Textile properties of smart textiles and their characterisation

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TEXTILE PROPERTIES OF SMART TEXTILES AND THEIR CHARACTERISATION

LU4.2
Contents

• Strength-related textile properties
• Haptic-related properties
• Comfort-related properties
STRENGTH-RELATED TEXTILE PROPERTIES
TENSILE TEST
Tensile test
Tensile test

[Graph showing force vs. elongation]
Tensile test

Maximum force (and force at rupture)
Tensile test

Maximum force (and force at rupture)

Elongation at maximum force (and elongation at rupture)
## Tensile test

<table>
<thead>
<tr>
<th>Strip method</th>
<th>Grab method</th>
</tr>
</thead>
</table>


# Tensile test

<table>
<thead>
<tr>
<th>Strip method</th>
</tr>
</thead>
</table>
| • *Woven fabrics*  
  ISO 13934-1:2013  
• *Nonwoven fabrics*  
  ISO 9073-3:1989 |

<table>
<thead>
<tr>
<th>Grab method</th>
</tr>
</thead>
</table>

![Diagram showing strip method and grab method for tensile test](image_url)

- **Specimen**: 200 mm
- **Clamp**: 50 mm
- **Clamp**
## Tensile test

### Strip method
- **Woven fabrics**
  - ISO 13934-1:2013
- **Nonwoven fabrics**
  - ISO 9073-3:1989

### Grab method
- **Woven fabrics**
- **Nonwoven fabrics**
  - ISO 9073-18:2008

---

**Specimen**
200 mm  
50 mm  

**Clamp**

---

**Specimen**
100 mm  

**Clamp**
Tensile test

**Strip method**
- Woven fabrics
  ISO 13934-1:2013
- Nonwoven fabrics
  ISO 9073-3:1989

**Grab method**
- Woven fabrics
  ISO 13934-2:2014
- Nonwoven fabrics
  ISO 9073-18:2008

**Testing conditions**
- 5 specimens in both warp and weft (or machine and cross) directions
- Clamping distance and speed will depend on the type of test and fabric
TEARING TEST
Tearing test
Tearing test

![Tearing test equipment](image)

<table>
<thead>
<tr>
<th>Force [N]</th>
<th>Elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tearing test
Tearing test
# Tearing test

<table>
<thead>
<tr>
<th>Single tear method</th>
<th>Double tear method</th>
</tr>
</thead>
</table>

**LU4.2 | Textile properties of smart textiles and their characterisation**
# Tearing test

## Single tear method
- Trouser-shaped specimens
- ISO 13937-2:2000

## Double tear method
# Tearing test

<table>
<thead>
<tr>
<th>Single tear method</th>
<th>Double tear method</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Trouser-shaped specimens</td>
<td>• Tongue-shaped specimens</td>
</tr>
</tbody>
</table>
Tearing test

**Single tear method**
- Trouser-shaped specimens
- ISO 13937-2:2000

**Double tear method**
- Tongue-shaped specimens
- ISO 13937-4:2000

**Testing conditions**
- 5 specimens in both warp and weft (or machine and cross) directions
- 100 mm/min
ABRASION TEST
Abrasion test

Martindale method

Load
Specimen
Abrasive element
Abras ion test

Martindale method

Lissajous curve

Load

Specimen

Abrasive element
Abrasion test

Martindale method

Determination of:
• Number of cycles necessary to produce failure (wear-off observed in the fabric)
  or
• Loss of weight suffered by the test piece after a certain number of abrasion cycles

Standards:
• ISO 12947-1,3,4:1998
• ISO 12947-2:2016
PILLING TEST
Pilling test

- The appearance of the specimens tested is compared with a scale of photographic patterns and the level of pilling is classified from 0 to 5.
## Pilling test

<table>
<thead>
<tr>
<th>Container methods</th>
<th>Flat methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low speed</strong></td>
<td><strong>High speed</strong></td>
</tr>
<tr>
<td>• ICI/M&amp;S Pilling tester</td>
<td></td>
</tr>
<tr>
<td>• ISO 12945-1:2020</td>
<td></td>
</tr>
<tr>
<td>• Random Tumble Pilling Tester</td>
<td></td>
</tr>
<tr>
<td>• ISO 12945-3:2020</td>
<td></td>
</tr>
</tbody>
</table>

- The appearance of the specimens tested is compared with a scale of photographic patterns and the level of pilling is classified from 0 to 5
Pilling test

- The appearance of the specimens tested is compared with a scale of photographic patterns and the level of pilling is classified from 0 to 5.
TAILORABILITY
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

Compressibility  Flexural stiffness  Extensibility  Relaxation shrinkage (ER) & hygroscopic expansion (EH)
Tailorability (FAST)

• Mechanical properties when the fabrics are subjected to small forces
• To predict the resistance of the fabric to overcome industrial clothing operations

- Compressibility
- Flexural stiffness
- Extensibility

Relaxation shrinkage (ER) & hygroscopic expansion (EH)

Thickness difference at 2 compressive loads
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**
- Extension under different weights

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**
- Extension under different weights

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**
- Fabric length vs. time
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**
- Extension under different weights

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**
- Fabric length
- Drying
- Time

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Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**
- Extension under different weights

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**

- Fabric length
- L1
- L2

- Drying
- Wetting

Time
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

**Compressibility**
- Thickness difference at 2 compressive loads

**Flexural stiffness**
- Cantilever length

**Extensibility**
- Extension under different weights

**Relaxation shrinkage (ER) & hygroscopic expansion (EH)**

![Diagram showing fabric length changes over time with stages labeled Drying, Wetting, and Drying](image)
Tailorability (FAST)

- Mechanical properties when the fabrics are subjected to small forces
- To predict the resistance of the fabric to overcome industrial clothing operations

Compressibility

- Thickness difference at 2 compressive loads

Flexural stiffness

- Cantilever length

Extensibility

- Extension under different weights

Relaxation shrinkage (ER) & hygroscopic expansion (EH)

\[
ER = 100 \frac{L_1 - L_3}{L_1} \\
EH = 100 \frac{L_2 - L_3}{L_3}
\]
DRAPABILITY
Drapability

Kawavata test (KES-F)
Drapability

Kawavata test (KES-F)
FASTNESS
Fastness

Washing fastness

Original sample

Washing
1, 5, 10, 20 or 50 washing cycles

Exposed sample

Testing functional properties

LU4.2 | Textile properties of smart textiles and their characterisation
Washing fastness

Original sample

Washing
1, 5, 10, 20 or 50 washing cycles

Exposed sample

Testing functional properties

Colour fastness

Original sample

Exposition to different actions/environments
rubbing, wear, ironing, high temperatures, wetting, etc.

Exposed sample

Colour measurement
COMFORT-RELATED PROPERTIES
STIFFNESS & RECOVERY ANGLE
Stiffness & Recovery angle

Stiffness: Shirley method

- UNE 40392:1979
- ASTM D1388-96R02
**Stiffness & Recovery angle**

**Stiffness: Shirley method**

- UNE 40392:1979
- ASTM D1388-96R02

![Stiffness measurement device]

**Wrinkle recovery angle**

- ISO 2313-1:2021
- ISO 2313-2:2021

![Wrinkle recovery angle measurement device]
WATER VAPOUR RESISTANCE & THERMAL RESISTANCE
Water vapour resistance & Thermal resistance

Water vapour resistance

- ISO 15496:2018

Saturated solution of potassium acetate

Fabric

Membrane

Measurement of weight increase

H₂O Water vapour
**Water vapour resistance & Thermal resistance**

**Water vapour resistance**
- ISO 15496:2018

![Diagram of water vapour resistance](image)

**Thermal resistance**

![Diagram of thermal resistance](image)

**Measurement of weight increase**

**Saturated solution of potassium acetate**
- Fabric
- Membrane

**Measurement of heating power**
- Controlled atmosphere at 20 °C, 65% RH
- Airflow at 1 m/s
- Hot plate at 35 °C
AIR PERMEABILITY & WATER WICKING
Air permeability & Water wicking

Air permeability

- *Woven Fabrics*
  ISO 9237:1995
- *Nonwovens*
  ISO 9073-15:2007
## Air permeability & Water wicking

### Air permeability

- *Woven Fabrics*
  ISO 9237:1995
- *Nonwovens*
  ISO 9073-15:2007

### Water wicking

- *Vertical wicking test AATCC 197*
- *Horizontal wicking test AATCC 198*
Summary

In this lecture you have revised how to determine the textile properties of smart textiles and the common standards used for testing:

- the **strength-related textile properties** (tensile, tearing, abrasion and pilling tests)
- the **haptic-related properties** (tailorability, drapability and fastness)
- the **comfort-related properties** (stiffness, recovering angle, water vapour resistance, air permeability, thermal resistance and water wicking).
Partners:

Project:
Innovative smart textiles & entrepreneurship
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