

Respiratory protective devices — Methods of test —

Part 7: Determination of particle filter penetration

ICS 13.340.30

National foreword

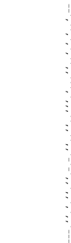
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A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Respiratory protective devices - Methods of test - Part 7: Determination of particle filter penetration

Appareils de protection respiratoire - Methode d'essai -
Partie 7 : Détermination de la pénétration de filtres à
particules

Atemschutzgeräte - Prüfverfahren - Teil 7: Bestimmung des
Durchlasses von Partikelfiltern

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Foreword

This document (EN 13274-7:2008) has been prepared by Technical Committee CEN/TC 79 “Respiratory protective devices”, 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of an identical text or by endorsement, at the latest by July 2008, and conflicting national standards shall be withdrawn at the latest by July 2008.

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.

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For relationship with EU Directive 89/106/EEC, see informative Annex ZA, which is an integral part of this document.

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Introduction

This European Standard is intended as a supplement to the specific device standards for respiratory protective devices. Test methods are specified for complete or parts of devices. If deviations from the test method given in this standard are necessary, these deviations will be specified in the relevant device standard.

1 Scope

This European Standard specifies the procedure for testing particle filter penetration for respiratory protective devices.

2 Normative references

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

EN 132:1998, *Respiratory protective devices — Definitions of terms and pictograms*

EN 13274-5, *Respiratory protective devices — Methods of test — Part 5: Climatic conditions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 132:1998 apply.

4 Pre-requisites

In order to implement this part of EN 13274, at least the following parameters need to be specified in the appropriate device standard:

- items to be tested;
- number of samples;
- test method(s);
- flow rate through the filter;
- sequence of conditioning phases, where more than one is required;
- specification of any observations to be carried out;
- sample preparation and orientation;
- sample holding;
- in the case of the exposure test, the specified mass of test aerosol;
- pass/fail criteria;
- any deviations from this method.

5 Test requirements

5.1 General

Unless otherwise specified, the values stated in this European Standard are expressed as nominal values. Except for temperature limits, values which are not stated as maxima or minima shall be subject to a tolerance of $\pm 5\%$. Unless otherwise specified the ambient temperature for testing shall be in the range between 16 °C and 32 °C and the temperature limits shall be subject to an accuracy of ± 1 °C.

Two test aerosols are used for measurement of filter penetration:

- a) Sodium Chloride, using the equipment described in Clause 6:
- b) Paraffin Oil, using the equipment described in Clause 7.

NOTE Laboratories should give consideration to the following factors:

- Test chamber should be designed to minimise air velocity variations across the surface of the filter under test. Localised high air velocity ("jets"), may result in artificially high filter penetration.
- Paraffin oil used for testing should not have been exposed to heating and compressed air for a long period of time, as this may alter the composition of the oil, possibly causing inaccurate results. Replacement of paraffin oil in the test rig should be done every 3 months.

The test aerosol is fed into the test chamber, where the particle filtering device under test is mounted under a leaktight manner on a suitable adaptor. Aerosol is passed through the device and the aerosol concentration is measured immediately before and after the particle filtering device by the photometer.

5.2 Penetration test

The measurement of penetration, according to 5.1, shall be taken as the average over a time of (30 + 3) s, beginning 3 min after the start of the aerosol test.

5.3 Exposure test

Penetration shall be recorded throughout the test at sample intervals not exceeding 5 min.

NOTE Continuous recording of penetration is recommended.

For particle filtering devices being tested using paraffin oil, continue the test until the particle filtering device has been exposed to the specified mass of the test aerosol as defined in the appropriate device standard.

For particle filtering devices being tested using sodium chloride, continue the test until the particle filtering device has been exposed to the specified mass of the test aerosol as defined in the appropriate device standard, unless:

- a) for single shift use particle filtering devices, the penetration shows continued decline for 5 min or 5 sample intervals, whichever is the greater;
- b) for re-useable particle filtering devices, the penetration shows continued decline for 5 min or 5 sample intervals, whichever is the greater, and the maximum penetration is lower than when tested using paraffin oil test aerosol.

If these conditions are met, the exposure test may be terminated early.

Report the maximum penetration during exposure.

5.4 Storage test

For re-useable particle filtering devices the storage test shall be performed immediately after the completion of the exposure test.

Remove the particle filtering device from the penetration test chamber and store the particle filtering device in accordance with EN 13274-5, for duration of (24 ± 1) h under ambient conditions as described in 3.1 of EN 13274-5:2001, ensuring that particle filtering devices are not in contact with each other.

The particle filtering device shall not be removed from the suitable adaptor if this may result in damage to the device.

After storage, immediately repeat the penetration test according to 5.2.

6 Sodium chloride test method

6.1 Principle

An aerosol of sodium chloride particles is generated by atomising an aqueous solution of the salt and evaporating the water. The concentration of this aerosol is measured before and after the filter under test by means of flame photometry. Accurate determinations are possible in the range $< 0,001\%$ to 100% filter penetration.

When an alternative design of test equipment to that given in 6.2 is used, it shall be correlated directly with this reference method and shall be shown to be equivalent over the whole of the operational range.

6.2 Test equipment

The apparatus is shown schematically in Figure 1. The aerosol is generated by using a Collison atomizer filled with a 1% solution of sodium chloride. The atomizer, an example of which is shown in Figure 2, consists of a glass reservoir into which is sealed an atomizer head having three spray nozzles. Air is supplied to the atomizer at a pressure of $3,45$ bar and the resulting liquid spray impinges on a baffle which removes the large particles. The particles which do not impact are removed in the air flow and, on mixing with dry air the water evaporates leaving a dry sodium chloride aerosol.

The aerosol produced by this method is polydisperse with a mass median particle diameter of approximately $0,6\text{ }\mu\text{m}$. The particle size distribution is given in Figure 3. It has been found that the aerosol remains constant, within acceptable limits, with respect to particle size and concentration provided that the supply pressure is in the range from $3,3$ bar to $3,6$ bar and the flow rate of air to the three nozzles is from $12,5\text{ l/min}$ to $13,0\text{ l/min}$. The output is mixed with 82 l/min of dry air in a chamber with a minimum volume of $1\text{ }750\text{ cm}^3$ giving a total flow rate of 95 l/min .

NOTE 1 The sodium chloride solution in the atomizer is consumed at a rate of approximately 15 ml/h . This loss is due in part to the atomization of the solution and in part to evaporation of water from the reservoir. The volume of the reservoir is such that the change in concentration and loss in volume of the solution during an 8 h period will not cause an appreciable change in the characteristics of the test aerosol.

The sodium chloride aerosol is analysed before and after the filtering device under test by flame photometry. The photometer used for this analysis can be any suitable instrument having the required sensitivity, however, a photometer specially designed to meet these requirements is available.

NOTE 2 Information concerning the supplier of the photometer and the aerosol generator can be obtained from the secretariat of CEN/TC 79.

In the photometer, the hydrogen burner is housed in a vertical flame tube through which the aerosol to be analysed flows. The hydrogen burner, which gives a flame symmetrical about the vertical axis, is surrounded

by a heat proof glass tube. This tube shall be optically homogeneous to minimize the effect on the light emitted by the flame.

Sodium chloride particles in air passing through the flame tube are vaporized giving the characteristic sodium emission at 589 nm. The intensity of this emission is proportional to the concentration of sodium in the air flow.

The intensity of the light emitted by the flame is measured by using a photomultiplier tube. To separate the sodium emission from background light of other wavelengths, a narrow band interference filter with appropriate sideband filters is used. This filter should preferably have a half-peak band width of no more than 5 nm.

As the photomultiplier output is only proportional to the incident light over a relatively small range, high light intensities are attenuated by neutral density filters. These filters are accurately calibrated in conjunction with the interference filter in use and so the actual light intensity can be calculated from the output of the photomultiplier. The signal from the photomultiplier is amplified and recorded.

6.3 Test conditions

| | |
|--|-----------------------------|
| Particle size distribution of the test aerosol at the test chamber | see Figure 3 |
| Test aerosol concentration at the test chamber | (4 to 12) mg/m ³ |
| Relative humidity of the test aerosol at the test chamber | less than 60 % |
| Flow rate of test aerosol from the generator | 95 l/min |
| Air pressure to atomizer | (3,3 to 3,6) bar |
| Flow rate to atomizer | (12,5 to 13,0) l/min |
| Flow rate of diluting air | 82 l/min |

NOTE Flow rate of hydrogen to photometer, 450 ml/min to 500 ml/min (typical).

6.4 Procedure

The test aerosol is fed into the test chamber, where the filter under test is fixed. The specified flow is passed through the filter and the aerosol concentration is measured immediately before and after the filter by the photometer.

Where the specified flow is less than 95 l/min, a bleed shall be incorporated to reduce the flow through the filter to the required rate.

Where the specified flow through the filter is greater than 95 l/min, a supply of clean air of less than 60 % relative humidity shall be added to the output of the aerosol generator so as to obtain the required flow rate. The air shall be added prior to the test chamber so as to ensure a homogeneous aerosol concentration within the test chamber. This procedure will also have the effect of reducing the aerosol concentration before the filter which shall be taken into account when calculating the filter penetration in accordance with 6.5.

6.5 Calculation of the penetration

$$P(\%) = \frac{C_2}{C_1} \times 100 \quad (1)$$

where

P is the penetration;

C_1 is the sodium chloride aerosol concentration upstream of the filter;

C_2 is the sodium chloride aerosol concentration downstream of the filter.

The concentrations C_1 and C_2 are calculated by taking background readings into account.

7 Paraffin oil test method

7.1 Principle

An aerosol of paraffin oil droplets is generated by atomising paraffin oil. The concentration of this aerosol is measured before and after the filter under test by means of a light scattering aerosol photometer. Accurate determinations are possible in the range < 0,001 % to 100 % filter penetration.

When an alternative design of test equipment is used it shall be correlated directly with the reference method and shall be shown to be equivalent over the whole of the operational range.

7.2 Test equipment

An example of the apparatus is shown in Figure 4. The aerosol is generated using an atomizer filled with paraffin oil (paraffinum perliquidum CP 27 DAB 7¹). The atomization vessel is heated by means of an electric heating device so that the temperature of the oil is kept to nominally 100 °C by means of a thermostat. Filtered compressed air at 4 bar is preheated and blown through the multiple nozzle unit. Large droplets in the generated oil mist are separated by a control nozzle and spiral tube. In the mixing vessel the oil droplets are diluted with 50 l/min filtered air. The generated aerosol is the test aerosol, which is reduced to the test concentration of $(20 \pm 5) \text{ mg/m}^3$ by wasting an appropriate fraction of the oil mist and by further dilution with filtered air at a flow rate of 83 l/min in the cyclone (Figure 5) which further modifies the particle size distribution. The test aerosol produced by this method is polydisperse. The particle size distribution is a logarithmic normal distribution with a number median Stokes diameter of 0,4 µm and a geometric standard deviation (σ_g) of 1,82 (see Figure 6).

The test aerosol is fed into the test chamber (Figure 4, (1)), where the filter under test is to be fixed. The excess of the aerosol is filtered by a high efficiency filter with a low flow resistance (Figure 4, (10)). The specified flow rate is drawn through the filter under test. The test concentration is measured before and after the filter under test by means of an integrating light scattering photometer with a 45° scattering angle. The light source is directed to the measuring cell and to the photomultiplier. The direct beam to the multiplier is interrupted by a chopper, so that the scattered light from the particles is always corrected for the source intensity variations. The reference beam is attenuated by means of neutral density filters and of a neutral density wedge automatically to the intensity of the scattered light beam.

The intensity of the scattered light, which is a measure of the aerosol concentration, is displayed.

1) Information concerning the supplier of the paraffin oil can be obtained from the secretariat of CEN/TC 79.

7.3 Test conditions at filter

| | |
|--|------------------------------|
| Particle size distribution of the test aerosol | see Figure 6 |
| Aerosol concentration | (15 to 25) mg/m ³ |

7.4 Procedure

The test aerosol is fed into the test chamber, where the filter under test is fixed.

For filter volume flow rates up to 95 l/min, the aerosol is sucked through the filter at the specified volume flow rate, by means of a suitable pump. The aerosol concentration is measured immediately before and after the filter by the aerosol photometer.

Where the specified flow through the filter is greater than 95 l/min, a supply of clean air shall be added to the output of the cyclone so as to obtain in excess of the required flow rate. The air shall be added prior to the test chamber so as to ensure a homogeneous aerosol concentration within the test chamber.

This procedure will also have the effect of reducing the aerosol concentration before the filter which shall be taken into account when calculating the filter penetration in accordance with 7.5.

NOTE It is important that the flow rate through the cyclone remains constant as this has been found to affect the particle size distribution.

7.5 Calculation of the penetration

$$P(\%) = \frac{l_2 - l_0}{l_1 - l_0} \times 100 \quad (2)$$

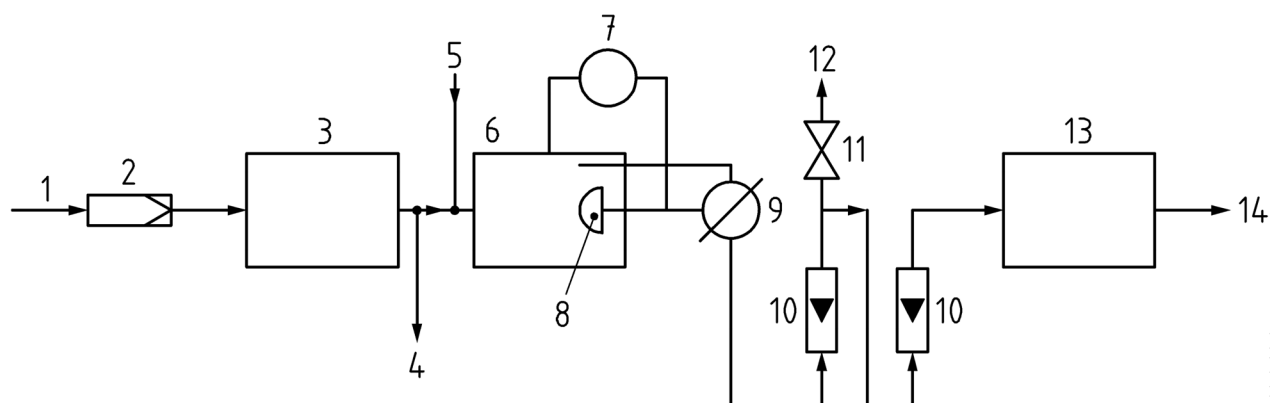
where

P is the penetration;

l_1 is the photometer reading in front of the filter;

l_2 is the photometer reading behind the filter;

l_0 is the photometer zero reading for clean air.

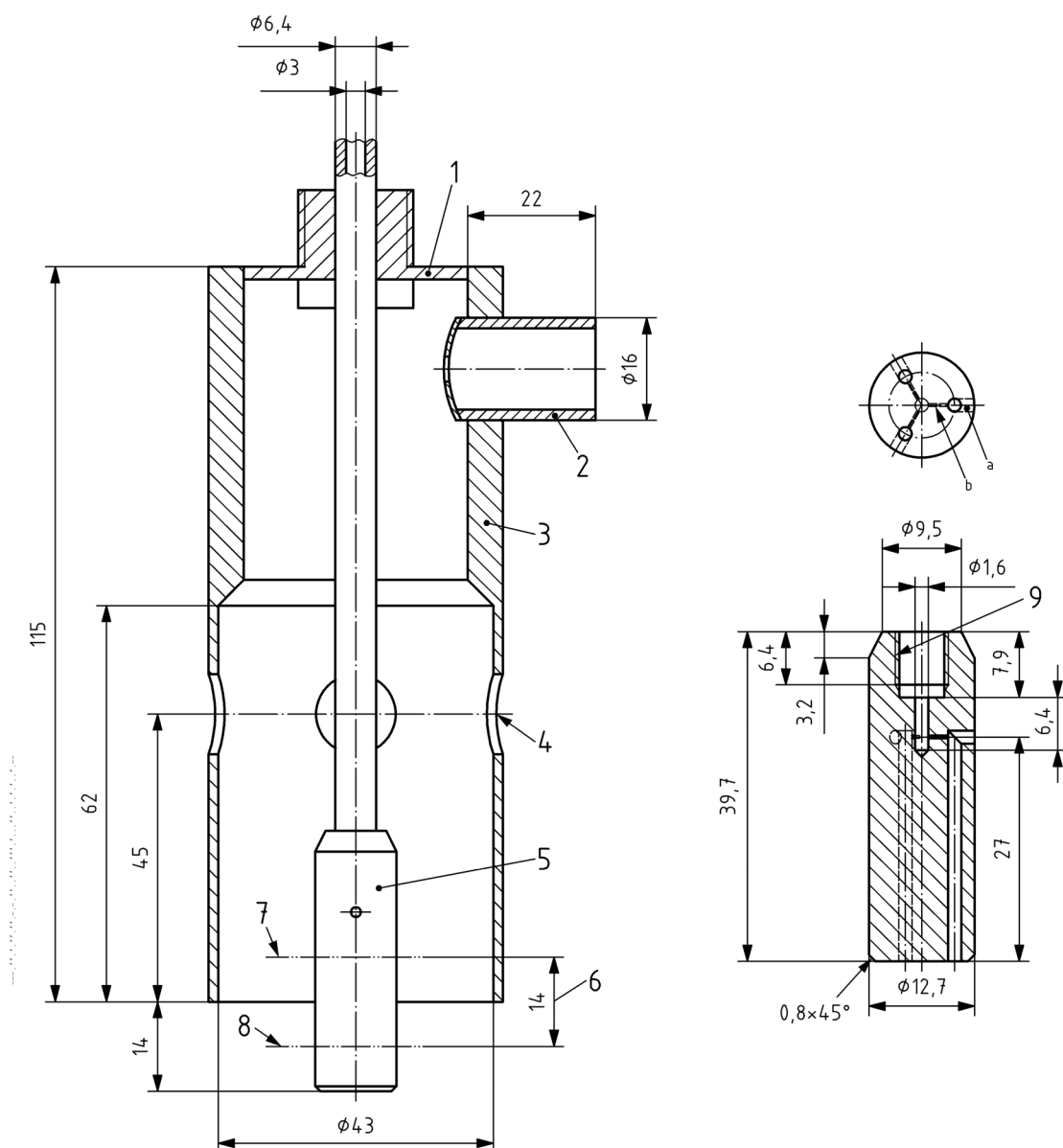


Key

| | | | |
|---|---------------------------|----|-----------------------------|
| 1 | compressed air | 8 | specimen |
| 2 | air filter | 9 | 3-way valve |
| 3 | test aerosol generator | 10 | flow meter |
| 4 | bleed | 11 | valve controlling flow rate |
| 5 | clean air | 12 | exhaust |
| 6 | test chamber | 13 | aerosol measuring apparatus |
| 7 | pressure gauge (optional) | 14 | exhaust |

Figure 1 — Schematic of an apparatus for sodium chloride test

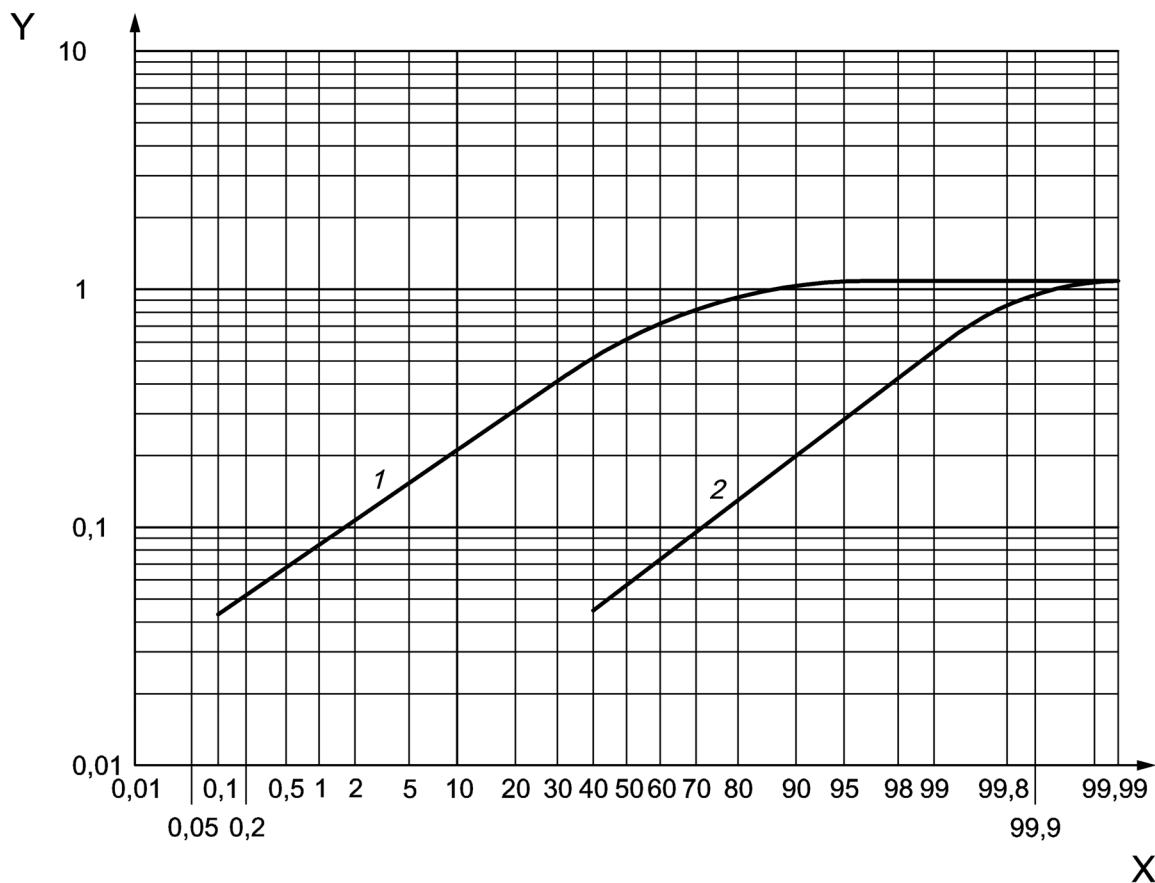
Dimensions in millimetres



Key

- | | |
|---|---|
| 1 threaded bush | 6 1% NaCl solution |
| 2 connector | 7 max. |
| 3 body | 8 min. |
| 4 4 holes, 12,5 minimum diameter, equi-spaced | 9 tapped 6,4 |
| 5 nozzle | a) 3 holes 1,6 dia, equally spaced on 7,9 P.C. dia. |
| | b) 3 holes 0,34 dia. |

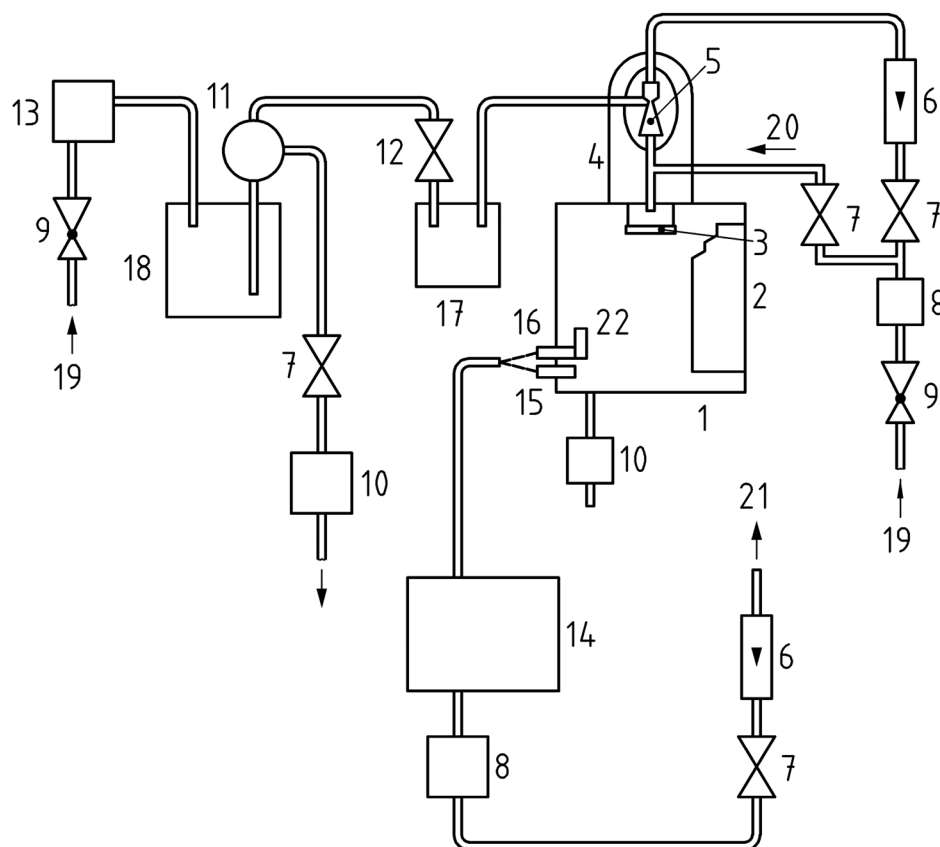
Figure 2 — Schematic of an atomizer body assembly for sodium chloride test showing maximum and minimum 1% NaCl solution levels



Key

- 1 mass distribution
- 2 number distribution
- X percentage below stated size
- Y longest diagonal of NaCl particle (μm)

Figure 3 — Size distribution produced by atomizing 1 % NaCl solution at 3,45 bar



Key

| | | | |
|----|---------------------------|----|--|
| 1 | test chamber | 12 | needle valve |
| 2 | access panel | 13 | aerosol generator |
| 3 | oil trap/baffle | 14 | scattered light photometer |
| 4 | cyclone housing | 15 | measuring port: chamber aerosol concentration |
| 5 | cyclone | 16 | measuring port: filtered air aerosol concentration |
| 6 | air flow meters | 17 | oil trap |
| 7 | air flow regulating valve | 18 | aerosol conditioning chamber |
| 8 | air filter | 19 | compressed air |
| 9 | compressed air regulator | 20 | dilution air supply |
| 10 | high capacity air filter | 21 | to vacuum pump |
| 11 | 'T'-piece | 22 | test specimen |

Figure 4 — Schematic of apparatus for paraffin oil test

Dimensions in millimetres

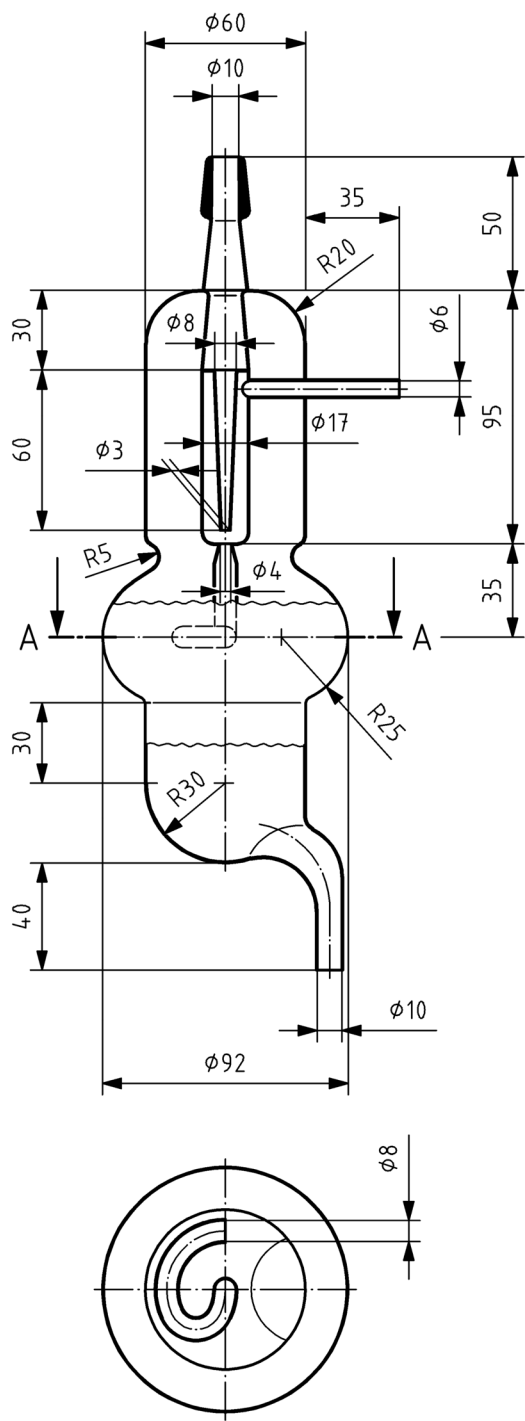
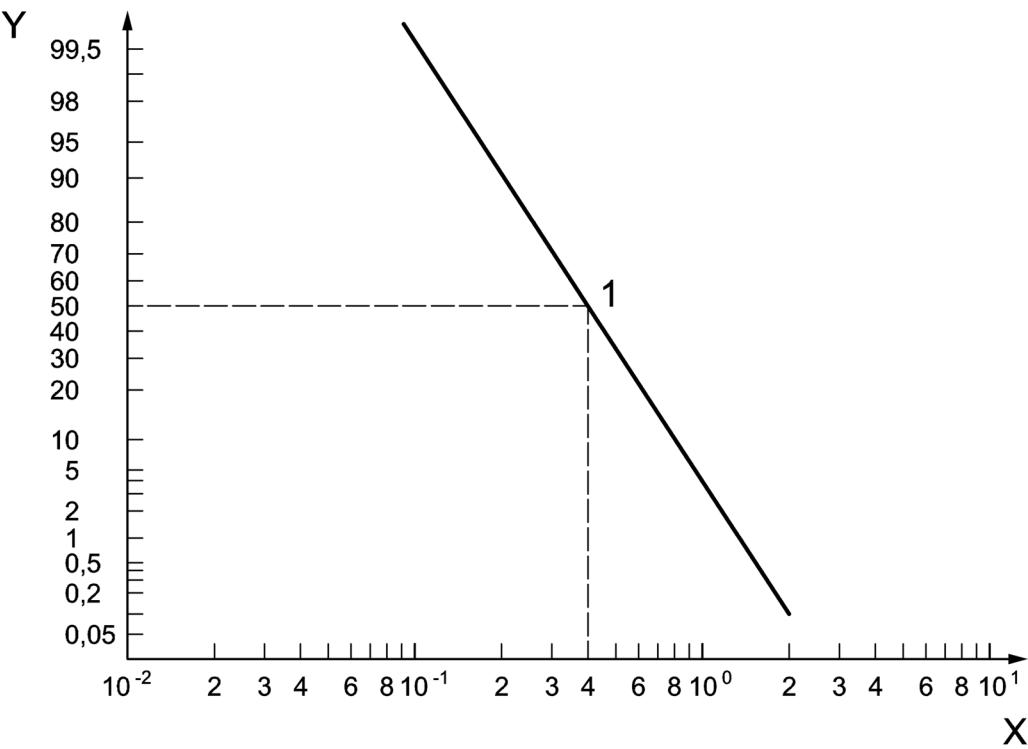


Figure 5 — Cyclone (type Friedrichs-Antlinger)



Key

- X stokes diameter in μm
- Y percentage above stated size
- 1 paraffin oil mist, number distribution $\sigma_{\log d} = 0,26$

Figure 6 — Particle size distribution of paraffin oil aerosol

Annex A (normative)

Test results - Uncertainty of measurements

For each of the required measurements performed in accordance with this European Standard, a corresponding estimate of the uncertainty of measurement shall be evaluated. This estimate of uncertainty shall be applied and stated when reporting test results, in order to enable the user of the test report to assess the reliability of the data.

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Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directives

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Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard, together with the requirements given in the specific product standard, confers, within the limits of the scopes of both standards, a presumption of conformity with the Essential Requirements of Directive 89/106/EEC, Annex II, clause 3.10.1.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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