TECHNICAL BULLETIN

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PRODUCTION OF COTTON/WOOL FABRICS

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INTRODUCTION

The popularity of cotton/wool blends has been growing as consumer demand for styling, comfort, and natural fiber content in apparel and home fabrics has increased. The combination of these two natural fibers joins the desirable characteristics of both fibers – the comfort of cotton with the added resilience of wool – in a fabric which can be worn year-round. To produce good quality, washable cotton/wool products, total engineering is required, beginning with fiber selection and progressing through all manufacturing phases including wool preparation, blending, yarn manufacturing, fabric construction, dyeing, and finishing.

FIBER SELECTION

In quality fabric production, and especially with cotton/wool blends, the importance of raw materials cannot be overemphasized. The selection of good quality, clean, high strength, mature upland cotton fiber and a quality wool fiber is extremely important.

The cotton fiber used in the majority of Cotton Incorporated's developments was a U.S. upland variety with typical average properties of 1 $^{1}/_{8}$ inch staple length, 28 – 30 grams/tex strength, and 4.0 – 4.2 micronaire fineness. Cotton fiber with different properties may also be used successfully.

Cotton Incorporated has used wool fibers from 56's to 80's without encountering any difficulties. Coarse wools will tend to be scratchier than finer wools. In order for the wool fiber to be processed on the cotton spinning system, fiber length must first be reduced to about 1 ½ inch mean length. This can be accomplished by cutting or stretch breaking wool top. The normal sequence in preparing wool top for length reduction includes scouring, carding, and combing into a sliver before cutting or breaking. No significant differences have been found in the final product when stretch broken wool has been used versus cut wool. A third option is the use of short-shorn wool, but its availability is limited.

YARN MANUFACTURING

With cotton system spinning, cotton can be blended with wool in either the opening hopper or in the draw frame. Cotton Incorporated has evaluated blend levels ranging from 60% cotton/40% wool to 90% cotton/10% wool. Blends or 80% cotton/20% wool were found to have the best overall balance of properties. Generally, yarn strengths decline as wool content is increased.

It is preferable to use combed cotton for better yarn strength and fewer finishing problems due to a cleaner yarn. The cotton fiber should be separately opened, cleaned, carded, drawn, and combed. With draw frame blending, wool sliver is then combined with the combed cotton. With hopper blending, the combed cotton is returned to the

opening line, weigh pan blended with the wool, and then carded. Generally, draw frame blends will be stronger and more uniform than hopper blended yarn.

If the wool is carded separately, static problems can be reduced by overspraying the wool with water and an antistat prior to carding. Additionally, static can be further reduced by raising the humidity level in the card room to at least 60%.

Cotton Incorporated's in-house spinning research is conducted in its Raleigh, North Carolina, Fiber Processing Center. Both ring and open-end cotton/wool yarns ranging from 6/1 Ne to 34/1 Ne were spun using the machinery listed as follows:

DESCRIPTION	**MANUFACTURING/MODEL**
Feeder Hoppers	Fiber Controls
Axi-Flo Cleaner	Whitin
XL Step Cleaner	Centrif-Air
Fine Opener	Fiber Controls-310
Cards	Platt Saco Lowell/Hollingsworth
Drawing	Platt Saco Lowell-DE8C
Lap Winder	Platt Saco Lowell
Comber	Rieter E7/4
Drawing	Rieter DO-5
Roving	Platt Saco Lowell-Rovematic®
Ring Spinning	Platt Saco Lowell-Spinomatic®
Rotor Open End Spinning	Rieter M1/1
Winding	Schlafhorst-Autoconer®

In general, all machinery settings should be as required for 100% cotton with only a few exceptions –

1. Reset the lickerin basket on the card to reduce the amount of wool removed as waste.
2. Roll settings at drawing, roving, and ring spinning should be set for the longer wool fiber.
3. With open-end spinning, the combing roll trash ports should be closed to reduce wool loss; and optimum rotor diameter, rotor speed (rpm), and combing roll speed (rpm) should be determined.

FABRIC CONSTRUCTION

A variety of cotton/wool fabrics have been developed by Cotton Incorporated in both woven and knitted constructions. Woven constructions produced include plains, twill variations, satins, sateens, herringbones, crepes, and corduroy ranging in weight from 3.5 to 10 ounces per square yard. Lightweight twill shirting and tropical suiting fabrics in 80% cotton/20% wool blends were particularly successful. Knitted cotton/wool developments include single jerseys, interlocks, punto di romas, piques, crepe looks,

pleated constructions, double-face, and sweater knits. Generally, cotton/wool yarns can be woven or knitted with the same set-up as for all-cotton yarns. However, in higher speed operations, the lower strength of cotton/wool yarn versus all-cotton may cause difficulties.

PREPARATION

Singeing of cotton/wool fabrics can normally be done without any special provisions. Singeing is not necessary for fabrics which will be surface finished.

Cotton/wool fabrics require unique wet processing considerations. Wool fiber is a complex structure composed of protein and keratin formed by condensation of amino acids. The basic amino groups, which are randomly positioned side chains along the long molecular backbone of the large molecular structure, as well as the cystine linkage which helps hold the structure together, can easily be damaged by alkali. On the other hand, cotton is composed of anhydro-b-glucoside units linked by glucoside oxygen bridges, which can easily be damaged by strong acids.

The key to a properly prepared cotton/wool fabric, or in fact, any fabric, is uniformity:
- uniform extraction of extraneous materials, including sizes, waxes, lubricants, pectins, etc.
- uniform whiteness
- uniformly swollen fibers
- uniform pH at the desired level
- uniform absorbency at the desired level

Water soluble sizes such as polyvinyl alcohol, polyacrylates, and carboxy methyl cellulose are readily removed by hot water at 195 – 205F (90 - 95C) and nonionic detergent, or can be oxidatively removed in the bleaching process. Enzymatic desizing is the safest and surest way to remove either natural or modified starches. Generally, enzymes are most effective in the pH range of 6.5 – 7.5 and may be activated even at high temperatures in continuous operations. Oxidative desizing will also work but must be carefully controlled to avoid damage to the cotton fiber.

With dark shades, bleaching may not be required – scouring alone may suffice. A recommended scouring procedure is as follows:

Cotton/Wool Scour

1 – 2 g/l nonionic detergent
2 – 4 g/l tetrasodium pyrophosphate
0.5 – 2 g/l sequestering agent (high complexing of iron)
Scour at 180F (82C) for 30 minutes

Note the use of a sequesterant with high iron complexing capabilities to avoid catalytic damage during the subsequent bleaching operation.

Fabrics with a high oil or grease content should be prescoured prior to bleaching. A prescour at 120F (50C) for 30 minutes with 1 g/l nonionic detergent plus 0.5 – 2 g/l solvent based detergent at a pH of 9 (adjusted with ammonia) is usually adequate.

In order to obtain bright or light shades free of dark seed husk fragments, a bleaching process will be necessary. The bleaching time required for cotton/wool blends is longer than normally required for 100% cotton or cotton/synthetic blends because a compromise of temperatures and pH is needed to protect the wool. However, while alkaline damage occurs rather easily on 100% wool and high wool content blends, the blending of cotton with wool does provide some alkaline protection. But even with this protection, the alkaline sensitivity of the wool must be considered during wet processing.

Exhaust bleaching of cotton/wool can be achieved using the process listed below. Other bleaching techniques may also be adequate, but this process has proven effective in our fabric development and mill trials.

Exhaust Bleach of Cotton/Wool
(On Weight of Fabric)
0.5 – 1.0% Anionic Scouring Agent
5.0% Organic Hydrogen Peroxide Activator (neutral pH)
20.0% Hydrogen Peroxide (35%)
Adjust to pH 8.5 with sodium silicate (42° Be)
Run at 175F (80C) for 1 ½ hours
Rinse at 160F (70C)

If a better white is desired, the fabric should be processed for an additional 1 ½ hours at 120F (50C) with 3 g/l of a stabilized sodium hydrosulfite system. Addition of an optical brightner will further increase the overall whiteness.

Cotton/wool fabrics can be pad/batch desized and bleached, or bleached only be deleting the sodium persulfate in the following formulation.

Pad/Batch Desize/Bleach
15 g/l Organic Hydrogen Peroxide Activator
30 g/l Sodium Silicate (42° Be)
77 cc/l Hydrogen Peroxide (35%)
8 g/l Sodium Persulfate
Pad bath temperature – 70 – 85F (20 – 30C)
Pad at 100% wet pick-up – Wrap in plastic – React
12 hours – Wash at 180F (82C) – Neutralize

Beam washing is less desirable with oxidative desize techniques due to the possibility of filtration of the partially solubilized sizing materials through the fabric layers.

Liquid ammonia processing has been used successfully both as a pretreatment and as a finishing treatment on cotton/wool blends without adversely affecting the wool fiber.

In the preparation of cotton/wool blended fabrics, there may be some concern about whether a particular process will have a damaging effect on the wool fiber. It is difficult to determine wool damage in high cotton content blends. However, the use of the following dye procedure will indicate whether significant wool damage has occurred. With no damage, the wool will dye to a bright red shade; with severe damage, the wool will dye to a dull red shade.

Dye Test for Wool Damage

0.5% Hostalan Red F3BA (American Hoechst Corporation)
1.5% Acetic Acid (56%)
0.5 – 1.0% Dispersing and Sequestering Agent
Dye at a boil for 1 hour at pH 5 – 6

DYEING

Versatility in dyeing single components, cross dyeing, or union shades are possible with cotton/wool blends. The primary concern, or limitation, in dyestuff selection is the alkaline sensitivity of wool and the acid sensitivity of cotton. Several techniques for applying colo to cotton/wool blends are available. The selection of technique is determined by depth and type of shade (solid, heather, cross dye, etc.), fastness requirements, blend ratio, and cost.

The most common choice of dyes for achieving light to medium shades in solids, heathers, and cross dyes is direct dyes on cotton and acid dye on wool. Generally, the 2:1 neutral premetalized dyes are used on the wool portion of the blend and are applied at a pH of 5.5 – 7.0. The direct dye/neutral premetalized dyes can either be applied in separate dye baths or in a single bath if the wool is pretreated with an anionic reserving agent to resist direct dye staining. With heathers and cross-dyes, the most important consideration is that the wool component should be dyed the deeper shade.

Another technique which has been found effective for producing heather or cross-dye effects with minimum cross-staining of the cotton is the use of special reactives such as modified vinyl sulfones to dye the wool and directs to dye the cotton. A two bath procedure will usually produce the best clarity of shade for both fibers. Satisfactory washfastness of the direct in a light to medium shade on the cotton is achieved by use of a fixative and/or application of a glyoxal resin in finishing.

Other techniques employing fiber reactive/acid dyes and fiber reactive/fiber reactive dyes have been developed by many dyestuff suppliers. Information on these processes and those mentioned previously can be obtained directly from the respective dyestuff supplier.

Pad/batch dyeing is the most widely accepted semi-continuous technique for dyeing cotton fabrics with reactive dyes. The pad/batch process can be used on cotton/wool blends as well. Normal cotton dye/alkali systems can be used for union shades, with two procedure changes. First, the reaction time must be extended to 20 – 24 hours even when using highly reactive dyes and strong alkali, and secondly, the water used in the initial wash-off of the unfixed dyes must be cold until the pH is reduced to 8. With some fabrics or shades, it may prove difficult to obtain a good union. Generally, if there is a poor union the wool will be lighter in shade. This problem can be overcome by the addition of premetalized dyes in the final scour of the reactive dyes to adjust the shade on the wool.

FINISHING

Conventional cotton resin formulations and application conditions are suitable for treating high cotton/wool blends. The system used on many of Cotton Incorporated's cotton/wool developments follows:

	% OWB
Wetting Agent	0.2
Acetic Acid (56%)	0.1
Silane Crosslinker	0.5
MgCl Catalyst	0.5
Organo-tin Catalyst	0.5
Glyoxal Resin	5.0 – 7.5
Reactive Silicone	5.0

All ingredients were added in the order listed. The fabrics were padded at 50 – 60% wet pick-up. Drying and curing were done with one pass through the oven at 350F (175C) to achieve a 30 second curing time.

Higher wool content blends may require higher resin levels for stability, which may cause excessive weakness of the cotton component. Washability of most cotton/wool products is desired and therefore, blend levels exceeding 40% non-chlorinated wool in heavyweight fabrics and 30% wool in lightweight fabrics may prove unsatisfactory as washable products.

Soft, supple hands on cotton/wool fabrics are best achieved by semi-decating and/or decating after resin application. Liquid ammonia treatment and/or mechanical compaction also improve hand and provide shrinkage control.

Cotton Incorporated has successfully developed a large selection of cotton/wool woven and knit fabrics. Samples of these fabrics as well as complete specifications, processing details, and physical properties are available by request from any of Cotton Incorporated's offices.

RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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