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Textile fibres — Determination of linear density — Gravimetric method and vibroscope method

Fibres textiles — Détermination de la masse linéique — Méthode gravimétrique et méthode au vibroscope

Reference number
ISO 1973:1995(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1973 was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 6, *Fibre testing*.

This second edition cancels and replaces the first edition (ISO 1973:1976), which has been technically revised.

Annexes A and B of this International Standard are for information only.

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Textile fibres — Determination of linear density — Gravimetric method and vibroscope method

1 Scope

This International Standard specifies a gravimetric method and a vibroscope method for the determination of the linear density of textile fibres applicable respectively to:

a) bundles of fibres;

b) individual fibres.

Useful data can be obtained on man-made fibres and, with less precision, on natural fibres.

The procedures can be applied only to fibres which can be kept straight and, in the case of bundles, parallel, during test preparation. These methods are properly applicable when the fibres are readily freed of crimp. They are not applicable to tapered fibres.

NOTE 1 The vibroscope method may not be applicable to hollow and flat (ribbon-like) fibres.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 139:1973, *Textiles — Standard atmospheres for conditioning and testing.*

ISO 1130:1975, *Textile fibres — Some methods of sampling for testing.*

ISO 6989:1981, *Textile fibres — Determination of length and length distribution of staple fibres (by measurement of single fibres).*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 tension: Force tending to cause the extension of a body.

NOTE 2 In textile testing, the tension applied is based on the linear density or cross-sectional area.

3.2 tensioning force: Force effective on a fibre specimen during the vibroscope test.

4 Principle

Two methods for determining linear density are described:

4.1 Gravimetric method (direct method by weighing), for bundles of fibres

Specimens of a given length are weighed on a balance. This method is applicable to bundles of fibres.

4.2 Vibroscope method, for individual fibres

Individual fibres of a given length and under specified tension are subjected to vibration at resonance frequency. The linear density is determined from the conditions of the resonance state, i.e. the resonance frequency, the length of the fibre and the tensioning force. The linear density is read directly on the scale of the vibroscope apparatus. This method assumes that the linear density of the tested length of the fibre is constant.

NOTE 3 For high-modulus fibres (e.g. aramid fibres) the use of the vibroscope method should be agreed on by the interested parties, because the high stiffness of such fibres may influence the results.

5 Apparatus

5.1 Gravimetric method

5.1.1 Balance, suitable for weighing the bundles of fibres to an accuracy of at least ± 1 %.

5.1.2 Device for cutting the bundles under tension to a length known within an accuracy of ± 1 % and allowing an adjustment of the tension of the bundles to be cut.

For example, two razor blades set parallel in a suitable holder may be used.

5.1.3 Combsorter, for preliminary alignment of fibres.

5.1.4 Textile support fabric, of a colour contrasting with that of the fibres to be tested.

5.1.5 Glass plate, measuring approximately 100 mm × 200 mm, with one polished edge.

5.1.6 Forceps.

5.2 Vibroscope method

5.2.1 Vibroscope[1)], having the following accuracy:

a) The applied tensioning force shall be within the range of ± 0,5 % of the specified value;

b) The error in the vibroscope reading of resonance frequency measured or applied shall not exceed ± 0,5 %;

c) The error in the vibroscope reading of vibration length of the fibre shall not exceed ± 1 %.

6 Conditioning and testing atmospheres

The atmospheres for preconditioning, conditioning and testing shall be in accordance with ISO 139.

7 Sampling

To ensure that the laboratory sample is representative of the material and that the test specimen taken from the laboratory sample is representative of that sample, sampling shall be carried out in accordance with ISO 1130.

8 Procedure

8.1 Gravimetric method

8.1.1 Condition the test specimens and carry out the tests in the standard atmosphere for testing as specified in clause 6.

8.1.2 From the laboratory test sample, take ten tufts having a mass of several milligrams and bring the fibres of each tuft into parallel alignment by carefully combing them several times with the combsorter (5.1.3).

8.1.3 Cut the middle part of each combed tuft to a given length (as great as possible), under the minimum tension necessary to remove crimp, by means of the cutting device (5.1.2). Take the necessary precautions so that there are no free fibre ends anywhere except at the two ends of the cut bundle.

8.1.4 Place the ten bundles so obtained on the textile support fabric (5.1.4) and cover them with the glass plate (5.1.5), from the polished edge of which they shall protrude slightly.

8.1.5 From each of the ten bundles in turn, take out five fibres so as to form a bundle of 50 fibres, in each case drawing the fibres from one cut end. Make at least ten of these bundles. Recondition the specimen in the atmosphere specified in clause 6, if necessary. Weigh these bundles individually, using the balance (5.1.1), to an accuracy of 1 %.

NOTE 4 If the bundle of 50 fibres cannot be weighed on the balance to the required 1 % accuracy, the number of fibres may be increased up to 500.

8.2 Vibroscope method

8.2.1 Check the vibroscope, before examining the laboratory test sample, as follows. Test 100 individual fibres using the vibroscope in question. Test these same fibres, for comparison, using the gravimetric method. Calculate the arithmetic mean and coefficient of variation of the vibroscope readings of linear density. If the coefficient of variation of the vibroscope readings is larger than 10 %, the sample is not suitable for determination of linear density using this vibroscope.

1) For a list of suppliers of suitable vibroscope equipment, apply to the Secretariat of ISO Technical Committee 38.

Weigh the bundle of 100 fibres that have been tested with the vibroscope using the balance (5.1.1). Measure the length of all fibres in accordance with ISO 6989 with an accuracy of ± 1 %. Or, where appropriate, cut the 100 fibres to a known length using the cutting device (5.1.2).

Calculate the mean linear density, $\bar{\rho}_{l,b}$, of the fibre, expressed in decitex, using the following formula:

$$\bar{\rho}_{l,b} = \frac{m_b}{\sum_{i=1}^{100} l_i} \times 10^4$$

where

m_b is the mass, in milligrams, of the fibre bundle;

l_i is the length, in millimetres, of the ith fibre in the bundle.

Compare this mean linear density with the mean value of the linear density readout on the vibroscope. The relative difference shall not exceed ± 3 % of the mean value of the vibroscope readings.

8.2.2 From the laboratory test sample, take ten tufts having a mass of several milligrams and with these form a bundle by repeated halving and doubling. From this bundle take a tuft of at least 50 fibres and condition them as specified in clause 6.

8.2.3 Fix each of the fibres to the vibroscope under the applied tensioning force, which shall be sufficient to remove the crimp, using forceps (5.1.6) and taking care to avoid any damage or distortion of the fibre.

Calculate the tensioning force to be applied from the nominal linear density. If the nominal linear density is not known, an approximate value of the linear density shall be established by preliminary tests, recorded from the scale of linear density readings.

Once this tensioning force has been selected, it shall be applied and maintained with the required accuracy (see 5.2.1).

Normally tensions chosen within the range (0,6 ± 0,06) cN/tex are suitable.

For highly crimped fibres, increase the tension to remove the crimp but not to stretch the fibre, in accordance with the vibroscope manufacturer's specifications. Alterations in tensioning force shall be stated in the test report.

9 Expression of results

Examples of calculations of mean linear density are given in annex A.

9.1 Gravimetric method

9.1.1 For each bundle, calculate the mean linear density ($\bar{\rho}_{l,b}$) of the fibre, and calculate the mean linear density ($\bar{\rho}_l$), expressed in decitex, of the fibre in all bundles tested, to three significant figures.

9.1.2 Calculate the coefficient of variation of the mean linear density ($\bar{\rho}_l$), expressed as a percentage to the nearest 0,1 %.

9.1.3 Calculate the 95 % confidence interval of the mean linear density ($\bar{\rho}_l$), expressed in decitex, to the same precision as the mean linear density value.

9.1.4 Calculate the 95 % confidence interval expressed as a percentage of the mean linear density value ($\bar{\rho}_l$).

If the value of the confidence interval expressed as a percentage of the mean is within ± 2 %, the number of bundles tested is adequate and the mean of the linear density shall be taken as the mean linear density of the laboratory sample.

If the value of the confidence interval expressed as a percentage of the mean is above ± 2 %, the number of bundles tested shall be increased until the value of the confidence interval is within ± 2 %.

9.2 Vibroscope method

9.2.1 Calculate the mean of the vibroscope readings of linear density of the fibres tested, expressed in decitex to three significant figures.

9.2.2 Calculate the coefficient of variation of the individual values for the linear density, expressed as a percentage to the nearest 0,1 %.

9.2.3 Calculate the 95 % confidence interval of the mean linear density in decitex to the same precision as the mean linear density value.

9.2.4 Calculate the 95 % confidence interval expressed as a percentage of the mean linear density value.

The mean of the linear density values obtained shall be taken as the mean linear density of the fibres in the sample, provided that the value of the confidence interval expressed as a percentage of the mean linear density is less than ± 2 %.

If the value of the confidence interval is too high, the number of fibres tested shall be increased until the value of the confidence interval, expressed as a percentage, lies within ± 2 %.

10 Test report

The test report shall include the following information.

10.1 General

a) Reference to this International Standard and date of test;

b) complete identification of the sample tested;

c) type of package, its condition (e.g. raw, bleached, dyed);

d) conditioning and testing atmosphere used;

e) sampling scheme used, number of specimens tested;

f) test method (gravimetric or vibroscope) and type of tester used;

g) any deviation, by agreement or otherwise, from the procedure specified.

10.2 Gravimetric test results

a) Length of the cut bundle;

b) number of bundles tested;

c) mean linear density of the sample, in decitex;

d) coefficient of variation, as a percentage;

e) 95 % confidence interval, in decitex.

10.3 Vibroscope test results

a) Number of fibres tested;

b) tensioning force used;

c) mean linear density of the sample, in decitex;

d) coefficient of variation as a percentage;

e) 95 % confidence interval, in decitex.

Annex A
(informative)

Examples of calculation of mean linear density

For additional details see ISO 2602.

A.1 Gravimetric method — Bundles of 50 fibres

A.1.1 Data

Values of weighings of ten bundles, in milligrams:

0,385; 0,388; 0,381; 0,379; 0,375;

0,383; 0,388; 0,377; 0,400; 0,381.

Cut length: 50 mm.

A.1.2 Calculations

Mean linear density of the fibre in each bundle, in decitex:

$$\bar{\rho}_{l,b} = \frac{m_b}{n_f \cdot l_f} \times 10^4 = \frac{m_b}{50 \times 50} \times 10^4 = \begin{matrix} 1,54;\ 1,55;\ 1,52;\ 1,52;\ 1,50; \\ 1,53;\ 1,55;\ 1,51;\ 1,60;\ 1,52. \end{matrix}$$

where

m_b is the mass of the fibre bundle, in milligrams;

n_f is the number of fibres in the bundle;

l_f is the length of the individual fibres in the bundle, in millimetres.

Mean linear density of the fibres in all bundles: $\bar{\rho}_l$ = 1,53 dtex.

Coefficient of variation: v = 1,8 %.

Confidence interval:

$$\Delta = \pm \frac{s \cdot t}{\sqrt{n_b}} = \pm 0,02 \text{ dtex}$$

where

s is the standard deviation, calculated to be 0,028 dtex;

n_b is the number of fibre bundles;

t is the Student's distribution, taken from a statistical chart and equal to 2,26 for n_b = 10 and a probability level P = 95 %.

Value percentage of the confidence interval:

$$\Delta\ \% = \frac{100 \cdot \Delta}{\bar{\rho}_l} = \pm\ 1{,}3\ \%$$

As this value is less than 2 % limit specified in 9.1.4, the calculated mean of 1,53 dtex can be accepted as the mean linear density of the sample.

A.2 Vibroscope method — Individual fibres

Values of 50 individual determinations of linear density in decitex:

1,51; 1,47; 1,42; 1,64; 1,38;
1,55; 1,41; 1,56; 1,44; 1,41;
1,37; 1,66; 1,58; 1,41; 1,52;
1,68; 1,63; 1,40; 1,73; 1,67;
1,53; 1,40; 1,39; 1,58; 1,38;

1,40; 1,67; 1,60; 1,50; 1,73;
1,61; 1,36; 1,37; 1,49; 1,23;
1,60; 1,72; 1,71; 1,47; 1,38;
1,45; 1,28; 1,58; 1,70; 1,58;
1,53; 1,48; 1,55; 1,53; 1,36.

Mean linear density of the 50 individual fibres: $\bar{\rho}_l = 1{,}51$ dtex.

Coefficient of variation: $v = 8{,}3\ \%$

Confidence interval:

$$\Delta = \pm\ \frac{s \cdot t}{\sqrt{n}} = \pm\ 0{,}04 \text{ dtex}$$

where

s is the standard deviation, calculated to be 0,125 dtex;

n is the number of determinations;

t is the Student's distribution, taken from a statistical chart and equal to 2,01 for $n = 50$ and a probability level $P = 95\ \%$.

Value percentage of the confidence interval:

$$\Delta\ \% = \frac{100 \cdot \Delta}{\bar{\rho}_l} = \pm\ 2{,}3\ \%$$

As this value is greater than the 2 % limit specified (Δsp) in 9.2.4, the number of tests must be increased by a quantity n_2, calculated by the formula:

$$n_2 = \frac{t^2 \cdot v^2}{(\Delta sp)^2} - n_1$$

where, for our example:

$n_1 = 50$;

$v = 8{,}3\ \%$;

$\Delta sp = 2\ \%$;

$t = 2{,}01$.

The additional number of tests is thus:

$$n_2 = \frac{2{,}01^2 \times 8{,}3^2}{2^2} - 50 = 20$$

The values from the 20 additional determinations of $\bar{\rho}_l$ are:

1,67; 1,53; 1,41; 1,45; 1,68; 1,73; 1,56; 1,54; 1,70; 1,52;

1,49; 1,63; 1,70; 1,52; 1,36; 1,52; 1,50; 1,39; 1,35; 1,37.

The mean of 50 + 20 individual determinations of linear density is: $\bar{\rho}_l = 1,52$ dtex.

The new standard deviation, s, is calculated to be 0,125 dtex, the coefficient of variation, $v = 8,2$ %, and the new confidence interval, Δ, becomes $\pm$ 0,03 dtex. The value percentage of the confidence interval is thus now acceptable:

$$\Delta\ \% = \frac{100 \cdot \Delta}{\bar{\rho}_l} = 2,0\ \%$$