INTRODUCTION

DOW XLA elastic fiber meets this industry need by delivering a soft stretch, along with excellent chemical resistance and thermal stability. Designed to enable stretch in new applications, DOW XLA fiber frees designers from previously held constraints and allows yarn spinners and mills to improve process efficiencies.

To maximize stretch performance and meet customer specifications it is essential to use the proper dyeing and finishing processes when producing fabric made with DOW XLA fiber. After weaving, a greige fabric is obviously still not suitable for the end uses it has been designed for in the textile marketplace.

Color, touch, appearance, handle, and other physical and mechanical properties are often improved by means of specific finishing processes. In the case of stretch fabrics, elasticity is an additional feature that must be appropriately developed during finishing.

CHARACTERISTICS OF A STRETCH FABRIC

Elongation and elastic recovery are the qualifying characteristics of a stretch fabric. Both of these attributes can be achieved by incorporating yarn containing DOW XLA fiber in an extended state into the greige fabric. During the finishing process, the greige fabric shrinks to a certain extent, thereby obtaining the ability to stretch. For a stretch fabric, the degree of stretch is determined by a number of factors:

- Fabric structure (i.e., end and pick density, weave type, yarn count, loom settings)
- Amount of elastic fiber used in the fabric (a function of denier, draft, etc.)
- Effectiveness of the finishing process in relaxing the fabric (a function of residence time, temperature, etc.)

The degree to which a stretch fabric returns to its original condition after being extended is determined by:

- The elastic recovery force of the stretched fiber
- The opposing resistance of the “jammed” textile structure

UNIQUE STRETCH PERFORMANCE

One of the main advantages that DOW XLA fiber brings to stretch fabrics, in comparison with other elastic materials, is a comfort stretch. This is due to the fiber’s soft extension and retraction forces. Whenever an elastic fiber is extended during wearing, the force exerted by the body is proportional to the modulus of the fiber.
WOVEN FABRIC FINISHING

The load-elongation response and recovery characteristics of drafted, heat-exposed 70 denier DOW XLA fiber and spandex are given in Figure 1 (page 3). After heating and without releasing the extension force, a stress-strain test was performed up to 45% elongation (1st load and 5th unload curve shown). The flatter slope of the curve representing DOW XLA fiber indicates higher elongation at lower levels of force.

Similarly, the recovery of DOW XLA fiber from elongation results in less force exertion. In other words, DOW XLA fiber “comes back” in a much softer way, resulting in lower compressive force of the garment against the body. This soft recovery behavior also enhances garment dimensional stability. These attributes give a softer stretch, meaning that fabrics based on DOW XLA fiber require less force to stretch than spandex-based fabrics in the same construction. This results in a fabric that offers a more natural comfort stretch as opposed to a snappy, power stretch.

The potential shrinkage of a fabric containing elastic fiber depends directly on the retractive force of the fiber and the fabric’s resistance to compression, which is a function of the friction forces between and within yarns. The retractive force of each elastic yarn that contains DOW XLA fiber starts to work right off the loom. When the fabric is no longer kept in a stretched state by mechanical means, the fabric will shrink to a level that corresponds to the equilibrium state between the retractive force and compressive resistance.

During subsequent finishing processes, the compressive resistance decreases due to mechanical forces that are exerted onto the fabric and lower yarn friction. The fabric then reaches a new equilibrium point that is narrower than the previous one.

During the finishing process for stretch fabrics containing DOW XLA fiber, the lower retractive force also helps to eliminate creases and curling selvages, reduces the tendency of the fabric to shrink excessively, and enables easier control of the final fabric width.

PRELIMINARY TESTS ON GREIGE FABRIC

In order to design the appropriate process, finishers need to be provided with the most precise manufacturing data on the greige fabric. Therefore, preliminary tests aimed at determining the extent of shrinkage in the fabric have to be carried out, especially when dealing with unfamiliar constructions or new fibers. These tests can determine whether the finished fabric will meet customer specifications in terms of fabric weight, density, width and elasticity, and can also identify the need for modifications in the fabric’s construction and provide information on the suitability of certain finishing methods.

As illustrated in Figure 2 (page 3), the maximum shrinkage of a garment based on DOW XLA fiber can be determined by washing a piece of greige fabric in a home washing machine at typical laundry conditions. The wash cycle water should be at room temperature at the beginning, rising approximately 2°/min until it reaches 50°C (120°F). The cycle duration should be 30 minutes at this temperature with continuous alternate tumbler motion to allow for maximum relaxation. Adding some cleaning powder also helps to induce relaxation. Then, the fabric sample should be dried without tension in a tumble dryer at 80°C (175°F) for 30 minutes.

NOTE: Standard testing methods that are commonly used for fabrics containing elastane-based yarns and that require treating fabric samples in boiling water (100°C/212°F), such as the boil-off test, are not suitable for DOW XLA fiber. As a result of the fiber’s particular chemistry, fabrics based on DOW XLA fiber will not develop their maximum level of elasticity under these types of conditions.

While other elastic fibers might cause the fabric width to shrink excessively during lab tests, DOW XLA fiber, due to its unique thermal-mechanical behavior, shows a degree of shrinkage that is comparable to what will occur after finishing with industrial processing procedures. Nevertheless, the industrial finished width is often wider than the width demonstrated during testing, especially when processed in open-width continuous treatments.
Figure 1: Load-Elongation Response of 40 Denier Spandex and DOW XLA Fiber

% Elongation

4-inch gauge length at 20 inches per minute

Fabrics based on DOW XLA fiber require less force to stretch than spandex-based fabrics.

Figure 2: Preliminary Tests on Cotton Greige Fabric Containing DOW XLA Fiber to Determine Maximum Shrinkage

Fabric construction: Plain weave
Warp yarn: Ne 40/1 100% cotton
Reed width: 177.6
Total number of ends: 6750

Weft yarn: Ne 50/1 cotton core spun with 78 dtex DOW XLA fiber
Number of picks/cm: 24

Greige fabric samples were washed in a laboratory washing machine at two different conditions:

<table>
<thead>
<tr>
<th></th>
<th>Set 1</th>
<th>Set 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Filling</td>
<td>R.T.</td>
<td>70°C (160°F)</td>
</tr>
<tr>
<td>Maximum Temperature</td>
<td>50°C (120°F)</td>
<td>90°C (195°F)</td>
</tr>
</tbody>
</table>

Wash was run for 30 minutes after maximum temperature was reached.

Fabric width (cm), in comparison with greige, was:

<table>
<thead>
<tr>
<th>On Loom</th>
<th>Off Loom</th>
<th>Set 1</th>
<th>Set 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>177.6</td>
<td>152</td>
<td>104</td>
<td>118</td>
</tr>
</tbody>
</table>

Treating samples according to Set 1 allowed 13% more shrinkage.

DOW XLA fiber shows a degree of shrinkage that is comparable to what will occur after industrial finishing processes.
ACHIEVING MAXIMUM RELAXATION IN THE GREIGE FABRIC

Following the fabric assessment, a suitable finishing process must be selected to properly develop the stretch within the fabric and to obtain specific characteristics, such as target width and weight, tensile and tear strength, fabric drape, and handle. It is important to allow the fabric to relax completely in the first stage of the finishing process to achieve the highest possible level of shrinkage and ensure maximum dimensional stability in the finished garment. The most commonly applied techniques to achieve this are:

- Steaming on a steaming table
- Steaming at the entrance of a stenter frame
- Wet treatments

The first two methods are widely applied when finishing fabrics that contain other elastic fibers, such as spandex, because they can be followed with heat setting. This additional step in the finishing process, however, is not needed with DOW XLA elastic fiber.

Throughout the relaxation process it is essential to:

- Reduce warp tension
- Avoid stretching the fabric in the weft direction
- Keep the temperature during the first wet processes at a maximum of 60°C (140°F) DOW XLA fiber allows the manufacturer to develop elasticity within the fabric during the normal scouring and/or desizing initial process.

However, as illustrated in Figure 3 (page 5), it is important to reduce treatment temperatures to approximately 50°C (120°F) during the initial steps (i.e., first two to three washes on semi-continuous washing machine) to achieve the highest possible retractive force.

As shown in Figure 4 (page 5), treating the fabric at approximately 50°C (120°F) while maintaining the lowest possible longitudinal tension and using common processing speeds leads to sufficient fabric relaxation, reduction in the frictional force, and maximum development of the retractive force in the elastic yarns.

APPLYING FINISHING PROCESSES

Once the fabric’s stretch potential has been maximized through complete relaxation, any additional finishing processes, such as singeing, scouring, bleaching, mercerizing, washing, drying, dyeing, sanforizing, decatizing, steaming, and pressing can be applied at standard conditions used for non-elastic fabrics.

Treatment temperatures are not a limitation during processing because DOW XLA fiber can withstand temperatures of up to 220°C (430°F) without loss of stretch performance. Heat setting is not required and high temperature drying/setting is also unnecessary, unless required to obtain other results, such as heat setting polyester or curing. Also, lengthy high temperature treatments, such as dyeing at various conditions (jigger, overflow, jet, etc.), do not affect the stretch properties of DOW XLA fiber. DOW XLA elastic fiber has excellent resistance to most chemical agents commonly applied in the textile industry, including acid, caustic, oxidative and reductive agents.

As a result, there is no need for specific chemical selection and/or concentration control to prevent the degradation of elastic properties.

SINGEING

Singeing can be performed without any particular settings in terms of fabric feed velocity, flame power, or orientation, due to the excellent thermal resistance of DOW XLA fiber. The singeing process can be applied to the optimum extent to obtain the degree of hairiness required by the fabric design without loss of stretch performance.

SCOURING AND DESIZING

The unique chemical resistance of DOW XLA fiber allows manufacturers to perform scouring processes under conditions commonly used for a non-elastic fabric. Caustic soda (NaOH) concentration can be brought up to 80 g/l without diminishing elastic properties.

Temperatures can also be set at the most suitable level to improve efficiency and control process costs according to the practices applied to rigid fibers. For desizing, all kinds of agents can be applied to the stretch fabric. It is possible to combine scouring and/or desizing with the fabric relaxation step described earlier. The temperatures must be set and controlled in order to achieve both relaxation and scouring/desizing efficiency. In the case of desizing, it is advisable to check for residual sizing agent on the fabric after this process.
**Figure 3:** Retractive Force of Greige Yarn Made From DOW XLA Fiber as a Function of Temperature

![Graph showing retractive force of greige yarn made from DOW XLA fiber as a function of temperature. The graph plots force percentage against temperature in °C and °F.](image)

When processing fabric based on DOW XLA fiber, reduce treatment temperatures to approximately 50°C (120°F) during initial steps to achieve maximum elasticity.

**Figure 4:** Relaxation of Cotton Fabric Containing DOW XLA Fiber

Greige fabric samples were washed in an open-width, continuous washing machine from Benninger, consisting of 7 separate tanks kept at a temperature of 50°C (120°F).

Fabric was previously padded at room temperature with a solution of detergent, sequestrant agent, and NaOH and then stored 48 hours at room temperature to desize.

Washing machine was running at 30 m/min.

Drying process was performed on a set of 20 steam-heated cylinders; surface temperature = 130°C (266°F).

Fabric width (cm) changed as follows:

<table>
<thead>
<tr>
<th>On Loom</th>
<th>Off Loom</th>
<th>After Washing</th>
</tr>
</thead>
<tbody>
<tr>
<td>177.6</td>
<td>152</td>
<td>135</td>
</tr>
</tbody>
</table>

Fabric elasticity after washing was: 23%

Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -3.0%

Note: Method for elongation testing performed according to ASTM D 3107 Standard, modified as follows: standard weight applied = 5 kg; specimen gauge length = 200 mm; loading time = 5 minutes.

Proper treatment of cotton fabrics made with DOW XLA fiber leads to maximum development of retractive force in the elastic yarns.
DRYING/HEAT SETTING

Following initial relaxation, either performed as a single process or combined with scouring/desizing, the fabric is usually dried and rolled before undergoing subsequent finishing treatments.

Drying can be done using hot air flow, as in a stenter frame, at temperatures between 130 and 150°C (265-300°F), or by contact with hot surfaces like heated cylinders. Normally these types of surfaces are around 130°C (265°F). In both cases, the fabric temperature has to go above 100°C (212°F) to allow for the water to evaporate and to leave final moisture content around 6 to 10% in weight.

A stretch fabric that has been properly treated during the relaxation process at low temperatures has already reached a width that corresponds to the equilibrium between the retractive force of the elastic fibers and the resisting force of the rigid fibers. When the retractive force decreases during drying, there will be no further shrinkage. This is because the fabric has reached its optimum dimensional stability.

Figure 5 (page 7) shows the change in width of the fabric during the finishing process outlined in Figure 4 (page 5). After the initial relaxation procedure, the width shows very little change, confirming that after drying on heated cylinders the reduced retractive force of the fiber does not allow further shrinkage. The dimensional stability while washing at 90°C (195°F) was also tested throughout the finishing process, as illustrated in Figure 5. It remains within the range of acceptability, improving with the stabilization of the cotton.

DOW XLA fiber does not need to be heat set at a specific, very high temperature, as is typical with other elastomers. During subsequent processing, such as mercerizing or dyeing, the fabric will not tend to shrink further, preventing creases, wrinkles or curling selvedges.

Nevertheless, if heat setting at high temperatures is required to fix colors, polymerize resin finishing, or set synthetic rigid fibers, such processes can be accomplished without damaging DOW XLA fiber, because it can withstand temperatures up to 220°C (430°F) for a residence time of 2-3 minutes. The retractive force will remain at the same level as it does after a treatment at around 100°C (212°F).

BLEACHING

Fabrics containing DOW XLA fiber can be bleached under optimum conditions typically used for cotton. During these operations, it is recommended to keep the fabric free of tension so that it can be totally relaxed. The only chemical limitations in bleaching are those imposed by the base rigid fiber.

Oxidizing agents, such as chlorine and peroxides, can be used over a broad range of pH, temperature, time, and concentration. A typical process would be washing the fabric (40 m/min) at 60-80°C (140-175°F) and then wetting the fabric with a standard solution of NaOH, peroxides and stabilizers. After holding the wet fabric for 2 minutes, the reaction can be completed on a stenter frame at 130°C (265°F). Then the fabric can be washed again at 60-80°C (140-175°F).

It is possible to combine bleaching processes by using sodium hypochlorite followed by peroxide to reduce the use of the more expensive reagent. This approach also decreases costs and avoids potential oxidative decomposition of the cotton fiber, which can occur when the reaction is carried out with peroxides only.

 Mercerizing

During mercerization, the fabric is treated in a strong alkaline solution, typically at low temperatures. Mercerization modifies the fabric’s mechanical properties, luster, and ability to take dye. Typically, mercerization conditions are manipulated to yield the desired properties. For example:

- To increase the fabric’s luster, tension is increased (up to 20% stretch can be imposed) and the temperature is lowered (by approximately 10-15°C)
- To increase the fabric’s mechanical properties, tension is increased
- To improve the fabric’s dyeing properties, the tension, temperature, or caustic concentration is lowered

Because DOW XLA fibers do not degrade in the presence of caustic, high concentrations such as 270-300 g/l (33° Baumé), can be used. Wetting agents can also be used to speed up the process. Residence times longer than the typical 60 seconds are acceptable. The final washes with acid solutions can be done using acetic, sulfuric, or hydrochloric acid. As illustrated in Figure 6 (page 7), it is preferable to use chainless machines to mercerize fabrics based on DOW XLA fiber.
After initial relaxation procedures, fabrics based on DOW XLA fiber will not shrink further.

Figure 6: Mercerizing Cotton Fabric Containing DOW XLA Fiber Using a Chainless Machine

Desized and bleached fabric was mercerized with caustic soda at 28° Baumé. Fabric feed velocity was 30 m/min.

Subsequent washing and neutralizing was performed in 5 tanks; open-width washing line with liquor at 90°C (195°F).

Drying process was performed on a set of 20 steam-heated cylinders; surface temperature was 130°C (265°F).

<table>
<thead>
<tr>
<th>On Loom</th>
<th>Off Loom</th>
<th>After Washing</th>
<th>After Mercerizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>177</td>
<td>152</td>
<td>135</td>
<td>132</td>
</tr>
</tbody>
</table>

Fabric elasticity after mercerizing was: 23%

Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -1.5%

Note: Method for elongation testing performed according to ASTM D 3107 Standard, modified as follows: standard weight applied = 5 kg; specimen gauge length = 200 mm; loading time = 5 minutes.

Chainless machines are preferable to mercerize fabrics containing DOW XLA fiber.
This is due to the unique temperature response of DOW XLA fiber. At the beginning of the process, it is possible to impart low tension to the fabric (up to 5% elongation) using banana rolls, followed by total relaxation of the fabric in the second washing part of the process. A low tension or slack mercerization process provides the opportunity to completely relax the fabric and recover elasticity.

If chain machines are preferred (Benninger, etc.), the minimum required tension can be applied to the fabric. However, to make sure that the fabric is fully relaxed at the end of the mercerization process, it is best to wash the fabric in a free relax machine. An alternative to the standard mercerization process can be used on fabrics containing DOW XLA fiber. Based on liquid ammonia impregnation at -33°C (-28°F), followed by cold and warm rinsing and then drying, this new process (Monforts or Kleinewefers KTM lines) will provide an excellent soft handle to the fabric.

**PIECE DYEING**

Many dyeing processes have traditionally been avoided for stretch fabrics due to elastic fiber degradation or processing issues. Because DOW XLA fiber offers high chemical resistance, all types of dyestuff and auxiliaries can be applied to the fabric without impairing its stretch properties. As a result, the dyeing recipe can be designed to get the best performance in terms of quality and economy, selecting dyestuff, auxiliaries, and concentrations accordingly. A sample dyeing process is illustrated in Figure 7 (page 9).

The extreme heat resistance of DOW XLA fiber (up to 220°C [430°F] for considerably long residence times [3-4 mins]) allows dyeing using the most severe thermal conditions. For instance, thermosol dyeing of polyester blends elastified with DOW XLA fiber can be carried out successfully without loss of stretch or recovery force. Economical considerations or crease-sensitive fabrics may dictate (or specify) piece dyeing in open width, using jig or beam technology, or techniques like pad batch or pad steam dyeing. Pad batch and pad steam dyeing can be performed without risk of stripes or creases if the fabric is not stretched in the weft direction on the stenter frame during color sublimation.

When the fabric can withstand (or requires) rope dyeing in winch, overflow, or jet-flow, it can be carried out with ease given the wide range of processing temperatures and product selection allowed by DOW XLA fiber.

As shown in Figure 8 (below), DOW XLA elastic fiber does not dye with any of the typical classes of dyestuff developed for the textile industry. This allows dyeing that does not affect the final result, color evenness, or color fastness of the fabric, and does not limit the choice of dyestuff class and/or particular shades. DOW XLA fiber is transparent and improves color brightness because light is not absorbed by the elastic fiber.

**SANFORIZING**

To provide customers with dimensionally stable garments it is necessary to eliminate the internal tensions created in weaving and finishing, allowing the fabric to shrink before it is cut and sewn.

The best process to pre-shrink the finished fabric is known as sanforizing. The process consists of feeding damp fabric between a rubber and metal surface to compact the fabric in the warp direction, as outlined in Figure 9 (page 9). For fabrics containing DOW XLA fiber, this process can be executed at typical conditions used for 100% cotton fabrics.

**Figure 8:** Dye Staining of DOW XLA Fiber and Spandex in Polyester Fabric

DOW XLA fiber retains its transparent shade after disperse dyeing cycle.
Figure 7: Dyeing Cotton Fabric Containing DOW XLA Fiber With Jigger and Jet Processes

Mercerized fabric was dyed with jigger and jet processes.

Jigger process was performed under standard conditions for cotton fabric (hot reactive dyestuff type H; main process temperature 80°C [175°F]).

Fabric width (cm) changed as follows:

<table>
<thead>
<tr>
<th>After Washing</th>
<th>After Mercerizing</th>
<th>After Jigger Dyeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>132</td>
<td>133</td>
</tr>
</tbody>
</table>

Fabric elasticity after dyeing was: 25%
Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -2.5%

Jet process was performed under standard conditions for cotton fabric (hot reactive dyestuff type H; main process temperature 80°C [175°F]).

Fabric width (cm) changed as follows:

<table>
<thead>
<tr>
<th>After Washing</th>
<th>After Mercerizing</th>
<th>After Jet Dyeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>132</td>
<td>138</td>
</tr>
</tbody>
</table>

Fabric elasticity after dyeing was: 26.5%
Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -6.5%

Note: Method for elongation testing performed according to ASTM D 3107 Standard, modified as follows: standard weight applied = 5 kg; specimen gauge length = 200 mm; loading time = 5 minutes.

Due to the high chemical resistance of DOW XLA fiber, dyes do not affect stretch performance.

Figure 9: Sanforizing Cotton Fabric Containing DOW XLA Fiber After Jigger and Jet Dyeing Processes

Fabric dyed with jigger and jet processes was softened through padding in silicone-based softening liquor at room temperature, drying in stenter frame at 150°C (300°F), and sanforizing at 105°C (220°F).

Width (cm) of fabric dyed in jigger changed as follows:

<table>
<thead>
<tr>
<th>After Jigger Dyeing</th>
<th>After Softening/Sanforizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>133.5</td>
<td>135</td>
</tr>
</tbody>
</table>

Fabric elasticity after sanforizing was: 23.5%
Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -1.8%

Width (cm) of fabric dyed in jet changed as follows:

<table>
<thead>
<tr>
<th>After Jet Dyeing</th>
<th>After Softening/Sanforizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>138</td>
<td>141</td>
</tr>
</tbody>
</table>

Fabric elasticity after sanforizing was: 19%
Fabric dimensional stability to washing at 90°C (195°F) and tumble drying was: -3.9%

Note: Method for elongation testing performed according to ASTM D 3107 Standard, modified as follows: standard weight applied = 5 kg; specimen gauge length = 200 mm; loading time = 5 minutes.

Sanforizing fabrics containing DOW XLA fiber can be performed under the same conditions as cotton.
A FEELING THAT LASTS

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For more information about XLA fiber by DOW:
www.dowxla.com

or call:

Europe: +32 3 450 22 40
US and Canada: +1 800 441 43 69
Mexico: +95 800 441 43 69
Asia Pacific: +603 7 958 33 92