EVALUATION OF THE CARE AND PERFORMANCE OF COMFORT STRETCH KNIT FABRICS

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Introduction

"Stretch is not something that you see; it's something that you feel, and once you've experienced it, you don't want to go back."[1] Apparel designers and fabric manufacturers have combined function with design potential to create the concept of 'comfort stretch', 'flex-fit' or the 'feel good factor' and 'soft stretch performance'. The most widely used stretch fiber is spandex in proportions ranging from 1 percent to over 10 percent to create fabrics that enable the consumer to feel the comfort of fit. Since most 'comfort stretch' fabrics contain a high percentage of cotton, for example, 90 – 99 percent cotton combined with one to ten percent spandex, the majority of consumers will expect to follow the same care instructions as their 100 % cotton or cotton/polyester bends. Obviously, consumers expect comfort-stretch fabrics to maintain their original feel, and combine the aesthetic attributes of softness, comfort, stretch and resiliency expected by consumers in today's casual and business casual styles. Ideally fabric blends with such small percentages of fiber should be laundered by the consumer at the recommended temperature and care of the dominant fiber in the blend. Cotton, a fiber often combined with spandex can withstand the highest temperature settings on the consumer's clothes dryers. Combining spandex, a heat-sensitive fiber, with cotton or other fibers that can withstand higher temperatures during care generates the following questions: Do cotton/spandex blend knit fabrics need special care labels? Do the fabrics retain their stretch and recovery after multiple wash/dry cycles?

To answer these questions, the Clothes Care Research Center™ (CCRC) identified two issues associated with comfort stretch fabrics, such as cotton/spandex knits. One is that the typical care label instructions recommend either an 'Easy Care or Delicate wash cycle' and 'Hang to Dry' and the second issue is the number of consumer complaints of dimensional change, fuzzing or pilling and loss of stretch. CCRC is a cooperative alliance among Cotton Incorporated; GE Consumer Products; Milliken & Company; Procter & Gamble; VF Imagewear; the University of Kentucky's Textile Testing Laboratory and Northwestern University's McCormick School of Engineering and Applied Science. The members represent every phase of clothing care in the home, from textiles and apparel to appliances and detergents. The mission of CCRC is to understand, evaluate and improve clothes care in the home.

The overall objective of the project was to develop recommended care instructions for "stretch fabric samples" by specifically addressing the interaction of 'knit fabrics' (cotton/spandex) with products and appliances used in clothes care.

Experimental Design

A factorial research design was used to evaluate the aesthetic and functional characteristics of comfort stretch knits. The research design benchmarked the performance of cotton/spandex knits against a 100% cotton knit of comparable construction. The aesthetic characteristics included smoothness appearance, color change, fuzzing and pilling, while the functional characteristics included dimensional change, stretch and stretch recovery. All performance characteristics were evaluated at wash/dry intervals of 1, 5 and 10 cycles. The effects drying procedures and/or temperatures had on the aesthetic and functional performance of the stretch knit fabrics was included in the research design.

Fabric Description: Cotton Incorporated prepared the yarns and knit fabrics. The 100% cotton fabric was tubular finished and the cotton/spandex fabric was finished open width, pad extracted followed by conveyor drying. Both fabrics were bleached and dyed in a soft flow jet with fiber reactive dyes @ 140F. Test samples were prepared from both fabrics by cutting samples that were 24" long (wale direction) by 48" wide (course direction); folding to make a double-thickness 24" x 24" sample, which was serged around the edges with the face side out to simulate a T-shirt. Fifty-two samples of 100% cotton knit, color navy blue weft knit construction were made for the study. Fifty-two samples of 92% cotton / 8% spandex (the spandex was 40 denier Lycra® from Invista): color navy blue, weft knit construction was made. One hundred and four fabric samples were laundered according to the specified conditions of the experimental design. Additional knit fabric samples were retained as controls.

Washing Procedures: Based on the experiences of CCRC's members, the following conditions were selected to represent typical consumer laundering practice by utilizing a vertical axis washing machine and electric dryer with evaluations after 1, 5 and 10 wash cycles.

- Each clothes load consisted of 12 fabric swatches: Weight 7 lbs.
- Liquid Detergent – 98 grams and 30 grams of Fabric Softener
- Wash Temperature – 'Warm – 90 ˚F with a cold – 65 ˚F water rinse cycle.
- Water Usage – Load Size large – 21 gallons/wash & rinse cycle at 7.8 grains of hardness
- Cycle Profile of Washer – Easy Care Cycle at medium soil level; medium wash speed; fast spin speed for a total cycle time of 37 minutes.

Drying Procedures: Based on the recommended care instructions and consumer research on habits and practices, three options were selected for drying the knit samples.

- 2 – Electric Clothes Dryer Cycles – 1, 5 and 10 dry cycles
  - Cycle Profile Knits Sensor Dry with a 'dry' dryness level; low heat setting for a total time to dry of 44 minutes.
  - Cycle Profile Cotton Sensor Dry with a 'dry' dryness level; high heat setting for a total time to dry of 33 minutes.
- Air Drying – Lie Flat to Dry – 1, 5 and 10 dry cycles with a 'dry' dryness level at a average temperature of 75˚F for an average time to dry of 2 to 2 ½ hours.

The overall experimental design enabled the researchers to compare the performance of a cotton/spandex knit to 100% cotton after machine washing and three levels of drying.

Aesthetic Evaluations: For each drying condition, after the 1st, 5th & 10th wash/dry cycles were complete, samples were evaluated for appearance retention. The following test methods were used:

- Appearance of Fabric Samples After Repeated Home Laundering – Color Change Rating – AATCC Evaluation Procedure 1[2]
- AATCC 124 – Evaluation of Smoothness in Fabrics after Repeated Home Laundering[3]

- Pilling and Fuzzing - ASTM D 3512 Photographic Pilling Replica and a Cotton Incorporated experimental 7-point fuzz-pill photographic grading scale.
- Color Retention (“Delta E”) - Measured using a Hunter Ultrascan XE dual beam xenon flash spectrophotometer. The Delta E value was determined in accordance with AATCC Evaluation Procedure 6 “Instrumental Color Measurement”. SLI-Form® software was used to perform the CIELab Color Difference calculations. Illuminant D-65/10° observer were used to calculate the colorimetric values.

Performance Evaluations: After each wash/drying condition, samples were evaluated for performance or functional characteristics. The following methods were used:

- AATCC 135 – Evaluation of Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics - Each sample was measured at 3 locations in the warp and weft directions. [4]
- Stretch & Growth – Two methods of evaluation of stretch and growth:
    1. ASTM 6614: Test Method for Stretch Properties of Textile Fabrics – CRE Method[5] with the Sintech 1/S Instrument - Method: 4.1 Fabric Stretch and Fabric Growth – Two, 14 x 2 inch specimens in each fabric directions were evaluated. Fabric growth was calculated from the difference in length prior to load and after relaxation.
    2. ASTM D2594: Standard Test Method for Stretch Properties of Knitted Fabrics Having Low Power[6] Five specimens, 125 x 500 mm specimens were tested in each fabric direction.

Data Analysis

When the laboratory evaluations were completed, for each of the tests performed (i.e. Dimensional Change, Smoothness, Color Change, Stretch, and Growth), an Analysis of Variance (ANOVA) model was fit to the data and tests were conducted on the statistical significance of the main effects and two-factor interactions of the following factors: Spandex (0% or 8%), Dry Cycle (Heated Dry, Low Heat, or Lie Flat to Dry), Fabric Softener (None or Liquid), and Washes (1, 5 or 10 Wash/Dry Cycles). All tests were conducted at the 99% confidence level.

Results

The results of testing the 100% cotton knit will be presented as the control knit and the results of testing the cotton/spandex blend will be compared to the control. The cotton knit was not a stretch knit fabric; its use serves primarily as a baseline performance fabric.

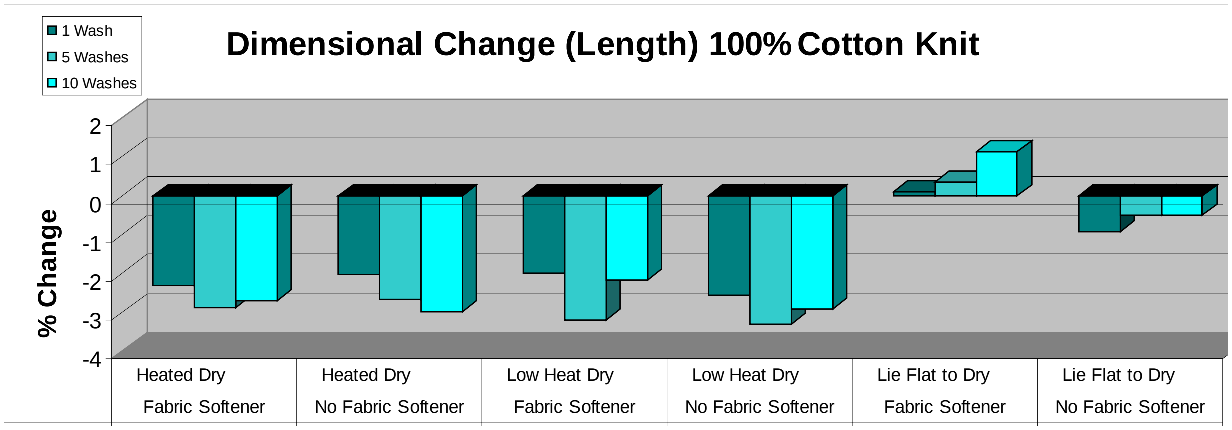

Figure 1. Evaluation of Dimensional Change in the Length Direction for 100% Cotton Knits

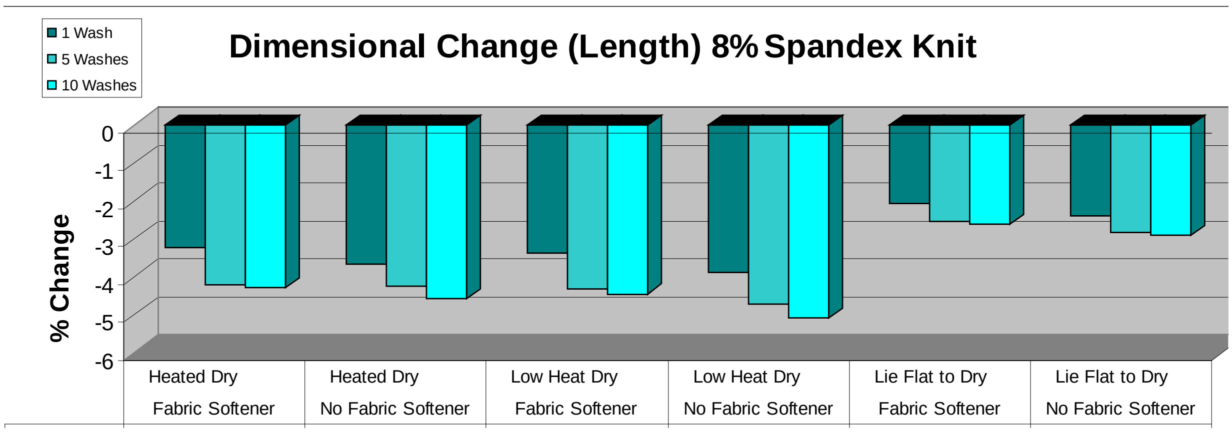

Figure 2. Evaluation of Dimensional Change in the Length Direction for 8% Spandex Knits

<u>Evaluation of Performance – Dimensional Change</u>: It was noted that the dimensional change for the nine (three sets/direction/three specimens) measurements in the length direction were highly correlated with each other and thus the average dimensional change of the three measures was plotted in Figures 1 and 2. They show the effects of the washing conditions on the length dimensional change. The same was true of the nine benchmarks measured in the width direction. The graphs in Figures 3 and 4 show the effects of washing on the average dimensional change in the width direction. The primary finding is that under all these laundering conditions, the cotton and the cotton/spandex fabric samples performed extremely well over the 10 wash cycles. No fabric sample shrunk more than 6% and no fabric sample grew by more than 2.5%. The majority of shrinkage occurred during the first wash/dry cycle. The cotton/spandex fabric samples shrunk more in the length direction than their 100% cotton counterparts. However the opposite was true for the width direction where the cotton/spandex fabric samples shrunk less than the 100% cotton fabric samples on average. When the fabric samples were laid flat to dry, average shrinkage was reduced by less than 2 percentage points compared with the average shrinkage of the low heat and heated dry cycles, which have similar dimensional change. The effects of using fabric softener on dimensional change were too small to be of practical interest.

Thus, all these wash and dry conditions represent acceptable care for these fabric samples in terms of dimensional change.

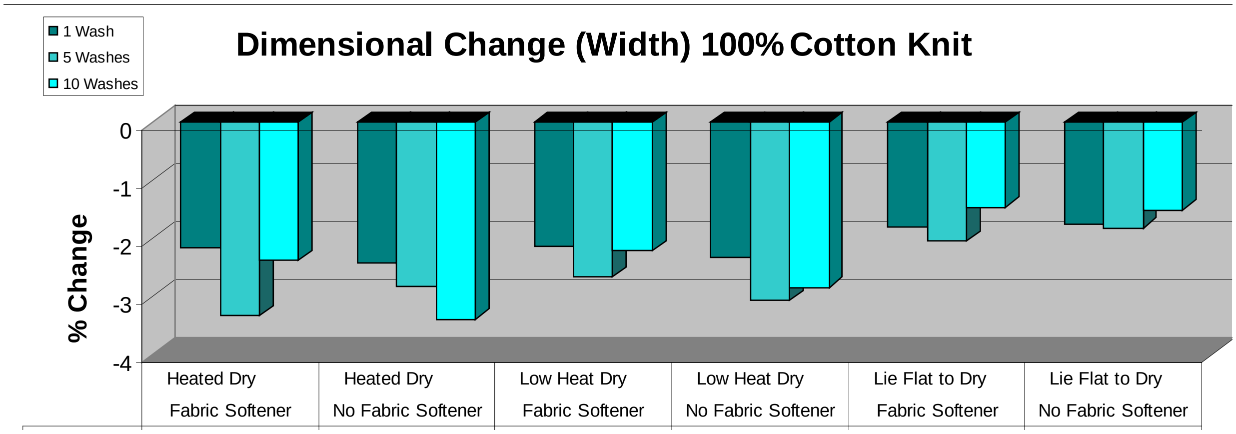

Figure 3. Evaluation of Dimensional Change in the Width Direction for 100% Cotton Knits

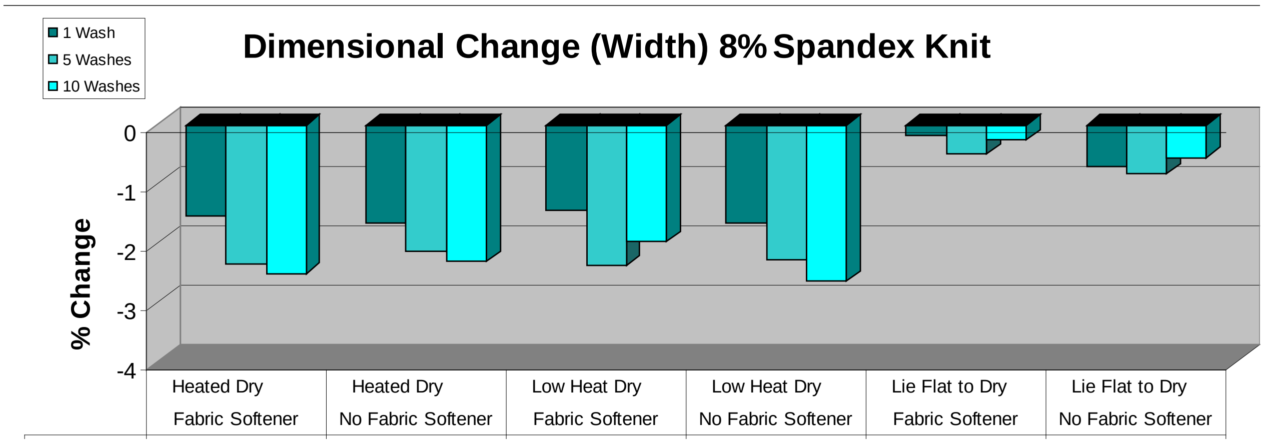

Figure 4. Evaluation of Dimensional Change in the Width Direction for 8% Spandex Knits

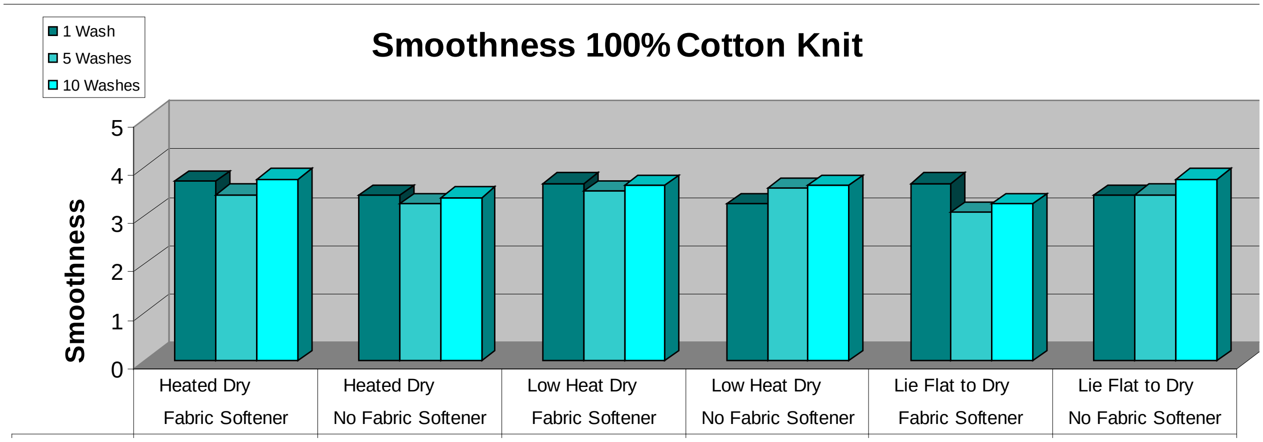

Figure 5. Evaluation of Smoothness for 100% Cotton Knits

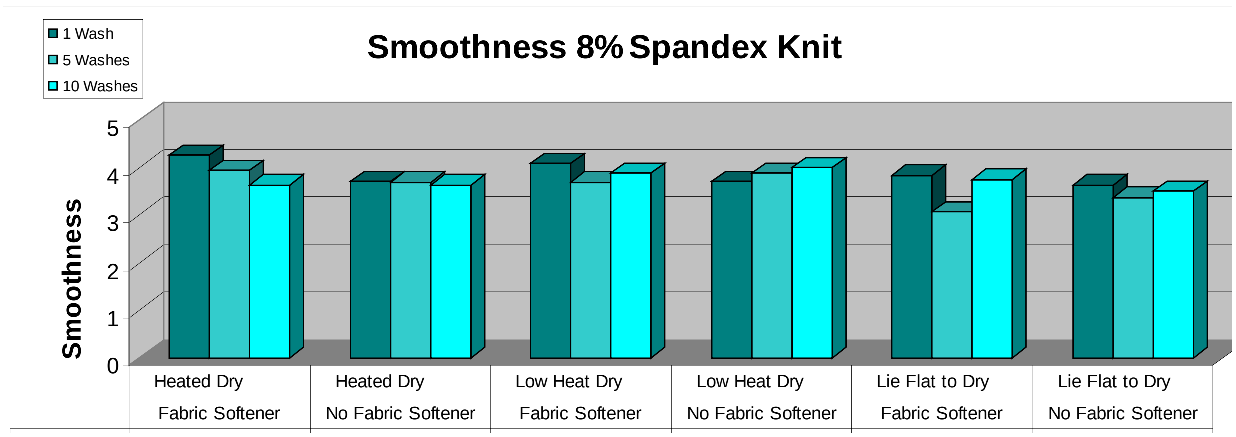

Figure 6. Evaluation of Smoothness for 8% Spandex Knits

<u>Evaluation of Performance – Smoothness</u>: As with dimensional change, all of the laundering conditions represented in this study give reasonably good smoothness ratings (only two fabric samples had a rating lower than 3.0). Figures 5 and 6 show plots of the data. The cotton/spandex fabric samples had slightly higher smoothness appearance ratings than their 100% cotton counterparts. When the fabric samples were laid flat to dry, smoothness appearance ratings decrease slightly when compared with the low heat and heated dry cycles. The effects of using fabric softener on smoothness were too small to be of practical interest.

<u>Evaluation of Performance – Color Grade Change as evaluated by Delta E_{cmc}</u>: None of the laundering conditions produce substantial color change as evaluated by Delta E_{cmc}. The 100% cotton fabric samples had slightly more color change than the cotton/spandex fabric but were at levels after 5 and 10 launderings that were likely not to be observed by consumers. To reduce length, the figures for Color Grade change are not included in this article.

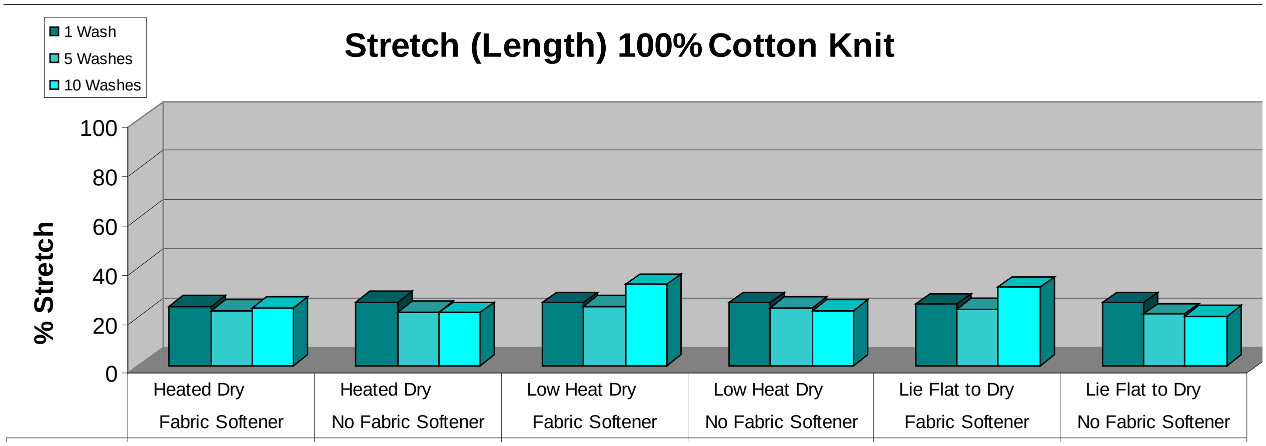

Figure 7. Evaluation of Stretch in the Length Direction for 100% Cotton Knits

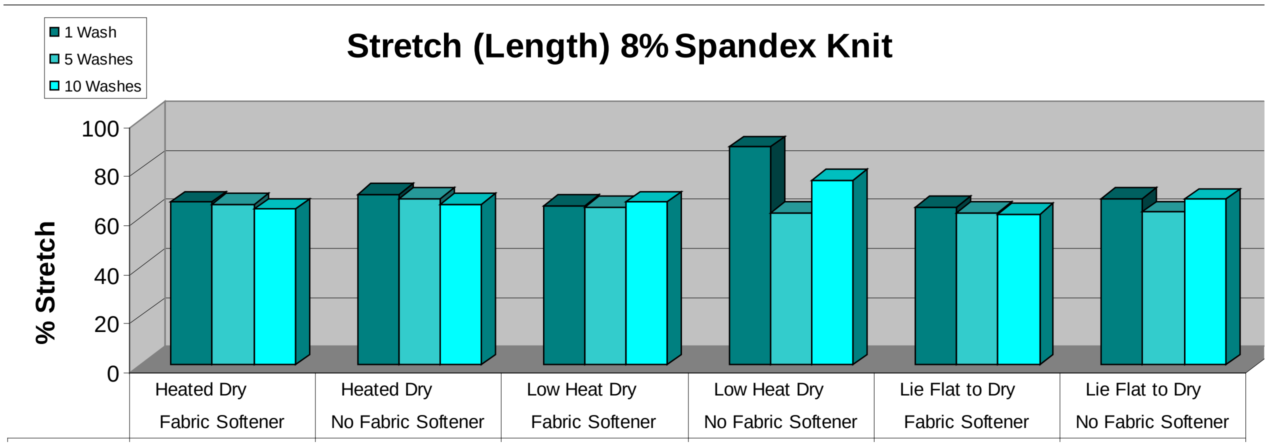

Figure 8. Evaluation of Stretch in the Length Direction for 8% Spandex Knits

Evaluation of Performance – Stretch: Stretch is between 20% and 95% in the Length Direction and between 21% and 100% in the Width Direction. None of these laundering conditions interfered with the stretch properties of these fabrics. Naturally the cotton/spandex fabric samples stretch much more than the 100% cotton fabrics. Stretch ranged between 20% and 95% in the length direction and between 21% and 100% in the width direction. The effects of using fabric softener on stretch could not be differentiated under these test conditions. After multiple washes, 100% cotton knits decreased, especially in the width direction, but this was not true for the cotton/spandex fabric samples.

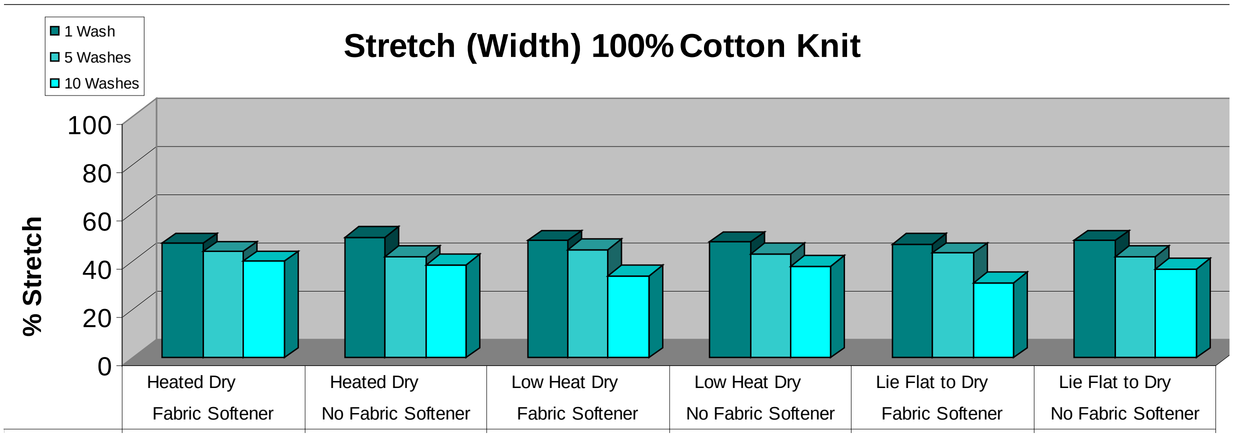

Figure 9. Evaluation of Stretch in the Width Direction for 100% Cotton Knits

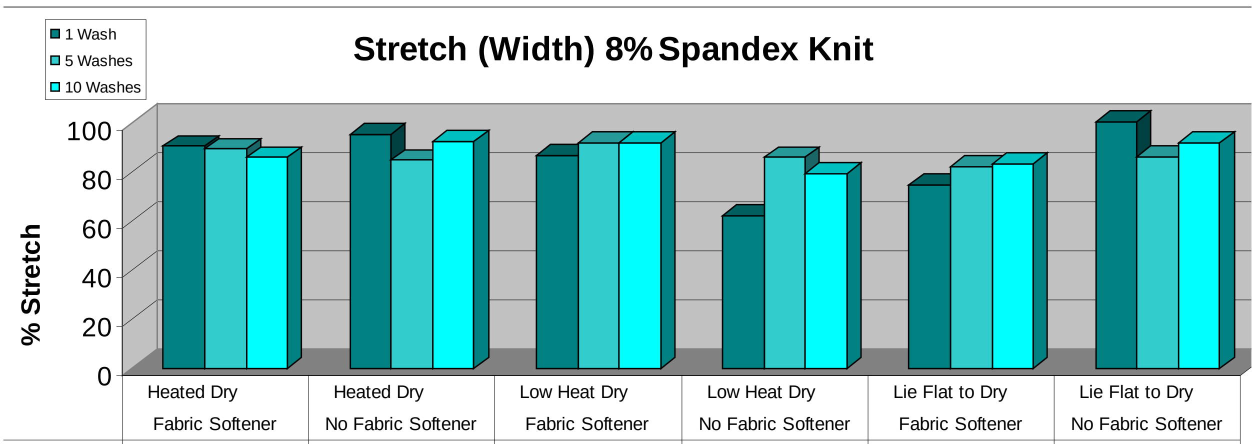

Figure 10. Evaluation of Stretch in the Width Direction for 8% Spandex Knits

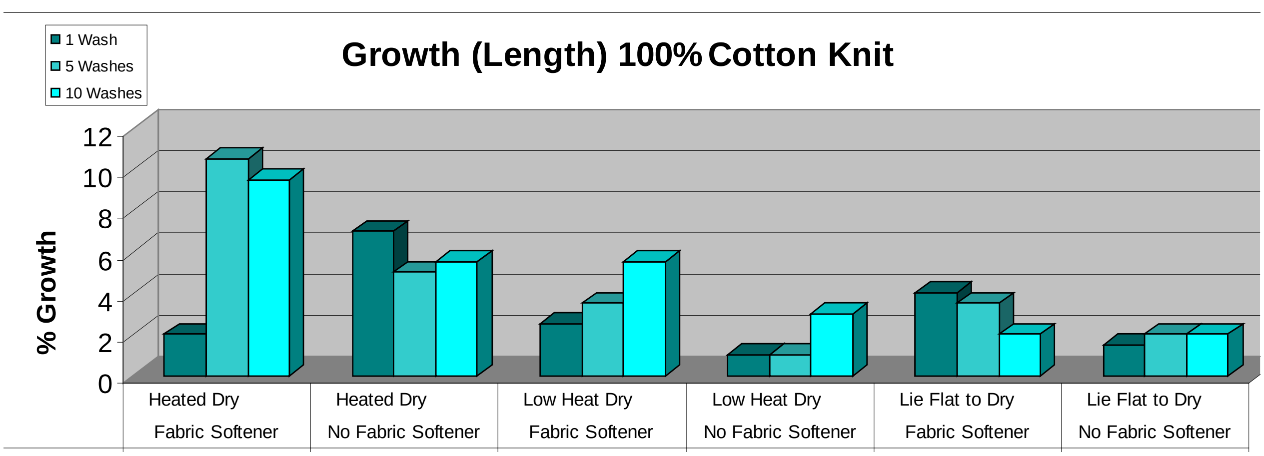

Figure 11. Evaluation of Growth in the Length Direction for 100% Cotton Knits

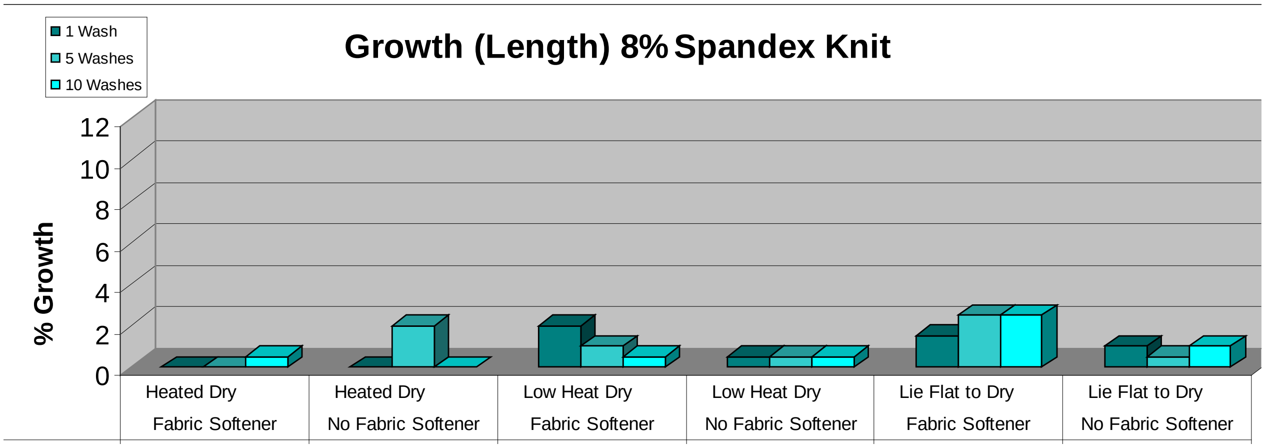

Figure 12. Evaluation of Growth in the Length Direction for 8% Spandex Knits

Evaluation of Performance – Growth: The cotton/spandex fabric samples show less than 5% growth regardless of the laundering conditions. The 100% Cotton fabric samples showed growth in the length direction of 5-15% when using the heated dry cycle, but showed less growth for the low heat dry cycle and when laid flat to dry. The trend for growth in the width direction of the 100% cotton fabric samples was completely reversed. The growth in the width was between 5-15% after 10 wash/dry cycles when using the low heat dry cycle and when laid flat to dry, but showed less growth for the heated dry cycle.

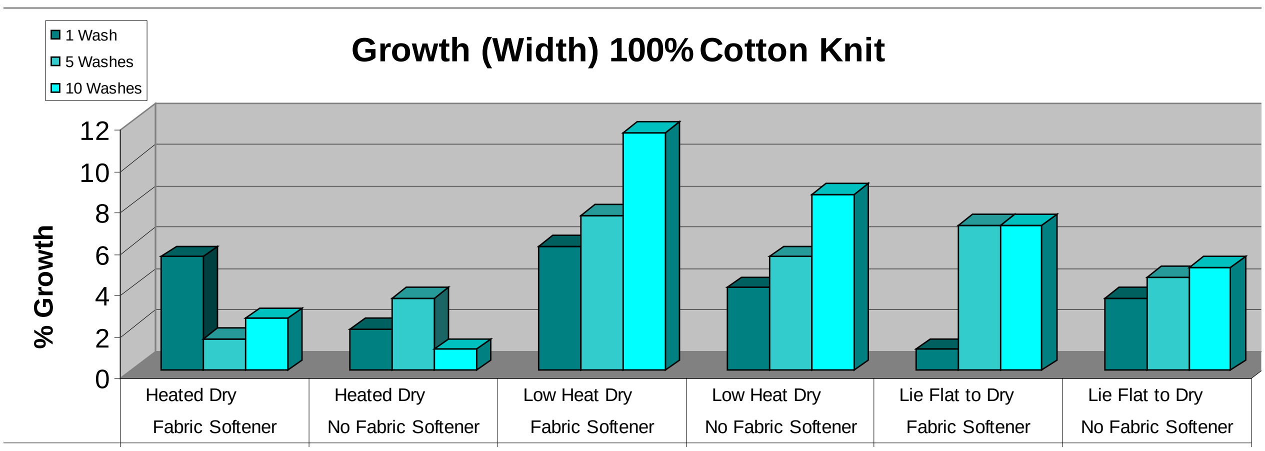

Figure 13. Evaluation of Growth in the Width Direction for 100% Cotton Knits

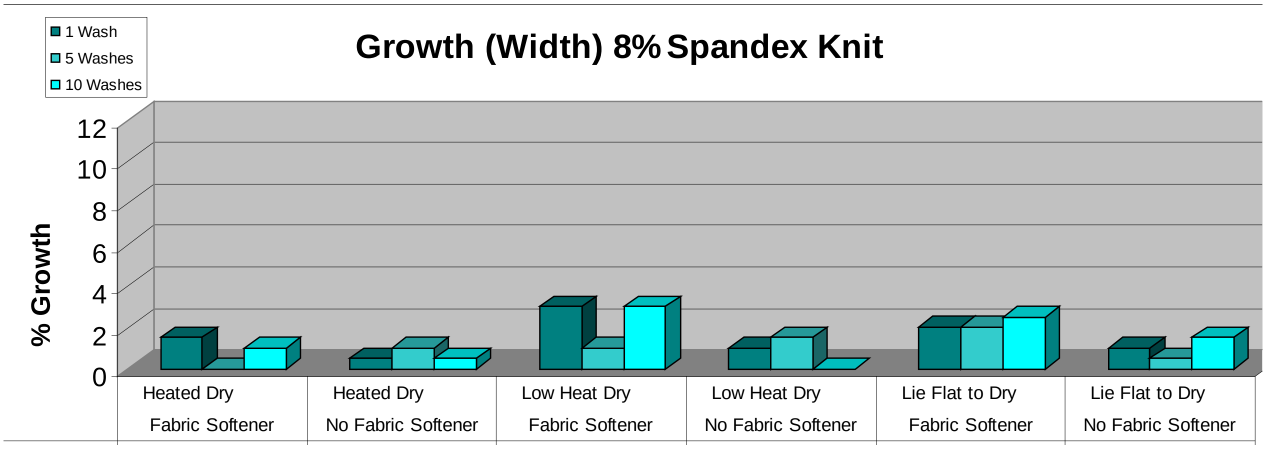

Figure 14. Evaluation of Growth in the Width Direction for 8% Cotton/Spandex Knits

Discussion

Stretch and Growth: Understanding the terminology of the textile terms stretch and growth are elemental to the discussion of fabric stretch and growth as defined by the test methodology and also to understanding the results of different test methods. Both ASTM D2594[7] and ASTM D6614[8] define stretch and growth as follows: *fabric stretch*, *n* -- the increase in length of a specimen of fabric resulting for a tension force applied under specified conditions. The difference usually is expressed as a percentage of the initial length of the fabric specimen. Fabric stretch differs from fabric elongation in that the latter (up to the point of rupture) reflects the instantaneously existing amount of stretch under a constantly increasing tension force. *Fabric growth*, *n* -- the difference between the original length of a specimen and its length after the application of a specified tension for a prescribed time and the subsequent removal of the tension[8] Fabric growth usually is expressed as a percentage of the length of the specimen prior to application of the tension.

The description of the differences between the two stretch and growth standard test methods points the importance of knowing when and to what products standard methodology should be used. The rate of load application may be the least understood part of both test methods and is likely to impact test results.

It should be noted that the study's samples, a 100% cotton single jersey and a 92%cotton/8%spandex single jersey are distinct fabrics. The 100% cotton fabric is considered in the comfort stretch category due only to its knitted construction, whereas, the cotton/spandex blend has additional stretch and recovery properties because of the spandex yarn plaited with a cotton yarn. This highlights the challenges of using current test methods to generate reproducible stretch/recovery data across multiple fibers and fabrics and suggests an opportunity for a more universal stretch/recovery test method across broad ranges of conditions.

ASTM D3512 Pilling Photograph Replica[9] was used to grade the study's samples for the prescribed laundering conditions and intervals. Samples were graded in standard atmospheric conditions using a MacBeth Sample Grading system under daylight illumination. All samples after laundering were judged to have a pill rating of 5= no visible pills. The 7-Point Cotton Incorporated experimental Fuzz Pill Scale was used to evaluation the laundering conditions impacted surface disruptions. The 7-Point Scale was developed to grade fuzzing, for which there is no standard scale available. The scale also visually represent a range from 7= no fuzz, through levels of slight, and medium fuzz, followed by a progression to slight, moderate, 1= severe pilling. The results from this grading process performed on non-conditioned samples under florescent illumination in an office environment. All samples graded between the 6 and 7, none to slight fuzzing levels. Therefore, on the non-comprehensive data set using subjective scales, it can be said that cotton/spandex fabric's surface changes were not evident when judging pills and fuzzing.

Conclusions

Based on the results of this study, the care label for 'stretch fabrics' of cotton/spandex blends can recommend washing and drying instructions according to the dominant fiber in the blend if the yarn and fabric utilize recommended construction procedures. The cotton/spandex fabrics shrank less than two percent more when dried in a clothes dryer when compared to air drying flat. Shrinkage occurred after the first wash, regardless of the drying method but the difference between drying flat and low or high heat drying was minimal after 5 and 10 wash/dry cycles. The appearance changes were not affected by the method of drying as smoothness, color change and fuzzing or pilling were not adversely impacted by drying in a tumble dryer.

The original scope of this study was to investigate the effect of the clothes dryer on the aesthetics and performance of stretch fabrics in order to determine the best care procedures for cotton/spandex blends. However, as noted above, many of the common consumer complaints for such blends were not observed, *even when using a tumble dryer on high heat*. Since the fabrics used in this study were constructed and wet-processed in a pilot lab under controlled conditions, this suggests that some of the consumer problems may arise because of construction and/or wet processing issues. Since wear testing was not part of this study, however, further investigation would be required to determine if such issues are truly the root cause of these problems.

For both 100% cotton and 92% cotton/8% spandex, the amount of stretch was roughly twice as much when evaluated by the ASTM D6614 method. This was an obvious response given the weight was twice a much. For the 100% cotton samples there was a high correlation between the amount of stretch in both D6614 and D2594. This was true regardless of the direction but the 100% cotton fabric was used as a control in this study and was not a 'comfort stretch' fabric. When a stretch fabric was tested, i.e. 92% cotton/8% spandex, there was virtually no correlation between the amount of stretch in D6614 vs. D2594. In addition, D6614 appears to have taken the fabrics well beyond their yield point and thus there was also no correlation between the amounts of growth in D6614 vs. D2594. This raises a real concern regarding the test method that should be used by the industry.

References

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