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Ull — Bestämning av medelfiberdiameter — Luftgenomströmningsmetod

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Wool — Determination of mean diameter of fibres — Air permeability method

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Wool — Determination of mean diameter of fibres — Air permeability method

0 INTRODUCTION

When a current of air is passed through a uniformly arranged mass of fibres packed in a chamber with perforated ends, the ratio of air flow to differential pressure is uniquely determined by the total surface area of the fibres, and by various constants. This was predicted from the hydrodynamic equations of Kozeny and others.

For fibres of circular or near-circular cross-section and constant density, such as non-medullated wool, the surface area of a given mass of fibres is proportional to the average fibre diameter. This principle can be utilized to construct apparatus giving an estimate of fibre diameter. Because of its speed and simplicity, the method is particularly suitable for quality control in mill testing laboratories.

Since the method is indirect, the apparatus must first be calibrated from wools of known fibre diameter. For this purpose, eight reference slivers have been provided (see annex E).

It has been shown that the estimate of fibre diameter actually given by the permeability method is $d(1 + c^2)$, where d is the average fibre diameter (length biased) measured by the projection microscope, and c is the fractional coefficient of variation. Since c normally lies within comparatively small limits for unblended slivers, it is usual, however, to calibrate the apparatus directly in terms of d .

The method requires that the fibres be reasonably clean and dispersed in a uniform open state, such as card slivers or combed slivers. It is thus unsuitable for raw wool unless first scoured and carded. Some types of wool may need special calibrations as described in annex D.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method for the determination of the mean diameter of wool fibres, using an apparatus which passes a current of air through a bundle of fibres.

The method is applicable to clean, unmedullated wool fibres dispersed in a uniform, open state. It is particularly suitable for combed slivers. The method is also applicable to oil-combed slivers without cleaning, if the oil content is constant and the apparatus suitably calibrated.

The method is less accurate for lambswool and for wool which is appreciably medullated (see annex D).

2 REFERENCE

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*.

3 DEFINITIONS

For the purposes of this International Standard, the following definitions shall apply :

3.1 laboratory sample : The conditioned sample of fibres, representative of the bulk, from which the test specimens are weighed out. In many cases the laboratory sample will consist of one or more short lengths of sliver.

3.2 test specimen : The weighed amount of fibre which is packed into the constant volume chamber.

4 PRINCIPLE

A specified mass of fibres to be tested is compressed to a constant volume in a cylindrical chamber with perforated ends to which a flowmeter and a manometer are connected. The fibres are packed in such a way that they lie predominantly at right angles to the long axis of the chamber. A regulated current of air is then passed through the compressed fibres and the average fibre diameter read off from a scale on the manometer or the flowmeter.

5 APPARATUS

5.1 Forms of apparatus

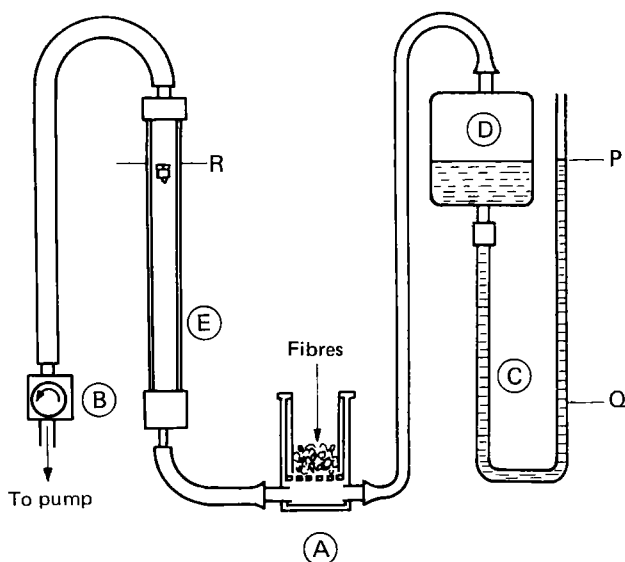
Two alternative forms of apparatus are described : "constant flow" and "constant pressure". Both forms of apparatus have the same arrangement of parts, as illustrated in figure 1.

The constant flow apparatus utilizes a specimen mass of 1,5 g; the flowmeter is adjusted to a fixed value and the fibre diameter is read off from the manometer scale. This scale is not linear since the successive intervals, corresponding to $1 \mu\text{m}$, decrease with the diameter.

The constant pressure apparatus utilizes a specimen mass of 2,5 g; the manometer is adjusted to a fixed pressure and the fibre diameter is read off from the flowmeter. The constant pressure apparatus gives a nearly linear scale in micrometres. Since less accuracy in weighing the specimen is required, this method has some advantages for mill use.

5.2 Detailed parts

The apparatus consists of the following parts arranged as shown in figure 1.



- (A) Constant volume chamber
 - (B) Air valve
 - (C) Manometer
 - (D) Reservoir
 - (E) Flowmeter
- P, Q, R Reference marks

FIGURE 1 — General arrangement of apparatus

5.2.1 Air valve (B), giving sufficiently fine control of the air supply, such that the lever of the flowmeter or manometer may be quickly adjusted to the working value.

5.2.2 Suction pump, of a type providing a smooth output of at least 30 l/min at 200 mmH₂O* with minimal fluctuation of the float of the flowmeter. A filter to trap any loose fibres may be inserted between the pump and the air valve (B).

5.2.3 Constant volume chamber (A), of brass, hardened steel, or any other suitable metal, comprising the three following parts: the base into which the fibres are packed, the plunger which compresses the fibres, and the screw cap which clamps the plunger to the base. The finish shall be smooth so that the plunger slides easily into the base without trapping fibres.

Suggested dimensions of the constituent elements of the chamber are given in figure 2.

5.2.4 Manometer (C), made of glass tubing of internal diameter at least 5 mm to reduce surface tension effects. In both cases a small amount of dye may be added to the manometer fluid, and where this consists of distilled water, a small trace of chromic acid should be added to give a clear meniscus. A millimetre scale is fixed behind the open limb as described in A.3.1 of annex A.

5.2.5 Reservoir (D) of the fluid manometer (5.2.4), having the characteristics specified in the following table, and mounted at a sufficient height to give a clear working distance PQ of 350 mm in the open limb of the manometer.

TABLE — Manometer and flowmeter characteristics

Characteristic	Constant flow	Constant pressure
Minimum diameter of reservoir	150 mm	60 mm
Type of manometer fluid	n-Propyl alcohol	Distilled water
Working range of flowmeter	10 to 20 l/min	5 to 25 l/min

5.2.6 Flowmeter (E), having the characteristics indicated in the table in 5.2.5.

5.2.7 Rubber tube, connecting the manometer reservoir (D) to the chamber (A), consisting of pressure tubing of small internal diameter to avoid constriction at the bends.

5.2.8 Rubber or plastic tube from the chamber (A) to the flowmeter (E), of internal diameter not less than 6 mm. The tube shall be as short as possible and shall not be twisted or kinked between calibration of the apparatus and its subsequent use.

5.3 Balance, capable of weighing the specimen to an accuracy of ± 2 mg for the constant flow method and of ± 4 mg for the constant pressure method.

6 CONDITIONING AND TESTING ATMOSPHERE

6.1 Whenever possible, the laboratory sample shall be conditioned to equilibrium and tested in one of the standard atmospheres for testing specified in ISO 139.

6.2 If tests are not carried out in the standard atmosphere for testing, the laboratory sample shall be conditioned to equilibrium near the apparatus and the relative humidity of the atmosphere at the time of test noted. The final results shall be corrected by the factors given in annex C.

NOTE — A source of error may occur if the moisture of the specimen changes during test. This may happen if the laboratory sample is allowed insufficient time to attain moisture equilibrium with the testing atmosphere. The minimum time required to ensure conditioning to equilibrium of a length of sliver in an opened-out state in a well-ventilated room is about 60 min.

* 1 mmH₂O = 9,806 65 Pa = 9,806 65 N/m²

Dimensions in millimetres

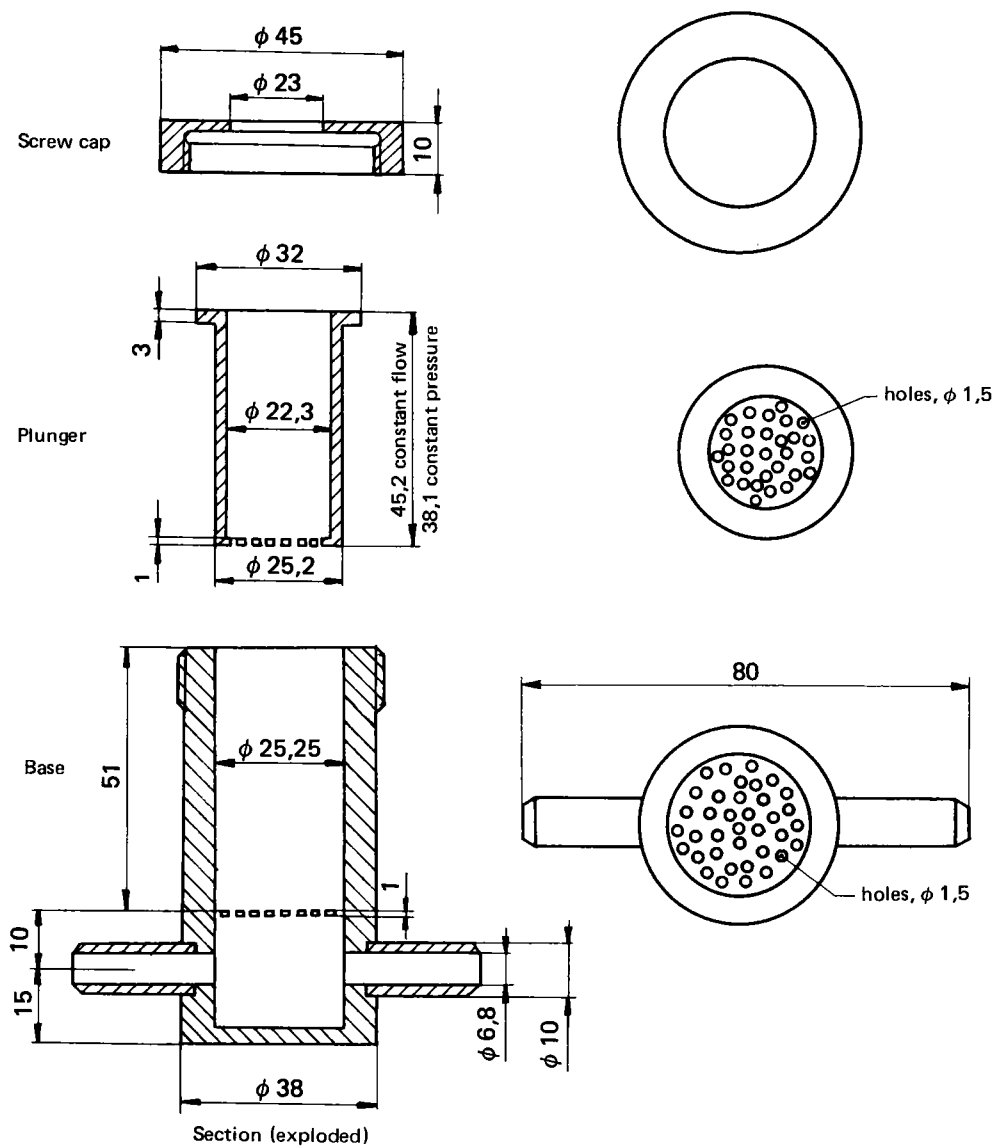


FIGURE 2 — Suggested dimensions of constant volume chamber (A)
Important dimensions are 22,3 — 25,2 — 25,25 — 42,5 and 38,1 mm

7 PREPARATION OF TEST SPECIMENS

7.1 Cleaning

In general the laboratory sample shall have a mass of about 8 g and shall first be degreased by rinsing well in two baths each of about 20 ml of petroleum ether before conditioning.

If the laboratory sample is known to be dry-combed with fatty matter content below 1 % (*m/m*), the test specimens may be taken from it without cleaning.

If the laboratory sample is known to be oily with fatty matter content between 3 and 4 % (*m/m*), the test specimens may be taken from it without cleaning provided the apparatus has been calibrated from oil-combed slivers.

7.2 Number of specimens

Unless otherwise specified, test a minimum of two specimens for fibre diameter below 30 μm and a minimum of three specimens for fibre diameter above 30 μm .

7.3 Selection of specimens

The specimens shall be taken from different places in the laboratory sample. In the case of balls of sliver, the laboratory sample shall be made up of pieces of sliver from both inside and outside the ball.

7.4 Specimen mass

For the constant flow method, the specimen mass shall be $1,5 \pm 0,002$ g. For the constant pressure method, the specimen mass shall be $2,5 \pm 0,004$ g.

7.5 Preparation

For slivers with cut ends, the specimen shall be prepared by cutting off with scissors a length to give as nearly as possible the specimen mass and then making up to the exact mass by adding shorter cut lengths or portions.

For slivers with pulled ends, about five hand draws shall be removed and discarded and the specimens weighed out by taking several successive hand draws.

These two methods of sampling give the same results if carried out properly.

8 PROCEDURE

8.1 Ensure that the meniscus of the manometer is at the zero mark and if required carry out an orifice plate check as detailed in A.3.3 of annex A.

8.2 Pull out the weighed test specimen into a long thin sliver and feed it evenly into the constant volume chamber (A), packing the fibres down with a smooth rod from time

to time. Insert the plunger and screw down the cap to the furthest extent so that the lip of the plunger is in contact with the base.

8.3 Depending on the method to be used, adjust the air valve as follows :

a) for the constant flow method, adjust the air valve until the top of the float of the flowmeter coincides with the reference mark R and note the fluid level of the manometer to the nearest 1 mm or 0,1 μm (see A.3.1 of annex A);

b) for the constant pressure method, adjust the air valve until the fluid level of the manometer coincides with the 180 mm reference mark P and note the position of the float of the flowmeter to the nearest 1 mm or 0,1 μm (see A.3.2 of annex A).

8.4 Remove the specimen from the constant volume chamber, tease out the fibres by hand, repack in the constant volume chamber without loss of fibre, insert the plunger and screw down the cap.

8.5 Repeat the operation specified in 8.4 so that a total of three readings on each test specimen is obtained.

9 EXPRESSION OF RESULTS

Calculate the average of the three readings for each specimen and express the result to the nearest 0,1 μm .

10 TEST REPORT

The test report shall include the following particulars :

- a) the reference to this International Standard;
- b) the method used (constant flow or constant pressure);
- c) the results obtained in accordance with clause 9;
- d) whether the sample was tested after cleaning in petroleum ether or without cleaning;
- e) the relative humidity and temperature of the conditioning and testing atmospheres and whether the result has been corrected for the relative humidity;
- f) all operating conditions not specified in this International Standard, as well as any incidents that may have influenced the results.

ANNEX A

CALIBRATION OF APPARATUS

A.1 LEAKAGE TEST

After assembling the apparatus as in figure 1, remove the cap and plunger from the constant volume chamber (A) and insert a rubber stopper. By means of a Hoffmann clip, close the rubber tube between (A) and (E) after introducing a pressure difference causing the level of the meniscus in the manometer to alter by about 150 mm. Note the position of the meniscus periodically for several minutes; if it changes, examine the apparatus for leaks.

A.2 SAMPLES OF SLIVERS

Obtain sufficient quantities of the reference slivers (see annex E) for calibration. In requesting these, state

a) the test specimen mass for the apparatus to be used (1,5 or 2,5 g);

b) whether oil-combed or dry-combed samples are required.

Sufficient numbers of each type of sliver are normally supplied for four specimens.

A.3 GRADUATING THE SCALE

A.3.1 Constant flow apparatus

Make a horizontal mark R (see figure 1) near the top of the flowmeter scale, avoiding any position giving marked fluctuation of the float. Fix a scale graduated in millimetres behind the manometer and adjust the zero mark to coincide with the meniscus of the liquid. Then condition and weigh out, according to the procedure specified in clauses 6 and 7, 1,5 g specimens of each sample of reference sliver and test according to the procedure specified in clause 8, noting the distance in millimetres below the zero to which the meniscus falls. Do not clean the sliver before test. Test three specimens from each of the eight reference slivers in this way and calculate the average of the nine readings for each reference sliver.

Plot the average depression h , in millimetres, of the manometer meniscus against the known value of fibre diameter d , in micrometres, and, after inspection to ensure that the points lie about a smooth curve, fit a relation by least squares as given below. From this relation a conversion table may be prepared, in micrometres, or a scale may be graduated in micrometres and fixed behind the manometer.

Adjustment of results by the least squares method

The relation between d and h is of the form $hd^b = \text{constant}$ and it is thus necessary to take logarithms to obtain a linear relation.

Let $X = \log d$ and $Y = \log h$.

For each of the n lots of sliver used for standardization, two values (X_1 and X_2 , X_2 and Y_2 , etc.) are obtained.

First calculate the following quantities :

$$\Sigma X = X_1 + X_2 + \dots + X_n$$

$$\Sigma Y = Y_1 + Y_2 + \dots + Y_n$$

$$\Sigma Y^2 = Y_1^2 + Y_2^2 + \dots + Y_n^2$$

$$\Sigma XY = X_1 Y_1 + X_2 Y_2 + \dots + X_n Y_n$$

$$\Sigma y^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{n}$$

$$\Sigma xy = \Sigma XY - \frac{\Sigma X \Sigma Y}{n}$$

$$b = \frac{\Sigma xy}{\Sigma y^2}$$

The regression equation of X and Y which applies to the apparatus is then

$$X = \frac{\Sigma X}{n} + b \left(Y - \frac{\Sigma Y}{n} \right) \quad \dots (1)$$

Finally, construct a table relating h to d by taking values of h at 5 mm intervals, finding $\log h$, substituting in equation (1) to obtain X and so tabulating $d = \text{antilog } X$ for each value of h .

A.3.2 Constant pressure apparatus

Make a horizontal mark at a distance corresponding to 180 mm water pressure from the zero mark Q of the manometer. Fix a scale graduated in millimetres behind the flowmeter (E) so that the zero of this scale coincides with a file mark (zero) made near the bottom of the flowmeter. Condition and weigh out 2,5 g specimens of each sample of reference sliver according to the procedure specified in clauses 6 and 7, and test according to the procedure specified in clause 8, noting the distance y , in millimetres, of the float of the flowmeter from zero. Do not clean the slivers before test. Test three specimens from each of eight reference slivers in this way and calculate the average of the nine readings for each reference sliver.