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Textiles — Synthetic filament yarns — Determination of dynamic thermal draw-force of partially oriented yarns (POY)

Textiles — Fils de filaments synthétiques — Détermination de la force d'étirage thermique dynamique des fils partiellement orientés (POY)

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Foreword

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This document was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 23, *Fibres and yarn*.

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Textiles — Synthetic filament yarns — Determination of dynamic thermal draw-force of partially oriented yarns (POY)

1 Scope

This document specifies a method for the determination of the dynamic thermal draw-force of partially oriented synthetic filament yarns.

It is applicable to partially oriented polyester (PES), polyamide (PA) and polypropylene (PP) filament yarns, with a linear density less than 800 dtex.

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 2076, *Textiles — Man-made fibres — Generic names*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 2076 and the following 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/ui

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

3.1
dynamic thermal draw-force
force caused by drawing the running filament yarns to a certain ratio under a certain heater temperature and testing speed

4 Principle

The continuous filament yarn runs into the dynamic thermal draw-force tester at a certain testing speed under constant pretension, then passes a heater and drawing device. It is drawn to a specific ratio while being heated at a specified temperature. The dynamic thermal draw-force is determined.

5 Apparatus

5.1 Dynamic thermal draw-force tester, which meets the following requirements:

a) tensioning device to apply specified pretension on filament yarns and maintain tension to an accuracy of ±10 %;

b) heater to maintain temperature to an accuracy of ±2 °C;

NOTE The results of thermal draw-force being tested in heaters with different length can differ.

c) feeding device to adjust testing speed, with a speed variation less than 2 %;

d) drawing device to adjust draw-ratio within [1,20, 1,90], with a speed variation less than 2 %;

e) force measuring and data collecting device to indicate force values with an error less than 1 % of the nominal value, within [10 %, 90 %] of the full range;

f) yarn aspirator to clear the tested yarns and thereby allow continuous testing.

5.2 Sample holder, to support packages.

6 Testing conditions

6.1 Pretension

Pretension per unit linear density is intended to be (0,050 ± 0,005) cN/dtex.

6.2 Heater temperature

Heater temperatures are variable for different types and nominal linear densities of yarns.

Recommended values of heater temperature are listed in Table 1.

Other heater temperature values may be determined on agreement between the interested parties. Additional information is given in Annex A.

Table 1 — Heater temperature for different types of filament yarns

Type of the yarns	Heater temperature (°C)
poly (ethylene terephthalate) (PET)	170 ± 2
poly (trimethylene terephthalate) (PTT)	145 ± 2
poly (butylene terephthalate) (PBT)	150 ± 2
polypropylene (PP)	140 ± 2
polyamide 6 (PA6)	150 ± 2
polyamide 66 (PA66)	170 ± 2

6.3 Draw-ratio

Draw-ratios are related to the tensile properties of the yarns.

Recommended values of draw-ratio are listed in Table 2.

Other draw-ratio values may be determined on agreement between the interested parties.

Table 2 — Draw-ratios for different types of filament yarns

Type of the yarns	Draw-ratio
poly (ethylene terephthalate) (PET)	1,65 ± 0,01
poly (trimethylene terephthalate) (PTT)	1,75 ± 0,01
poly (butylene terephthalate) (PBT)	1,25 ± 0,01
polypropylene (PP)	1,70 ± 0,01
polyamide 6 (PA6)	1,25 ± 0,01
polyamide 66 (PA66)	1,25 ± 0,01

In order to ensure the comparability of test results, tests shall be carried out under the same draw-ratio.

6.4 Testing speed

Testing speeds are varied with different types and nominal linear densities of yarns.

Recommended testing speed is (100 ± 2) m/min.

Other testing speed values may be determined on agreement between the interested parties. Additional information is given in Annex A.

6.5 Testing length

Recommended testing length is (100 ± 2) m.

Other testing length values may be determined on agreement between the interested parties.

7 Sampling

Sampling shall be performed as follows:

a) bulk laboratory sample shall be taken on request;

b) number of lot sample and laboratory sample are listed in Table 3.

Packages that have been dampened, bruised, or opened during the transportation shall not be sampled.

Table 3 — Number of lot sample and laboratory sample

Number of containers in the consignment	Number of containers in the first selection	Number of containers taken for consignment sample	Number of packages sampled from each container	Number of packages chosen for laboratory sample
10 or less	all	all	See footnote [a]	20 approx.
11 to 20	10	10	2	20
21 to 40	20	10	2	20
more than 40	40	20	1	20

[a] Take an equal number of packages from container. The number of packages for laboratory sample should be at least 20. If the consignment includes less than 20 packages, sample all of them.

8 Test procedure

8.1 Preparation of test specimen

Discard yarns on the outer layer of the packages. Afterwards, condition the packages in accordance with ISO 139.

For bulk laboratory samples, each package is tested twice, and the total number of tests shall not be less than 20 for one lot.

For batch laboratory samples, each package is tested twice and the total number of tests shall not be less than 40.

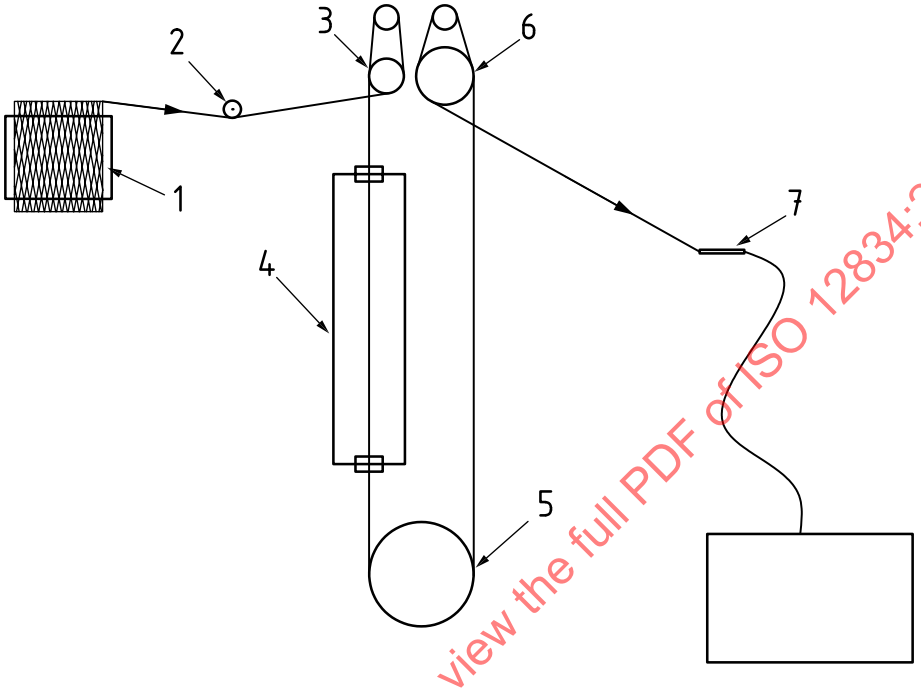
8.2 Setting of testing conditions

Turn on the tester and set pretension, heater temperature, draw-ratio, testing speed and testing length. Wait until the heater reaches the specified temperature and equilibrate for at least 10 min.

8.3 Threading of test specimen

Place the package on a sample holder. Thread the filament yarn successively through tensioning device, feeding roller, heater, force measuring device and drawing roller. Sufficient turns are required on both rollers to avoid slippage. Finally, guide it into yarn aspirator. Figure 1 shows a design example of a tester and the appropriate threading.

Different instruments are available, e.g. with electronic gear boxes and software settings to select the draw–ratio or different arrangement of drawing rollers and force measuring devices.



Key

1 package
2 tensioning device
3 feeding roller
4 heater
5 force measuring device
6 drawing roller
7 yarn aspirator

Figure 1 — Example of tester and test specimen threading

8.4 Specimen testing

Allow the tester to operate under specified conditions. After the testing speed is steady, begin to collect data of thermal draw-force and corresponding testing length. Operate at least for 1 min.

During the test, ascertain that the yarn does not show slippage at the rollers. Discard those measurements falsified by slippage or other abnormalities.

If the number of discarded measurements exceeds 10 % of the total number of tests, the tester should be checked and adjusted. Then restart the test.

9 Calculation and expression of results

Calculate arithmetic mean value, standard deviation, and coefficient of variation (C_V) for thermal draw-force in accordance with Annex B.

Express arithmetic mean value and standard deviation in cN, to be rounded to the first decimal.

Express coefficient of variation in percentage, to be rounded to the nearest 0,01 %.

10 Precision

Refer to Annex C.

11 Test report

The test report shall include at least the following information:

a) a reference to this document, i.e. ISO 12834:2024;

b) all details necessary for the identification of the sample tested;

c) the linear density of sample;

d) the number of packages and the number of test specimens per package;

e) information related to the dynamic thermal draw-force tester (including its model, heater length, etc.);

f) testing conditions (including pretention, heater temperature, draw-ratio, testing speed and testing length);

g) test results (including arithmetic mean value, standard deviation, and coefficient of variation of thermal draw-force);

h) any deviation, by agreement or otherwise, from the procedure specified;

i) any unusual features observed;

j) the date of the test;

k) any information needs to be indicated.

Annex A
(informative)

Optimization of heater temperature, testing speed and draw-ratio in determination of dynamic thermal draw-force

A.1 General

Select the appropriate heater temperature, testing speed and draw-ratio, to ensure stable and meaningful test results in the determination of dynamic thermal draw-force.

A.2 Selection of draw-ratio

The draw-ratio is usually selected as in the subsequent production process of POY, e.g. given by the ratio of the linear density of POY to post-processed drawn textured yarn (DTY) in texturizing.

If no draw-ratio in the instrument setup matches the above ratio, select the closest higher draw-ratio.

A.3 Selection of heater temperature and testing speed

A.3.1 Requirement

Select suitable combination of heater temperature and testing speed, in order to elevate the yarn temperature in the heater above its glass transition temperature (T_g). Thus, the most stable and meaningful test results are obtained.

In this situation, testing speed/thermal draw-force curve is relatively flat.

A.3.2 Heater temperature

The heater temperature is chosen depending on the yarn type and linear density of the yarn. Under the condition of fixed draw-ratio and testing speed, several heater temperature points can be selected for testing in a certain range.

A.3.3 Testing speed

Under the condition of fixed draw-ratio and heater temperature, several testing speeds within a certain range can be selected for testing.

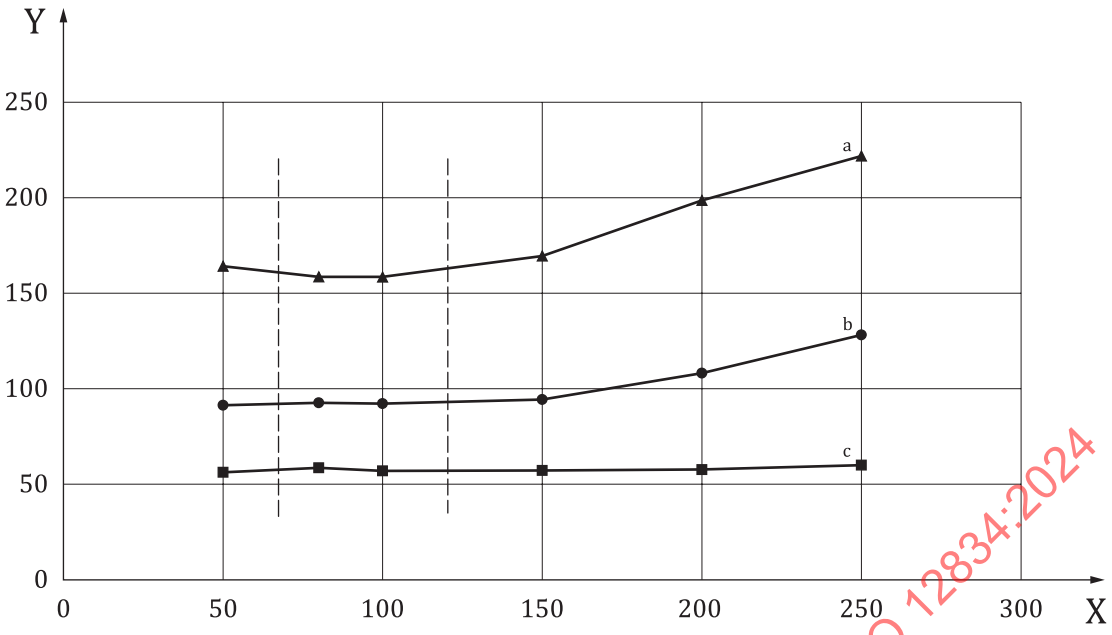
A.3.4 Confirmation of heater temperature and testing speed

Draw a series of testing speed/thermal draw-force curves at different temperatures. Select the combination of heater temperature and testing speed on the flat part of the curve.

It is generally considered that the testing speed is more suitable in the region where the thermal draw-force is rather stable in a certain interval of testing speeds in the testing speed/thermal draw-force curve.

A.4 Examples

The combinations of selected and confirmed heater temperature and testing speed of poly (ethylene terephthalate) and polyamide 6 POY under the specified draw-ratio are shown in Figure A.1 and Figure A.2.



Key

Y thermal draw-force, expressed in cN

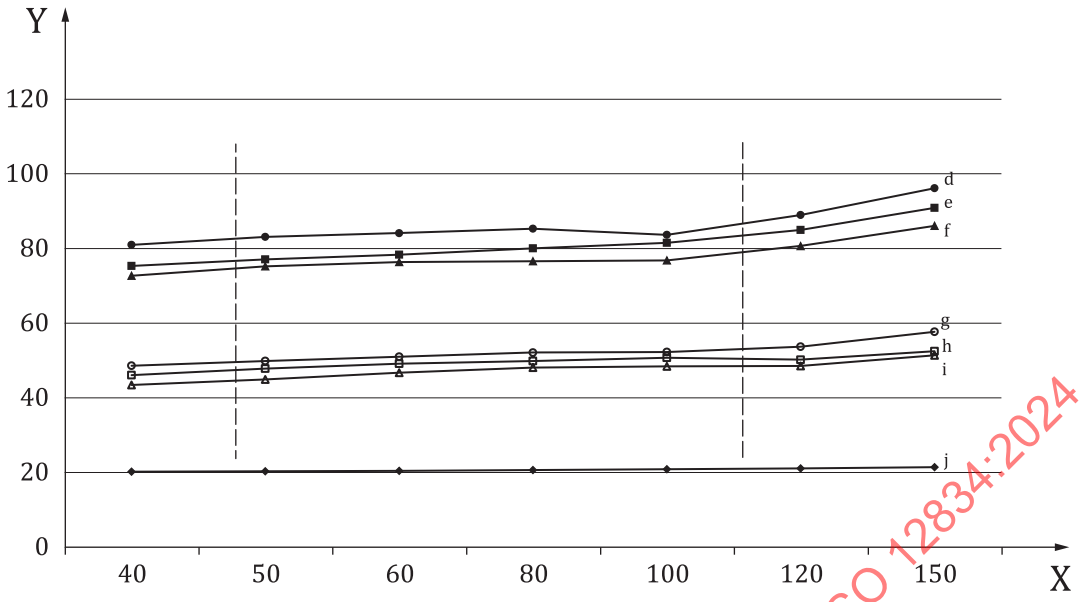
X testing speed, expressed in m/min

a 140 dtex/72 f (heater temperature 170 °C).

b 267 dtex/48 f (heater temperature 175 °C).

c 368 dtex/288 f (heater temperature 180 °C).

Figure A.1 — Testing speed/thermal draw-force curves of poly (ethylene terephthalate) POY



Key

Y thermal draw-force, expressed in cN

X testing speed, expressed in m/min

d 90 dtex/66 f (heater temperature 150 °C).

e 93 dtex/24 f (heater temperature 150 °C).

f 93 dtex/48 f (heater temperature 150 °C).

g 66 dtex/24 f (heater temperature 150 °C).

h 53 dtex/34 f (heater temperature 150 °C).

i 52 dtex/34 f (heater temperature 150 °C).

j 27 dtex/7 f (heater temperature 150 °C).

Figure A.2 — Testing speed/thermal draw-force curves of polyamide 6 POY

Annex B
(normative)

Calculation of statistic values

B.1 Arithmetic mean value

Arithmetic mean value is calculated according to Formula (B.1).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{B.1}$$

Where

$\bar{x}$ is arithmetic mean value of thermal draw-force, expressed in cN;

x_i is individual value of thermal draw-force, expressed in cN;

n is number of tests.

B.2 Standard deviation

Standard deviation is calculated according to Formula (B.2).

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}} \tag{B.2}$$

Where

s is standard deviation of thermal draw-force, expressed in cN;

x_i is individual value of thermal draw-force, expressed in cN;

$\bar{x}$ is arithmetic mean value of thermal draw-force, expressed in cN;

n is number of tests.

B.3 Coefficient of variation (C_V)

Coefficient of variation (C_V) is calculated according to Formula (B.3).

$$C_V = \frac{s}{\bar{x}} \times 100\ \% \tag{B.3}$$

Where

C_V is coefficient of variation of thermal draw-force;

s is standard deviation of thermal draw-force, expressed in cN;

$\bar{x}$ is arithmetic mean value of thermal draw-force, expressed in cN.