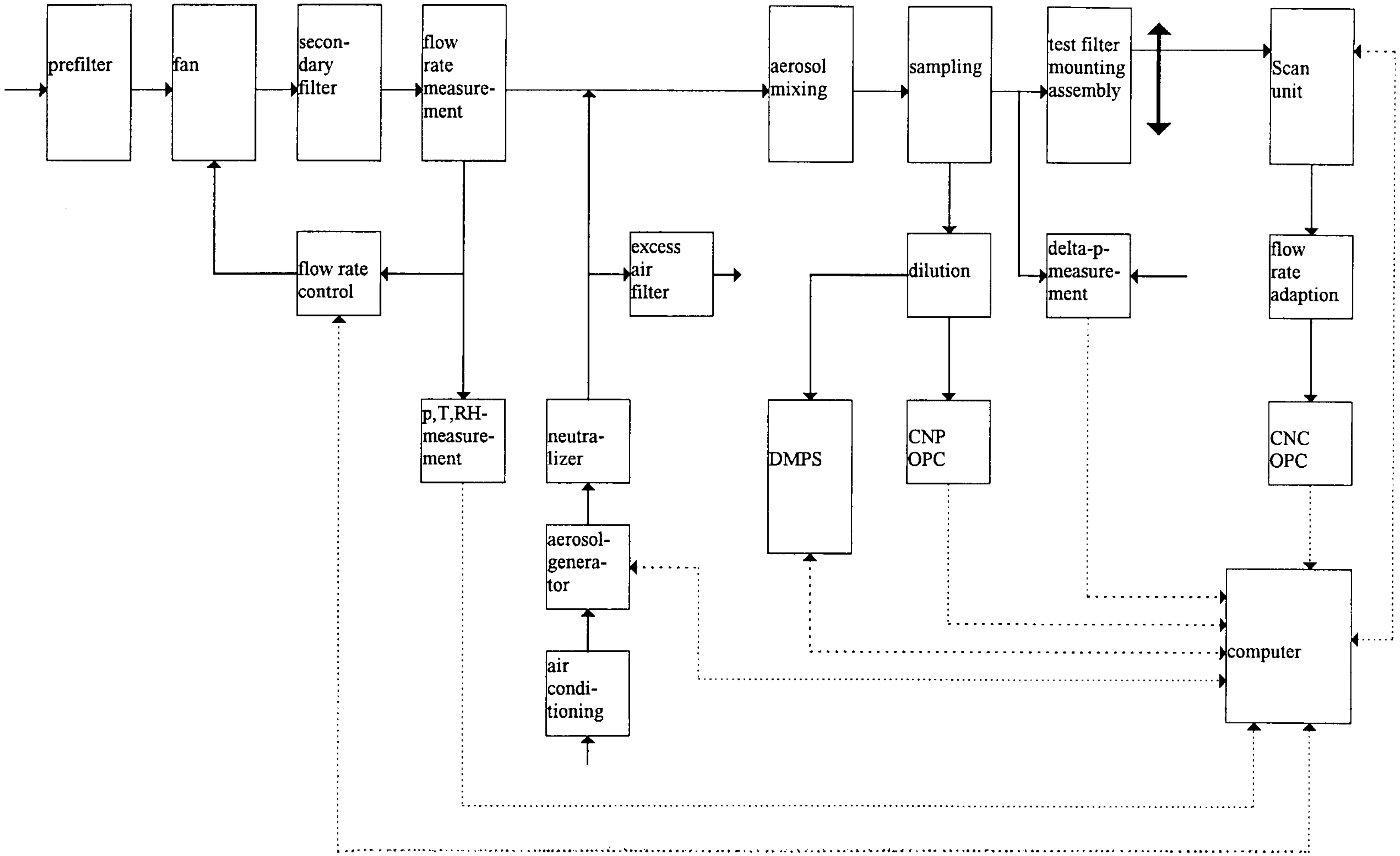

Figure 3 — Arrangement of apparatus for leak testing

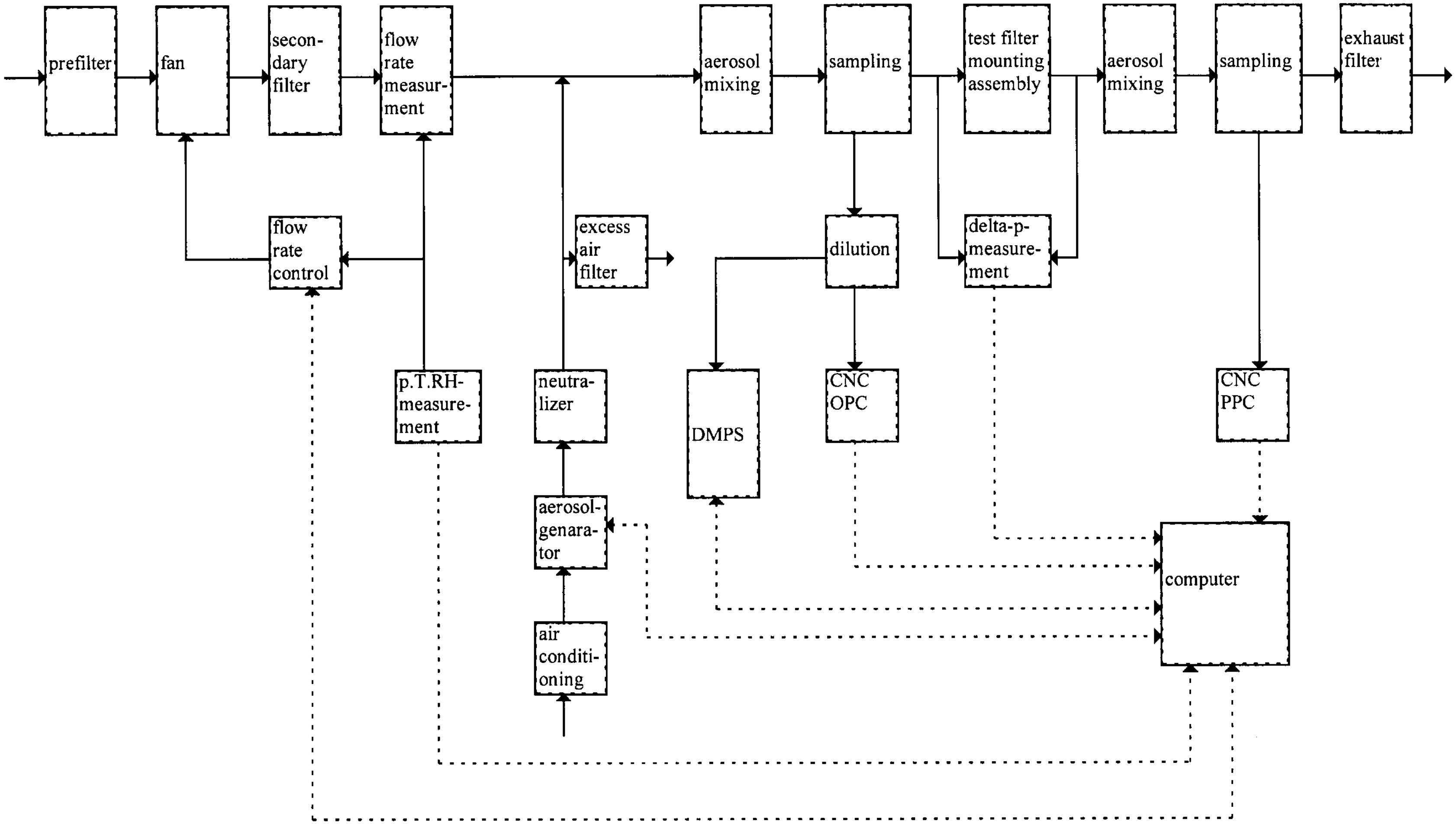

Figure 4 — Arrangement of apparatus for efficiency testing using the static measuring method

6.5.3.1.3 *Measurement procedure*

The filter element shall be subjected to the nominal air volume flow rate with the same aerosol as was used for the leakage test. The particle concentration shall be measured on the upstream and downstream sides of the filter element being tested; a dilution circuit shall be included on the upstream side used to adjust the concentration to that measurable by the particle counters (see EN 1822-2).

The pressure drop across the filter element has to be registered, before the filter is loaded with test aerosol.

6.5.3.1.4 *Evaluation of test results*

The overall efficiency shall be calculated from the particle concentrations measured on the upstream and downstream sides of the filter element being tested (see EN 1822-2 and prEN 1822-5).

6.5.3.2 *Efficiency testing using the scan method*

The overall efficiency may also be determined by calculation using the particle number concentrations determined in the course of the leakage test (see **6.5.2**) with the stationary sampling probe on the upstream side of the filter and the moving scan sampling probe or probes on the downstream side (further details in Part 4 and 5 of this standard).

7 Assessment of the filter, documentation

The high efficiency air filter tested fully in accordance with this standard shall be assigned to a filter class as specified in Table 1 on the basis of the local efficiency (penetration) determined in accordance with **6.5.2**, and the overall efficiency (penetration) determined in accordance with **6.5.3**.

The test results shall be documented in a test certificate. The test certificate shall contain the following information:

— serial number of the filter element;

— the efficiency vs particle size curve of the sheet filter medium, including the coordinates for the efficiency minimum;

— the pressure difference across the sheet filter medium at the nominal filter medium velocity;

— the result of the leakage test of the filter element;

— the pressure difference across the filter element at the nominal air flow rate;

— the overall value of the efficiency of the filter element.

8 Marking

8.1 The filter shall be marked. The following type identifying details shall be provided:

a) name, trade mark or other means of identification of the manufacturer;

b) type and serial number of the filter;

c) number of this standard;

d) class of the filter (see Table 1);

e) nominal air volume flow rate at which the filter has been classified.

8.2 If the correct mounting cannot be deduced, marking is necessary for correct fitting in the ventilation duct (e.g. “TOP” “Direction of flow”…).

8.3 The marking shall be as clearly visible and as durable as possible.

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