SLOVENSKI STANDARD

SIST EN 1822-2:2000

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

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

Schwebstoffilter (HEPA und ULPA) - Teil 2: Aerosolerzeugung, Meßgeräte, Partikelzählstatistik

Filtres a air a tres haute efficacité et filtres a air a tres faible pénétration (HEPA et ULPA) - Partie 2: Production d'aérosol, équipement de mesure et statistiques de comptage de particules

Ta slovenski standard je istoveten z: EN 1822-2:1998

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EUROPEAN STANDARD

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Descriptors: air filters, cleaning equipment for gases, ventilation, air conditioning, definitions, classifications, specifications, measuring instruments, particle counters, aerosols, tests, test conditions, effectiveness, marking

English version

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

Filtres à air à très haute efficacité et filtres à air à très faible pénétration (HEPA et ULPA) - Partie 2: Production d'aérosol, équipement de mesure et statistiques de comptage de particules

Schwebstoffilter (HEPA und ULPA) - Teil 2: Aerosolerzeugung, Meßgeräte, Partikelzählstatistik

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.

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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

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

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Contents

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 contains requirements, fundamental principles of testing and the marking for 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 senditivity.

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.

1 Scope

This European Standard applies to high effciency particulate air filters 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.

This European Standard describes the measuring instruments and aerosol generators used in the course of this testing. With regard to particle counting it specifies the statistical basis for the evaluation of counts with only small numbers of counted events.

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.

EN 1822-1	High efficiency air filters (HEPA and ULPA) - Part 1: Classification, performance testing, marking
EN 1822-3	High efficiency air filters (HEPA and ULPA) - Part 3: Testing flat sheet filter media

3 Definitions

For the purposes of this European Standard, the following definitions apply in addition to EN 1822-1:

3.1 Particle production rate

Number of particles produced per unit time by an aerosol generator

3.2 Coincidence error

An error which occurs because at a given time more than one particle is contained in the measurement volume of a particle counter. The coincidence error leads to a measured number concentration which is too low and a value for the mean particle diameter which is too high.

3.3 Counting efficiency

The counting efficiency of a particle counter expresses the proportion of the particles suspended in the volume flow under analysis which actually make their way through the measured volume and are counted. It is the ratio of the concentration determined by the instrument (corrected for possible coincidence errors) and the actual concentration of the aerosol. The counting efficiency depends on the particle size, and decreases progressively in the proximity of the lower detection limit of the particle counter.

3.4 Zero count rate

The zero count rate is the number of counts registered per unit time by the particle counter when air which is free of particles is passed through the measuring volume. These counts can be produced by particle sources within the air-ducting system, or by electronic noise, ionizing radiation, or irregularities in the electricity supply.

4 Aerosol production

When testing a filter a test aerosol with liquid particles shall be used as defined in EN 1822-1.

The testing of high-performance filters (U 16 and U 17) requires methods of aerosol production with high production rates (10^{10} s^{-1} to 10^{11} s^{-1}), in order to provide statistically significant measurements downstream of the filter.

By adjusting the operating parameters of the aerosol generator it shall be possible to adjust the mean particle diameter of the aerosol so that it is equal to the MPPS. The concentration and the size distribution of the aerosol produced shall remain constant throughout the test.

4.1 Aerosol substances

A suitable aerosol substance is a liquid with a vapour pressure which is so low at the ambient temperature that the size of the droplets produced does not change significantly due to evaporation over the time scale relevant for the test procedure (some seconds).

Possible substances include but are not limited to:

- DEHS
- DOP
- Paraffin oil (low viscosity).

The most critical properties of a possible aerosol substance are:

- Index of refraction,
- Vapour pressure,
- Density,

which should not differ too much from the values given for the three substances suggested in Table 1.

NOTE: Standard laboratory safety regulations shall be observed when handling these substances. It shall be ensured by means of suitable exhaust systems and air-tight aerosol ducting systems that the test aerosols are not inhaled. In case of doubt the safety data sheets for the appropriate substances shall be consulted.

Table 1: Important data for DEHS and DOP and a paraffin oil at 20°C

	DEHS	DOP	Paraffin oil (low visc.)
Chemical designation	Sebacic acid-bis(2-ethylhexyl) ester	Phthalic acid-bis(2-ethylhexyl) ester	Mixture
Trivial name	Diethylhexylsebacyte	Dioctylphthalate	Paraffinoil
Density (kg/m^3)	912	985	843
Melting point (K)	225	223	259
Boiling point (K)	529	557	
Flash point (K)	>473	473	453
Vapour pressure at 293K (µPa)	1,9	13	
Dynamic viscosity (kg/m s)	0,022 to 0,024	0,077 to 0,082	0,026
Index of refraction/ wavelength (nm)	1,450 /650 1,452 /600 1,4535/550 1,4545/500 1,4585/450 1,475 /400	1,4836/589	

4.2 Producing monodisperse aerosols

4.2.1 Condensation methods

Condensation methods are preferred for the creation of monodisperse aerosols, i.e. the particles are formed by condensation from the vapour phase. It is necessary to distinguish between heterogeneous and homogeneous condensation.

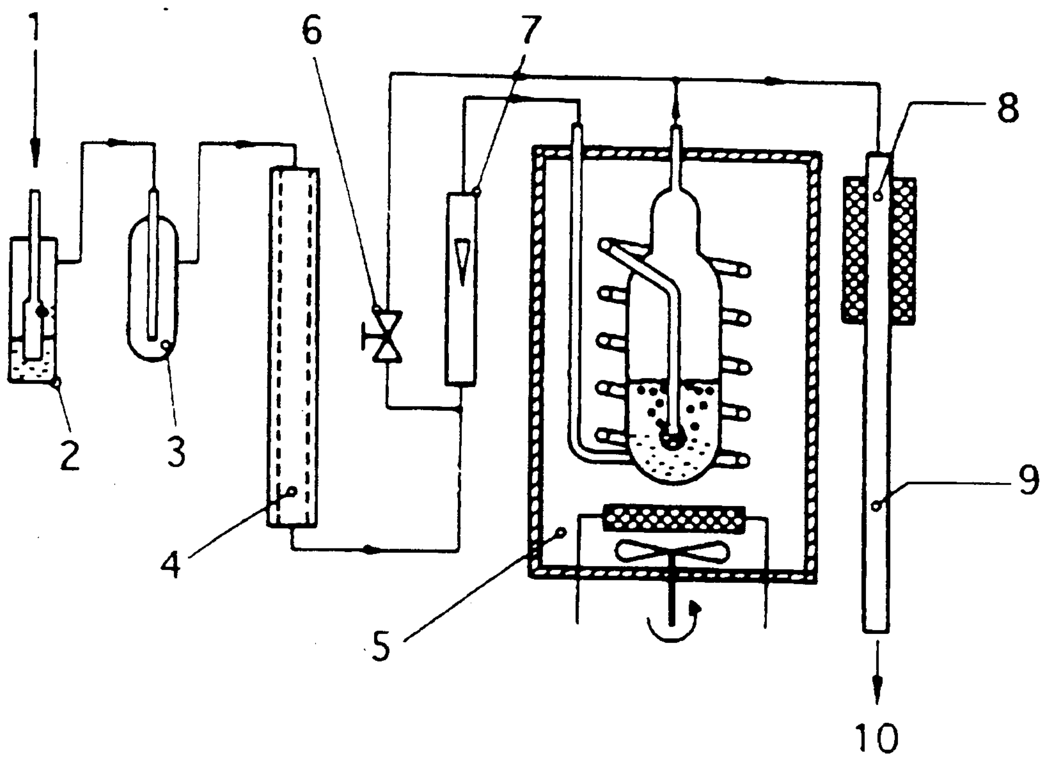
4.2.1.1 Heterogeneous condensation

In the case of heterogeneous condensation the vapour condenses at a relatively low level of supersaturation onto very small particles which are already present, the so-called condensation nuclei. The size distribution of the resultant aerosol has a geometrical standard deviation between σ_g= 1,05 and σ_g = 1,15.

Aerosol generators which operate using the principle of heterogeneous condensation are the Sinclair - LaMer generators (Figure 1)and the Rapaport - Weinstock generator (Figure 2).

4.2.1.1.1 Sinclair - LaMer aerosol generator (Figure 1)

A simple nebulizer operated with nitrogen nebulizes a weak aqueous solution of sodium chloride. After large water drops have been excluded in a drop eliminator, the smaller droplets are passed into a diffusion drier where they vapourise. The resultant sodium chloride aerosol is then passed into a vessel containing the actual aerosol substance, where it becomes saturated with the vapour of this substance. The aerosol vapour mixture is then passed through a re-heater, and then on through a condensation chimney, where the vapour condenses on the salt particles, forming an homogeneous droplet aerosol (see also [1]).



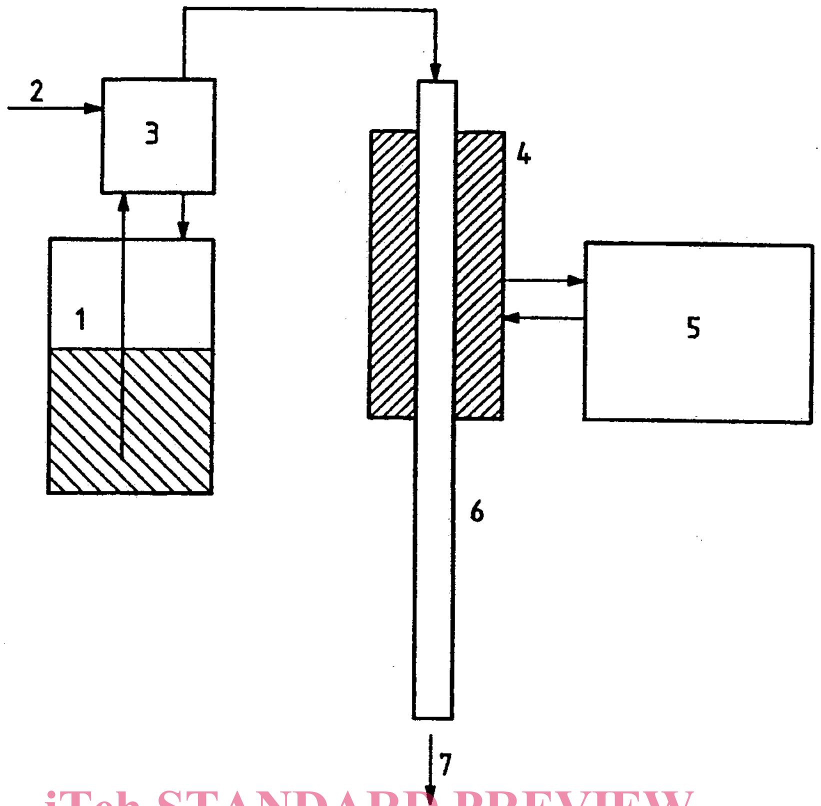
1	Nitrogen supply	6	By-pass valve
2	Nebulizer	7	Flow meter
3	Drop eliminator	8	Re-heater
4	Diffusion drier	9	Condensation chimney
5	Thermostatic oven	10	Aerosol

Figure 1: The structure of the Sinclair - LaMer aerosol generator

The vessel containing the aerosol substance is contained in a thermostatic oven, whose temperature can be adjusted so as to regulate the amount of vapour and the diameter of the particles. A part of the sodium chloride aerosol can also be diverted past the oven using the by-pass valve, and added to the flow again before the re-heater. This makes it possible to achieve a relatively rapid drop in the vapour concentration in the re-heater, and thus a reduction in the particle diameter.

The rates of particle production which can be achieved by means of this type of generator are in the order of 10^8 s^{-1}; the particle diameter can be adjusted between approximately 0,1 µm and 4 µm.

4.2.1.1.2 Rapaport-Weinstock generator (Figure 2)
An aerosol substance is nebulized through a nozzle, either as a pure substance or in solution, and the resultant polydisperse aerosol is then vapourised along the heated section of a glass tube. Residual nuclei of the impurities in the material remain.



1 Liquid reservoir
2 Compressed air
3 Nebulizer
4 Vapourisation section
5 Thermostat
6 Condensation section
7 Aerosol

Figure 2: The structure of the Rapaport and Weinstock aerosol generator

In the subsequent condensation section the aerosol substance then condenses on these nuclei to form a mondisperse aerosol (see also [2]).

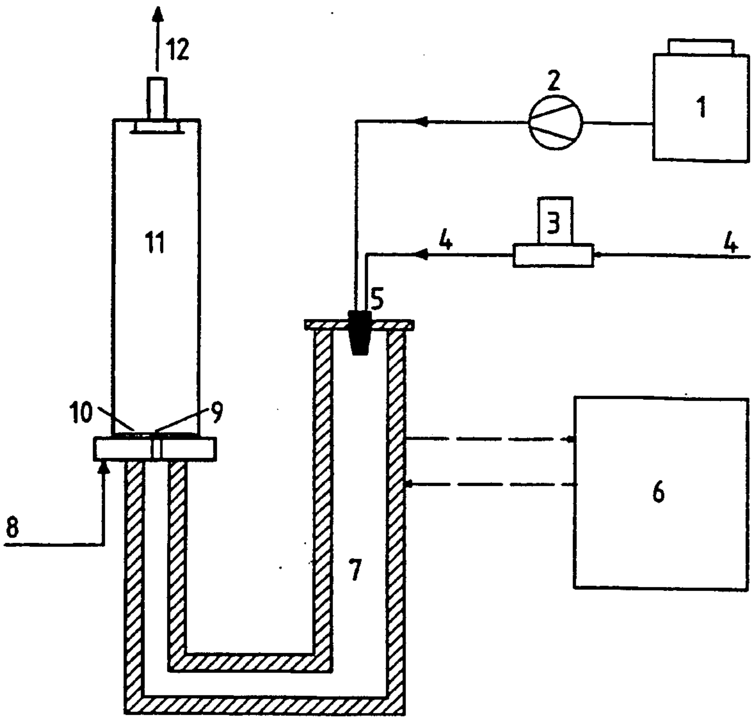
The particle diameter of this aerosol is determined by the mixing ratio of aerosol substance and solvent. The final aerosol contains the solvent used (e.g. propanol) as a vapour.

Generators of this type achieve particle production rates of 10^9 s^{-1}; the particle diameter can be adjusted between approximately 0,1 µm and 1,5 µm.

4.2.1.2 Homogeneous condensation

At higher levels of super-saturation, clusters of vapour molecules form spontaneously without the presence of condensation nuclei, and these then grow to particles which are some nanometres in diameter (homogeneous condensation). Larger particles then form as a result of coagulation of these particles with one another. The resultant size distribution has a standard deviation of $\sigma_g \approx$ 1,5 independent of the median particle size, and can thus only be referred to as quasi-monodisperse. On the other hand, rates of production of particles achieved can be as much as two orders of magnitude larger than those possible using heterogeneous condensation (more than 10^{11} s^{-1}).

Figure 3 shows the structure of a free-jet condensation aerosol generator which makes use of this principle.



1 DEHS tank
2 Pump
3 Flow controller
4 Nitrogen
5 Ultra-sonic nebulizer
6 Thermostat
7 Vapourisation pipe with heater and insulation
8 Sheath air
9 Nozzle
10 Sintered metal plate
11 Coagulation section
12 Aerosol

Figure 3: The set-up of a free-jet condensation aerosol generator

An aerosol substance is delivered by a pump at a defined flow rate to an ultrasonic nebulizer. The relatively large droplets which are produced (> 20 μm) are then vapourised in a heated pipe. The concentration of residual nuclei is so low that they do not influence the subsequent homogeneous condensation process. The hot stream of nitrogen carrying the vapour then passes through a nozzle into a cold, laminar flow of sheath air. The turbulent mixing of the free jet with the cold air produces the super-saturation necessary for the homogeneous condensation.

The particle size and particle concentration can be adjusted by varying the volume flow rates of the aerosol substance (DEHS), nitrogen and envelope air.

4.2.2 Particle size classification

Using a differential mobility analyser as described in 5.3 it is possible to separate a fraction with almost the same electrical mobility from a polydisperse aerosol (see also [3]). Provided all these particle carry only a single electrical charge, then this mono-mobile fraction is also monodisperse. If necessary, larger particles which carry a multiple charge, and which thus have the same electrical mobility as the single-charged particles, must be removed from the polydisperse input aerosol by suitable means.