INTERNATIONAL STANDARD

ISO 1973

Third edition
2021-01

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 1973:2021(E)

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 23, *Fibres and yarns,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 248, *Textiles and textile products,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO1973:1995), which has been technically revised.

The main changes compared to the previous edition are as follows:

— ISO 6989 has been added as a normative reference in Clause 2 and 8.2.1;

— a note specifying the tension application has been added in 3.2;

— a correction factor (for measurements on stiff fibres) has been permitted in 4.3, 8.2.1 and 10.3;

— testing equipment without a scale but with a display, respectively connection to a computer system in 4.3 for linear density reading is permitted;

— reference to 5.2.2 “Forceps” (instead of 5.1.6) has been corrected;

— automatic application of a loading force instead of the use of forceps in 5.2.2 and 8.2.3 is permitted;

— Formulae (A.1) to (A.8) have been corrected;

— grammar and linguistic consistency of definitions in 4.3, 8.1.3, 8.2.2, 9.2.1, A.1 and A.2 have been reviewed.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The linear density of individual fibres is one of the most important physical characteristics in terms of processability and predictability of the next-step intermediate product, such as spun-yarns and nonwovens. Other than testing methods, such as air-permeability on test specimen consisting of mass of fibres (Micronaire), this document describes two measurement methods to determine the mass per unit length (= linear density) using either a bundle of 50 fibres, or on individual fibres. While the first method determines an average value, only, in relatively short time, the second method measures the individual fibre fineness and therefore the statistical distribution of the laboratory sample, too.

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

1 Scope

This document 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.

This document only applies to fibres which can be kept straight and, in the case of bundles, parallel, during test preparation. It is properly applicable when the fibres are readily freed of crimp. The methods in this document are not applicable to tapered fibres.

The vibroscope method is not always applicable to hollow and flat (ribbon-like) fibres.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
tension
force tending to cause the extension of a body

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

Note 1 to entry: In textile testing, the tensioning force applied is based on the linear density or cross-sectional area.

4 Principle

4.1 General

Two methods for determining linear density are described.

4.2 Gravimetric method, for bundles of fibres

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

4.3 Vibroscope method, for individual fibres

Individual fibres of a given length and under specified tensioning force 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 vibrating length of the fibre and the tensioning force. The linear density is read directly on the scale or a display of the vibroscope apparatus respectively reported by a connected computer system. This method assumes that the linear density of the tested length of the fibre is constant.

Under certain circumstances (e.g. a short vibrating length, a low tensioning force, high-modulus fibres) the vibroscope method results are falsified by the bending stiffness of the fibre. As a compensating countermeasure, a correction factor can be applied (refer to 8.2.1), if agreed on by the interested parties.

5 Apparatus

5.1 Gravimetric method apparatus

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 Comb sorter, 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.

5.2 Vibroscope method apparatus

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 %.

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

5.2.2 Forceps, to apply the tensioning force to the individual fibre to be tested.

If the apparatus can apply the tensioning force automatically (e.g. by a moving lower clamp and a upper clamp connected to a force measuring device, as mentioned in 8.2.3), forceps are not required.

6 Sampling

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

7 Conditioning and testing atmospheres

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

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 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 comb sorter (5.1.3).

8.1.3 Cut the middle part of each combed tuft to a given length (greatest 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 tuft 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 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 %.

If the bundle of 50 fibres cannot be weighed on the balance to the required 1 % accuracy, the number of fibres shall be increased accordingly (up to a maximum of 500).

8.2 Vibroscope method

8.2.1 Check the vibroscope, before examining the laboratory 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.

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, $\bar{\rho}_{1,b}$ of the fibre, expressed in decitex, according to Formula (1):

$$\bar{\rho}_{1,b} = \frac{m_b}{\sum_{i=1}^{100} l_i} \cdot 10^4 \quad (1)$$

where

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

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

Compare this mean linear density with the mean value of the linear density readout on the vibroscope. The relative difference should not exceed ±3 % of the mean value of the vibroscope readings. If the relative difference exceeds ±3 %, a correction factor should be applied. The use of a correction factor shall be agreed on by the interested parties.

8.2.2 From the laboratory sample, take ten tufts having a mass of several milligrams, and with these tufts 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 (5.2.2) or by specifying the tensioning force (in case the apparatus can apply the tensioning force automatically). Take 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.

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

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

For highly crimped fibres, increase the tensioning force to remove the crimp but not to stretch the fibre, in accordance with the vibroscope manufacturer's specifications.

9 Expression of results

9.1 General

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

9.2 Gravimetric method

9.2.1 For each bundle, calculate the mean linear density $\left(\bar{\rho}_{1,b}\right)$ of the fibres, and calculate the mean linear density $\left(\bar{\rho}_1\right)$ of the fibres in all bundles tested, expressed in decitex to three significant figures.

9.2.2 Calculate the coefficient of variation of the mean linear density $\left(\bar{\rho}_1\right)$, expressed as a percentage to the nearest 0,1 %.

9.2.3 Calculate the 95 % confidence interval of the mean linear density $\left(\bar{\rho}_1\right)$, expressed 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 $\left(\overline{\rho}_1\right)$.

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 %.

9.3 Vibroscope method

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

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

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

9.3.4 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 laboratory 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

10.1 The test report shall include the following information.

10.2 General

a) a reference to this document, i.e. ISO 1973:2021, and the 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;

h) any unusual features observed;

i) the date of the test.

10.3 Gravimetric test results

a) length of the cut bundle;

b) number of bundles tested;

c) mean linear density of the sample, in decitex, including a reference to the clause which explains how the result was calculated;

d) coefficient of variation, as a percentage, including a reference to the clause which explains how the result was calculated;

e) 95 % confidence interval, in decitex, including a reference to the clause which explains how the result was calculated.

10.4 Vibroscope test results

a) number of fibres tested;

b) tensioning force used;

c) correction factor, if applied;

d) mean linear density of the sample, in decitex, including a reference to the clause which explains how the result was calculated;

e) coefficient of variation as a percentage, including a reference to the clause which explains how the result was calculated;

f) 95 % confidence interval, in decitex, including a reference to the clause which explains how the result was calculated.

Annex A
(informative)

Examples of calculation of mean linear density

A.1 General

For additional details, see ISO 2602.

A.2 Gravimetric method — Bundles of 50 fibres

A.2.1 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.2.2 Calculations

The mean linear density of the fibre in each bundle, in decitex, can be calculated according to Formula (A.1):

$$\bar{\rho}_{\mathrm{l,b}} = \frac{m_{\mathrm{b}}}{n_{\mathrm{f}} \cdot l_{\mathrm{f}}} \cdot 10^4 \qquad \text{(A.1)}$$

where

$m_{\mathbf{b}}$ is the mass, in milligrams, of the fibre bundle;

$n_{\mathbf{f}}$ is the number of fibres in the bundle;

$l_{\mathbf{f}}$ is the length, in millimeters, of the fibres in the bundle.

In the above example, using Formula (A.1) with the data shown in A.2.1 results in individual bundle linear density values of

= 1,54; 1,55; 1,52; 1,52; 1,50;1,53; 1,55; 1,51; 1,60; 1,52.

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

Coefficient of variation: v = 1,8 %.

Calculate the confidence interval according to Formulae (A.2) and (A.3):

$$\bar{\rho}_{1,b} - \Delta < m < \bar{\rho}_{1,b} + \Delta \quad \text{(A.2)}$$

with

$$\Delta = \frac{s \cdot t}{\sqrt{n_b}} \quad \text{(A.3)}$$

where

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

n_b is the number of fibre bundles;

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

In the above example using Formula (A.3) with the data shown in A.2.1, Δ will result in 0,02 dtex

Calculate the value percentage of the confidence interval according to Formula (A.4):

$$\Delta\% = \frac{100 \cdot \Delta}{\bar{\rho}_1} \quad \text{(A.4)}$$

In the above example using Formula (A.4) with the data shown in A.2.1, Δ% results in 1,3 %.

As this value is less than the 2 % limit specified in 9.2.4, the calculated mean of 1,53 dtex can be accepted as the mean linear density of the sample.

A.3 Vibroscope method — Individual fibres

A.3.1 Data

Values of 50 individual determinations of linear density in decitex:

1,51; 1,47; 1,42; 1,64; 1,38; 1,40; 1,67; 1,60; 1,50; 1,73;
1,55; 1,41; 1,56; 1,44; 1,41; 1,61; 1,36; 1,37; 1,49; 1,23;
1,37; 1,66; 1,58; 1,41; 1,52; 1,60; 1,72; 1,71; 1,47; 1,38;
1,68; 1,63; 1,40; 1,73; 1,67; 1,45; 1,28; 1,58; 1,70; 1,58;
1,53; 1,40; 1,39; 1,58; 1,38; 1,53; 1,48; 1,55; 1,53; 1,36.

A.3.2 Calculations

Mean linear density of the 50 individual fibres: $\bar{\rho}_1$ = 1,51 dtex.

Coefficient of variation: v = 8,3 %