Ingeo™ Fibre Apparel Product Guidelines

Fiber to Fabric
1. Introduction to Ingeo™ fibers
2. Fiber to yarn
3. Yarn to fabric
Apparel Products

1. Introduction to Ingeo™ fibers
Ingeo™ fibre

- The only synthetic fibre commercially available in bulk quantities, that is made entirely from annually renewable raw materials - not oil

Not only from nature - but also back to nature
Ingeo™ fibre

From nature, and back to nature
- plus performance:

- Excellent wicking properties
- Moisture management
- Low odor retention
- Does not support bacterial growth
- Hypoallergenic
- Rapid soil release
- Quick drying
- Excellent after wash appearance

And all supported by detailed technical bulletins …..
Ingeo™ fibre

From nature, and back to nature - plus performance:

Positive performance appeal (bedding)

- High loft which is maintained
- Difficult to ignite
- Low heat of burning
- Low smoke emission

⇒ Long life durability
⇒ Fire safety regulations

Technical bulletins available to support all these properties
<table>
<thead>
<tr>
<th>Subject</th>
<th>Bulletin number</th>
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</thead>
<tbody>
<tr>
<td>Apparel</td>
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<tr>
<td>Odour release</td>
<td>290904</td>
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<tr>
<td>Hohenstein Institute testing</td>
<td>260904</td>
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<tr>
<td>Washing and dry cleaning performance</td>
<td>50904</td>
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<tr>
<td>Fibre &amp; fabric properties</td>
<td>180904</td>
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<tr>
<td>Home textiles</td>
<td></td>
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<tr>
<td>Fibre fill compression testing</td>
<td>200904</td>
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<tr>
<td>Duvet / comforter performance</td>
<td>130904</td>
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<tr>
<td>Pillow performance</td>
<td>320904</td>
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<tr>
<td>Furnishing flammability characteristics</td>
<td>110104</td>
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<tr>
<td>Non woven</td>
<td></td>
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<tr>
<td>Moisture transport in Ingeo™ fibre non woven fabrics</td>
<td>380904</td>
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<tr>
<td>Wipes regularity technical bulletin (toxicology)</td>
<td>390904</td>
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<tr>
<td>Wipes commercial production information</td>
<td>110804</td>
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<tr>
<td>Multi product</td>
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<tr>
<td>Compostability</td>
<td>120904</td>
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<tr>
<td>Ingeo™ fibre fabric UV resistance</td>
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These and more available on [www.ingeofibers.com](http://www.ingeofibers.com)
Apparel Products

2. Fiber to Yarn
## Ingeo™ fibre properties

<table>
<thead>
<tr>
<th></th>
<th>Staple</th>
<th>Filament</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>POY</td>
</tr>
<tr>
<td>Fibre, dtex</td>
<td>1.5</td>
<td>120/68</td>
</tr>
<tr>
<td>Tenacity, cN/tex</td>
<td>30 - 35</td>
<td>23-26.5</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>50 - 60</td>
<td>50 - 75</td>
</tr>
<tr>
<td>Moisture Regain, %</td>
<td>0.4 – 0.6</td>
<td>0.4 – 0.6</td>
</tr>
<tr>
<td>Crimp, per 10cm</td>
<td>30 – 35</td>
<td>----</td>
</tr>
<tr>
<td>Cross Section</td>
<td>Round</td>
<td>Round</td>
</tr>
<tr>
<td>Surface</td>
<td>Smooth</td>
<td>Smooth</td>
</tr>
<tr>
<td>Density, g/cm³</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Melt Point, °C</td>
<td>170</td>
<td>170</td>
</tr>
<tr>
<td>Boiling water shrinkage</td>
<td>18% (yarn)</td>
<td>----</td>
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</table>
## Comparative Staple Fibre Properties

<table>
<thead>
<tr>
<th></th>
<th>Synthetic Fibres</th>
<th>INGEO</th>
<th>“Natural” Fibres</th>
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<tbody>
<tr>
<td></td>
<td>Nylon 6</td>
<td>PET</td>
<td>Acrylic</td>
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<tr>
<td>Specific gravity</td>
<td>1.14</td>
<td>1.39</td>
<td>1.18</td>
</tr>
<tr>
<td>Tenacity (cN/tex)</td>
<td>42 - 48</td>
<td>45 - 55</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>4 - 4.5</td>
<td>0.2 - 0.4</td>
<td>1.0 - 2.0</td>
</tr>
<tr>
<td>Melting point (°C)</td>
<td>215</td>
<td>255</td>
<td>320</td>
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</tbody>
</table>
Fibre Stress Strain Data

INGEO
1.5dtex 38mm
Fibre Stress Strain Data
INGEO™ Short Staple Spinning

- Fibre characteristics similar to other thermoplastic fibres:
  - controlled crimp
  - smooth surface
  - low moisture regain
- Processing conditions usually similar to 100% polyester.
- Be aware of low melt point / high friction generating heat
- Yarns:
  - Good regularity
  - Few imperfections
  - High elongation

DETAILED TECHNICAL MANUAL AVAILABLE
**INGEO™ Short Staple Spinning**

- **Blending**
  - Required for consistent dye uptake
  - Blending with other fibres possible

- **Opening**
  - One opening
  - Too much opening
    - Increased neps
    - Fibre damage

- **Finish**
  - Already applied
  - No need for overspray
INGEO™ Short Staple Spinning

- **Carding**
  - Similar to PET settings
  - Cotton type cards too aggressive
  - 23 – 27°C, 50 – 55% RH
  - Speeds, 35 – 50Kg/hr
  - Regularity <4.0CV%
  - Nep count low, often zero
INGEO™ Short Staple Spinning

• **Drawing**
  - Two passages
  - Minimum nip pressures
    (tongue and groove rollers in particular)
  - Speeds, 400m/min with 4 – 5gm/m sliver
  - Regularity around 2.5CV%

• **Roving**
  - Twist levels as PET (around 0.8TM)
  - Speeds up to 1,200rpm
  - Regularity 4.0 – 4.5 CV%
• **Spinning**
  - 23 – 28°C, 45 – 50% RH
  - Twist
    - 3.60TF for knitting
    - 3.85TF for weaving
  - Regularity
    - Ne10, 8 - 8.5CV%
    - Ne 30, 12-13CV%

• **Splicing**
  - Settings as PET for most types
  - Strength around 85% of parent yarn (min 60%)
• **Steaming**
  - If needed - to reduce knit fabric spirality
  - 80°C for 20 mins
  - Good vacuum and consistent control
  - Minimal effect on disperse dye uptake

• **Winding**
  - Reduce speeds to prevent surface abrasion
  - Care on winding tensions - usually reduced
  - Lower melting point waxes advised
### Short Staple Yarn Properties

<table>
<thead>
<tr>
<th>1.5dtex 38mm INGEO Fibre - Ring Spun - Cones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count (Ne)</td>
</tr>
<tr>
<td>Tenacity (cN/tex)</td>
</tr>
<tr>
<td>Elongation (%)</td>
</tr>
<tr>
<td>CV% (UT3/4)</td>
</tr>
<tr>
<td>Thins -50%</td>
</tr>
<tr>
<td>Thicks +50%</td>
</tr>
<tr>
<td>Neps +200%</td>
</tr>
<tr>
<td>Hairiness (UT3H)</td>
</tr>
</tbody>
</table>
• 3.3dtex variable (Bias) cut 80-110mm semi dull fibre
• Carded and combed tops – no stretch breaking tow
• Care with additives to prevent accidental weakening of fibres
• Conventional blending and gilling, usually with wool
• Rubbed or twisted roving
• Spinning to normal limits (typically 48Nm) with normal worsted twist
• Folding, winding and waxing as for polyester/wool blends

Yarn properties dependent on the wool, but similar to those for 100% wool generally
Apparel Products

3. Yarn to Fabric
Ingeo™ Fabric Formation - Knitting

• No major issues
• Knit as for most other yarns
• Stitch lengths:
  ➢ Staple yarns - similar or slightly longer than for cotton
  ➢ Filament yarns - up to 20% longer than for PET
  ➢ Experiment to give desired aesthetic / performance
• Avoid excessive takedown tensions
• Circular or flat bed knitting
No special techniques have been found necessary.

Some guidelines:

- **Warping** ⇒ high yarn elongation - minimum yarn tension (0.3 - 0.35g/denier)
- **Sizing** ⇒ avoid strong alkaline conditions in desize:
  - PVA sizing (or other water soluble size)
  - Typical size conditions:
    - 8-10% PVA
    - Size box temperature 35 to 40º C
    - Drying temperature of 75 to 85º C
    - Slight warp sheet overfeed (~6%)
Weaving ⇒ no major issues - use minimum warp tension
- use good weft yarn tension control

Fabrics ⇒ structures to allow for ~15% shrinkage, greige to finished
⇒ Ingeo™ is sensitive to hot ironing, so consider:
  - natural fibre warp faced constructions (safe ironing on warp face)
  - formal wear products (minimum/cool ironing)
More information at www.ingeofibers.com

humanity, nature and technology in balance
IMPORTANT NOTES:
1) The information provided in this document is given in good faith based on the best knowledge of current technology. The information provided can only be taken as a start point for trials to establish production routes for Ingeo™ fibre products. Cargill Dow cannot be held responsible for any claims arising from the information contained within this document, howsoever caused.

2) Yarns produced from different merges, and from different suppliers of INGEO(TM) PLA fibers, may vary in dye uptake, which can influence the reproducibility of shades. It is therefore recommended that before carrying out any production dyeing on new merges or fiber from new suppliers, that the dye recipe is verified by a laboratory check. This is a similar procedure to other man made fibers, and so similar practices should be adopted to control color reproducibility at the final coloration stage.

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