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Textiles — Unevenness of textile strands — Capacitance method

Textiles — Irrégularité des fils textiles — Méthode capacitive

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Foreword

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The main task of technical committees is to prepare International Standards. 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.

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.

ISO 16549 was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 23, *Fibres and yarns*.

This International Standard cancels and replaces ISO 2649 which is now obsolete.

Introduction

In the 1960s the International Wool Textile Organization (IWTO) prepared an unevenness method destined for yarns and other strands made of wool. The method was adopted by ISO as ISO 2649:1974. It contains a discussion of the principles of unevenness testing and refers to the then-popular unevenness tester, the 1960s model of the Uster Evenness Tester, which was obsolete in mid-2000 when the present International Standard was written. Later, the IWTO prepared a new method, IWTO-18-00, published in 2000.

ISO 16549 has mostly new wording but includes some elements of ISO 2649 and of IWTO-18-00 – with thanks to IWTO.

Textiles — Unevenness of textile strands — Capacitance method

1 Scope

This International Standard describes a method, using capacitance measuring equipment, for determining the unevenness of linear density along the length of textile strands.

The method is applicable to tops, slivers, rovings, spun yarns and continuous filament yarns, made from either natural or man-made fibres, in the range of 4 tex (g/km) to 80 ktex (kg/km) for staple-fibre strands and 1 tex (g/km) to 600 tex (g/km) for continuous-filament yarns. It is not applicable to fancy yarns or to strands composed fully or partly of conductive materials such as metals; the latter require an optical sensor (see A.4).

The method describes the preparation of a variance-length curve, as well as the determination of periodicities of linear density. It covers also the counting of imperfections in the yarn, namely of neps and of thick and thin places.

Irregularities in the distribution of additives such as sizes, in moisture content and in fibre blending may increase the measured unevenness above its true value.

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.

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

3 Terms and definitions

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

3.1
unevenness
variation of linear density along the length of a continuous strand or yarn

NOTE The term is also used occasionally for the variation of yarn diameter.

3.2
coefficient-of-variation unevenness
CV_u
value of **unevenness** (3.1) expressed as a coefficient of variation

NOTE 1 The coefficient-of-variation unevenness is expressed in percent, for example $CV_\mathrm{u} =$ 18,3 %.

NOTE 2 See also 4.5 and 4.6.

3.3
mean-deviation unevenness
U_u
value of **unevenness** (3.1) expressed as an average mean deviation

NOTE 1 The mean-deviation unevenness is expressed in percent, for example, $U_\mathrm{u} =$ 14,6 %.

NOTE 2 See also 4.5 and 4.6.

3.4
capacitor length
effective length of the capacitor in the direction of the specimen movement, usually 8 mm to 20 mm

3.5
length between
L_b
length of the test specimen for which the instrument takes an individual reading of mass

NOTE 1 The unevenness value decreases as L_b is increased.

NOTE 2 In the capacitance method, L_b is normally the capacitor length but it can be increased electronically.

NOTE 3 L_b is sometimes referred to in the literature as B.

3.6
length within
L_w
length of the specimen for which an individual value of unevenness is determined and a reading is given

NOTE 1 The unevenness value increases as L_w is increased. When L_w is more than 100 m or so, then a further lengthening of L_w increases CV_u (or U_u) only slightly.

NOTE 2 L_w is sometimes referred to in the literature as W.

3.7
total measured length
sum of all measured lengths L_w

3.8
nep
tightly tangled knot-like mass of unorganized fibres

3.9
package
yarn wound to a shape, which may be supported (for example, bobbins, cones) or unsupported (for example, skeins, cakes), suitable for conditioning and testing

3.10
spectrogram
attachment to unevenness testers for the calculation and presentation of periodic variations in the strand

3.11
thick place
yarn defect with linear density substantially (at least 50 %) greater than that of the adjoining segments of the yarn and extending for at least 5 mm

3.12
thin place
yarn defect with linear density substantially (at least 50 %) smaller than that of the adjoining segments of the yarn and extending for at least 5 mm

4 Principle

4.1 A specimen is passed between two plates of a capacitor causing changes in capacitance which are proportional to the changes of mass of the specimen. The instrument evaluates these changes and reports them as CV_u or U_u.

4.2 The fibre dielectric constant is also a factor determining the capacitance change. As long as the dielectric constant is unchanging (non-blended strands or perfectly uniform blending), the dielectric constant has no influence on the unevenness reading, which depends solely on the variation of mass. If the dielectric constant differs for the types of fibres in a blend and if, at the same time, the blend is irregular, then the reading of unevenness is increased above its true value. The interpretation of results therefore requires caution.

4.3 Several studies have been conducted over the years, see Reference [3] for example, comparing the true unevenness of a specimen, determined by cutting and weighing (see A.3.1), with the reading from an unevenness tester. Good agreement was obtained, so the readings from the tester can be taken as being the true unevenness value.

4.4 The value of unevenness has meaning only if both L_b and L_w are known and they should, in principle, always be reported, preferably as CV_u (L_b, L_w).

EXAMPLE CV_u (10 mm, 1 000 m).

In practice, these two values are usually left unstated and are assumed to be those of the most commonly used unevenness tester, namely

— L_b: 8 mm for yarns, 12 mm for rovings, 20 mm for slivers and tops;

— L_w: total length of yarn on the package.

4.5 There are two possible expressions for unevenness, CV_u and U_u. The U_u is now obsolete and its use, while permitted, is discouraged. CV_u is the preferred expression.

4.6 If mass is distributed near to "normal", then the ratio of CV_u/U_u is approximately 1,25. This conversion factor must be used cautiously because, in case of departures from normality, the ratio can be considerably different. The conversion factor may be used to convert a table of quality levels from U_u to CV_u.

4.7 When CV_u is plotted against L_b, a "variance-length curve" is obtained which gives additional information on the material's unevenness. When the plot is made on log-log paper, then the curve is almost a straight line and its slope gives information on the relationship between short-term and long-term unevenness.

4.8 Unevenness testers usually contain a spectrogram, which analyses the data and provides information on periodic variations of linear density. This information is useful in finding faults in the processing. The analysis uses an algorithm based on the Fourier transformation.

4.9 Unevenness testers usually contain a counter for yarn imperfections, namely neps, and thick and thin places. The level beyond which the imperfections are counted can be adjusted.

4.10 Unevenness is a fundamental feature of yarn construction. It influences the efficiency of processing as well as fabric appearance. Lower unevenness generally results in a better-looking fabric but the relation is not simple and interpretation requires special care.

5 Apparatus

5.1 Different types of apparatus are in use for measuring strands made of staple fibres and filament yarns.

5.2 The apparatus consists of the following elements:

a) measuring device, featuring

— several measuring condensers, usually grouped into one unit, for strands of varying linear density,

— yarn guiding and pretensioning devices,

— an adjustable-speed motor to advance the strand;

b) signal processing unit, which

— computes and indicates the values of CV_u or U_u and may also calculate the variance-length curve and present a graph of the periodic variations of linear density,

— also counts the number of imperfections in most instruments. The unit shall be able to operate at the threshold level of $+$ 50 %, above which thick places are counted, and the level of $-$ 50 %, below which thin places are counted.

— reports a reading for neps which shall be a product of the length, expressed in millimetres, of the nep and the percent excess over the average linear density of the yarn (for example, 4 mm $\times$ 50 %). The level of $+$ 200 %, above which neps are counted, shall be available.

— other levels (for the three imperfection types) are also usually available;

c) printer (optional), which provides a plot of the linear density of the strand;

d) twisting device for testing untwisted or low-twist filament yarns. This device produces false twist in an untwisted or low-twist filament yarn, so that the yarn presents a nearly round cross-section as it passes through the condenser. If the yarn passes through in a flat mode, there is the danger of adding variation depending on the way the flat yarn is presented. The direction of the imparted false twist must be the same as that of any twist present in the yarn. The twisting device need not be used for the testing of monofilaments.

5.3 To calibrate, use the procedure built into the instrument if possible. Alternatively, use a standard (usually tape) of known unevenness provided by the instrument manufacturer and follow the manufacturer's instructions. Finally, if the manufacturer's standard is not available, an in-house material of known and preferably low unevenness, may be used.

6 Atmosphere for conditioning and testing

The standard atmosphere for preconditioning, conditioning and testing shall be as specified in ISO 139. Assure that the total length of the material to be tested is in moisture equilibrium. Conditioning for 24 h is usually sufficient for unsupported packages. Supported packages shall be conditioned for 48 h.

7 Sampling

7.1 Select laboratory samples in one of the following two ways:

— according to a material specification, if available;

— by agreement between the parties.

7.2 The following minimum numbers of packages are recommended:

— tops and slivers: 3 packages;

— rovings: 4 packages;

— staple-fibre yarns: 10 packages;

— filament yarns: 5 packages.

7.3 The material shall be unwound directly from the package during testing so as to avoid possible deformation during handling.

7.4 Test the number of specimens per package given in the material specification. If no specification is available, test one specimen per package.

7.5 Test the following lengths of test specimens. These are minimum values for the total measured length.

— tops and slivers: 50 m;

— rovings: 100 m;

— staple-fibre yarns: 400 m;

— filament yarns: 400 m.

8 Procedure

8.1 Setting of the apparatus

If the tester allows a choice between a “normal” and an “inert” test, perform the “normal” test and then the “inert” if desired to establish the variance-length curve. The “normal” choice for some testers will result in the performance of both the “normal” and the “inert” tests automatically, so the setting can be to “normal”.

8.2 Setting of the diagram scale

The following diagram scale settings are recommended for most cases:

— tops and slivers: ± 25 %;

— rovings: ± 50 %;

— glass-fibre rovings: ± 100 %;

— spun-fibre yarns: ± 100 %;

— filament yarns: ± 10 % or 12,5 %.

8.3 Selection of the condenser's measuring slot

The measuring ranges of the neighbouring slots overlap to some extent, so that certain specimens can be tested in two slots, and the results may differ. Follow the instrument manufacturer's recommendation as to selection of slot for strands of a particular linear density.

8.4 Selection of running speed

The following speeds are recommended. Other speeds may be used by agreement and shall then be stated in the test report.

— tops and slivers: 25 m/min;

— rovings: 50 m/min;

— yarns: 400 m/min.

8.5 Guiding facilities

Before starting the test, adjust the guiding and tensioning devices to provide a pretension which does not extend or otherwise distort the material. The specimen needs to pass through the condenser without fluttering which would produce an error of measurement.

8.6 Twisting device

Thread low-twist or untwisted filament yarns through the twisting device [see 5.2 d)].

8.7 Plot representing the linear density along the strand

Switch on the drive of the printer, if used. Only a short length of the plot will be needed.

8.8 Preliminary run

Old instruments may not stabilize their electronic measuring system automatically. In such cases, a preliminary run is recommended of approximately 20 % of the prescribed length.

8.9 Test run

Set the feed in motion and observe that the passage through the condenser is smooth and undisturbed. Run the test until the indicated CV_u or U_u value is stable, or for a specified time or length of strand, as mutually agreed.

9 Calculations and expression of results

9.1 If several packages were tested with one reading for each package, calculate the average CV_u or U_u value and, if required, the coefficient of variation of the individual values and the 95 % confidence limits. Round all results to the nearest 0,1 %.

9.2 If desired, determine the variance-length curve. If the instrument does not give the CV_u for long lengths, determine an additional CV_u for long-term unevenness by cutting and weighing, usually 100-m segments of yarn.

9.3 Express the incidence of imperfections as the number per kilometre.

9.3.1 Express the incidence of thick places as the number for which the linear density exceeds the average linear density of the yarn by at least 50 %. Counts at threshold levels other than $+$ 50 %, if used, shall also be reported.

9.3.2 Express the incidence of thin places as the number for which the linear density is less than 50 % of the average linear density of the yarn. Counts at threshold levels other than $-$50 %, if used, shall also be reported.

9.3.3 Express the incidence of neps as the number which exceeds a reading of $+$ 200 % [see 5.2 b)]. Counts at a threshold reading of other than 200 %, if used, shall also be reported.

NOTE A reading of $+$ 200 % is normally used for ring yarns and $+$ 280 % for open-end yarns.

10 Test report

The test report shall include the following information:

a) reference to this International Standard (ISO 16549:2004);

b) date of the test;

c) identification of the sample, including type of package;

d) average unevenness value CV_u or U_u, in percent. If required, report also the individual results, their coefficient of variation and 95 % confidence limits;

e) “length between”, L_b, and “length within”, L_w, if either differs from the usual values (see 4.4);

f) graph of the variance-length curve, if determined;

g) graph of the periodic variations, if determined;

h) a short length of the plot of the linear density along the strand, if determined;

i) number of thick places, if determined (see 9.3);

j) number of thin places, if determined (see 9.3);

k) number of neps, if determined (see 9.3);

l) threshold for thick places if other than + 50 % (see 9.3.1);

m) threshold for thin places if other than − 50 % (see 9.3.2);

n) threshold for neps if other than + 200 % (see 9.3.3);

o) running speed, if different from those given in 4.4;

p) any deviation in procedure from this International Standard.

Annex A
(informative)

Other methods for the determination of unevenness

A.1 Principles of test methods

There are three methods for evaluating unevenness:

a) visual assessment;

b) measuring devices which determine the variation of the mass of the material or other characteristics proportional to mass. Capacitance-type testers are covered in the body of this International Standard. Methods by squeezing are referred to in A.3.2;

c) measuring devices which determine the variation of the diameter of the material or other characteristics proportional to diameter. Optical methods are referred to in A.4;

d) since no exact ratio exists between mass and diameter, the results determined from methods A.1 b) and A.1 c) cannot be compared.

A.2 Visual assessment (suitable for yarns)

A.2.1 Yarn kept static and wound around a panel

The yarn is wound around a panel with specified winding density which depends on the linear density of the yarn. The panel can be rectangular or trapezoidal and should be of a contrasting colour. Trapezoidal panels highlight short periodical irregularities in the yarn by producing a moiré effect. The panels are assessed visually using agreed upon lighting. It may be helpful to tilt the panel during assessment.

For assessment use a comparison with standard materials or photographs. Alternatively, use agreed upon classification schemes or a verbal description of the observations.

For documentation, the panel with the wound yarn may be stored. Taking photographs is common. Placing photographic paper directly on the sample during lighting has been found to be helpful for avoiding eye irritation.

The visual method is simple to apply and is used quite often, despite the subjective assessment procedure. Image-analysed systems and storing-and-evaluation systems may be applied, if available.

A.2.2 Running yarn

Continuous unwinding and parallel grouping of rows of yarns allows visual observation of the running yarns by a test person, using appropriate lighting and a contrasting background. Verbal description of the observation is most often used and documentation of the test run is not possible.

A.3 Determination of mass

A.3.1 Cutting and weighing

This is a laborious and time-consuming method, used for special purposes such as evaluation of unevenness testers or research. The material is cut into segments of length L_b using appropriate equipment and the segments are weighed individually. The coefficient of variation of unevenness is calculated using the individual weights.

Note the following relationships.

a) length of cut, L_b: As L_b increases, the value of unevenness decreases.

b) number of packages: If segments of different packages are mixed, increased variation is expected. For example, when testing neighbouring yarns out of a warp (large number of packages), a higher variation results than for neighbouring yarns from a weft (small number of packages).

c) order of segments: The cut segments may follow each other consecutively or not (at a regular or non-regular distance). A tendency to larger variation is observed using the non-regular distances; the results cannot be compared directly.

A.3.2 Method using squeezing (applicable mainly to tops and slivers)

The strand is guided into a test area where it is squeezed against a steady bottom roller or plate by a movable measuring device. The movement of the measuring device is registered by mechanical or electrical means and is evaluated statistically.

A.4 Optical methods (suitable for yarns)

The evaluation of the unevenness of yarn diameter using optical means is expected to produce an irregularity pattern similar to visual impression. The system is applied mainly to the control of filament yarns or for conductive and wet yarns.

The specimen is passed through an optical sensor (one or several systems of light sources and receivers). Optically distinguishable deviations of the diameter as detected by the system are registered by the receivers and can be evaluated statistically.

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[4] Zellweger-Uster Co: "Uster Tester-4", *Theory and practice of unevenness testing* (copyright 2002)

[5] Zellweger-Uster Co: "Uster Tester 4-CX", *Theory and practice of unevenness testing of filament yarns* (copyright 2002)

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