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Textiles — Determination of fabric deformability by forced mechanical distension

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

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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*, 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.

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*

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
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.

3.10
waviness
continuous deformation over a certain region (>2 cm^2) 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 mm^2 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.

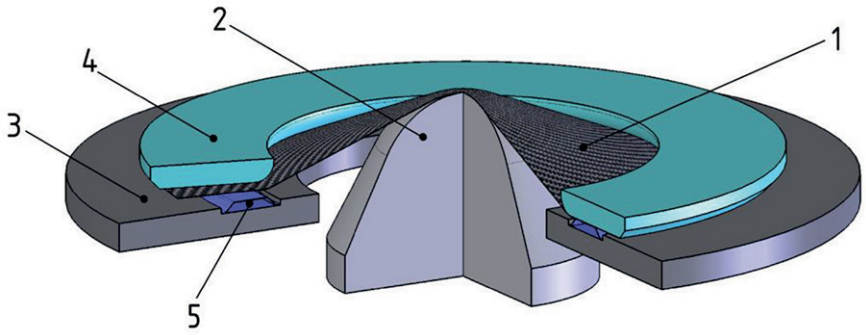
5.2 Deformability test apparatus

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 ± 0,1) min^{-1}], a motor-driven vertically moving deformation body [elevation 0,00 – (100,00 ± 0,01) mm], a force sensor (0 N to 500 N with an accuracy of ±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 ± 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

Figure 1 — Specimen holder and deformation body