TECHNICAL BULLETIN

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WRINKLE-RESISTANT FINISHING OF COTTON FABRICS AND GARMENTS

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INTRODUCTION

Various durable press processes were introduced in the early 1960s. For the first time, slacks were available with creases and surface smoothness durable to multiple machine washes. At the time, the emphasis was primarily on the durable press aspect with little attention given to the hand or the durability of the fabric. Fabric pilling of blends was accepted when it occurred. Improved systems were introduced in the 1970s and included vapor phase treatments.

During the 1980s, a casual, comfortable, and back-to-nature lifestyle became firmly entrenched in the United States. Increased attention to environmental concerns also became apparent. All of these factors were strong driving forces for the popularity and use of cotton clothing. As a result, cotton garments without as well as with wrinkle resistance (WR) became a tremendous success.

Now, in the 1990s, there is still a strong desire for natural looking, comfortable clothing. However, consumers seek a neater look in casual apparel. The consumer's lifestyle demands the product be care free (little or no ironing). This report describes current products and procedures used to manufacture 100% cotton wrinkle-resistant fabric and garments having both comfort and style.

GENERAL CONSIDERATIONS

For 100% cotton wrinkle-resistant products that perform well, considerable attention has to be given to the total engineering including the selection of the fiber, the yarn characteristics, the fabric construction, preparation, dyeing, finishing formulations, and procedures. With any textile product, a number of performance tests must be met. Not only is wrinkle resistance expected, but also comfort, style, and adequate wear life.

Particularly important for wrinkle-resistant 100% cotton is to employ a finish formulation that will yield the desirable balance of physical properties. If excessive crosslinking is achieved, the strength and abrasion resistance may be too low for adequate wear life of the garment. On the other hand, if too little crosslinking is obtained, there may be inadequate shrinkage control, smoothness, crease retention, and undesirable surface appearance. Laboratory and pilot trials are necessary to obtain the proper formulation and processing conditions.

Compared to nonresinated cotton fabrics, resinated (crosslinked) fabrics have a number of advantages. These properties include less wrinkling after washing and tumble drying, shrinkage control, better color retention, and less fuzzing and distortion of the surface.

Selection of the appropriate resin is important with respect to performance and to maintain acceptable physical properties. For most fabrics, the conventional dimethyloldihydroxy-ethyleneurea (DMDHEU) is used. **The reactant product made from dimethylurea and glyoxal (DMUG) is interesting since it gives good surface smoothness while maintaining better strength and abrasion resistance than DMDHEU. However, the crease retention with DMUG is not as good as that achieved with DMDHEU. A good compromise of these properties may**

be achieved by blending DMDHEU and DMUG (reference formulations and test results on page 9).

Sulfur-dyed fabrics may present a special problem. On occasion, sulfur-dyed fabrics impregnated with a resin finish may deteriorate due to the generation of acid from the sulfur dye. This behavior is more common for sulfur blacks. To reduce the possibility of this occurrence, the sulfur dyes should be thoroughly oxidized, and **the resin impregnated fabric must be cooled on the tenter frame before rolling.** One may use test method AATCC 26-1989 as an accelerated ageing test to determine if there is a potential problem. If a fabric demonstrates a propensity for a problem, the addition of 1.0 to 2.0% urea to the finishing bath is often helpful. Since urea will reduce the efficiency of the resin, it may be necessary to increase the resin level slightly, i.e., about 10% more. (If 15.0% is used initially, then an increase to 16.5% should be considered.)

The construction of the garment itself will have a significant influence on wrinkle-resistant properties. Sewing thread with minimum shrinkage is important. The stitch length and tension should be appropriate to lessen the distortion. The type of seams used exert a major influence. For example, double-needle flat-felled seams will frequently cause more puckering than single-needle seams.

PRECURE PROCESS

The precure process is the simplest and easiest method to achieve wrinkle resistance. Here the crosslinking resin is applied and cured in the textile finishing mill. This method imparts a permanent memory to the cotton fabric in a flat configuration. This type of finishing is most frequently conducted on fabrics where permanent pleats or creases are not needed such as sheeting, shirting, dress goods, knits, and some slacks. However, one manufacturer has offered slacks made from precured fabrics where the crease was imparted and made permanent by a silicone adhesive (LINTRAK® or Crease-Set® Process).

SUGGESTED PRECURE FORMULATION

Fabric: 100% Cotton Oxford Shirting

	% OWB
Nonionic Wetter	0.1
Buffered DMDHEU (45%)	10.0
Magnesium Chloride Hexahydrate (64%)	2.5
Polyurethane (40%)	4.0
High Density Polyethylene (25%)	2.0

% Wet Pickup: 82

Dried for 5 minutes at 93C (199F).

Cured for 3 minutes at 150C (303F). (In production, curing is normally done on a tenter frame; however, a loop cure oven may also be used when curing at low temperatures for a longer period of time, i.e., whites.)

Test Results

Durable Press Rating	3.5
% Shrinkage, W	0.9
% Shrinkage, F	0.3
Tensile, F	41
Tear, F	3.9
Stoll Flex Cycle, W (0.5 x 2 lbs)	633

POST-CURE PROCESS

This process was practiced extensively in the 1960s. The finish, including a crosslinking resin and catalyst, is impregnated by the finishing plant and dried with little or no curing. After the garment is made, pleats and/or creases are imparted by pressing. Finally, the garment is passed through a curing oven where the crosslinking resin imparts wrinkle resistance with crease retention. In addition to permanent creases, the conventional post-cure process also provides less seam puckering when washed as compared to the precure process.

During processing, there are certain precautions that the finishing plant should exercise in order to ensure a good performing product. The pH of the fabric before finishing should be 5.0 - 7.0 with the total alkalinity not greater than 0.05% NaOH. In order to minimize any curing of the impregnated fabric, it should come off the tenter frame with about 10% moisture measured by a moisture meter. The fabric should be wrapped cool, not hot. If the finished fabric is to be Sanforized™ processed, water is not sprayed and care is taken not to overdry. It may be necessary to reduce the temperature of the palmer unit of the Sanforizer.

Another important consideration for post-cure is the shipment and storage of sensitized (treated) fabric. Studies have shown that there is a time/temperature relationship whereby premature crosslinking may occur. This would prevent the formation of a sharp crease when pressed; thus the crease rating after laundering may be lower. The type of catalyst (regular vs. hot) and resin (buffered or not) will also have a direct influence on premature curing.

Frequent testing is necessary to maintain adequate quality control. From the finished fabric (dried only), pant legs are constructed, pressed, and cured using the same procedures that the garment manufacturer uses.

Tests would include the following:

- Tensile (ASTM D5034)
- Tear (ASTM D1424)
- Durable Press Rating (AATCC 124)
- Shrinkage (AATCC 135)
- Crease Retention Rating (AATCC 88C)
- Stoll Flex Abrasion (ASTM D3885)
- Cuff Wear After 5, 10, and 25 Home Launderings and Tumble Dryings
- Shade Change

Satisfactory results would depend upon prior agreement between the finishing plant and the garment manufacturer.

SUGGESTED FORMULAS FOR POST-CURE

Fabric: 100% Cotton Twill, 8.0 oz/yd²
% On Weight of Bath

	1	2	3
Nonionic Wetter	0.1	0.1	0.1
Buffered DMDHEU (45%)	12.5	12.5	12.5
$MgCl_2$ Hexahydrate (64%)	3.1	3.1	3.1
High Density Polyethylene (25%)	3.0	--	--
Aminofunctional Silicone (20%)	--	--	2.0
Polyurethane (Water Soluble) (40%)	--	5.0	5.0
Cationic High Density Polyethylene (25%)	--	3.0	3.0

% Wet Pickup: 60

Dried 6 minutes at 95C (202F).

Cured 15 minutes at 155C (310F).

Test Results

	1	2	3
Durable Press	3.2	3.3	3.5
% Shrinkage, W	1.3	1.4	1.7
% Shrinkage, F	1.0	0.7	0.7
Tensile, F	42	41	40
Stoll Flex	369	366	430

NOTE: The 100% cotton twill fabric available for these experiments was a standard twill fabric and not engineered for wrinkle-resistant finishing. Before application of the above formulations, the filling tensile was 70 pounds.

Chemical percentages are based on products as received from the supplier. Check with the product supplier for recommendations as concentrations may vary.

GARMENT DIP PROCESS

Instead of finishing the fabrics with the conventional post-cure process as described in the last section, in this process, all of the finishing is conducted in garment form. After the garments are constructed from non-resinated fabric, they are impregnated with a finish quite similar to the finish used in the conventional post-cure process, extracted, dried, pressed, and cured. This process of achieving wrinkle resistance was first introduced to the industry in the mid-1980s by Cotton Incorporated.

The garment dip process has some advantages over the conventional post-cure method. The most recognizable benefit is a much softer hand. Other reported advantages of this process include better inventory control, better casual shelf appeal, and the flexibility of performing such operations as stone washing and other garment processes prior to wrinkle-resistant treatment.

In the first step, the dry garments are impregnated with the finishing solution. The garments may be agitated briefly in the solution, or a bundle of the garments may be dipped in the finishing solution. The important factor is that the garments become thoroughly saturated with the finish. A typical finish will contain a wetting agent, a crosslinking resin, a catalyst, and a softener.

Important factors in optimizing the composition of the finish are similar to those for the conventional post-cure process.

After the garments are saturated with the finish, they are extracted to about 50 to 70% wet pickup. The level of wet pickup will depend primarily upon the construction of the fabric.

Tumble drying the impregnated garments is a critical step. If the area to be creased becomes too dry and hot, some curing may take place. The problem with this partial precuring is that it will inhibit the formation of a sharp crease. Moisture in the area to be creased should not fall below 8 to 10%. This can be easily determined by a moisture meter.

Conditions for pressing should permit a sharp crease to be formed. For example, 5 seconds steam, 10 seconds bake, and 5 seconds vacuum at 135C - 150C (275F – 303F) are conditions that have worked well on a hot head press utilizing adequate pressure for a sharp crease. Where a single operator can operate three of these presses, this time should not be excessive.

The final step of the process is curing in a suitable oven. Usually, the curing oven is one that permits continuous operation at a residence time of about 15 minutes and a temperature of 145C - 150C (294F – 303F), (depending on the garment and finish used). Lower temperatures may be required for whites to prevent yellowing.

There are several quick tests a garment finisher may use to ensure that sufficient reaction of resin with the cellulose has taken place. A standard white slack-weight fabric may be included in the treatment. At frequent intervals, a portion of this fabric is tested in the following manner:

- Direct Blue Dyeing. Cut a 10 gram sample, rinse in diluted soda ash (approximately 5 g/l), and rinse again in clean water. Boil for 15 minutes in 500 milliliters of water containing 0.20 grams of Direct Blue 1 dye and 5 grams of sodium chloride. After rinsing and drying, compare the color to a standard where good results were obtained. The depth of shade is inversely proportional to the extent of crosslinking.

- Take another portion of the fabric, steam briefly to condition, and perform a filling tensile break test.

The results of these tests will indicate quickly if the wrinkle-resistant treatment has properly taken place. The dyeing results will indicate if adequate crosslinking has occurred. The decrease in tensile strength will also indicate if adequate reaction has taken place.

A third test that may be useful is to flag each production lot with a lightweight cotton fabric such as a broadcloth shirting. By snap breaking the sample between the thumbs, it can be determined whether sufficient reaction has taken place. The crosslinking reaction will cause a decrease in strength that can be detected reasonably well with a little practice at breaking treated and untreated lightweight cotton fabrics.

To produce a consistent wrinkle-resistant garment with good performance, there are certain precautions that the garment finisher should take. These considerations are in addition to those already made.

A. Fabric. The same factors discussed under general consideration apply for garment finishing.

B. Auxiliary Garment Items. Pocketing, belt loops, interfacing, labels, sewing thread, buttons, zippers, etc. should be selected that will not be adversely affected by the chemicals or heat. Some of these items may be excessively weakened, discolored, or disfigured.

C. Treating Solution. It is imperative that a sample garment be treated and tested before committing to a large run. The influence of the finish on durable press, strength, abrasion resistance, shade, and hand must be ascertained. The percent wet pickup must be uniform and reproducible. When treating garments that have been dyed sulfur black, special additives such as urea may be needed to avoid tendering of fabric during storage.

A convenient laboratory procedure for imparting a wrinkle-resistant finish to a pair of cotton slacks may be conducted in the following manner:

- Prepare 2000 grams of treating solution for each pair of slacks.

- Pour the treating solution into a suitable container (e.g. a five gallon bucket). Saturate the slacks in this solution.

- Turn off the water to the washing machine. Pour the solution and the saturated slacks into the washing machine. Set the washer on the spin cycle and extract the excess solution. To measure the wet pickup, weigh the slacks before and after the wet impregnation. The wet pickup is usually about 50% (+/- 5%).

- Tumble dry the impregnated slacks until moist dry (i.e. damp). Then air dry overnight.

- Take slacks to dry cleaners and request press only with sharp crease.

- Post-cure slacks in Despatch Oven or other suitable hot air oven for 15 minutes at 155C (310F).

GARMENT DIP PROCESS

Influence of Resin Selection

Experiment was Carried-out on 100% Cotton Slacks, 8 oz/yd²

% of Product as Received Based on Bath Weight

	1	2	3	4	5
Wetting Agent	0.1	0.1	0.1	0.1	Untreated
DMDHEU (Buffered) (45%)	12.5				
DMDHEU (Not Buffered) (45%)			5.0	10.0	
DMUG (45%)		20.0	15.0	10.0	
Appropriate Catalyst for DMUG		5.0	5.0	5.0	
Mg Cl_2•$6H_2O$ (64%)	3.1				
Polyethylene (25%)	3.0	3.0	3.0	3.0	
Aminofunctional Silicone (20%)	0.5	0.5	0.5	0.5	
Perfume	0.1	0.1	0.1	0.1	

% Wet Pickup: 45. (In commercial practice, 50 - 70% wet pickup is typical, and formulations should be adjusted accordingly.)

Cured 15 minutes at 155C (310F).

Test Results

	1	2	3	4	5
Durable Press (AATCC 124)	4.2	4.0	3.2	3.8	2.3
% Shrinkage, Warp (AATCC 135)	0.2	0.2	0.0	0.2	1.8
% Shrinkage, Fill (AATCC 135)	0.2	0.4	0.2	0.6	1.6
Crease Retention (AATCC 88C)	4.3	2.0	2.3	2.7	1.0
Tensile, Fill (ASTM D5034)	49	72	70	62	101
Tear, Fill (ASTM D1424)	2.2	3.2	3.0	2.8	5.8
Stoll Flex Abrasion, Warp (ASTM D3885)	219	1348	175	860	1101

CONCLUSIONS

One hundred percent cotton wrinkle-resistant slacks have been accepted by the consumer. Long-term success will depend on the proper engineering of fabrics and garments and the understanding and control of the right balance between wrinkle-resistant performance and adequate wear life.

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 the grower and his 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 from specific cotton fiber profiles for various products.

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

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