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Textile — Biaxial tensile properties of woven fabric — Determination of elasticity properties using a cruciform test piece

Textiles — Propriétés biaxiales des tissus — Détermination des propriétés d'élasticité au moyen d'éprouvette cruciforme

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Foreword

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This document was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 24, *Conditioning atmospheres and physical tests for textile fabrics*.

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Textile — Biaxial tensile properties of woven fabric — Determination of elasticity properties using a cruciform test piece

1 Scope

This document specifies a test method for determination of the elasticity and related properties of woven textile fabrics, using biaxial stress states, which exhibit stretch characteristics imparted by the presence of an elastomeric fibre, mechanical, or chemical treatment.

This biaxial elasticity test is restricted to the use of constant rate of extension (CRE) testing machine.

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 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

3 Terms and definitions

For the purposes of this document, the 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 https://www.electropedia.org/

3.1
biaxial elasticity test
method for measuring the stress-strain curves of test specimens subject to biaxial tension using a cruciform test piece

3.2
CRE biaxial tensile testing machine
testing machine for applying biaxial tensile stress with a constant speed to a test specimen in the orthogonal directions parallel to the arms of the cruciform test piece

3.3
grip separation length
distance between the two gripping points of the testing device

3.4
gauge length
distance between the two effective gauge mark points of the test specimen in each direction

3.5
gauge mark
marks on the test specimen surface for measuring the extension using optical extensometer

3.6
initial length
length of the test specimen between the two effective gauge mark point under specified pretention, at the beginning of the test

3.7
pretension
force applied to a test specimen at the beginning of certain tests

Note 1 to entry: Pretension is used to determine the initial length of the test specimen.

[SOURCE: ISO 20932-1:2018, 3.9]

3.8
extension
increase in gauge length of a test specimen produced by a force as a result of testing

Note 1 to entry: Extension is expressed in unit of the length.

3.9
elongation
ratio of the extension of the test specimen to its initial length

Note 1 to entry: Elongation is expressed as a percentage.

[SOURCE: ISO 20932-1:2018, 3.11]

3.10
maximum force
force at the position at the maximum extension on the final cycle

Note 1 to entry: Maximum force is expressed in newtons.

3.11
maximum extension
extension recorded in millimetres at the maximum force on the final cycle

Note 1 to entry: See Annex A.

Note 2 to entry: Maximum extension is expressed in unit of the length.

3.12
force decay due to time
loss of force measured over time when a test specimen is stretched to a specified elongation or force and held at this position for a given time period

Note 1 to entry: The decay in force is expressed as a percentage of the original force recorded at the specified position.

Note 2 to entry: See Annex A.

[SOURCE: ISO 20932-1:2018, 3.16]

3.13
force decay due to exercising
loss of force, calculated and expressed as a percentage, as measured and recorded at the same elongation point on two different cycles when the test specimen is cycled several times between the gauge length and a specified elongation

Note 1 to entry: See Annex A.

[SOURCE: ISO 20932-1:2018, 3.17]

3.14
permanent deformation
ratio of unrecovered extension of the test specimen after cycling (to a specified force or specified extension) to its initial length

Note 1 to entry: Permanent deformation is expressed as a percentage.

Note 2 to entry: See Annex A.

[SOURCE: ISO 20932-1:2018, 3.18]

3.15
recovered elongation
ratio of recovered extension of the test specimen after cycling (to a specified force or specified extension) to its initial length

Note 1 to entry: The recovered elongation is the complement of the *permanent deformation* (3.14) to the *elongation* (3.9).

Note 2 to entry: Permanent deformation is expressed as a percentage.

[SOURCE: ISO 20932-1:2018/Amd.1:2021, 3.19]

4 Principle

A fabric test specimen of cruciform shape is biaxially extended at a constant rate to a specified load for an agreed number of cycles. The loads are applied cyclically in the orthogonal directions parallel to the arms of the cruciform test piece simultaneously. Measurements of stress and strain are used to determine the biaxial properties of the fabric.

5 Sampling

Select samples either in accordance with the product specification for the fabric, or as agreed between the interested parties.

In the absence of a product specification for the fabric, the example of a suitable pattern for cutting test specimens from the laboratory sample is given in Figure B.1, Annex B.

Avoid test specimens with folded or creased areas, selvedges, and areas not representative of the fabric.

6 Apparatus

6.1 CRE biaxial tensile testing machine

The CRE biaxial tensile testing machine shall be capable of simultaneously applying loads to the test specimen in the orthogonal directions parallel to the arms of the cruciform test specimen. It shall be capable of measuring loads, strains and/or displacements using load cells and optical extensometer at suitable locations simultaneously.

The clamping or holding devices shall be capable of holding four grips of a cruciform test specimen without allowing it to slip and designed so that they minimize damage to the test specimen.

6.1.1 The biaxial tensile testing machine shall be provided with the means for indicating or recording the force and extension values when cycling between gauge length and either a fixed load or fixed grip separation length. Under conditions of use, the accuracy of the apparatus shall be class 1 of ISO 7500-1. The error of the indicated or recorded force at any point in the range in which the machine is used shall not exceed ±1 % and the error of the indicated or recorded gauge length shall not exceed ±1 mm.

6.1.2 The machine shall be capable of constant rate of extension including 1 N cm^{-1}·min^{-1} to 10 N cm^{-1} min^{-1} with an accuracy of ±10 %.

6.1.3 The machine shall be capable of setting the grip separation length to 200 mm, to an accuracy of ±1 mm.

6.1.4 The machine shall have a function for measuring and storing the values of the applied force and gauge length in the warp and weft directions simultaneously during biaxial tensile test.

6.1.5 The clamping or holding devices shall be positioned with their central point in line of the applied force. Two opposing grips shall move along a single straight line, and the x- and y-axes shall intersect at an angle of 90° ± 1°.

6.1.6 The faces of the jaws shall be smooth and flat, except that when, even with packing, the test specimen cannot be held satisfactorily with flat-faced jaws, engraved or corrugated jaws can be used to prevent slippage. Other auxiliary materials for use with either smooth or corrugated jaws to improve specimen gripping include paper, leather, plastics or rubber.

6.1.7 Pneumatic operated grips are recommended as hand tightening of manual grips can cause distortion of the test specimen. The air pressure should be sufficient to prevent slippage when compensating the decreasing thickness of the fabric but should not cut or otherwise weaken the test specimen.

7 Atmosphere for conditioning and testing

The atmosphere for preconditioning, conditioning, and testing shall be as specified in ISO 139.

The test specimens shall be conditioned for at least 24 h in a tension free state.

8 Preparation of test specimens

8.1 General

From each laboratory sample, cut two sets of test specimens, one set in the warp and the other in weft direction. Each set shall consist of at least five test specimens, except that if a higher degree of precision is required.

According to Clause 5 and Annex B, no test specimens shall be cut from within 150 mm of either edge of the laboratory sample. No test specimen taken from the warp direction shall contain the same longitudinal threads and no test specimen taken from weft direction shall contain the same peaks.

8.2 Test specimen preparation

The cruciform test specimen is recommended in this document. The length of each test specimen and the width of arms shall be 300 mm ± 1 mm and 60 mm ± 1 mm, respectively. A line shall be drawn at a distance of 50 mm from end of each arm of test specimen. The gauge marks and warp direction shall be marked on the surface of the specimen. The gauge marks shall be placed at the same distance from the centre of specimen in the warp and weft directions parallel to counter gauge mark. The displacement of gauge marks shall be able to measure using the optical extensometer. The internal corners of the specimen shall be rounded with a radius (R = 15 mm) to prevent tear propagation.

NOTE An example of the cruciform test specimen is illustrated in Figure C.1, Annex C.

9 Procedure

9.1 Gauge length

Set the grip separation length of the biaxial tensile testing machine to 200 mm ± 1 mm, unless otherwise agreed between interested parties. Check the gauge length by measuring the distance between the two effective gauge mark points using optical extensometer.

9.2 Rate of extension

Set the extension and retraction rate of the test specimen to 6 N cm^{-1} min^{-1}.

9.3 Mounting of test specimen

The warp and weft directions shall be aligned in the warp and weft directions with the loading axes of the test device. The test specimen shall be mounted using suitable grips, and line drawn on each arm of test specimen shall be aligned with end of each grip.

NOTE The test specimen shall not slip in the grips during the test.

9.4 Loading

Set the required cycling limits to between gauge length and a load of 6 N cm^{-1} width, other loading can be used as agreed between parties. Set a pretension of 0,5 N to determine the initial length at start of test and to calculate the permanent deformation after cycling.

9.5 Operation

Engage the device for measuring and recording the values of the force and elongation during biaxial tensile test with the specified accuracy and time interval. Put the clamp in motion and cycle the test specimen between gauge length and the specified load for five cycles. In case a pretension is used, the clamp moves to specified pretention to record the initial length.

If it is required to determine force decay, due to time, on the final cycle set the biaxial tensile testing machine to “hold” at the maximum force for the chosen period. Re-measure at 1 min ± 5 s, the distance between the gauge marks in each direction previously made on the specimen or calculate it automatically at the specified pretension.

If it is necessary to determine the permanent deformation, read the unrecovered extension results in the warp and weft directions directly from the recorded curve. If not, remove the test specimen carefully from the biaxial tensile testing machine to avoid variations in results and lay on a flat surface for either period 1 min or 30 min. Re-measure the distance between the gauge marks in each direction previously marked on the specimen using the calibrated steel rule. If a pretension is used, the length at pretension is used for calculation. Automatic determination of permanent deformation is allowed.

10 Recording

Record the extension and/or elongation at the maximum force, from the curves or data generated in the test, as agreed between the relevant parties.

Record the force at specified elongation at any elongation point along the load or unload curves as agreed between the relevant parties.

11 Calculation and expression of test results

The following values shall, where applicable, be calculated from the data recorded during the test.

a) Elongation, *S*, in the warp and weft directions expressed as a percentage, as shown in Formula (1):

$$S = \frac{E}{L} \times 100 \quad (1)$$

where

E is the extension (mm) at maximum force on the final cycle;

L is the initial length (mm).

b) Permanent deformation, C, in the warp and weft directions expressed as a percentage, as shown in Formula (2):

$$C = \frac{Q - P}{P} \times 100 \quad (2)$$

where

Q is the distance between the gauge marks (mm) in each direction; or, in case a pretension is used, the gauge length (mm) under pretension after the final cycle;

P is the distance between the gauge marks (mm) in each direction; or, in case a pretension is used, the initial length at the beginning of the test.

c) Recovered elongation, D, in the warp and weft directions expressed as a percentage, as shown in Formula (3):

$$D = \frac{E - Q}{E - L} \times 100 \quad (3)$$

d) Force decay due to time, A, in the warp and weft directions expressed as a percentage, as shown in Formula (4):

$$A = \frac{V - W}{V} \times 100 \quad (4)$$

where

V is the maximum force (N) from the final cycle;

W is the maximum force (N) in the final cycle, after a specified holding period.

e) Force decay due to exercising, B, in the warp and weft directions expressed as a percentage, as shown in Formula (5):

$$B = \frac{X - Y}{X} \times 100 \quad (5)$$

where

X is the maximum force (N) at the specified elongation on an initial (specified) cycle;

Y is the maximum force (N) at the same specified elongation in a subsequent (specified) cycle.

12 Test report

The test report shall include the following information:

a) a reference to this document: i.e. ISO 13118:2024;

b) the date of test;

c) identification of test sample and sampling procedure, if required;

d) grip separation length and gauge length used, in millimetres;

e) rate of extension used in millimetres per minute;

f) state or condition of test specimens (original, washed, aged);

g) number of test specimens, particularly if less than five;

h) width of specimen if not as per the dimensions specified within this procedure;

i) if used, the pretension (cN/cm);

j) any deviation from this procedure;

k) maximum cycling force, in newtons;

l) arithmetic mean of maximum extension and/or elongation, whichever is required and for which cycle;

m) arithmetic mean of force at specified elongation, the elongation point and cycle;

n) arithmetic mean of permanent deformation, when required;

o) arithmetic mean of recovered elongation, when required;

p) arithmetic mean of force decay – due to time and relevant cycles, when required;

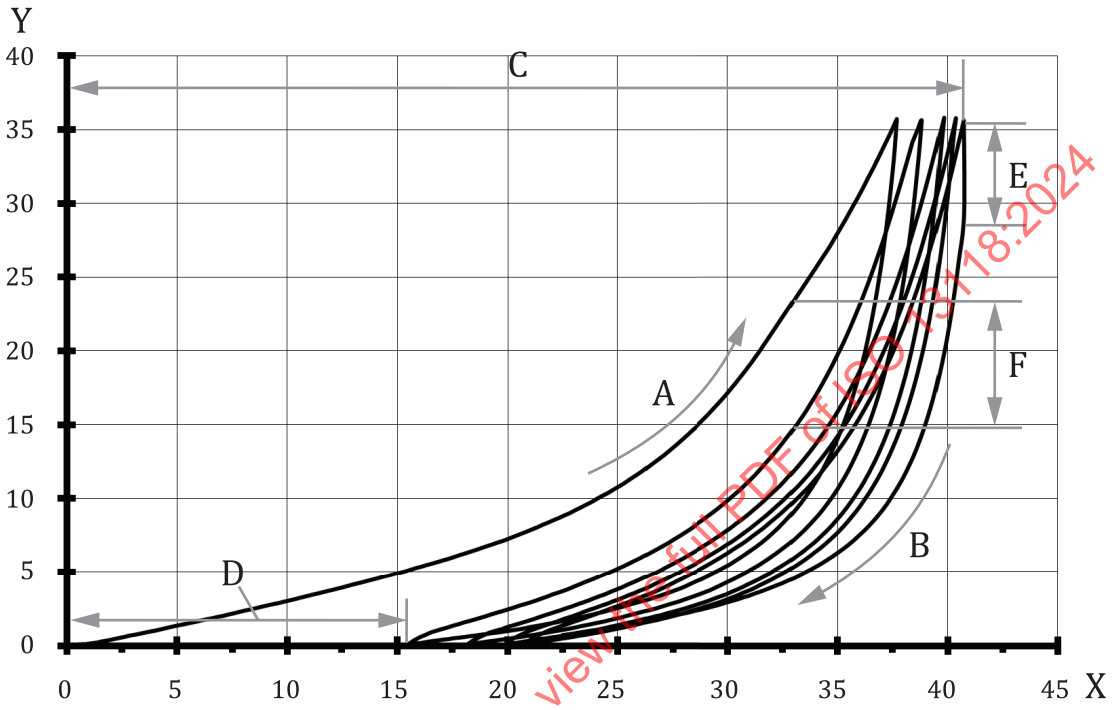
q) arithmetic mean of force decay – due to exercising and the relevant cycles, when required;

r) if required, the coefficient of variation for the relevant measured and calculated values;

s) if required, the 95 % confidence limits of the relevant measured and calculated values.

Annex A
(informative)

Example of a typical cycling graph



Key

X extension axis (mm)
Y force axis (N)
A load cycles
B unload cycles
C maximum extension (mm)
D permanent deformation length (mm)
E force decay due to time
F force decay due to exercising

Figure A.1 — Example of a typical cycling graph