
**Textiles — Determination of fabric
deformability by forced mechanical
distension**

*Textiles — Détermination de la déformabilité des étoffes par
distension forcée mécaniquement*

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Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	3
5 Apparatus	3
6 Test specimen	5
7 Procedure	6
7.1 Inserting the test specimen	6
7.2 Specifications of the test	6
7.2.1 Test parameters	6
7.2.2 Evaluation parameters	6
7.3 Test procedure	7
8 Calculation and specification of the results	7
8.1 Non-crimp fabric	7
8.1.1 General	7
8.1.2 Deformation force	8
8.1.3 Gap width	8
8.1.4 Gap portion	8
8.1.5 Gap shape	8
8.1.6 Fibre-angle change	8
8.1.7 Undulation	8
8.1.8 Loop formation	8
8.1.9 Waviness	9
8.1.10 Out-of-roundness	9
8.2 Woven fabrics	9
8.2.1 Characteristic value names, symbols and units	9
8.2.2 Deformation force	9
8.2.3 Gap portion	9
8.2.4 Gap area	10
8.2.5 Gap shape	10
8.2.6 Fibre-angle change	10
8.2.7 Undulation	10
8.2.8 Shearing angle	10
8.2.9 Waviness	10
8.2.10 Out-of-roundness	10
8.2.11 Residual deformation	10
8.3 Knitted fabrics	11
8.3.1 Table with characteristic value names, symbols and units	11
8.3.2 Deformation force	11
8.3.3 Gap portion	11
8.3.4 Gap area	11
8.3.5 Gap shape	11
8.3.6 Waviness	11
8.3.7 Out-of-roundness	11
8.3.8 Residual deformation	12
8.4 Nonwovens	12
8.4.1 Table with characteristic value names, symbols and units	12
8.4.2 Deformation force	12
8.4.3 Anisotropy	12

8.4.4	Thinning-out.....	12
8.4.5	Waviness.....	12
8.4.6	Out-of-roundness.....	13
8.4.7	Residual deformation.....	13
8.5	Evaluation.....	13
9	Test report.....	13
Annex A	(informative) Example images.....	16
Annex B	(informative) Statistical data.....	18
Bibliography	19

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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 24, *Conditioning atmospheres and physical tests for textile fabrics*, 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).

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 determination of the deformation characteristics is relevant for all production processes in which flat textile fabrics (including reinforcement textiles) are formed into a three-dimensional shape. This example is the case for upholstery applications or the majority of current liquid composite molding (LCM) processes. Knowledge about the development of deformation effects such as changes in fibre orientation, undulation, and gaps in the textile is crucial for the safe design of processes and components.

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Textiles — Determination of fabric deformability by forced mechanical distension

1 Scope

This document specifies a method for the automatic determination of the deformability of textile fabrics, including continuous-fibre reinforcement textiles. This method is not applicable to resin impregnated fabrics.

The method is suitable for use with fabrics such as woven or knitted fabrics, nonwovens, non-crimp fabrics, fabrics made of glass rovings or untwisted carbon filament yarns intended for reinforced composite materials. When applying the method to multi-axial non-crimp fabrics, the evaluation of the fibre orientation and gaps only incorporates the uppermost layer.

The method can be used for fabrics treated with powder binder.

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 21765:2020

3 Terms and definitions
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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 reinforcement textile

fabric whose fibres are used to absorb and transfer the mechanical loads within a fibre-reinforced composite material

3.2 deformability

conformability for forced three-dimensional deformation

3.3 specimen plane

plane which is defined by the inserted undeformed test specimen

3.4 specimen holder

device consisting of a retaining ring and a ring-shaped fitting body that retains the test specimen during deformation with a settable, evenly distributed pressure

**3.5
deformation body**

rotationally symmetrical body that deforms the test specimen centrally out of the *specimen plane* (3.3) in a vertical upward direction

**3.6
deformation level**

level with specified height to which the *deformation body* (3.5) elevates out of the *specimen plane* (3.3)

**3.7
deformation force**

resulting force acting vertically on the *deformation body* (3.5) that arises during deformation

**3.8
fibre orientation**

orientation of the fibres or filaments of the test specimen, determined in the textile plane using image processing

**3.8.1
fibre-angle change**

change of the global *fibre orientation* (3.8), determined using image processing

**3.8.2
undulation**

local change of the *fibre orientation* (3.8), determined using image processing

**3.9
gap**

open area between adjacent yarns, determined using image processing

EXAMPLE Non-crimp fabric gap, woven/knitted fabric gap.2020

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**3.10
waviness**

continuous deformation over a certain region (>2 cm²) diverging from the textile plane, determined using laser triangulation

**3.11
loop formation**

deformation of individual yarns out of the textile plane, determined using laser triangulation

**3.12
out-of-roundness**

deviation of the contour of the test specimen from a circular shape of equal area, determined using image processing

**3.13
overall image**

image recorded with the overall image camera for determining the contour of the test specimen

**3.14
detail image**

image recorded by the detail camera with a minimum size of 1 000 mm² and a minimum resolution of 64 pixels per millimetre

**3.15
non-crimp fabric**

fabric made of several unidirectional layers of straight multifilament yarns which are bonded using an auxiliary stitching thread or chemical means

Note 1 to entry: The expression “non-crimp fabric” is commonly used in the composite sector.

3.16**residual deformation**

continuous deformation of the sample diverging from the support surface, determined using laser triangulation, measured after completion of the deformation and return of the *deformation body* (3.5) below the support surface

3.17**anisotropy**

measure for the orientation of fibres in a nonwoven

Note 1 to entry: Values are between 1 (all fibres parallel to reference direction) and -1 (all fibres perpendicular to reference direction), where 0 means complete isotropic (random) orientation

3.18**thinning-out**

tendency of a nonwoven fabric to build local thin places due to mechanical stress

4 Principle

This document specifies a method by which the textile fabric (including reinforcement textiles) to be examined is forced to be deformed in a defined manner by a rotationally symmetrical deformation body. Key figures and characteristic values that describe the textile to be examined regarding its deformability are determined. For this, the mechanical resistance to a defined three-dimensional deformation is measured and the resulting structural faults in the mesostructure and macrostructure are examined using a digital image analysis system and laser triangulation.

The test is carried out on a circular test specimen, which the testing instrument - by means of a pneumatic specimen holder - holds in position with a defined force, which is equal around the circumference of the retaining ring. During the test, the test specimen is incrementally deformed by a deformation body acting from below and measured after each deformation level.

The force acting vertically on the deformation body caused by the deformation is measured.

Several images of the original undeformed test specimen and later of the deformed test specimen are recorded with a detail camera on a central circular path and evaluated. For non-crimp fabrics, the fibre orientation as well as the occurrence of gaps between the yarns of the non-crimp fabric are determined. For woven fabrics, the angle between the warp threads and weft threads as well as the area and proportion of the woven fabric gaps are determined. For knitted fabrics, the area and proportion of the gaps is determined. For nonwovens, the anisotropy and thinning-out are determined. The out-of-roundness of the test specimen is additionally determined with an overall image camera.

Additionally, deformations out of the textile plane may be recorded on the rotating test specimen using a laser triangulation sensor and output as numerical values for the waviness and the loop formation.

5 Apparatus

5.1 Mechanical cutting equipment, to produce the circular test specimen from the laboratory sample.

NOTE Examples of suitable mechanical cutting equipment include punches and ultrasound cutters.

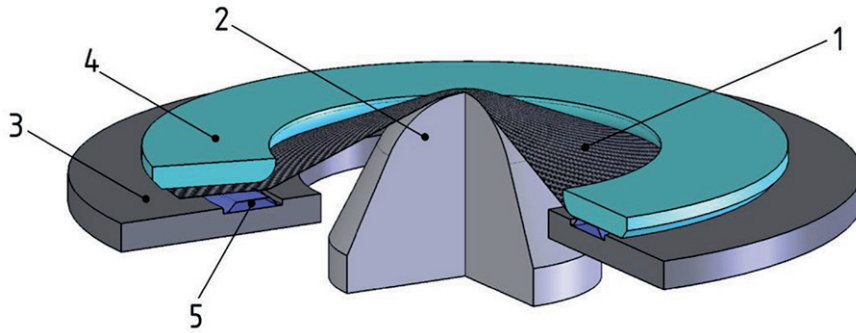
5.2 Deformability test apparatus

Test device in which the test specimen is inserted and uniformly retained over the entire circumference using a specimen holder, whereby the retaining pressure can be specified in the range of 0 MPa to 0,1 MPa (i.e. 1 bar). The test device has a rotation device for motor-driven rotation of the test specimen at variable speed [maximum speed $(10,0 \pm 0,1) \text{ min}^{-1}$], a motor-driven vertically moving deformation body [elevation $0,00 - (100,00 \pm 0,01) \text{ mm}$], a force sensor (0 N to 500 N with an accuracy of $\pm 0,5 \%$) to record the vertical force acting on the deformation body, an overall image camera to record the top

view of the entire test specimen, a detail camera to record detail images of the test specimen to detect fine structural faults, as well as a laser triangulation sensor (sampling time shorter than 20 ms from data acquisition to data storage) to record the deformations varying from the textile plane.

The deformation body features a spherical contact surface with a diameter of $(100,0 \pm 0,1)$ mm. This deformation body can be black or white. The black deformation body is used to test light-coloured materials and the white deformation body to test dark materials. The white deformation body can be backlit.

The equipment for retaining the test specimen and for defined deformation is shown in [Figure 1](#).



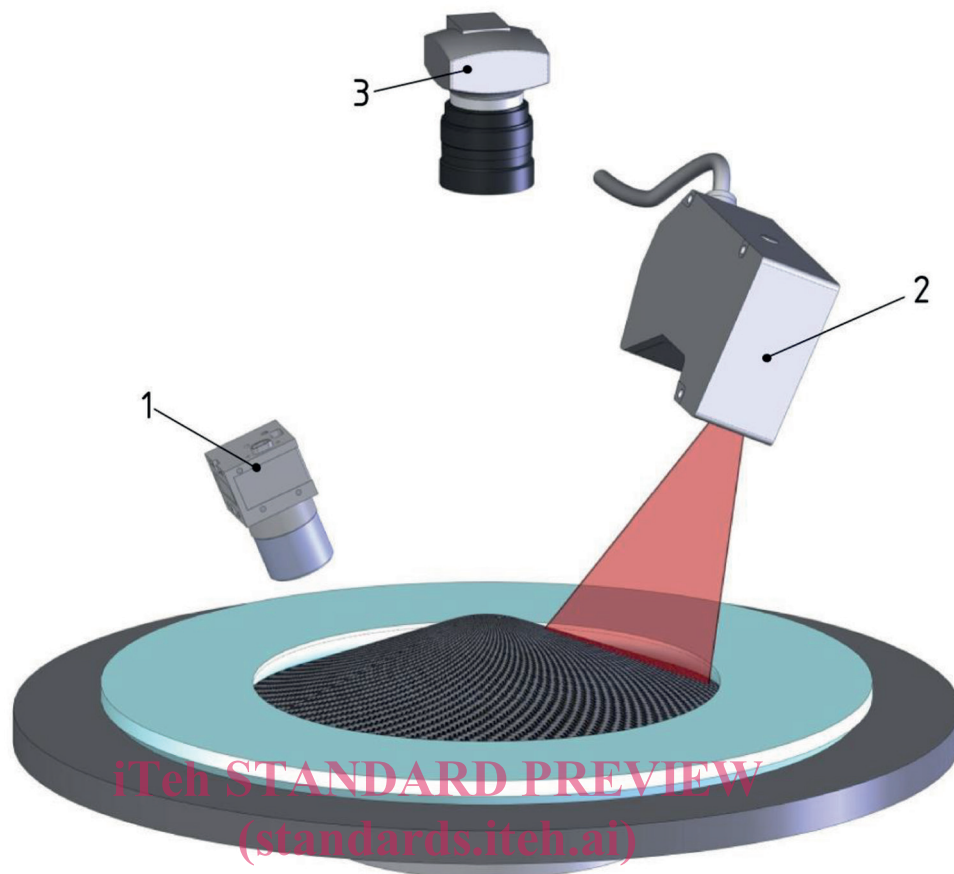
Key

- 1 test specimen
- 2 deformation body
- 3 support surface
- 4 retaining ring
- 5 fitting body

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Figure 1 — Specimen holder and deformation body

**Key**

- 1 detail camera
- 2 laser triangulation sensor
- 3 overall image camera

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Figure 2 — Schematic diagram of the optical sensors

[Figure 2](#) illustrates the arrangement of the optical sensors. It shows a detail camera with lighting, an overall image camera for recording the complete test specimen, as well a laser triangulation sensor to record the test specimen topography¹⁾.

[Annex A](#) shows an example of images of laser triangulation measurements.

6 Test specimen

A circular test specimen with a diameter of (327 ± 3) mm shall be used which is mechanically cut out of a laboratory sample. It shall especially be noted here that no test specimens are taken from the selvedge region or damaged areas of the laboratory sample. No thermal cutting procedure shall be applied to prevent adhesions and influences at the edges of the test specimen.

When producing the test specimen, it shall especially be ensured that all yarns are completely cut through and that the structure of the test specimen is not displaced.

1) An applicable tester is the “DRAPETEST” supplied by Textechno Herbert Stein GmbH & Co.. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.