TECHNICAL BULLETIN

COTTON INCORPORATED

6399 Weston Parkway, Cary, North Carolina, 27513 • Telephone (919) 678-2220

TRI 3020

WICKING WINDOWS™ MOISTURE MANAGEMENT TECHNOLOGY FOR COTTON

INTRODUCTION

WICKING WINDOWS™ finishing technology is designed to improve the moisture management properties of 100% cotton fabrics. A fabric treated with WICKING WINDOWS technology can move moisture from the skin to the outside of the fabric, so the wearer feels drier, the garment dries quicker, and the tendency for damp garments to cling or stick to the skin is substantially reduced.

WICKING WINDOWS technology is a discontinuous treatment in which some areas of the fabric are made water repellent while other areas are left untreated and absorbent. This can be achieved by a variety of methods, such as one-sided applications (e.g. printing or foaming), fiber and yarn treatments, and hydroentangling or needlepunching.

Most of the research to date has focused on a printing technique that is applied to the back or the inside of the fabric, which will be next to the skin. This technical bulletin details the WICKING WINDOWS printing technique, including print paste formulation, print screen pattern, and experimental data.

THE WICKING WINDOWS™ CONCEPT

A water repellent, typically a fluorochemical, is printed in a discontinuous stipple pattern on the back of the fabric, making some areas of the fabric water repellent while leaving the untreated areas absorbent. Because the print is only on the back of the fabric, liquid moisture or sweat is repelled from the printed areas and channeled from the back through the untreated, absorbent "windows" to the untreated, absorbent face (outside) of the fabric where it can evaporate. The absorbent capacity of the fabric is significantly reduced, and this, combined with the movement of moisture to the face of the fabric, reduces the drying time. The repellent printed areas make the fabric feel drier next to the skin and reduces potential of the fabric to stick or cling to the skin.

Figure 1 shows how the WICKING WINDOWS concept works.

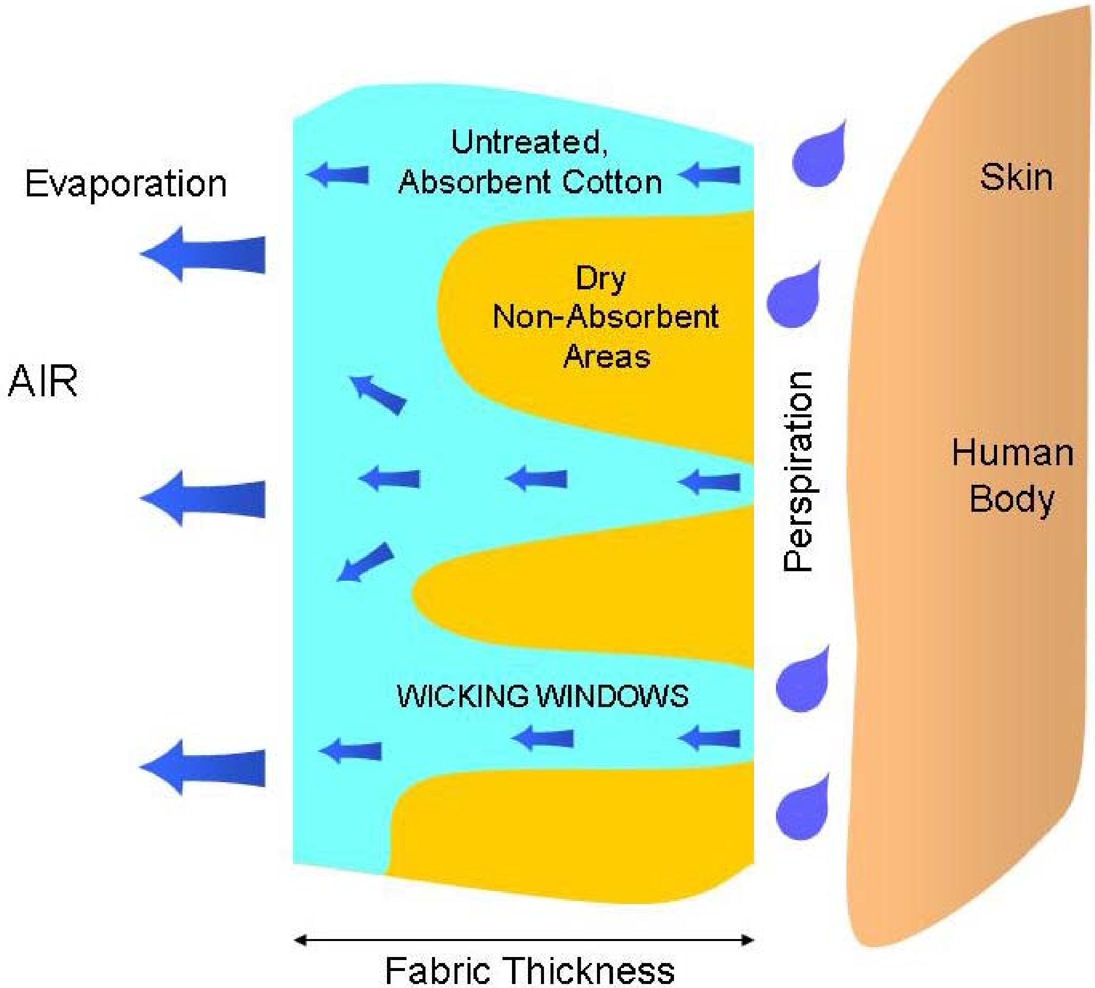

Figure 1. The WICKING WINDOWS™ concept. A cotton fabric treated with WICKING WINDOWS technology is designed to move moisture away from the skin to the surface of the fabric to evaporate.

Figure 2 shows the face and back of a knit fabric printed with WICKING WINDOWS™ technology. In the figure, dye was added so the print pattern could be seen. Normally, the WICKING WINDOWS print cannot be seen on the fabric.

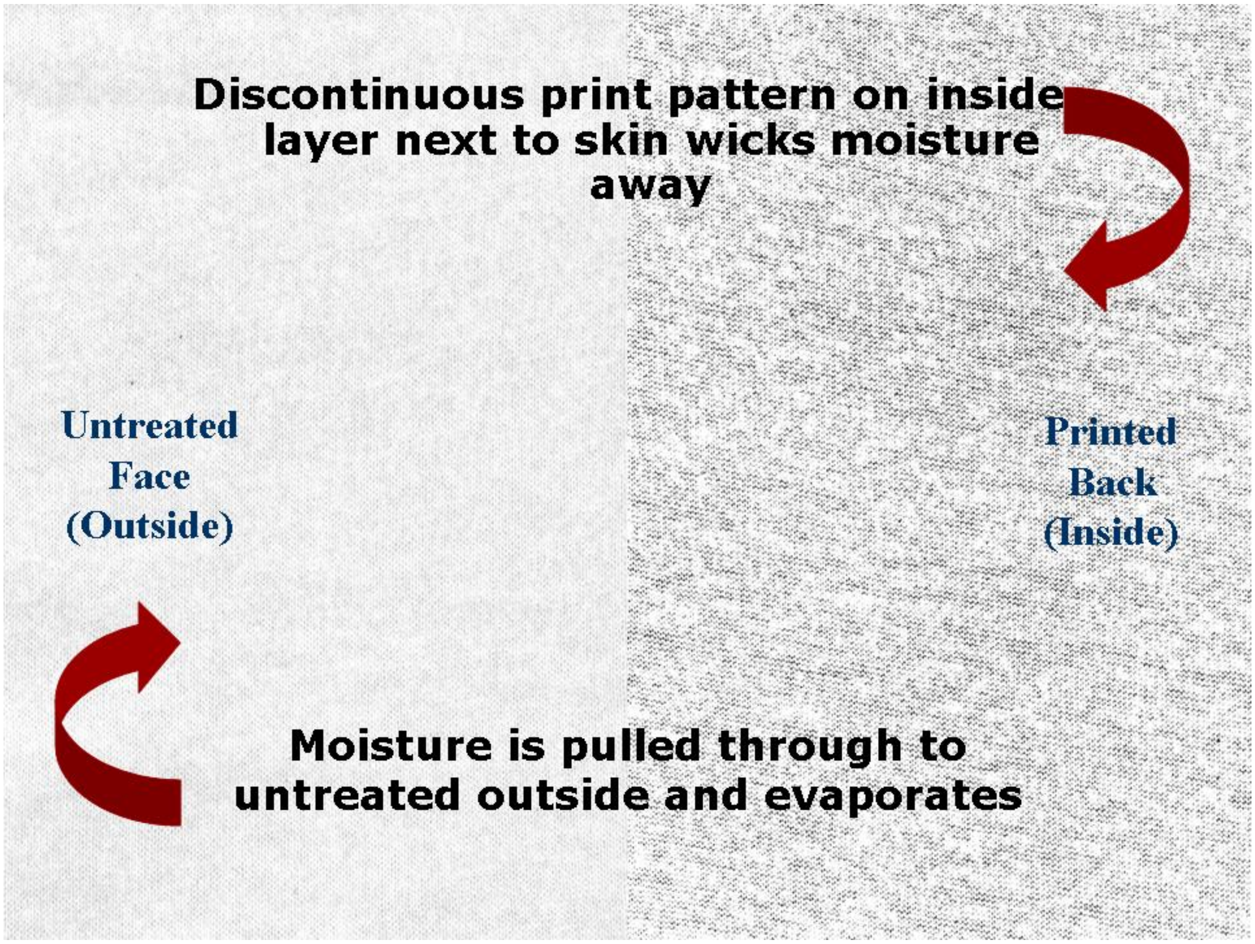

Figure 2. The face (outside) and back (inside) of a knit fabric treated with the WICKING WINDOWS finish.

FABRIC PREPARATION

In general, proper preparation of a cotton fabric can substantially improve its wicking properties. Residual natural waxes and auxiliary residues on the fabric, such as pretreatment agents, alkali, sizes, surfactants, knitting oils, or dyeing assistants, can impair the movement of water on or through a fabric.

For WICKING WINDOWS™ treatment, the condition of the fabric prior to printing has a large impact on the durability of the print. A good scour with or without a bleach is required to obtain a fabric that will absorb water in ≤ 5 seconds according to AATCC Test Method 79 "Absorbency of Bleached Textiles." The bleaching procedure used by Cotton Incorporated to prepare fabrics for moisture management research can be found in Appendix A. Proper preparation should be confirmed with the AATCC 79 Test Method prior to printing. As shown in Figure 3, a fabric with a good scour (on the right) will move moisture farther and more evenly than a fabric with a minimal scour (on the left).

Fabric pH, residual alkalinity, and water and solvent extractables should be tested before finishing to check for proper preparation. Recommended fabric properties are listed below:

> Fabric pH (AATCC 81) should be 5.5 – 7.5,
> Percent Alkalinity (AATCC 144) should be less than 0.05% NaOH,
> Water extractables (AATCC 97) should be less than 0.4%,
> Solvent extractables (AATCC 97) should be less than 0.1%, and
> Drop absorbency (AATCC 79) should be ≤ 5 seconds.

A spot test, found in AATCC 94 or in the reference below[1], can be done to ensure that there is no residual size on the fabric. A foaming test[2] can be done to check for residual surfactants.

For knits, edge gumming (discontinuous) of the fabric edge is recommended to prevent curling as the print is applied to the back of the fabric.

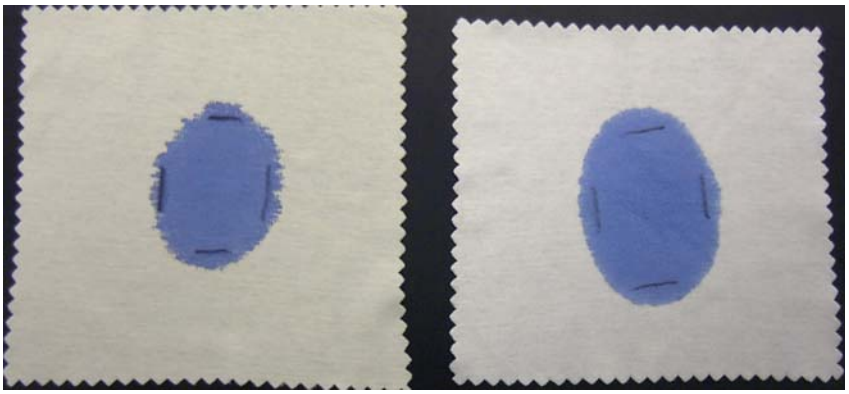

Figure 3. Horizontal spread of a cotton fabric with minimal scour (left) and improved scour (right).

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[1] *Analytical Methods for a Textile Laboratory,* 3rd edition, 1984, AATCC, Research Triangle Park, NC.
[2] 3M Application Guide, April 2003.

PRINTING

Mill trials have been conducted on a rotary screen printing machine with the capability of applying print paste with either a squeegee or magnetic bar. A recommended print paste formulation, screen pattern, and set-up for a rotary screen print machine are below. Machine settings and print paste viscosity should be such that the print remains on one side and is not transferred entirely through the fabric. Print should be applied to the back of the fabric so that it is inside the garment next to the skin.

Print Paste Formulation

PRODUCT	GRAMS/KILOGRAM (g/kg)
Polyacrylic acid (synthetic) thickener	22.0
Fluorochemical water repellent	12.0
Water	966.0

The above formulation gives a viscosity of approximately 8,900 centipoises (cps) using a Brookfield Model RVT viscometer at 20 rpm with the #6 spindle. The viscosity should be varied depending on the thickness of the fabric being printed in order to give the proper penetration of the print paste into the fabric. A lower (thinner) viscosity is needed for a thicker fabric. A higher (thicker) viscosity is needed for a thinner fabric. The viscosity can be changed by adjusting the amount of thickener in the formulation. The concept is to achieve penetration of 50-65% through the fabric. For example, for a jersey knit, the amount of thickener may need to be increased to 32.0 g/kg to give a viscosity of approximately 12,500 cps.

Other thickeners can be substituted but must be checked for compatability. The thickener shown above has very low solids in order to minimize the impact on fabric hand. The fluorochemical water repellent is a self-crosslinking fluoropolymer, therefore, a binder is not needed.

A small amount of dye or optical brightener can be added to the above print paste if desired. The viscosity of the paste may have to be adjusted. The advantage of seeing the print during processing ensures that even coverage is obtained and the back of the fabric (not the face) is printed. If a colored print is not desired, an optical brightener can be used, with as little as 5.0 g/kg in the print paste, as a relatively “invisible” way of tracking the print. A black light can be added to the tenter or production line as a means of inspecting the goods. Additionally, cut-and-sew operators can use a black light to insure correct assembly. Another way to see the print on some fabrics is to apply water or a colored liquid to the fabric.

Softeners can be applied before or after printing, but must not reduce the drop absorbency of the fabric. To ensure the best adhesion of the print to the fabric, apply the softeners AFTER printing. A suggested formulation for top softening is given in the “Softening After Printing” section.

Screen Pattern

A discontinuous stipple pattern, shown in Figure 4, is used for the WICKING WINDOWS™ print. Other patterns such as stripes and dots have been investigated, but the discontinuous stipple pattern has been found to give the best overall performance for most fabrics. Continuity between the absorbent areas is essential.

The discontinuous stipple pattern was manufactured into a screen by ROTHTEC Engraving[3] in Charlotte, NC. A digital screen file is available and a printed image is shown below (Figure 4). The screen tracking number at ROTHTEC is: CI3020.

A 125 mesh rotary screen was used during mill trials.

Figure 4. A close-up of the discontinuous stipple print pattern as shown on a knit fabric.

[3] ROTHTEC Engraving Corporation can be reached at: 3500G Woodpark Blvd., Charlotte, NC 28206-4206. Tel: +1 704.596.6727 Fax: +1 704.596.0136 www.rothtec.com

Print Machine Set-up

Trials have been conducted on a print machine that uses a magnet. The bar size has been varied from 10 to 15 millimeters. The larger bar was used on thicker fabrics to gain better penetration of the print paste. The smaller bar was used on thinner fabrics to reduce penetration. For thin woven fabrics, such as sheeting, a squeegee should be used in order to minimize penetration of the print paste.

Curing Conditions

The printed fabric should be dried and then cured for approximately 1.5 minutes at 340°F (171°C). A proper cure is necessary for the fluorochemical in the print to crosslink to the fabric. If the fabric is not cured properly, durability of the print will be drastically reduced.

Softening After Printing

After the printed fabric is cured, softeners can be applied to give the fabric sewing lubricity and the desired hand. The following suggested formulation for top softening includes a polyethylene softener as a needle-cutting lubricant and a hydrophilic silicone as a softener to improve hand. Note that a hydrophilic softener should be used to ensure that the WICKING WINDOWS™ areas are absorbent. Care should be taken in using aminofunctional silicone softeners which are often hydrophobic.

Pad-apply the following and then dry:

30.0 g/L Hydrophilic Silicone
10.0 g/L Polyethylene
2.0 g/L Wetting Agent, if needed

Important Notes

Durability of the print depends greatly on the condition of the fabric prior to printing. **Softeners, in particular, can harm both the moisture management properties as well as the durability of the print. Aminofunctional silicone softeners and most cationic softeners are hydrophobic and can significantly reduce wicking and absorbency.**

EXPERIMENTAL RESULTS

Two 100% cotton knit fabrics, including a 24-cut interlock and a 28-cut jersey, were printed with WICKING WINDOWS™ technology. The 4.5 oz/yd^2 interlock contained 40/1 combed ring spun yarns. The 3.7 oz/yd^2 jersey contained 30/1 combed ring spun yarns.

The fabrics were knit, bleached, and dyed at Cotton Incorporated. Print pastes were made with slightly different formulas as listed below to achieve different viscosities.

	Interlock	**Jersey**
Fluorochemical water repellent	12.0 g/kg	12.0 g/kg
Polyacrylic acid thickener	22.0 g/kg	32.5 g/kg
Water	962.0 g/kg	955.5 g/kg
Viscosity (20 rpm #6 spindle)	6,900 centipoise	12,550 centipoise

The fabrics were printed on a production print machine at a speed of 20 yards per minute with a 15 mm bar and a magnet setting of 5 for the interlock and 3 for the jersey. No print blanket adhesive was used. The increased viscosity and reduced magnet pressure used on the jersey fabric were done to reduce the print paste penetration on the relatively thin fabric.

The printed fabrics were cured on a tenter at 340°F (171°C) for 1.5 minutes. The rolls were then finished by padding on 30.0 g/L of hydrophilic silicone softener, 10.0 g/L of polyethylene, and 2.0 g/L of wetting agent and dried on the tenter at 300°F (150°C).

There are few standard industry test methods for evaluating moisture management properties and no single test tells the entire story. Therefore, several test procedures were used to evaluate fabrics treated with WICKING WINDOWS technology. The fabrics were tested for Drop Absorbency (AATCC 79), Vertical Wicking, Maximum Absorption (Absorbent Capacity) using the Absorbency Testing System (ATS-600), Fabric Cling, and Gravimetric Drying Time. Data from these tests are summarized in Tables I through III. In the Drop Absorbency, ATS, and Cling tests, the back of the fabric was tested instead of the face because the back will be next to the skin where moisture would be generated during exercise. Details on the various test procedures are given in Appendix B.

It should be noted that there are currently no standardized test methods for measuring movement of moisture from the back of the fabric to the face. The best way to quickly test the WICKING WINDOWS application is to visually observe a drop of water applied to the back of the fabric. The 10-Drop Test, a Cotton Incorporated internal test procedure described on page 12, was developed to measure the movement of moisture through a fabric, from back to face (inside to outside), or vice versa. Data from this test is given in Table IV.

As shown in Table I, the drop absorbency for all samples (control and WICKING WINDOWS™ finish) is less than five seconds, as desired. Vertical Wicking rate has been maintained after application of the WICKING WINDOWS finish and is greater than 0.5 cm/min, which may be desired for some active sports apparel fabrics.

As shown in Table II, the absorbent capacity (maximum absorption) of the fabric treated with the WICKING WINDOWS finish is significantly less than the control both initially and after five home launderings. The lower absorbent capacity results in a faster drying time.

In Table III, the results from the Cling Test show that the one-sided WICKING WINDOWS treatment significantly reduces cling of the wet fabric to the Plexiglas® plate. A similar reduction of damp or wet fabric cling against the skin can be demonstrated.

Table I. Summary of Drop Absorbency and Vertical Wicking Tests.
The control was the dyed fabric before printing and finishing.

	Jersey, Control	**Jersey, WICKING WINDOWS™ Finish**	**Interlock, Control**	**Interlock, WICKING WINDOWS™ Finish**
Drop Absorbency (AATCC 79), (seconds), Back (Average of 5 drops)				
0 HLTD*	2.8	4.0	1.0	3.6
5 HLTD	1.8	instant	1.0	instant
Vertical Wicking, Rate of Wick** **(cm./min.)** (Average of 5 specimens)				
0 HLTD	0.41	0.55	0.53	0.52
5 HLTD	1.09	0.91	1.40	1.01

* HLTD = Home laundering and tumble dry cycles
** For some active sports apparel, it may be desired to have vertical wicking greater than 0.5 cm/min (equivalent to 15 cm in 30 minutes).

Table II. Summary of Absorbency Tests with the ATS-600 and Drying Time Tests.
The control was the dyed fabric before printing and finishing.

	Jersey, Control	Jersey, WICKING WINDOWS™ Finish	Interlock, Control	Interlock, WICKING WINDOWS™ Finish
Maximum Absorption (ATS-600), (grams/gram), Back (Average of 5 specimens)				
0 HLTD*	3.89	2.44	4.45	3.43
5 HLTD	4.53	2.94	5.15	3.80
Gravimetric Drying Test, ** **Drying Rate (mg/min.)** (Average of 5 specimens)				
0 HLTD	6.8	8.2	6.7	7.8

* HLTD = Home laundering and tumble dry cycles
** The Gravimetric Drying test was conducted in standard testing conditions, 70°F and 65% relative humidity, using 1.0 mL of water. See Appendix B for more details. Higher values indicate faster rates of drying.

Table III. Summary of Cling Tests.
The control was the dyed fabric before printing and finishing.

	Jersey, Control	Jersey, WICKING WINDOWS™ Finish	Interlock, Control	Interlock, WICKING WINDOWS™ Finish
Cling (grams force, gf)** (Average of 3 specimens)				
0 HLTD*	97.8	40.6	94.9	45.5
5 HLTD	70.4	38.1	66.9	37.5

* HLTD = Home laundering and tumble dry cycles
** The Cling Test is performed with the fabric face up. The fabric is wet with 1.0 mL water and dragged with the back of the fabric against a Plexiglas® board. See Appendix B for more details. Higher values indicate more cling.

The 10-Drop Test was developed in an attempt to quantify the amount of water that is absorbed by a fabric and the amount that is transferred through the fabric. In this test procedure, ten drops of deionized water are gently applied to a fabric, which is placed over a piece of AATCC blotter paper. The fabric and blotter paper are weighed before and after the addition of the water. The fabric is tested separately with the face up and the back up. Additional details about the test are given in Appendix B.

Table IV shows the results from the 10-Drop Test. As shown in the table, a comparison is made between the fabric face and fabric back to demonstrate the one-directional movement of moisture away from the skin. When water is applied to the back of the WICKING WINDOWS™ treated fabric, most of the water passes through to the face of the fabric and the blotter paper. However, when water is applied to the face of the WICKING WINDOWS treated fabric, most, if not all, of the water is absorbed by the fabric. So, the WICKING WINDOWS application transports water from the back to the face of the fabric and then forms a barrier that holds the water away from the skin.

Table IV. Summary of 10-Drop Tests.

10-Drop Test (Average of 5 specimens)	**Jersey, WICKING WINDOWS™ Finish**		**Interlock, WICKING WINDOWS™ Finish**	
	Face up	**Back up**	**Face up**	**Back up**
0 HLTD*				
Water Absorbed by Fabric:				
(g)	0.31	0.05	0.28	0.07
(%)**	77%	12%	71%	17%
Water Passing Through Fabric (absorbed by blotter)**:**				
(g)	0.08	0.36	0.11	0.32
(%)	21%	87%	27%	84%
5 HLTD				
Water Absorbed by Fabric:				
(g)	0.39	0.07	0.42	0.14
(%)	96%	18%	99%	28%
Water Passing Through Fabric (absorbed by blotter)**:**				
(g)	0.01	0.33	0.004	0.37
(%)	3%	81%	1%	74%

* HLTD = Home laundering and tumble dry cycles
** The percentages in each column may not add up to 100% due to rounding errors, the precision of the scales, and the averaging of five specimens.

Figures 5 and 6 show pictures of the jersey and interlock fabric specimens, respectively, and corresponding blotter paper after the 10-Drop Test. Colored water was used for photographic effect.

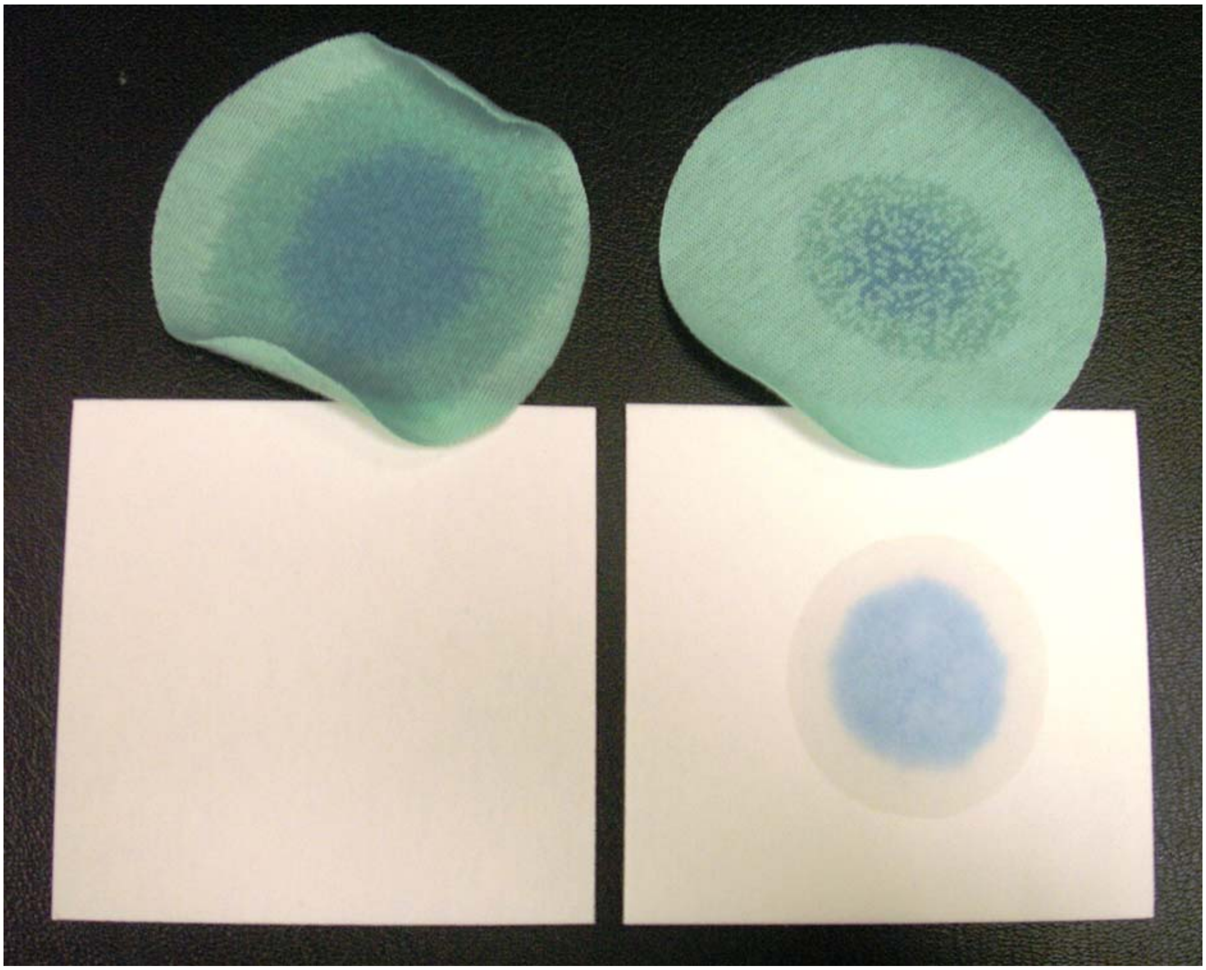

Figure 5. Jersey fabric, WICKING WINDOWS™ technology on back, after the 10-Drop Test. Specimen on left was tested face up. Specimen on right was tested back up.

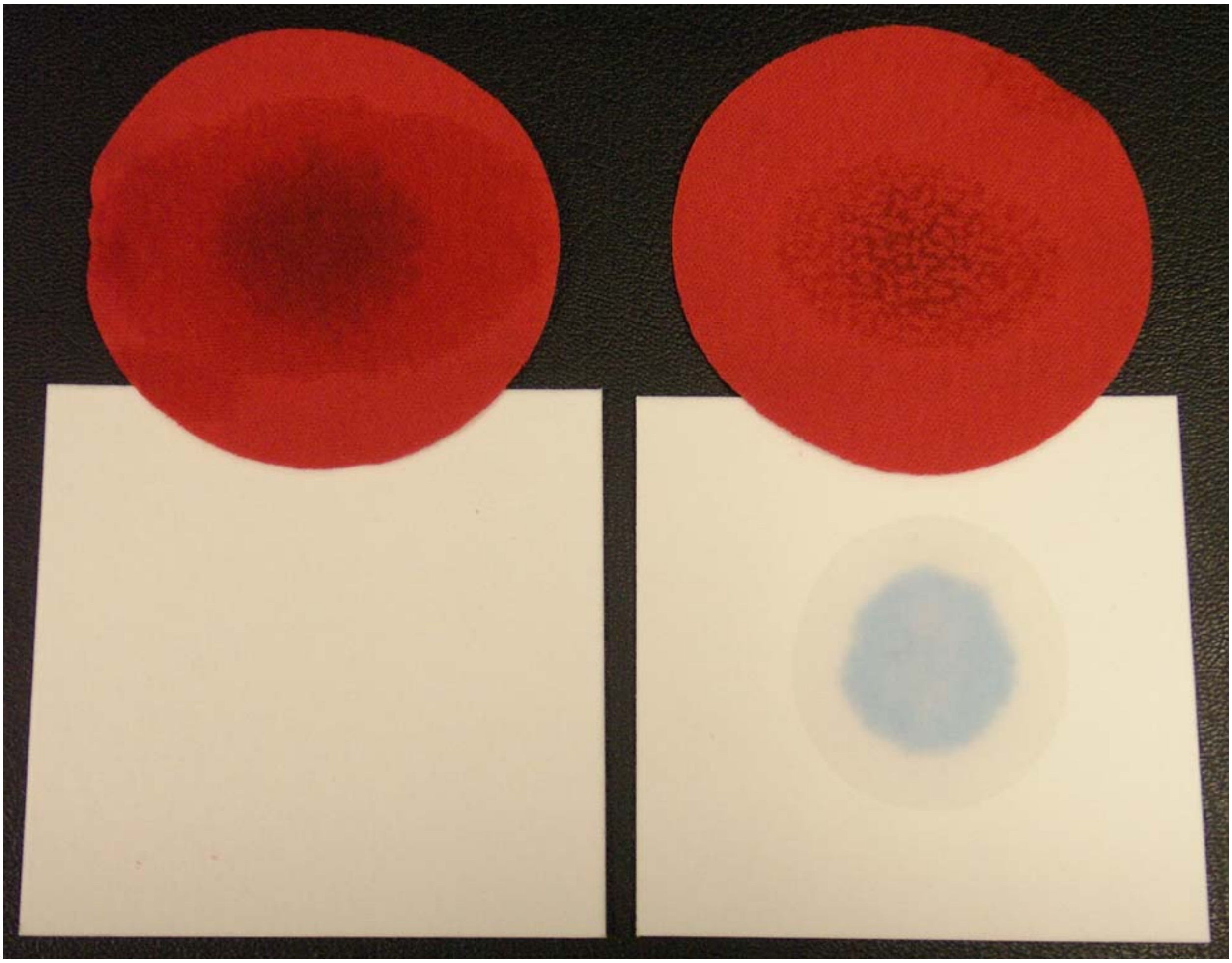

Figure 6. Interlock fabric, WICKING WINDOWS™ technology on back, after the 10-Drop Test. Specimen on left was tested face up. Specimen on right was tested back up.

CONSUMER PRACTICES

For the best performance of fabrics treated with WICKING WINDOWS technology, several laundering recommendations should be emphasized to consumers.

The use of liquid fabric softeners or dryer sheets should be avoided, as softeners can interfere with the performance of the fluorochemical repellent and the absorbency of the untreated portions of the fabric.

If performance decreases after many launderings, a hot tumble dry and/or ironing can often help rejuvenate the finish. The heat from tumble drying or ironing helps regenerate water repellency by reorienting the fluorochemical chains. An extra rinse to make sure the detergent is thoroughly removed can also help to restore performance.

APPENDIX A

EXHAUST PREPARE-FOR-PRINT BLEACH PROCEDURE

The following procedure is a starting guideline for achieving good drop absorbency, i.e. less than five seconds, on knit fabrics.

15:1 Liquor ratio

For Brazzoli, TSI TurboJet, and Sclavos

Add at 80°F (27°C):

Surfactant blend (scouring agent), minimum 60% solids........................1.0 g/L
Polymeric lubricant (fiber-to-metal)...1.0 g/L

Load fabric into bath containing the above chemicals.
Start machine and add the following, in order:

Hydrogen peroxide stabilizer (sequestrants / magnesium salt blend)............0.4 g/L
Liquid caustic (NaOH 50%) ....4.0 g/L
Hydrogen peroxide 35% ....5.0 g/L

Heat to 205°F (96°C) at 4°F/minute (2°C/minute).
Run 30 minutes.
Cool to 180°F (82°C).
Drop.
Refill with water blended to 160°F (71°C). Overflow 10 minutes at 160°F (71°C).
Drop.
Refill with 160°F (71°C) water. Run overflow rinse for 5 minutes at 160°F (71°C).
Cool with 80°F (27°C) water to 100°F (38°C).
Check fabric pH and adjust to 6-7 with acetic acid if necessary.
Rinse with 100°F (38°C) water after pH adjustment.
Unload or proceed to dyeing.

APPENDIX B

TESTING PROCEDURES

Water Drop Absorbency (AATCC Test Method 79)

The procedure for this method is given in the American Association of Textile Chemists and Colorists Technical Manual as Test Method 79 "Absorbency of Bleached Textiles." A water droplet is dropped from a height of 10±1 mm (0.375 inch) onto the fabric specimen, which is held taut in an embroidery hoop. The time required for the drop to lose its specular reflectance is reported. Results are the average of five drops on one specimen. Face and back can be tested separately for one-sided finishes.

Vertical Wicking

Cut three to five specimens 16 centimeters (cm) by 2.5 cm in the length (warp) direction of the fabric. Mark one-centimeter distances beginning at 0.2 cm from one end of the longest direction using fugitive (non-permanent) ink. Label even-numbered centimeter values next to the individual ink marks and make a deeper-colored mark at 15 cm to identify when the final wicking height has been reached.

Vertically hang the cut strips by any convenient means so the end with the marked distance of 0.2 cm just touches the surface of deionized water. Do not allow the 0.2 cm mark to be below the water surface. Begin timing with a stopwatch as soon as the specimen hits the water surface. Read and record the water rise at five minutes and after thirty minutes. Water height measurements can be made by estimating the distance between ink marks without removing the specimen from the water surface. If the 15 cm mark is reached before 30 minutes has elapsed, record the actual time that the water reaches 15 cm.

The rate of wicking is calculated by the formula: distance water traveled (cm) / time (minutes). A wicking rate of 15 cm in 30 minutes (rate of wick = 0.5 cm/min.) is commonly desired for performance apparel.

Absorbency Testing System (ATS-600)[4]

After conditioning overnight at standard laboratory conditions, a 2.7-inch (6.8-cm) circle of fabric specimen is placed on the ATS-600 stage, and the instrument is started. The instrument dispenses deionized water at a constant known rate to the underside of the fabric sample. The instrument records the weight of fluid absorbed by the specimen versus time until the maximum absorption has been reached. The data is automatically normalized by dividing the readings by the weight of the specimen before testing. Other liquids, such as synthetic perspiration, can be used in this test.

[4] Sherwood Instruments, Inc., 147 Locksley Rd., Lynnfield, MA 01940. Tel/Fax: (781) 334-9825.

Gravimetric Drying Test

This drying time procedure is designed to simulate initial skin wetting with perspiration. Complete saturation of the specimen with water, as in the home laundry, would likely yield a different result.

After conditioning for at least four hours at 70°F (21°C) and 65% relative humidity, place a 6-inch x 6-inch (15-cm x 15-cm) fabric specimen on a mesh screen platform on a tared balance. Record the initial (dry) weight of the specimen. Using a calibrated pipette, add 1.0 mL of deionized water to the center of the specimen. Wait 60 seconds for the fabric to absorb the water.

Record the weight of the wet sample every five minutes or at another pre-determined time interval. The sample is considered dry when it is within ±2% of its original dry weight. Cotton fabrics will retain some moisture due to regain. Plus or minus 2% of the original dry weight is considered to be dry to the touch.

Fabric Cling

The objective of this test is to simulate the amount of cling between a fabric and human skin during physical activity. This is achieved by measuring the amount of force required to drag a 6-inch x 6-inch (15-cm x 15-cm) fabric sample after 1.0 mL of water has been applied.

Condition three 6-inch x 6-inch (15-cm x 15-cm) fabric specimens for a minimum of 4 hours at 70°F (21°C) and 65% RH. Set up a CRE (constant rate of extension) tensile testing machine with a 250 N load cell. Attach a 0.25-inch (6 mm) thick 7-inch x 14.5-inch (18-cm x 37-cm) Plexiglas® plate to a platform and mount the platform to the bottom clamp holder of the tensile testing machine. Mount a pulley on the end of the platform. A 1/16-inch (1.5-mm) diameter steel cable is attached to a 6-inch (15-cm) wide plastic clamp and then threaded under the pulley and to the top clamp holder on the tensile machine to form an "L." See the diagram and picture in Figure 7.

Clamp a test specimen into place on the Plexiglas® surface with the back of the fabric, i.e. the surface to be worn against the skin, toward the Plexiglas®. The length direction of the fabric should be perpendicular to the clamp. Attach 0.25-inch (6 mm) of the entire fabric edge within the plastic clamp. Before testing, insure there is no load shown on the tester and minimum slack in the line between the load cell and the clip.

Apply 1.0 milliliter (mL) deionized water onto the center of the fabric. Allow the water to absorb for one minute. Start the tensile testing machine (150 mm/min) to determine the force required to drag the wet fabric over 2.5 inches (6.4-cm) of the Plexiglas® surface. Dry the surface between each specimen. Repeat for two additional specimens. Calculate the average of three specimens. It is recommended to compare a treated fabric to an untreated control fabric. Report the average peak force (gf) required to drag the sample along the Plexiglas® surface in the length direction.

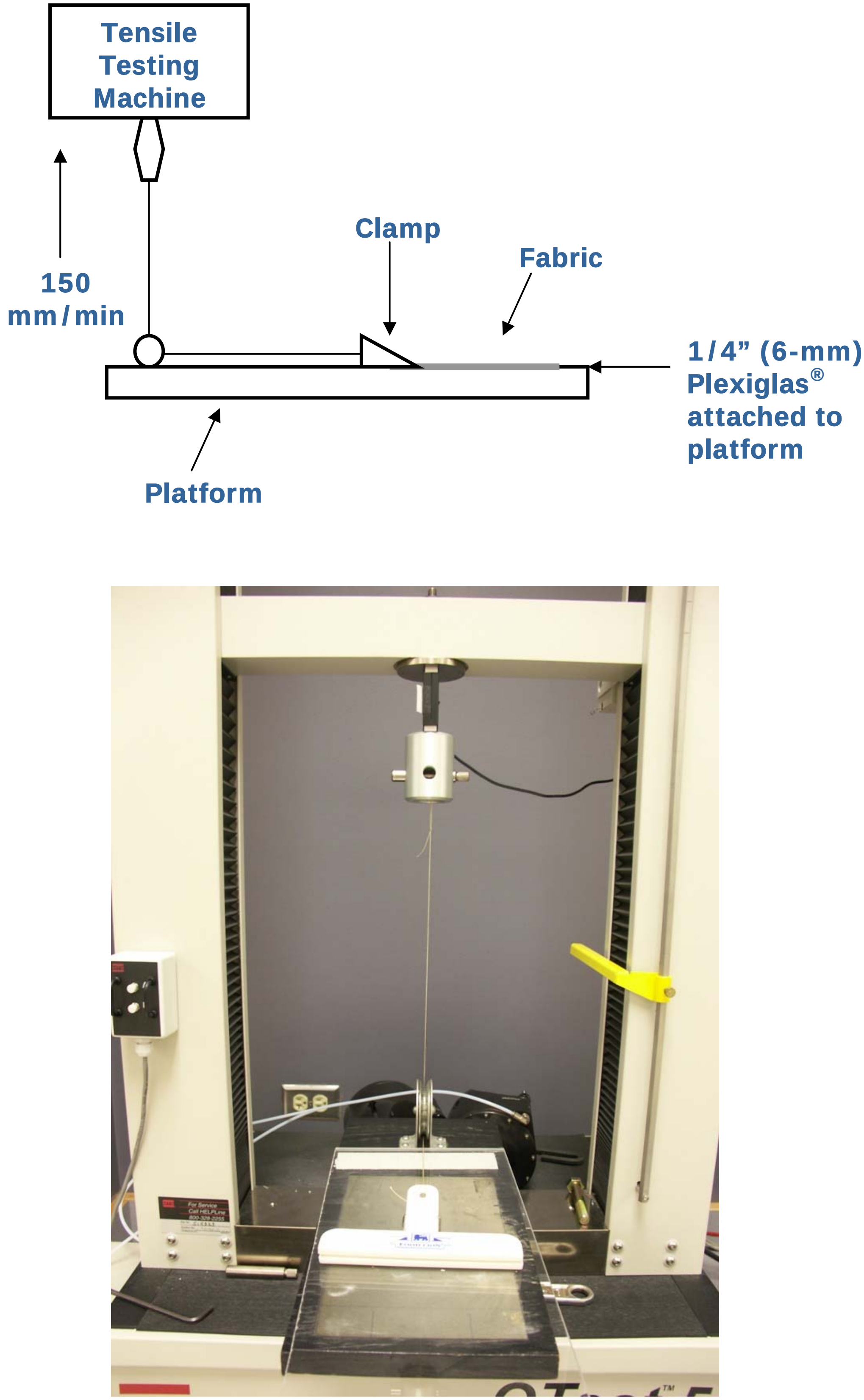

Figure 7. Diagram (top) and picture (bottom) of the Fabric Cling test.

10-Drop Test

The purpose of this test is to determine if water is transferred at a different rate from the back of the fabric through to the face versus from the face to the back.

Cut five 2.7-inch (6.8-cm) circles from the fabric sample to be tested face up and five circles to be tested back up. Cut AATCC blotter paper into 3-inch x 3-inch (7.5-cm x 7.5-cm) squares. Tare a balance that has a 0.01 gram precision. Add blotter paper to the balance and record the weight (blotter initial). Tare. Add a fabric specimen face up (with the fabric face towards the ceiling) and record the weight (fabric initial). Place a light round weight (38 grams) with a hole in the middle onto the specimen. Tare. The purpose of the weight is to ensure good contact between the fabric and the blotter paper.

Take a disposable pipette and gently place 10 drops of water onto the fabric surface in the center of the fabric (through the hole in the weight). Hold the pipette approximately 1 cm above the fabric when adding droplets. Wait 10 seconds to allow the water to be absorbed. Record the weight (weight of water). Remove the weight, fabric, and blotter paper. Tare the balance. Record the weights of the blotter paper (blotter final) and fabric (fabric final).

Calculate the change in weight of the blotter paper and the fabric. Using the weight of the water, calculate the percentage of water absorbed by the blotter paper and by the fabric. For example,

% water absorbed by fabric = [fabric final weight (g) – fabric initial weight (g)] / weight of water (g) x 100%.

Repeat for the remaining four specimens. Calculate the average of the five specimens.
Repeat for five additional specimens with the back of the fabric towards the ceiling (back up).

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.

For further information contact:

COTTON INCORPORATED
WORLD HEADQUARTERS
6399 WESTON PARKWAY
CARY, NC 27513
PHONE: 919-678-2220
FAX: 919-678-2230

COTTON INCORPORATED
CONSUMER MARKETING HEADQUARTERS
488 MADISON AVENUE
NEW YORK, NY 10022-5702
PHONE: 212-413-8300
FAX: 212-413-8377

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