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Fabric Defects 101
Understanding & Overcoming Pilling

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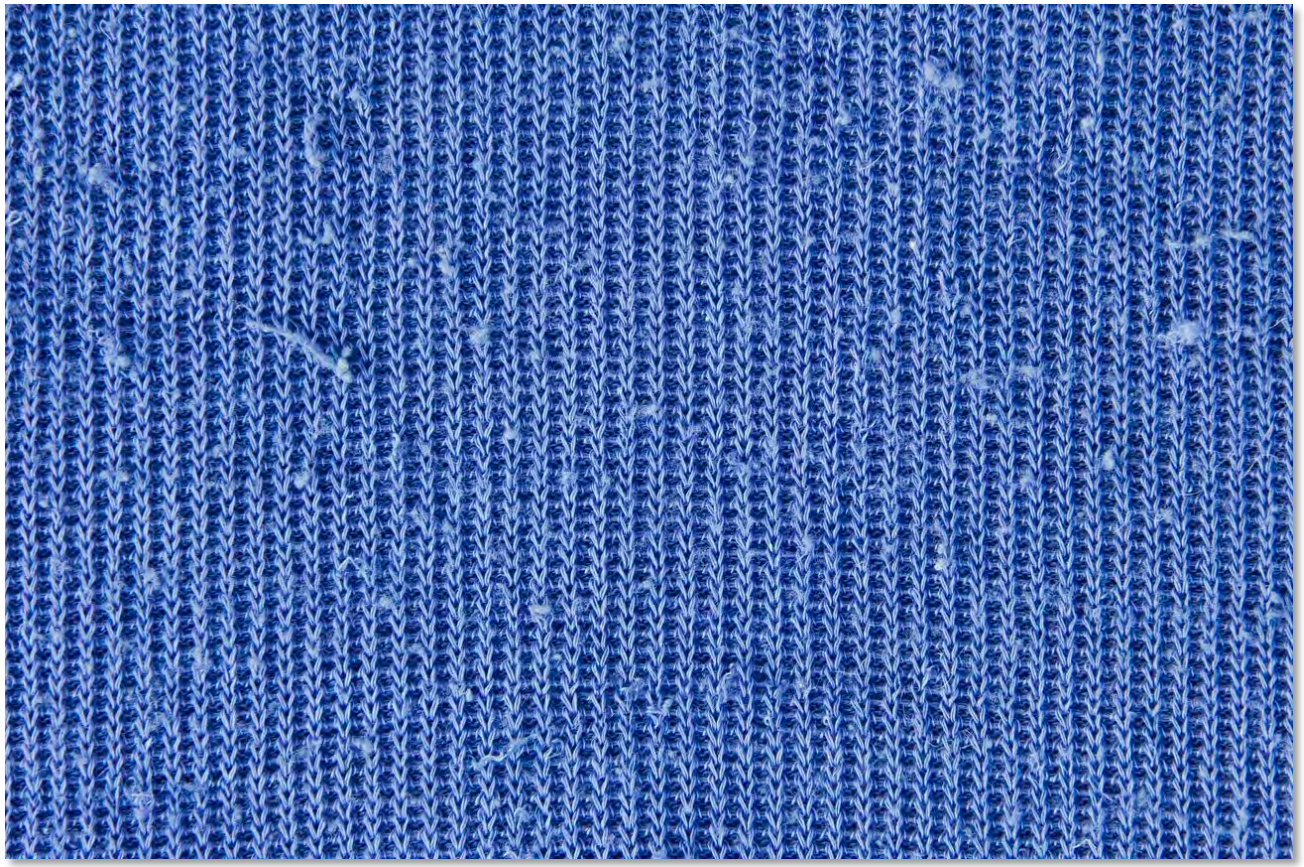
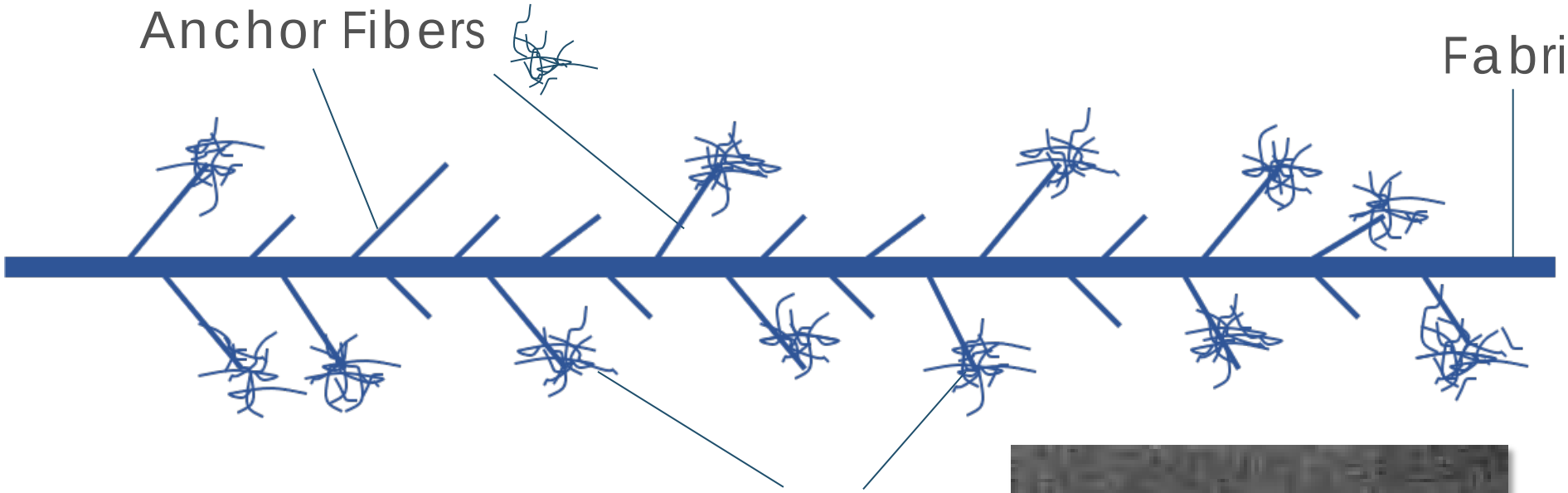
Fabric Pills



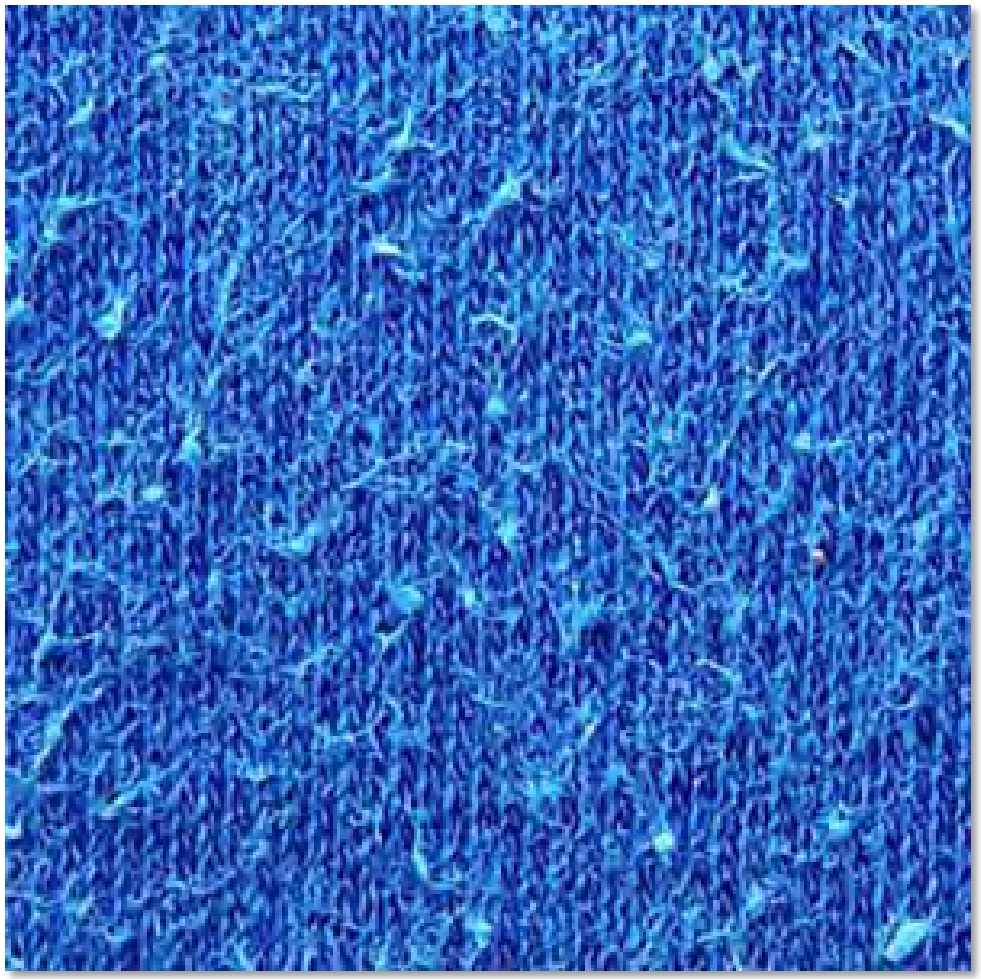
Pills are defined as small balls of entangled fibers that are attached on the surface of a fabric or material

The Pilling Phenomena



Animation

Anchor Fibers



The **pills** shown here have long, strong anchor fibers (polyester) which are holding entangled balls of loose fiber to the surface.

The anchors are pulled from the surface of the fabric during use and have captured the loose lint during wear and laundering.

The anchor fibers also entangle with other anchors fibers to also form pills.

Pilling Resistance

is the measurement of the tendency of a material or fabric to form pills on its surface

Surface Phenomena

The development of pills may be accompanied by other surface phenomena, such as:

- Loss of cover
- Color change
- Localized frosting
- Development of fuzz

Laundering & Wear

Pills form during both laundering and wear.

Pills that form during laundry are called **lint** or **laundry pills**.

Pills that form during wear are called **regular** or **natural pills**.

Lint or Laundry Pills

Most pills are formed in laundering where wet and dry abrasion occur from tumbling thereby generating an ample supply of loose fibers to aid in the formation of pills.

Lint or Laundry Pills

Regular or Natural Pills

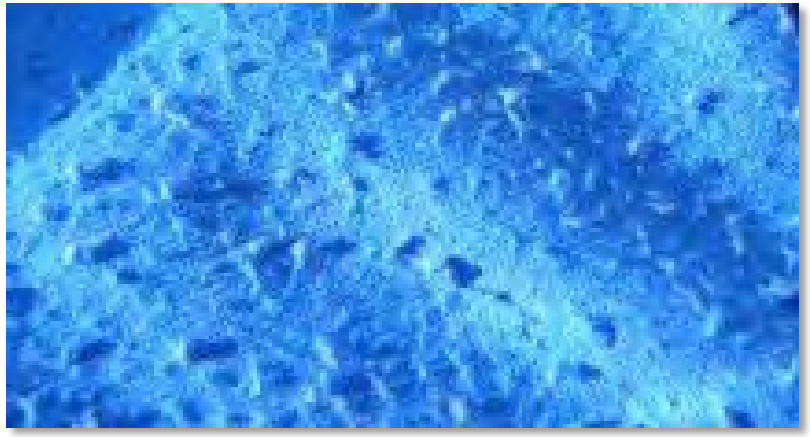
Pills formed during wearing occur:

- Under the sleeve arms on shirts
- Around the collar
- In the crotch area of pants/slacks

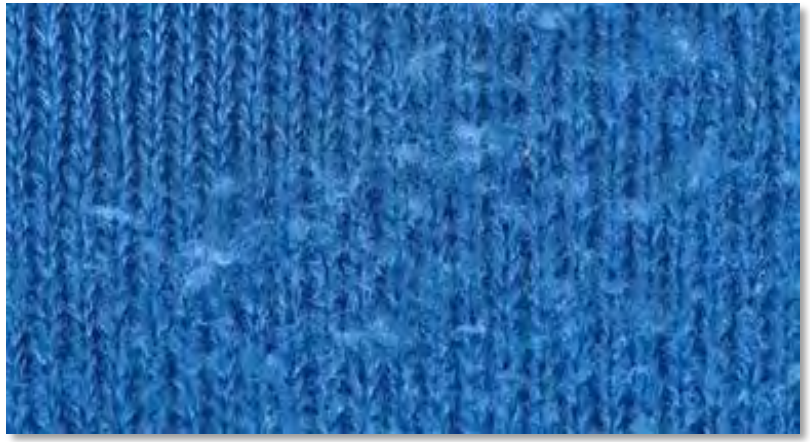
Referred to as **regular pills**, **natural pills**, or **wear pills**.

Fibers that form the anchor and lint come from the same fabric during use.

Regular or Natural Pills



These (regular or natural) pills were formed during wear when the fibers protruding from the surface rolled up with other protruding fibers and loose lint inside the sleeve of the shirt.



On this fabric it is easy to see the abrasion are where fibers are broken and entangled together during wear.

Regular or Natural Pills

Cashmere

Before any wear

After multiple wears

Regular or Natural Pills

Cashmere

After multiple wears

Snag

This accumulation of fibers is all filament polyester. It appears to be a pill but is technically a **snag**.

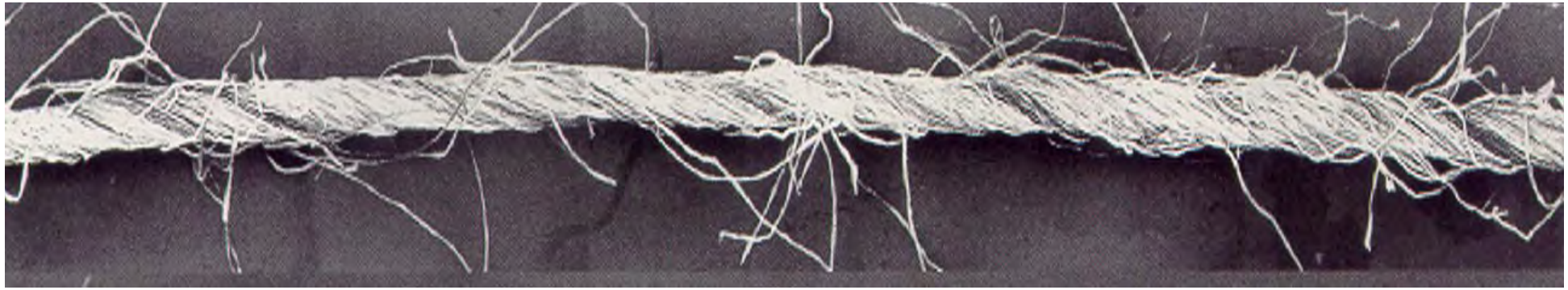
However, if it looks like a pill, then it has all the same aesthetic and quality problems as does a pill.

Pilling of textile products is a complex property affected by many factors including:

- Type of fiber or blends
- Fiber Fineness (denier)
- Yarn and fabric construction
- Fabric finishing treatments
- End use

Impact of Fiber & Yarn

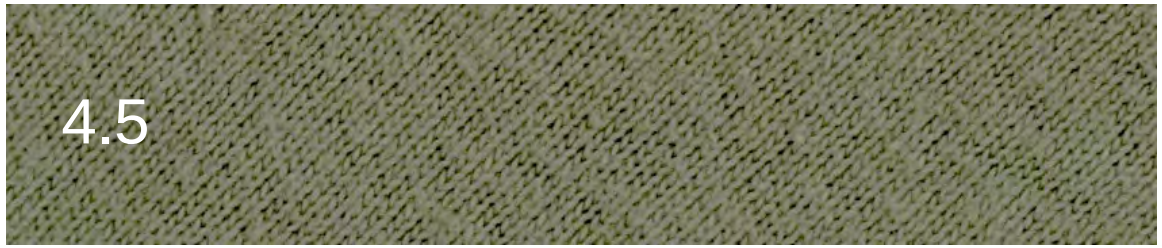
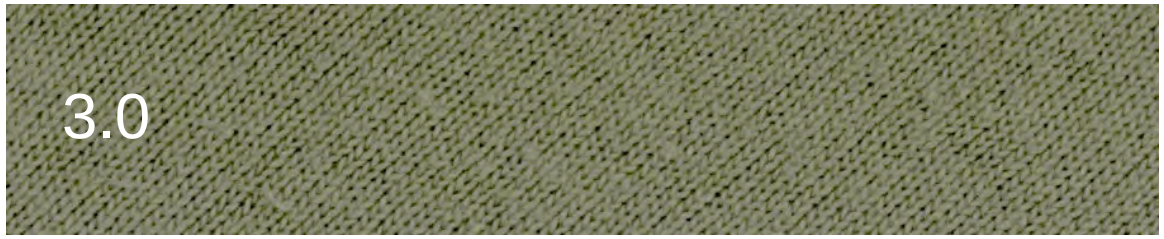
Pilling and fuzzing are common among fabrics made with spun yarns where many fiber ends protrude from the surface.



Spun yarns of low twist levels tend to fuzz more in wash and wear.

Impact of Spinning System

100% Cotton Spun Yarns –18/1
Carded - 18 ga. Single Jersey

Ring Spun	
Open End Spun	
MVS Vortex Air Jet Spun	

Random Tumble Pill Test - 30 min. test

Impact of Fiber & Yarn

- Spun yarns consisting of cotton and a man-made fiber tend to pill more than 100% cotton
- The strength of the synthetic fiber allows for a better anchor.
- Typically, 100% cotton fabrics do not pill.
- Animal fibers such as cashmere and fine wools may pill due to the strength of the fiber and long surface hairs.

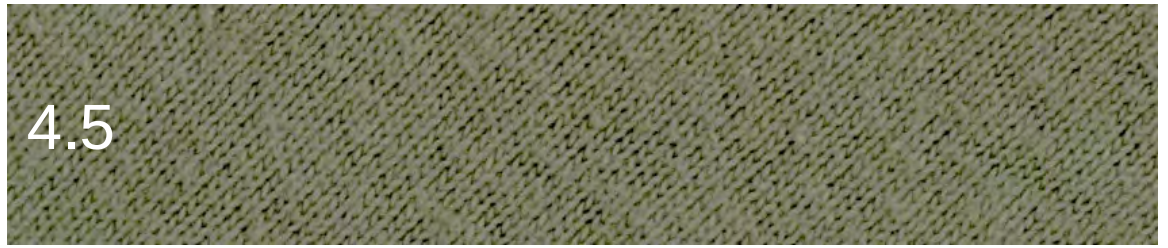
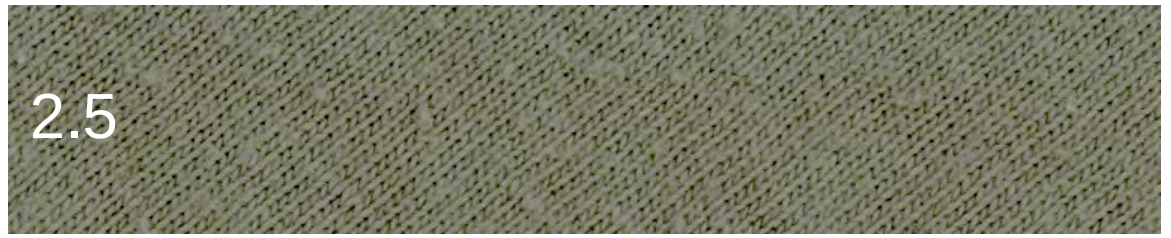
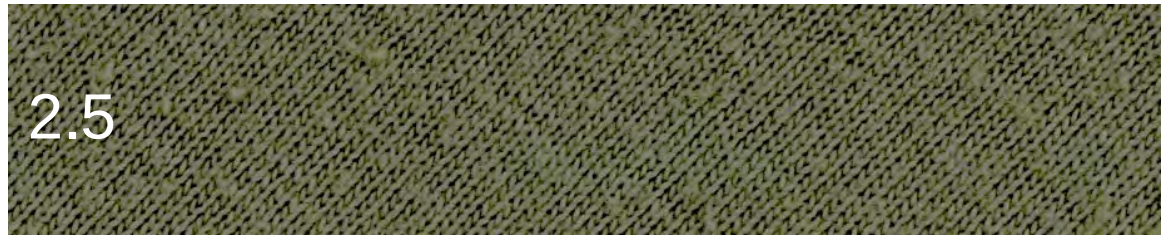
Impact of Fiber & Yarn

Blends of cotton and synthetic staple fibers have a high tendency to form pills.

Synthetic fiber provides a strong anchor fiber that will accumulate lint in the form of pills.

Impact of Changing Blend Level

Ring Spun Yarns –18/1 Carded - 18 ga. Single Jersey

100% Cotton	
60/40% Cotton/PE	
50/50% Cotton/PE	
35/65% Cotton/PE	

Random Tumble Pill Test - 30 min. test

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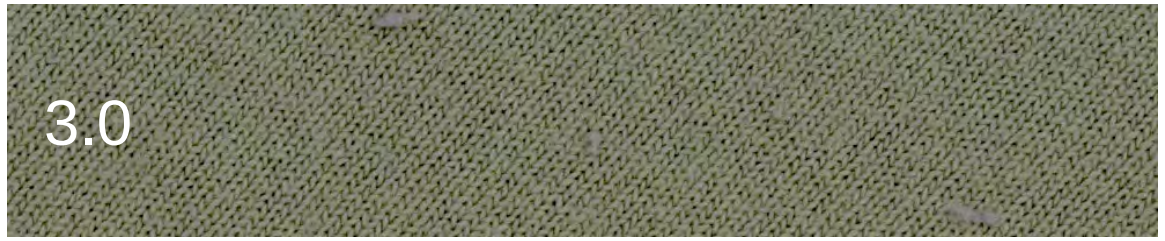
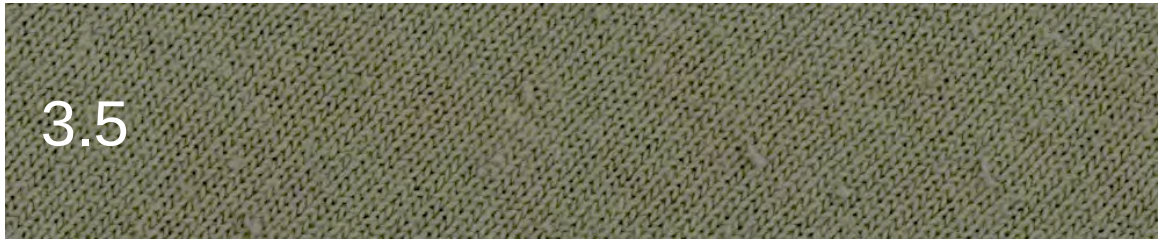
Impact of Changing Blend Level

MVS Vortex Spun Yarns –18/1 Carded - 18 ga. Single Jersey

100% Cotton	 5.0
60/40% Cotton/PE	 4.5
50/50% Cotton/PE	 3.0
35/65% Cotton/PE	 3.5

Random Tumble Pill Test - 30 min. test

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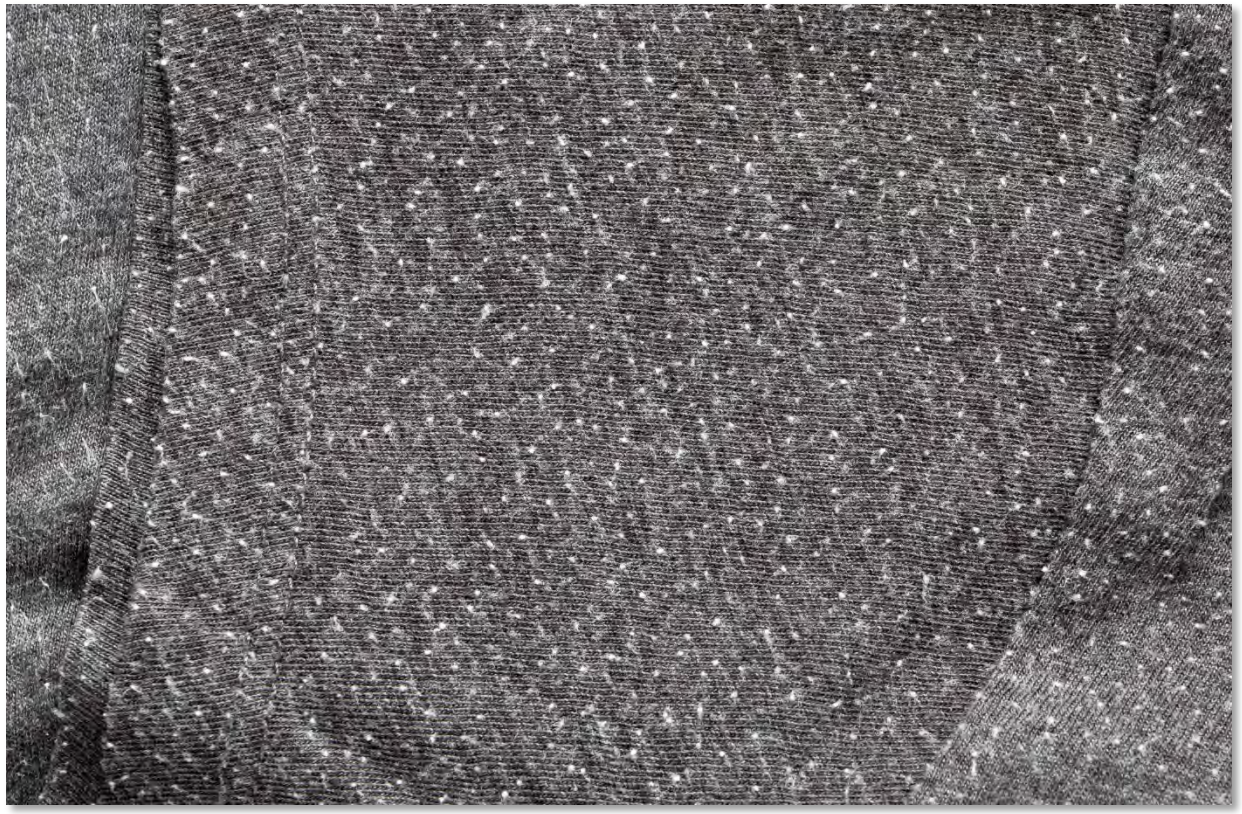
Typical Yarn Count Ranges

Ring Spun	1/1 to 100+/1 Ne
Open End	1/1 to 40/1 Ne
Vortex MVS	20/1 to 80/1 Ne

Impact of Adding Polyester Blends With Cotton



50/50% COT/PE 1.5d

Single Jersey

- Ring Spun Heather Yarn
- 50/50% COT/PE Cotton White and PE Black
- Pills of white cotton lint attached to fabric surface by black polyester ‘anchor’ fibers.
- Pill specimen from Random Pill Tester – 30-minute test.

Impact of Changing Denier of Polyester in Blends with Cotton

50/50% COT/PE 1.2d

50/50% COT/PE 1.5d

Random Tumble Pill Test - 30 min. test

Pilling of 2-End Fleece – Cotton/PE

Technical Face

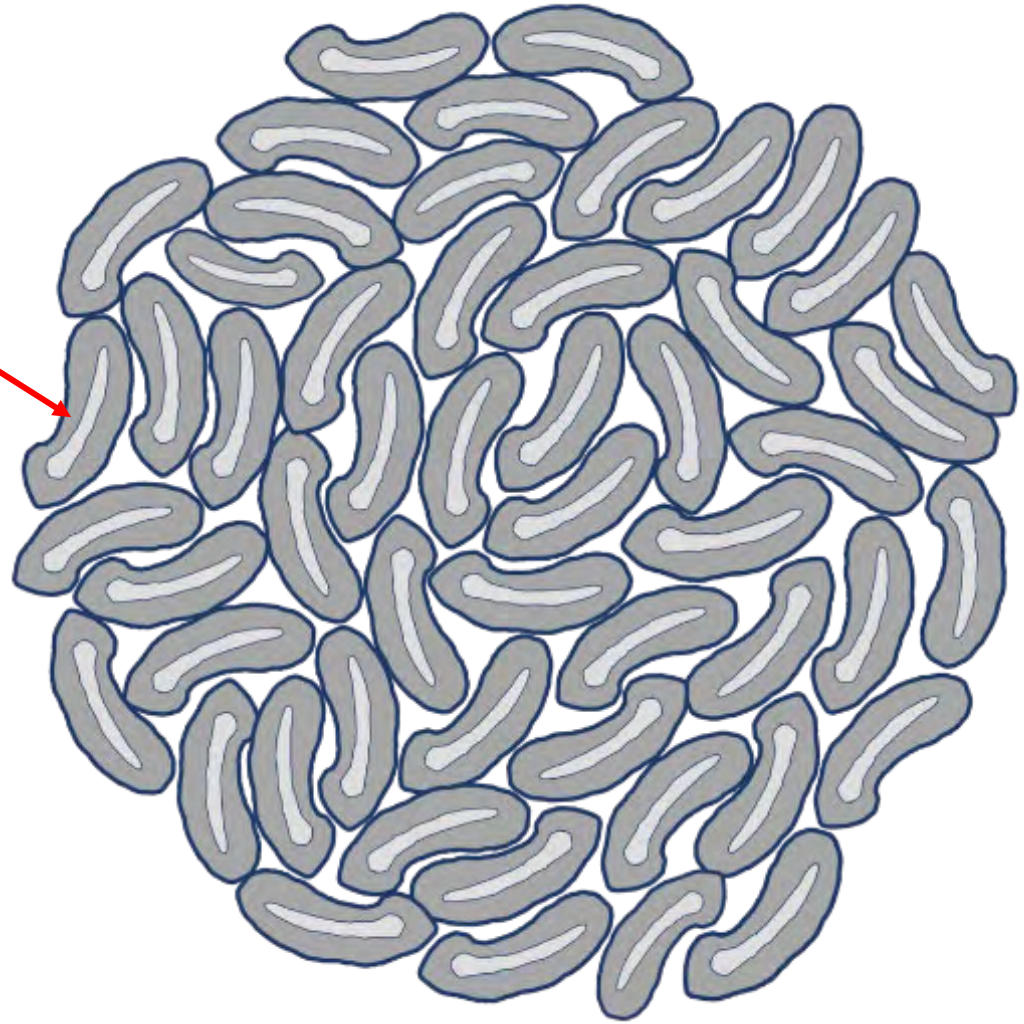
Medium Pilling – 3.0

Technical Back – Fleece Side

Extreme Pilling – 1.0

Cross-Section of a 100% Cotton Yarn

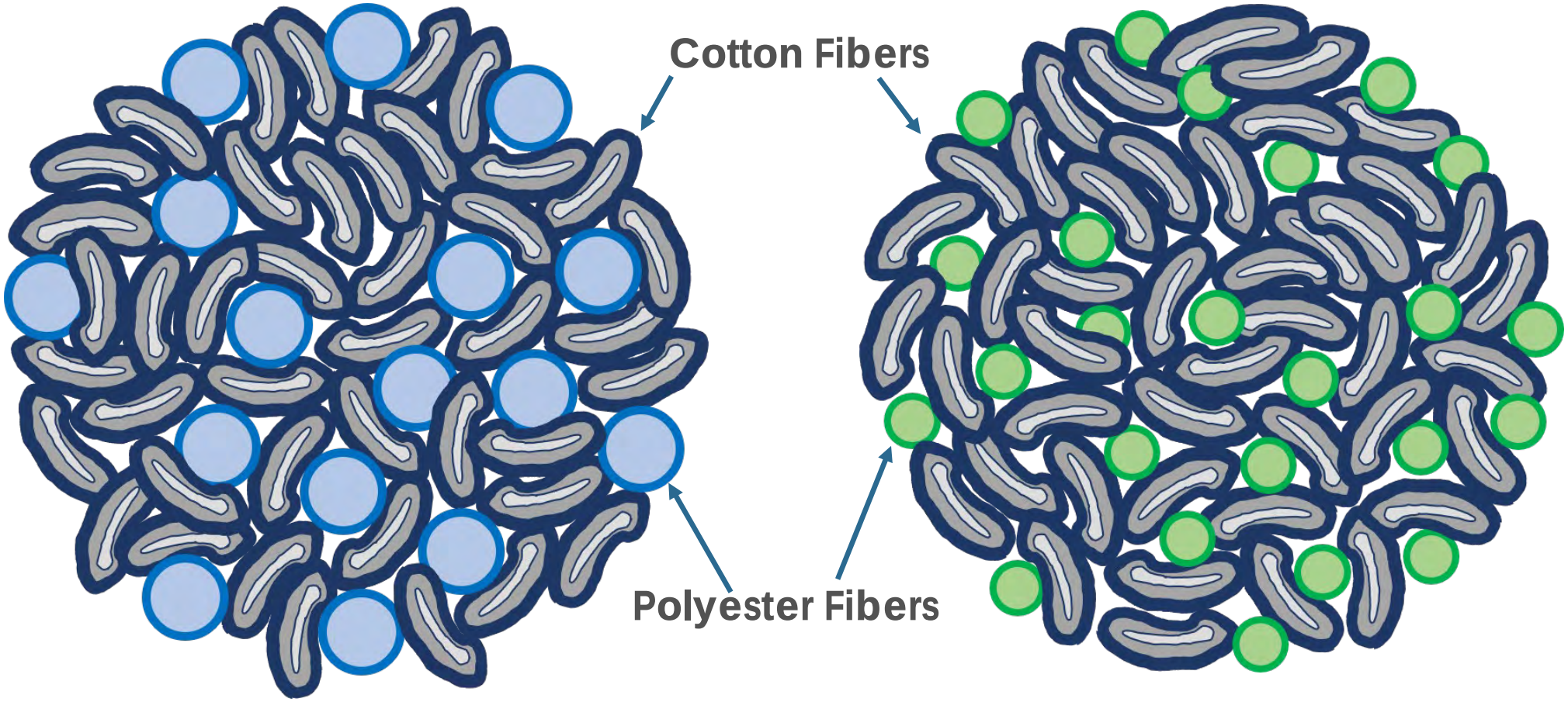
Cotton Fibers



Comparison of Blended Yarns with Different Deniers of Polyester

65%Cotton (1.5d)/35% PE (2.25d)Yarn

65% Cotton (1.5d)/35% PE (1.25d)Yarn



16 Polyester Fibers

24 Polyester Fibers

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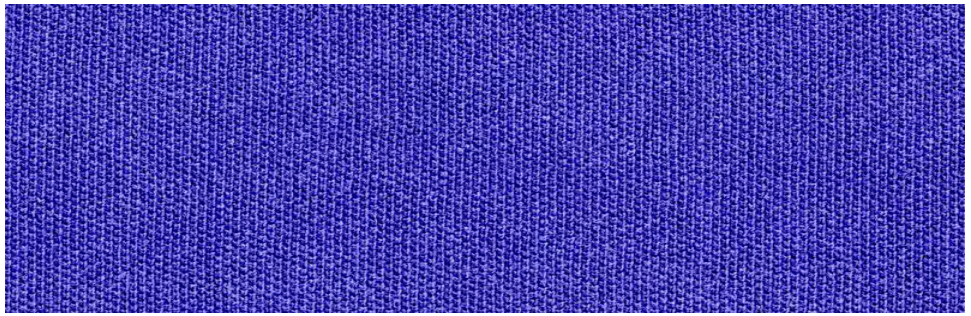
Impact of Fiber & Yarn

Filament fibers can pill if the individual filaments are subjected to breakage during use.

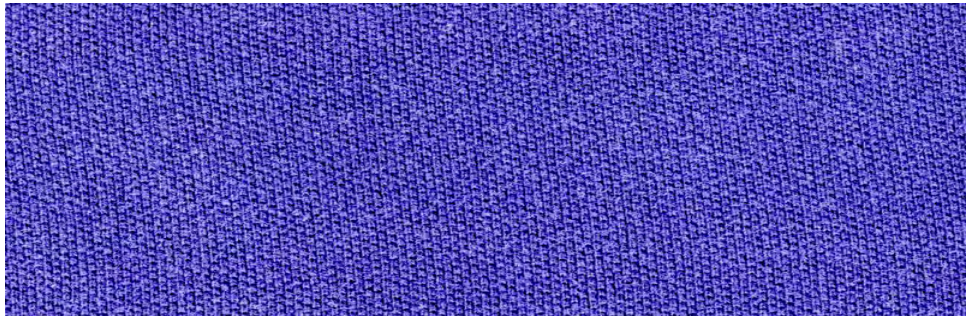
Pilling can occur during washing due to short fibers breaking and latching to filaments.

100% Cotton Pique Knit – Ne 18/1

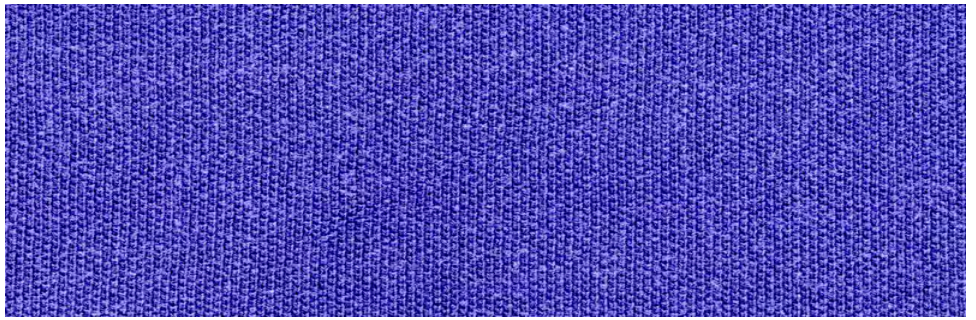
MVS
50 HLTD's



ROTOR
50 HLTD's



RING
50 HLTD's



50 Home Launderings and Tumble Dryings

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Evaluation of Pilling

To evaluate the potential of a product to pill, accelerated tests have been developed to simulate pilling over many cycles of wash-and-wear.

The more common methods are:

- Random Pill Tester
- Martindale Tester
- Pilling Box

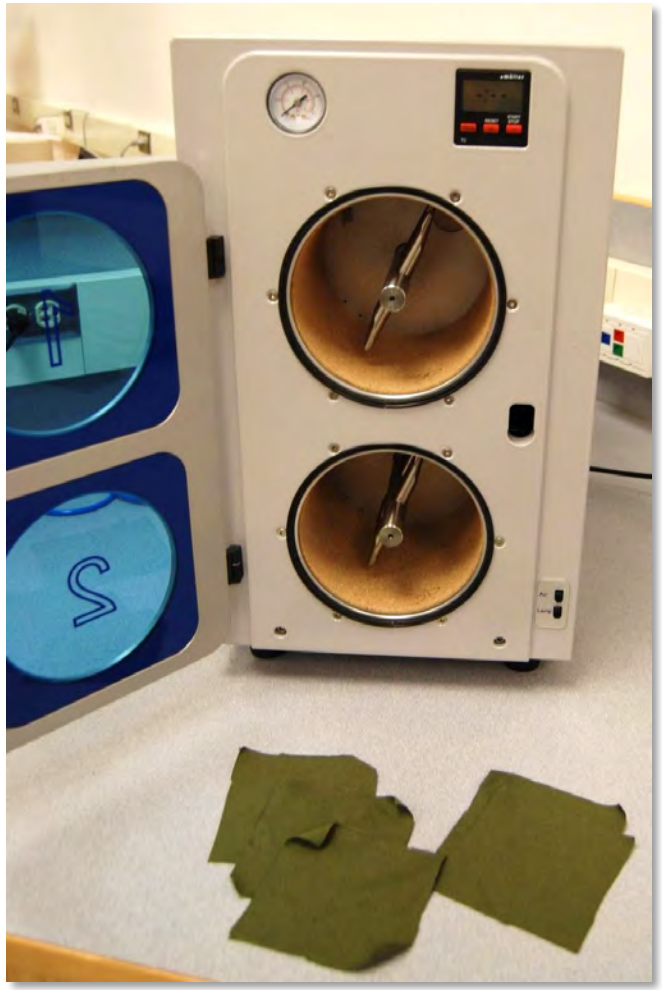
Pilling – Testing

The most commonly used tester for pilling is the "**Random Tumble Pilling Tester**."

The test method is ASTM D 3512, "Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Random Tumble Pilling Tester."

Random Pill Tester

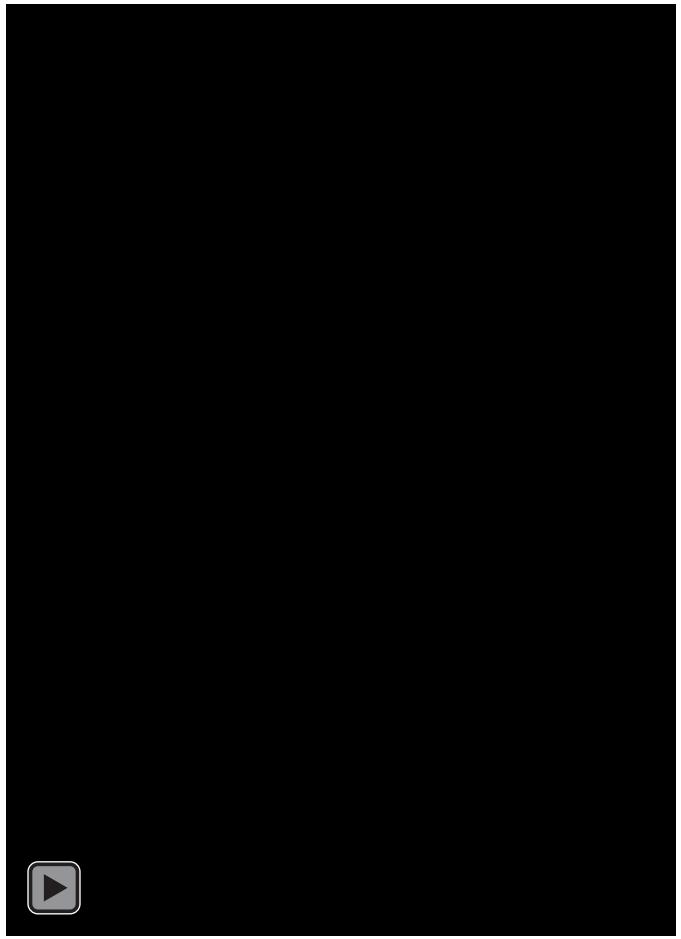
- A group of three specimens is placed into a cylinder where a spinning rotor or propeller tumbles the fabric for a specified testing time.
- The inside of the cylinder is lined with natural cork liner to serve as the main abradant.
- A small amount of “test lint” is added to the cylinder. Lint may also be generated from the specimens during the test.



Random Pill Tester

- The action of the propeller works the specimen against the cork liner in a random manner.
- The high rate of spinning results in numerous strikes.
- If anchor fibers are raised and are too strong to break off, the loose lint will accumulate on the tip of the anchor fiber and form a pill.

Test Method ASTM D4970 / D4970M



Random Pill Tester

- The test is run for a specified number of minutes, usually 30, the machine is stopped, and the specimens are removed.
- Any loose lint on the surface of the specimens is vacuumed off and the specimens are rated against the five-point scale. Also, the cylinders are vacuumed clean.
- If another 30 minutes of testing is needed, then new testing lint would be added with the vacuumed samples.

Pilling – Evaluation

The degree of fabric pilling is subjectively evaluated by comparing the tested specimens with visual standards, which may be actual fabrics or photographs of fabrics, showing a range of pilling resistance.

The observed resistance to pilling is reported based on a scale ranging from 5 to 1 (no pilling to very severe pilling).

5.0 No Pilling

1.0 Very Severe Pilling

Random Pill Tester

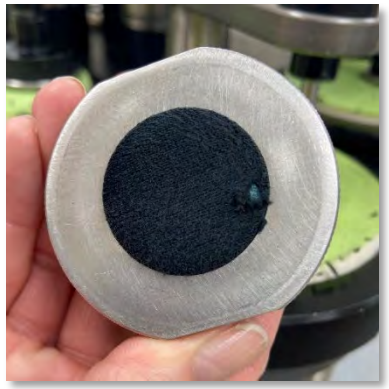
- The pilling specimens are rated on the five-point scale using ASTM Standard Test Procedure D3512.
- In most specifications, if the fabric passes, then another 30-minute cycle is run.
- In this scenario, a final rating is made after the total 60 minutes are run.
- If the fabric fails after 30 minutes, then the test is terminated.

Martindale Tester

This test method is ASTM D 4970, “Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Martindale Tester.”

Martindale Tester

- The apparatus and the settings used for abrasion are also used for pilling.
- The difference is that the abradant used for abrasion resistance testing is removed and a matching specimen of the test fabric is used to rub against the test specimen.
- Any pills formed are rated the same as in the Random Pill Testing Method.
- Compared to the Random Pill Tester, this test is more related to natural or regular pills.



Video

Martindale Tester

- Specimens of the same fabric are mounted on both positions on the tester. The top position has a small circular specimen, and the bottom has a large circle of the same fabric.
- The faces of the specimens are repeatedly rubbed against each other in a specified geometric pattern to cover the entire surface.
- The pressure between the two specimens is a light force.
- The degree of fabric pilling or surface appearance changes produced is evaluated using the same standards as those used with the Random Pill Tester.

Martindale Tester

- Fabric restrictions encountered for Martindale abrasion testing are related to pile height and thickness.
- Thick fleece and other pile fabrics do not process well on this tester.
- Other fabrics that have variable thickness or areas of different pattern heights might also cause inconsistency in the test. Examples of these fabrics are waffle, seersucker, thermal fabrics and other similar constructions.

Pilling Box Test

ISO 12945-1

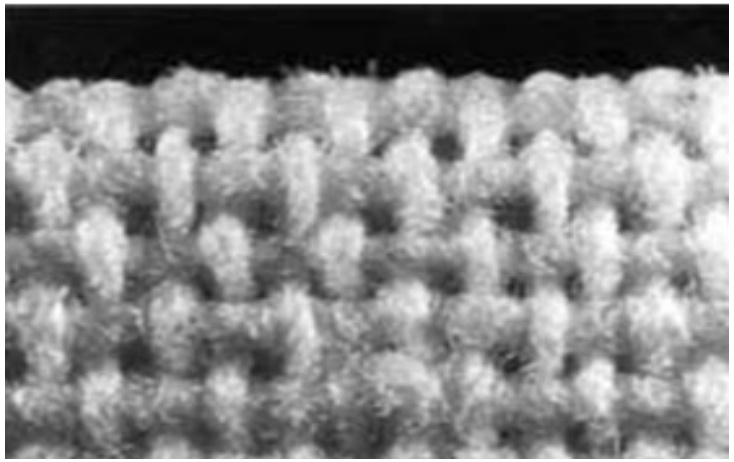
"Textiles – Determination of Fabric Propensity to Surface Fuzzing and to Pilling"

Pilling Box Test

ISO 12945-1“Textiles – Determination of Fabric Propensity to Surface Fuzzing and to Pilling”

- In this test, a group of four specimens are placed into a box which rotates and tumbles the specimens.
- The inside of the box is lined with a cork liner to serve as the main abradant.
- Each specimen is mounted on to a polyurethane tube prior to the test.
- An agreed upon number of revolutions are used for the pilling test.

Mechanical & Chemical Processes Prevention or Removal from Fabric



Singeing of Fabric or Yarn

Cellulase Enzyme Treatment of Fabric

Shearing Fabric

Singeing

The passing of a yarn or fabric over a gas flame or super heated ceramic surface to remove protruding ends of fibers thereby producing a clean, smooth, uniform surface.

- Better luster and definition of construction is achieved.
- Pilling is also improved.

Gassed (Singed) Yarn

Before After

- Gassing or singeing of yarn provides a smooth and lustrous yarn surface for higher end products.
- May or may not be used with yarn mercerization.
- Singles yarns can be gassed, but not mercerized.

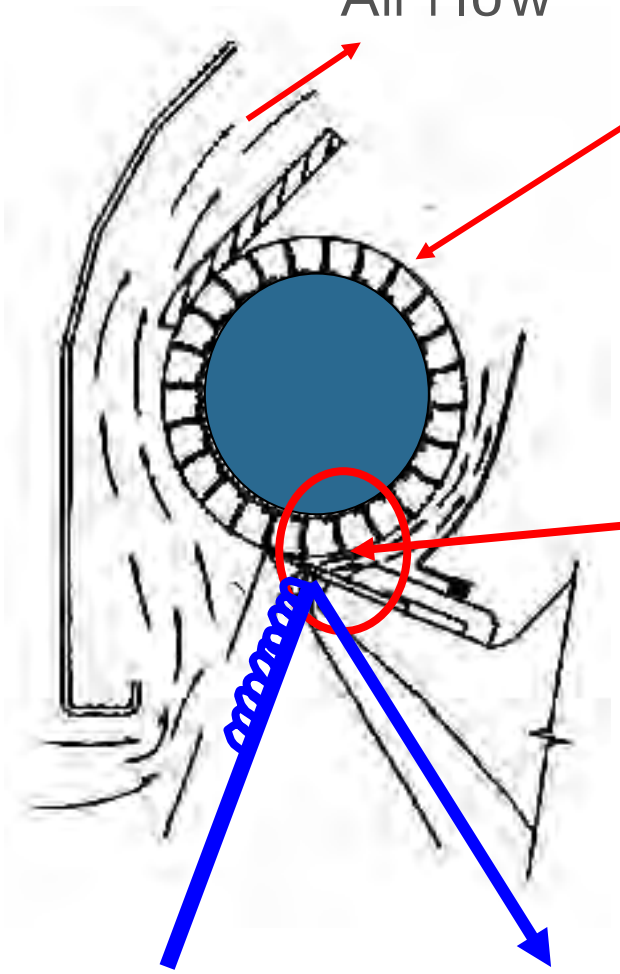
Gassed (Singed) Yarn

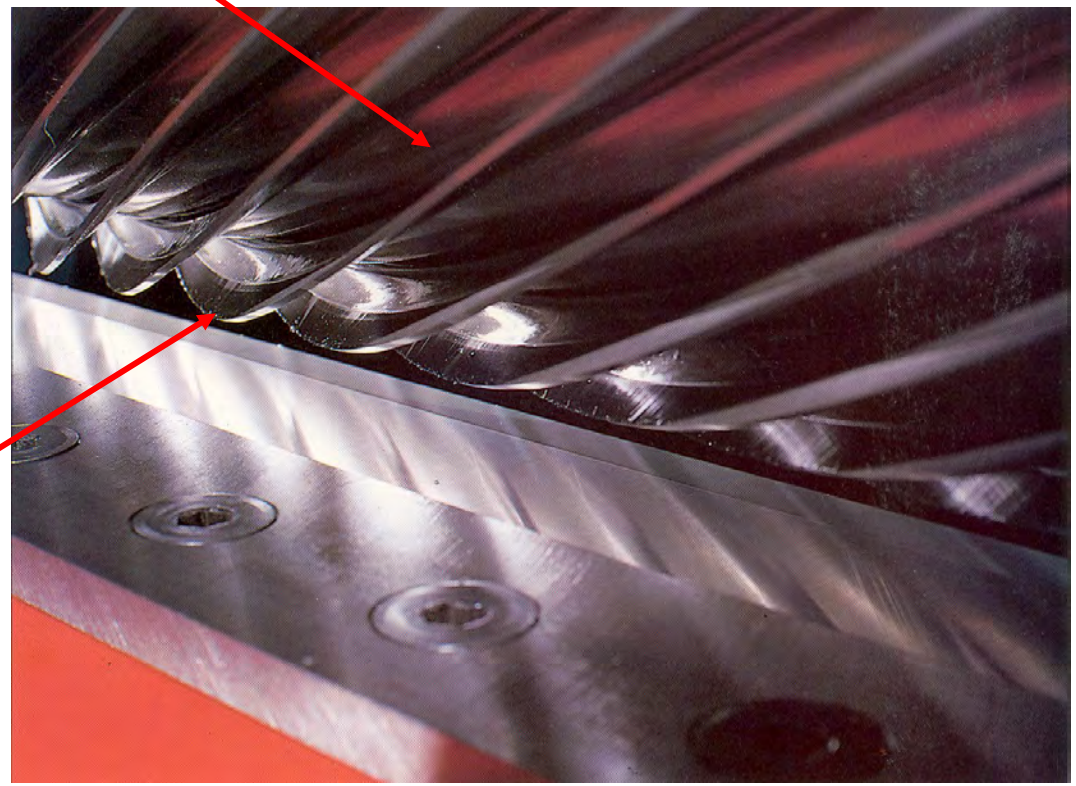
- Yarns are singed individually and processed package to package.
- Machines operate at 1,000 to 1,500 m/min.
- Positions from 10 to 192.
- Yarn counts from 3/1 to 80/1 standard.

Enzymes

- Organic substances that quicken natural reactions
- Cellulase enzymes are used in preparation and washing techniques
  - Fabric appearance becomes smoother and hand softer
  - Cleaner appearance achieved by removal. of surface fiber

Shearing





Animation

Methods to Improve Pilling

- With short staple yarns, keep **short fiber content** to a minimum.
- Increase **twist level** to reduce fiber shedding during laundering.
- In **blends of polyester and cotton**, keep polyester content to 20% or less and maintain at least a denier of 1.5 for the polyester.
- Use **low pill polyester**.
- With **filament yarns**, use finer gauges/yarns to reduce open surface.

Methods to Improve Pilling

- **Singeing** of fabric and yarns can remove anchor fibers, especially those containing polyester and other synthetic fibers.
- To reduce fuzzing and short fiber loss with cotton fabrics, use **enzyme** treatments when possible.
- Where possible, **shear** fabric surface to eliminate long surface fibers, especially pile fabrics.
- **Resin finishing** will cause potential anchors to be removed during wash and wear.

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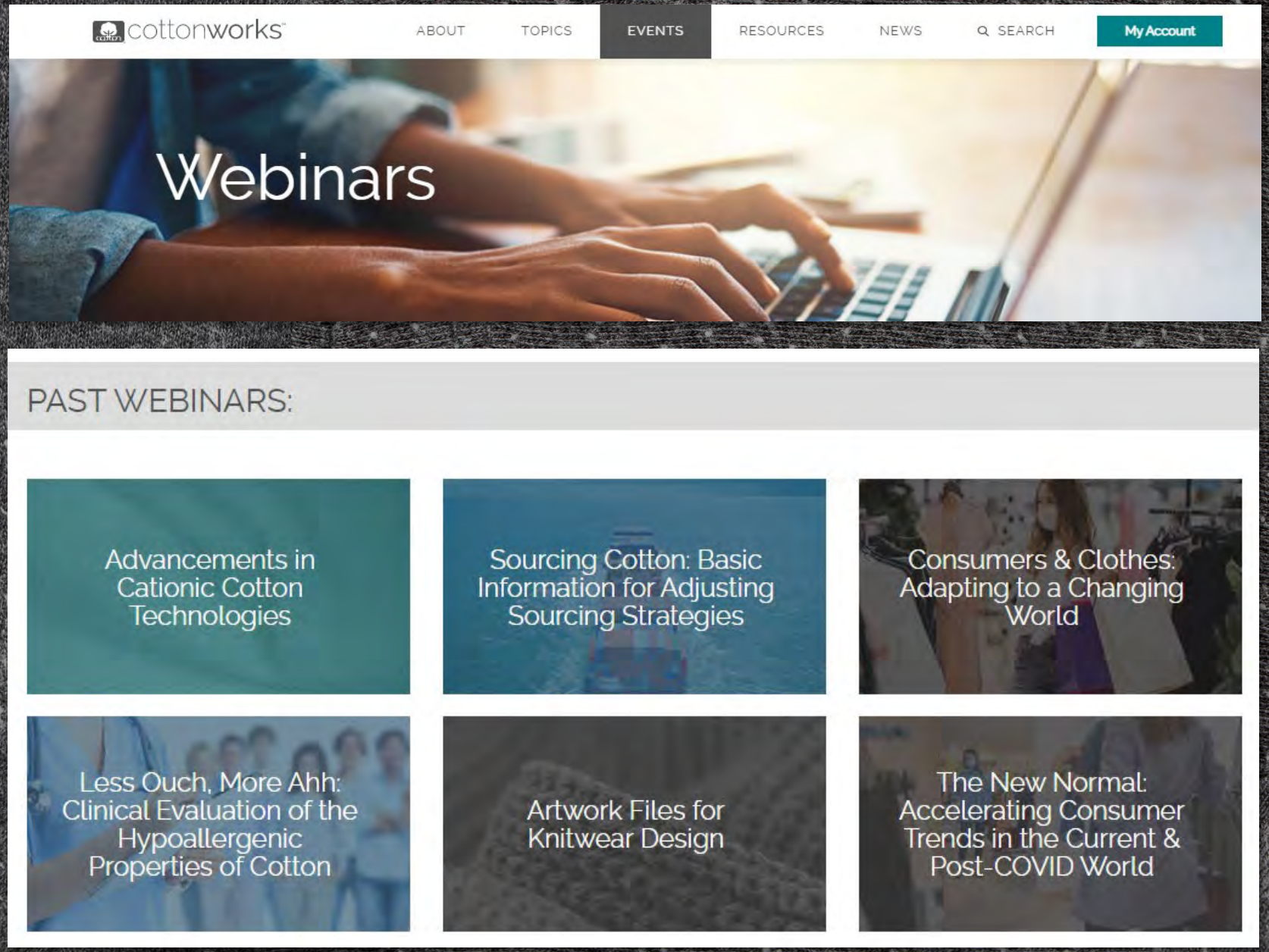

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