ABSTRACT

WYMAN, DIANA ANAHID. Dimensional Change in Home Laundering of Sewn Items versus Flat Fabric. (Under the direction of Pamela Banks-Lee.)

Dimensional change in the home laundering of textile items is often evaluated in the flat fabric state and again as a sewn item, usually using the same pass/fail criteria. This is a costly and time-consuming process.

If the behavior of flat fabric and the resulting sewn items is similar, as suggested by the equivalent pass/fail criteria, fabric testing should be sufficient. If the two are unrelated, fabric testing provides no practical information about final product performance and may be eliminated. Either case represents significant savings for the manufacturer and retailer in terms of time and money. Even if no exact mathematical relationship can be established, a better understanding of the differences between flat fabric dimensional change and sewn-item dimensional change will allow for the establishment of more practical specifications, better pass/fail decisions, and more efficient troubleshooting.

The research found that while fabric dimensional change provided some information about sewn item dimensional change, results were not equivalent. In general, sewn items may be expected to exhibit less dimensional change than the component flat fabrics. This research provides insight into the mechanisms of dimensional changes in the making-up process and the effect of these processes on dimensional change in laundering.

Dimensional Change in Home Laundering of Sewn Items versus Flat Fabric

by

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DEDICATION

This work is dedicated to my husband, Eric, and to my girls for their patience and support.

BIOGRAPHY

Diana Wyman is passionate about the textile industry. Wyman earned a BA in Fashion Merchandising from Radford University. During college, she worked in retail apparel and fabric sales. After graduation, Wyman went to work for McCalls Patterns and later managed the softlines testing lab at Specialized Technology Resources. Wyman is currently employed as an assistant editor for AATCC, writing and editing technical content for the Association's magazine and electronic newsletter. In her "spare" time, Wyman enjoys designing and sewing, especially for her two daughters.

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INTRODUCTION

Definitions

AATCC defines **dimensional change** as a generic term for changes in length or width of a fabric specimen subjected to specified conditions.[1] (Changes to thickness are usually evaluated separately.) In this research, evaluation and discussion will focus on dimensional changes following multiple home launderings.

The dimensional change of a textile is often referred to as "shrinkage," but this is not wholly accurate. While many textiles are smaller after laundering than before, others may be larger. For accuracy and clarity, "**shrinkage**" is used only for negative dimensional change (i.e., the "after" measurement is *smaller* than the "before" measurement). "**Growth**" refers to positive dimensional change (i.e., the "after" measurement is *larger* than the "before" measurement).

For the purpose of this study, "**flat fabric**" refers to fabric that has been dyed and finished, but not yet cut or sewn. For non-vertical operations, this is the product delivered from the fabric manufacturer, importer, or finisher to the end-product manufacturer.

Standardized test methods for dimensional change of sewn items generally refer to garments, although AATCC committee RA42, Dimensional Changes Test Methods is considering inclusion of "home textiles" in the title, scope, and text of TM150, Dimensional Changes in Garments after Home Laundering.[2] Despite its title, ISO 3759:2007(E), Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change, does include a procedure for "flat made-up textile articles," including sheets and drapes.[3] The term "**sewn items**" will be used as an inclusive terms for sewn textile products as they are delivered to the final consumer. Although a wide range of fabrics and sewn items will be considered in the Literature Review, the Experimental section will be limited to woven cotton fabrics and garment end-products.

Importance of Dimensional Change

Propensity to dimensional change in home laundering is an important characteristic of most textile apparel and household items. Dimensional change, along with colorfastness characteristics, is used to establish an appropriate care label, required for textile items in many countries.

Dimensional changes can affect the fit, function, comfort, and appearance of a sewn item. Poor dimensional stability is noticeable to consumers and may result in costly returns or a loss of repeat sales. As Jerram and Hoffman explained, "Shrinkage is swiftly and easily recognized...Suddenly: a jumper will no longer fit over a child's head, a fashion garment stops flattering and starts strangling...A garment that has shrunk by 5% is equivalent to a whole size smaller. Shrinkage of more than this can make an item impossible to wear."[4]

For these reasons, most textile testing protocols require evaluation for dimensional change in home laundering.

Cost of Testing

Dimensional change is one of the most costly properties to evaluate in terms of time and material. Accelerated methods exist, but most retailers and specifiers require full-scale laundering tests. This typically means three laundering cycles (~30 minutes each) and three drying cycles (~30 minutes each) , plus time to condition (4+ hours each time) and measure the specimens (~10 minutes each time) before and after laundering, sometimes after both one and three cycles. The total testing time is *at least* 11 hours.[5]

To get reliable results, AATCC Test Method (TM) 135-2004, Dimensional Changes of Fabrics after Home Laundering, requires three 380-millimeter (15-inch) square specimens of each fabric to be evaluated. These should be distributed across the length and width of the fabric, meaning a *minimum* fabric requirement of more than 0.75 meters of full-width fabric.[6] In comparison, the colorfastness tests required for establishment of a care label (colorfastness to laundering,[7] drycleaning,[8] and bleaching[9]) require less than 0.0075 square meters each.

Adding to the expense is the fact that a textile product is often required to be tested for dimensional change in both the flat fabric state and as a finished product, effectively doubling the cost of testing. It is this issue that will be addressed by the current research.

Implications

If the dimensional change of a fabric is, in fact, an accurate predictor of finished product dimensional change, or if a consistent mathematical relationship can be established, one phase of testing can be eliminated. In the second case, it may also be advisable to define separate dimensional change requirements for flat fabric and sewn products.

Fabric testing generally serves as a preliminary warning of any problems that might be encountered, prior to incurring the expense of purchasing notions and thread, cutting, and sewing. However, if there is no discernable relationship between dimensional change results in the flat and sewn states, this negates the rationale for separate fabric testing. A better correlation may be identified between finished products and seamed, interfaced, or otherwise-prepared fabric.

There is no clear concensus on how fabric dimensional change relates to that of the final sewn item. An informal survey of textile professionals yielded a variety of responses to the question of whether results were generally equivalent for fabric and garment dimensional change:

"Yes." (product research and testing manager, apparel and outdoor equipment brand/retailer)

"Yes, as long as you don't get seams involved with the measurements." (QA manager, camouflage brand)

"We usually see similar results, but garments tend to [have] a little less shrinkage." (development/QA manager, men's brand)

"Less change in garment than in the fabric." (director of product integrity, men's clothing retailer)

"No." (physical lab manager, apparel brand)

“Garments do react differently than fabrics due to the types of trims and seaming on the garments.” (softlines lab manager, commercial testing laboratory)

“I do think they behave differently. In addition to seams and such, you’ve got fused parts, parts with other things to hold it in place (zippers, grommets, extra sewing per that piece’s requirements) and all of those matter. They often can make it more stable.” (clothing design researcher, military contractor)[10]

It seems clear that scientific research is needed to determine if differences really exist between the dimensional change of flat fabric and sewn items, and if so, the nature of those differences.

LITERATURE REVIEW

Dimensional Change of End-products

It seems the question of garment dimensional change is more often approached from the practical standpoint than from that of pure research. Several books written for textile product manufacturers cover the issue in great detail. One of the most comprehensive resources is Solinger's *Apparel Manufacturing Handbook*, which addresses the philosophy of quality control as well as the specific operations for assembling, decorating, and finishing sewn items.[11]

While considerable scholarly research has been devoted to explaining, modeling, and predicting the dimensional changes of textiles in the fabric, yarn, and even the fiber state, surprisingly little has addressed the dimensional changes of finished products after laundering.

At the fiber level, cotton swells in water and with varying humidities. The swelling affects fiber length and diameter, which in turn influences yarn dimensions and subsequently, fabric dimensions.[12] The shrinkage of yarns constructed by various spinning processes was compared by Riva, et al.[13] Yarns produced by conventional ring spinning performed better than those produced by pneumatic spinning with real wrapping twist.

In the late 1930s, the Textile Institute examined the causes of shrinkage in cotton goods. The primary cause was determined to be swelling that led to external shortening and release of strains.[14] The effects of different finishes and water temperatures have also been studied (finish was important[15]; rinse temperature had no appreciable effect.[16])

Two explanations for the lack of data seem likely. If the dimensional change of sewn items is equivalent to that of flat fabric, there is no need to investigate sewn items separately. There is some evidence that this is the case, or at least that fabric dimensional change is the overriding factor in sewn-item dimensional change.

It may also be that the factors affecting the dimensional change of sewn items are many and varied, not lending themselves to a neat model.

End-products as Equivalent to Flat Fabric

A survey of more than 30 companies with established textile testing requirements found that all but one specified the same allowable dimensional change in flat fabric and finished product states, or did not differentiate at all.

In 1996, researchers presented work on the prediction of dimensional change for 100% cotton, knitted T-shirts during wear and care. It was reported that "The majority of difference between garment and fabric shrinkage during care is contributed to the different laundering habits of consumers and only a small part to relaxation of the fabric before making up and re-stretching of the garment by wearing it after each laundering cycle."[17] In this case, there should be no significant difference between results of controlled laboratory tests of dimensional change performed on flat fabric and those performed on sewn products.

End-products as Unique Specimens

AATCC TM 150-2003, Dimensional Changes of Garments after Home Laundering, states that "Measured dimensional changes [of garments] may be affected by garment construction, tensions, sewing threads or trims, in addition to fabric dimensional change."[18] The chair of AATCC's Committee RA42, Dimensional Change Test Methods, reiterated the difference in a 2006 *AATCC News* article. "A fabric, and garments made from the same fabric, may show different amounts of dimensional change." She listed number of layers, seams, hems, and construction details as some of the factors influencing this difference.[19]

ASTM International standards are defined for flat fabric, but are determined by the end use of the fabric. For example, ASTM D 4154-01, Standard Performance Specification for Men's and Boys' Knitted and Woven Beachwear and Sports Shirt Fabric, suggests a maximum allowable dimensional change of 2% for post-finished,

woven fabrics after five launderings.[20] ASTM D 7020-05, Standard Performance Specification for Woven Blouse, Dress, Dress Shirt & Sport Shirt Fabrics, allows 3% dimensional change.[21] Presumably, the same woven fabric could be used for men's sports shirts and other sports shirts, so it may be concluded that there is something different in the construction of these garments that warrants different dimensional change requirements. If the specifications were based on performance expectations, one would expect a stricter criteria for dress shirts than for beachwear.

Although the T-shirt study cited above concluded that most of the difference between fabric and garment dimensional change was attributable to varying laundering practices, it did report that "the construction of the garment itself also contributes to the difference" The researchers found that seams stabilized the shape of the garment and obstructed dimensional changes. [17]

In 2003, the Deutsches Wollforschungsinstitut (DWI, German Wool Research Institute) and the Institut für Nähtechnik (IfN, Institute for Sewing Technology) attempted to predict the amount of dimensional change associated with the making-up process.[22] Although this is somewhat different from the dimensional change experienced in laundering, there is an important relationship. If some of the residual shrinkage of a particular fabric is taken up during make-up, there should be that much less shrinkage in laundering.

Researchers found that even with identical production processes, different garments exhibited different amounts of change due to the various components of each garment.[22] Although the report did not find any reliable formula or test method for determining the extent of dimensional change during making-up, it did highlight important points which will be discussed in detail in the next section. Unpublished research at Colorado State University is also exploring the processes responsible for dimensional change during garment manufacturing.[23]

Factors in End-product Dimensional Change

If the case is to be made that end-product dimensional change is different from that of flat fabric, it is important to understand the changes the fabric undergoes in the creation of a final product. According to *Introduction to Clothing Manufacture*, the manufacturing functions are divided into several categories. The cutting room performs all the processes required to turn flat fabric into cut garment pieces. The sewing room is responsible for fusing, under pressing, pleating, embroidery, and quilting, in addition to actual sewing operations. The pressing room provides the final top pressing. The finishing section attaches buttons, labels, hangtags, and the like. Packing includes boxing folded merchandise or bagging hanging items.[24]

Spreading

The spreading process (superimposing plies of materials on a table in a manner which permits these plies to be cut simultaneously) can introduce tensions to the fabric. Since spread tension or slack can cause difficulties or waste during cutting, both should be avoided to the extent possible.[11,25] Excessive stapling of markers has been known to distort fabric pieces, but proper stapling or use of weights, adhesives, or clamps will eliminate this issue.[25]

The bottom plies of fabric are under significant pressure. For example, a 200-ply lay of shirting fabric can exert a downward pressure of as much as 40 kilogram per square meter.[25] Fortunately, since traditional fabrics are almost infinitely thin in comparison to their length and width dimensions, compression in this direction has no noticeable effect on the other dimensions.

Solinger claimed the tensions introduced at this stage would most likely be released while the fabric is waiting to be cut or during cutting—before sewing or laundering.[11] A more thorough treatment of this issue showed that this is true for most non-stretch fabrics (as used in the present study). Fabrics designed to have 10% to 50% stretch can be problematic. If plies are spread in a stretched state, the tensions are maintained in the lay, but contract after cutting or even after sewing.[26] While this will likely result in poorly-sized garments, as long as the

sewn item contracts prior to the pre-laundering measurement, there should be no effect on the dimensional change in home laundering.

Cutting

Theoretically, the action of cutting, whether by knife, shears, or die, could stretch the fabric, but probably only minimally and temporarily. Any noticeable drag on the knife or shear blade should be corrected for the sake of efficiency and accuracy before it is severe enough to affect the dimensions of cut pieces.

Once cut, some of the weaving tensions may actually be released. Since the preparation for testing dimensional change of flat fabric includes cutting specimens, any effect of cutting would be the same for a fabric test as for a finished product. An exception may be thermoplastic fiber fabrics in which the cut edges melt due to the heat and friction of the cutting blade. As with drag issues mentioned above, this situation should be avoided for multiple reasons. Melted edges often result in fusing of multiple plies or in uncomfortably stiff seam allowances in the final product.[17]

There is no published evidence that spreading or cutting affects the dimensional change of the finished product after laundering.

Sewing

Solinger listed the main production phases as cutting, sewing, and pressing and suggested that sewing was usually the most important.[1] Seams can stabilize the fabric and reduce dimensional change. Conversely, if the sewing thread shrinks significantly, it can cause increased dimensional change of the sewn item through puckering. Puckering is discussed in detail in a later section.

The sewing process itself, as well as the resulting seam, can affect the dimensions and the dimensional stability of a sewn item. Each layer is subject to different mechanical forces during seam construction, resulting in unequal tensions.[27]

In general, sewing thread, seam type, and stitch type are selected to complement the fabric and end use of the finished product. Much work has been devoted to identifying the ideal needle, thread, and seam construction for each application. “Correct selection of sewing thread requires consideration of its performance properties during sewing as well its performance in the completed garment under conditions of wear and cleaning.”[26]

Cotton threads generally increase in diameter and decrease in length, which may cause pucker in seams after laundering. Synthetic or blended yarns generally exhibit less shrinkage. Polyester and nylon yarns are processed specifically to ensure low dimensional change in laundering and dry heat. Between 0% and 1% shrinkage can be expected in washing at 100°C. Between 0% and 2% shrinkage is normal following heat treatments up to 150°C.[26]

Joining

Other forms of joining, including fusing, welding, cementing, and riveting, stabilize the fabric at the interface like seams, but do not generally cause puckering. Fusing produces a laminate by melting an adhesive layer between fabric layers. Fusing commonly takes place at 150°C, a temperature at which many fabrics are subject to thermal shrinkage.[26]

As fusible interfacings came into common use, they created new dimensional change issues. The British Interlining Manufacturers cited several such cases in 1978. In one instance, the fused front panels of a jacket were considerably shorter than the side panels. It was found that insufficient heat setting caused the base fabric to shrink considerably when exposed to the fusing press. The interfacing reduced the shrinkage, but could not maintain the original dimensions of the panels.[28]

Welding technology is used less frequently, and only under specific circumstances. Cementing with adhesives is rarely used as a means of construction, but is common in the form of sealing tape for the seams of waterproof items.[26] There does not appear to be any published data on the effect of such seam sealing on dimensional changes in laundering. It has been reported that welding and adhesives, or bonding technology, are becoming more commonplace in textile manufacturing operations.[24]

Fabric Compatibility

Several sources include warnings about joining fabrics with incompatible dimensional change.[4,27,29,30] A report of the American Apparel Manufacturers Association goes so far as to recommend, "Whenever possible, fabric from the same finishing lot should be used to minimize variation."[25] Elimination of this variable may reduce the need for sewn-item testing, but the joining of different fabrics is often necessary for aesthetic purposes (e.g., color blocking or decorative trim) and for functionality (e.g., lining or interfacing).

Schwartz said that "fabrics with very different physical properties when combined in a seam show these differences as pucker in subsequent handling, e.g., laundering."[27] Another source suggested that "if the two fabrics show a difference in dimensional change of two percent or more, pucker due to differential dimensional change may be expected to occur in finished garments."[26] Even relatively small dimensional changes may be deemed unacceptable if puckering or uneven shrinkage detracts from the overall appearance of the sewn item.

Other textile components of a finished item include labels, linings, interlinings, padding, insulation, lace, braids, and elastic. When these are joined to each other or to the base fabric, the overall dimensional change of the sewn item is affected by all the components. Shrinkage during manufacture and cleaning must be controlled so that the finished item is not distorted.[26]

The addition of non-fabric components may also result in different dimensional change values for the finished item. Zippers, appliqués, and such may be more dimensionally stable than the base fabric.[29] The area of fabric

directly attached to these components is kept at or near the original dimensions while other areas may become smaller or larger.

Embroidery

A study of embroidery on knit fabrics found that while the fabric itself had the biggest impact on dimensional change, the "additional shrinkages associated with the embroidery were not insignificant."[26] For embroidery and other decorative sewing, the stitching and stabilizing fabric can be expected to reduce dimensional change, but the heat of "baking" to remove excess backing fabric may cause additional shrinkage or swelling of the base fabric as described under steaming/pressing.[11]

Steaming/Pressing

Many items undergo steam treatment during making-up.[31] In fact, Brown reported that most sewn items require at least minimal pressing with some combination of heat, steam, and pressure.[29] There are three general pressing operations: under-pressing of garment parts during making up, molding to give a three-dimensional shape, and top-pressing to finish the fully assembled item.[32] Under-pressing includes the various pressing necessary before proceeding to the next step of assembly (e.g., flattening seams before hemming, smoothing collars and cuffs before top-stitching.) The most common means of pressing is with a steam iron or buck press.[29] Molding is most effective on wool fabrics.[32] It might mean stretching the fabric to cover a rounded form or pressing in to remove excess width. Top-pressing is also known as finishing. A relatively new steam process is the application of "tagless labels."[32]

In many cases, temperature, pressure, and time are selected to avoid dimensional change during pressing operations. Occasionally, however, dimensional change is unavoidable or even desirable. This is the case when fabrics are to be molded. A consistent amount of shrinkage is necessary to allow molding without randomly undersizing the finished items. Manufacturers may carry out a preshrinking process before cutting and spreading to help control dimensional change during make-up and finishing.[26]

Vacuum-suction pressing tables extract steam from pressed fabrics "to minimize garment distortion after pressing."[29] Steam, followed by cooling, and accelerated by suction or compressed air is used to set wool fabrics.[32]

Research by DWI found that of all the steps in the making-up process, operations employing steam and heat had the greatest effect on fabric shrinkage. [22] Other sources confirm that moisture may swell fibers or shrink a fabric.[11,26,32] Steam treatments vary from precise molding to a simple pass through a steam tunnel, but it has been noted that even the relatively mild conditions of a steam tunnel can be damaging to certain fibers; air turbulence should be limited for acrylics since excessive agitation makes the fabric pliable and subject to deformation.[26] If the damage is not so severe as to fail inspection, it will almost certainly affect the dimensional change in laundering. Of course, it is hoped that manufacturers are aware of their materials' limitations and adjust their processes so that damage of any kind is rare.

Solinger claimed that the dimensional change during production, particularly in molding with heat and/or moisture, could be calculated. "Many apparel manufacturers solve this problem of shrinkage, during molding, by innumerable 'cut and trys,' not aware that means exist for calculating the answers with the use of fabric tests before trial garments are made."[11] The standardized test methods for dimensional change published by several organizations were cited. The DWI investigation found that the exact amount of change could *not* be reliably predicted. Both sources cited varying equipment and processes as the main sources of difference. Solinger maintained that the difference can be controlled and that lab tests remain valid.[11] DWI concluded that "no laboratory method was able to produce reliable data for all processing methods and fabrics."[22]

Garment Finishing

While most finishing occurs in the flat fabric state, "permanent press" treatment can be carried out on a finished item. Since the function of these resin finishes is to maintain the shape of the item, they generally reduce dimensional change. Untreated flat fabric will exhibit greater change than the finished item.

Some fabrics are pre-cured as flat fabric, and this is becoming more common as garment manufacturers do not have the equipment or expertise to perform the treatment and curing. In post-cure processes, the fabric is resin-treated during finishing and the finished item, with pleats and creases pressed in place, is passed through a curing oven. In cases of dipping, spraying, or vapor-phase treatment, the finish is applied and cured after making-up.[26] In all forms of permanent press treatment, shrinkage and puckering often occur.[25]

Garment Washing

Obviously, washing a finished item as part of the finishing process will affect the dimensional change after home laundering. It is understood that dimensional change in laundering is progressive, but that the first laundering causes the majority of relaxation shrinkage.[29] This has shown to be particularly true for cotton knit fabrics; for cotton wovens, the relaxation of weaving tensions is spread over more cycles.[33] Nonetheless, if the first cycle occurs before the customer ever receives the item, he or she will experience less change than might be predicted by a fabric test.

Garment washing was once reserved solely for denim garments, but today the techniques are used for softness, contrast, and aesthetics.[25] In December 2007, AATCC conducted a two-day symposium focused specifically on "Fashion Garment Washing: Trends, Fabrics, Technologies & Sustainability."

Garment washing is also used for preshrinking.[34] In this case, the purpose is specifically to decrease the dimensional change experienced later in the lifecycle of the sewn item.

A garment wash can be a simple rinse or a complex series of steps including abrasion, bleaching, and softening. Chemicals and enzymes may be used.[25] In some cases, the processing temperature is quite high and can be expected to cause a noticeable dimensional change. In others, a resin treatment may actually prevent shrinkage in selected areas of the finished item.[35]

In addition to chemical washes, some looks require physically stretching or wrinkling the fabric,[35] which will obviously affect the starting dimensions as well as the propensity to grow or shrink after laundering.

Packing and Storage

The vacuum-packaging process is designed specifically to avoid dimensional change. Moisture is removed from finished items with hot, dry air. The items are then cooled with cool, dry air and encased in plastic. The conditioning process "permits the garment to be compressed with vacuum action without wrinkles or creases which remain in the garment after the sealed vacuum sack is opened." When the sack is opened, the fabric quickly regains moisture and releases any wrinkles or creases.[11] Performed properly, this process does not change the actual size of the item or create wrinkles that may mask the true dimensions.

Storage areas are often associated with heat and humidity and as discussed in the Pressing section, these conditions have the potential to influence dimensional change, However, as with other processes, storage should not affect dimensional change if done properly. Solinger recommends maintaining "a temperature and humidity approximating those used for testing textiles; 70°F [21°C], 65% humidity," At the least the storage conditions should not "go beyond levels which cause the fabrics stored there to either decrease or increase their moisture content to a point which affects the fabric's working characteristics or other quality factors."[11]

Suspended storage of finished items in controlled or uncontrolled conditions *has* been found to affect dimensional change.[8] Empirical evidence in any store or closet also shows that certain garments stored on hangers can become stretched or distorted over time. The heat and humidity of warehouses and transport

vehicles may further promote stretching due to gravity. For flat and folded items, any relaxation due to ambient conditions in storage is likely similar to that experienced by flat fabric in storage. For this reason, storage was not considered in this comparison of flat fabric and sewn items.

Nature of End-product Dimensional Change

Several types of dimensional change can occur in textile materials. The two basic types cited by most literature are relaxation shrinkage and felting.[4,29,36] Felting is particular to wool and similar animal fibers, and will not be addressed in the current study. Most types of dimensional change occur in the fabric regardless of whether it is part of a sewn item or not. Only puckering is unique to sewn items.

Relaxation Shrinkage

Relaxation shrinkage is not really shrinkage, but a return to the natural dimensions after being stretched in the production process, particularly during weaving.[11] This type of change is expected from most woven fabrics whether in flat form or in a sewn item, and it is this type of change that most standardized tests for dimensional change attempt to measure.

Swelling Shrinkage

Swelling shrinkage can also occur when textiles are exposed to humidity or wetting conditions.[11] This is particularly likely during the steam processes in the manufacture of sewn items. Sewn items certainly experience some humidity between the flat fabric state and the finished product, however, this type of change is generally reversible.[11] Under high humidity, some fibers or yarns swell. This crimps and shortens the yarns crossing perpendicularly as they weave around the now-larger yarns. The overall fabric thickness also increases.[11] When conditioned to standard atmospheric conditions, the yarns in both directions usually return to their normal dimensions.[11]

Fusion-Contraction

Synthetic fibers can permanently shrink on exposure to high heat.[11,36] In contrast with swelling that increases fabric thickness, contraction decreases fiber diameter and consequently, fabric thickness. This effect can, and should, be prevented by heat-setting or avoiding extreme temperatures.[11] Fusion-contraction will not be addressed further as it is a defect rather than a normal dimensional change phenomenon.

Seam Pucker

Puckered seams are one noticeable effect of dimensional change in sewn items that can not be evaluated in the flat fabric stage. Pucker may occur when an item is first sewn, but this is easily identified and corrected.[30] The specific models[27,37,38] for this phenomenon are of little value in predicting dimensional change after laundering, but the factors that affect initial puckering give some indication of what might affect puckering propensity after laundering. Inui and Yamanaka concluded that the conditions for seam stability (minimal puckering) are:

- Minimum thread tension
- Greater extensibility of sewing thread
- Finer stitch length
- Thicker fabric
- Greater bending stiffness of fabric
- Greater extensibility of fabric.[37]

Laundering inevitably changes the initial values for some of these factors and may lead to puckering even if none existed prior to laundering. Puckering may also occur when the item or item components are pressed or wetted in the course of processing.[26] This provides a different starting point for dimensional change after home laundering.

Several studies have confirmed the correlation between increased fabric thickness and decreased puckering.[38,39] Not surprisingly, increased fabric weight had a similar effect.[38] While the relationship between thickness and weight is obvious, Stylios and Lloyd proved it experimentally.[38] They found a correlation coefficient of 0.953

between fabric thickness and weight, and a clear trend of increasing pucker acceptability at higher thicknesses/weights.[38]

The thickness/weight connection to puckering was partially explained by Malek, et al.'s "limit of contraction," or the maximum in-plane compression that a fabric can accommodate before any visible pucker occurs.[40] As the limit increases, pucker decreases. The same study found that limit of contraction values increase not only with increases in weight and thickness, but also with fabric bending stiffness.[40]

"Structural jamming" is a similar phenomenon. Cheng and Poon explained that sewing threads displace the normal positioning of yarns in the fabric.[39] The displaced yarns try to return to their original positions and are prevented from doing so by the sewing threads, distorting the seam. Plain weave fabrics, with a high degree of interlacing, allow less yarn movement and result in more puckering. Twill weaves, with longer floats, allow more movement and less puckering.[39]

The same holds true for any fabric characteristics that affect yarn movement. A 1978 article in *Bobbin* magazine showed that a chainstitched seam is less likely to pucker than a lockstitched one because there is no crossing or looping of the sewing thread within the fabric. This creates less displacement of fabric yarns.[30] Fewer stitches per inch and finer sewing threads have a similar effect.[27,37]

A different explanation for the same phenomenon relates puckering to the elasticity of the stitch.[11] The 101 and 401 chainstitches are described as more elastic than 301 lockstitch because they contain more thread per stitch (Fig 1). The loops structure also adds some width at the end of each loop. The thread length making up the loop can be pulled into the stitch when stretched.[11] As mentioned, greater thread extensibility and minimal thread tension are conducive to reduced puckering.[37]

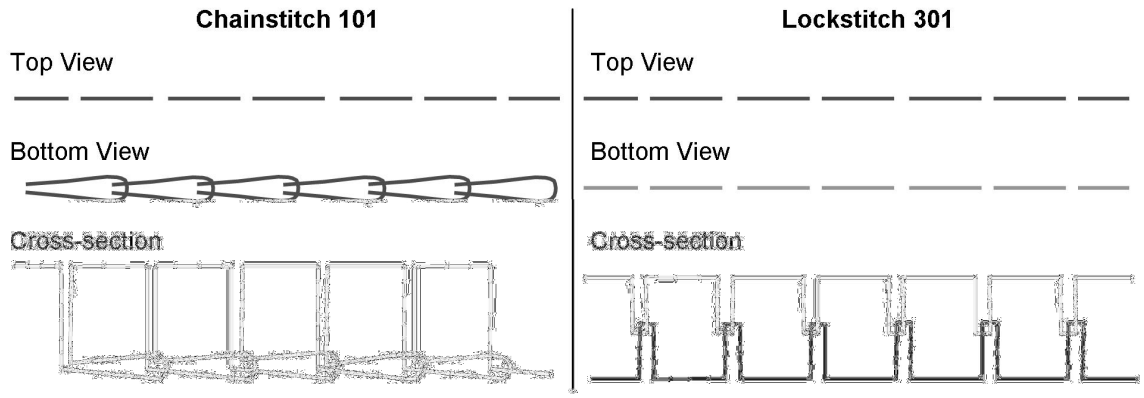


Fig. 1. Standard stitch types as listed in ASTM D6193-97(2004), Standard Practice for Stitches and Seams.[41]

Seams parallel to the weft tend to exhibit less puckering than those sewn parallel to the warp because weft yarns can move more easily along the warp yarns, relieving distortion or tension.[39] Seams sewn in the bias direction have the most mobility and the least puckering.[30,39]

EXPERIMENTAL

Materials

Fabrics were selected based on availability. All fabrics were cotton wovens weighing 99–256 g/m² (2.9–7.5 oz/yd²). Specimens were not taken from the beginning or end of sample rolls or bolts. Selvedge edges were also removed.

- Fabric A (Dynasty Collection, Rockland Industries Inc.) was a plain weave, 100%-cotton fabric weighing 114 g/m² (3.4 oz/yd²) and a with crease-resistant finish. According to the manufacturer, the fabric was preshrunk to allow 3% residual shrinkage for care instructions “machine wash cold with like colors, delicate cycle, line dry, low heat, cool iron, do not bleach.”
- Fabric B (Wideharbour Twill, Galey & Lord Inc.) was a 3/1 left-hand cotton twill. The fabric weighed 256 g/m² (7.5 oz/yd²). No specific care instructions were indicated.
- Fabric C (Sew Essential Muslin) was 100%-cotton, plain weave fabric weighing 99 g/m² (2.9 oz/yd²). The care instructions were, “machine wash cool, delicate, no chlorine bleach, line dry.”
- Fabric D (Baby Basics Gingham, Springs Creative Products Group LLC) was a printed, 100%-cotton, plain weave fabric. The care instructions were, “machine wash cold, delicate cycle, no chlorine bleach; tumble dry; warm iron.”

Procedures

A number of standardized test methods for dimensional change are in common use today. Additional methods are used to represent the various treatments a fabric may undergo on its way to becoming a final end-product. It was the intention of this project to use combinations and modifications of these methods to determine the effect of each stage of production on dimensional changes in home laundering. Dimensional change experiments in this study were based on AATCC TM 135. All measurements were made with the same steel ruler, marked in millimeters. Only the weight of the ruler was applied.

All specimens were conditioned for at least four hours prior to each measurement in a Parameter Generation & Control (PGC) conditioning chamber set to standard atmospheric conditions (21C/70F, 65% relative humidity). Fabrics were stored and transported flat. Handling was minimized throughout testing.

TM135 calls for three laundering cycles (or "an agreed number of cycles").[6] At least one study has indicated that for cotton, woven fabric, 10 launderings may be necessary to achieve complete relaxation of the weaving tensions.[42] A five-cycle test is referenced in ASTM International specifications and in *A Guide for Garment Evaluation*, published by the American Association for Textile Technology.[43] Five cycles, with measurements after the first, third and fifth, were used for all experiments in this study.

Additional specimens were also used. TM135 calls for three specimens, cut from across the width and along the length of the fabric; six specimens were tested for most conditions in this study. The number of specimens for each condition in each experiment is listed in Table I. A system of letters and numbers was used to identify all specimens during testing and in the Appendices to this report. Letters (A, B, C, etc.) indicated the position across the width (weft) of the fabric. Numbers (1, 2, 3, etc.) indicated position along the length (warp) of the fabric. Other modifications to the standard method are noted in the following sections.

TABLE I.

Number of Specimens and Measurements by Condition

	# Specimens/Fabric	Specimen Size	# Warp Measurements/Spec.	# Weft Measurements/Spec.
Seam Experiment				
Control[a]	6	400 × 400 cm	3	3
Warp Seam	6	400 × 400 cm	1	3
Weft Seam	6	400 × 400 cm	3	1
Seam Experiment (2)				
Control	6	400 × 400 cm	3	3
Warp Seam	6	400 × 400 cm	1	3
Weft Seam	6	400 × 400 cm	3	1
Fusing Experiment				
Control (w/hand-pressed)	6A, 6B, 2C, 1D	380 × 380 cm	3	3
Hand-pressed	6A, 6B, 2C, 1D	380 × 380 cm	3	3
Control (w/fused)	6A, 6B, 2C, 2D	380 × 380 cm	3	3
Fused	6A, 6B, 2C, 2D	380 × 380 cm	3	3
Compatibility Experiment				
Seamed	6	400 × 400 cm	(1/3)[b]	(3/1)[b]
Pressing Experiment				
Pressed	6	400 × 400 cm	3	3

[a]Seam controls also used for compatibility and pressing experiments.
[b]One measurement along warp/weft seam; three measurements across seam.

Seam Experiment

Warp and weft seams were constructed by folding fabric specimens in half, stitching, and cutting the seam allowances open. Flat fabric served as the control. Specimens (400 × 400 mm) slightly larger than those specified in TM135 (380 × 380 mm) were used to allow for seam allowances.

Thread, needle, and stitch selection for experimental seams were based on fabric weight and an assumed end-use as a man's shirt.

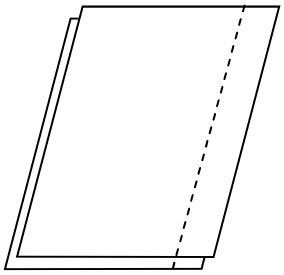


Fig. 2. Superimposed seam SSa-1 produced with stitch type 301.

As described in the Literature Review, lockstitched seams tend to result in the most pucker. In order to replicate a worst-case scenario, this type of stitch was chosen for all experimental seams. A simple superimposed seam was used. The seam is illustrated in Fig. 2; refer to the Literature Review for illustrations of the stitch. The selection of

stitch type 301 and seam type SSa-1 is representative of common apparel construction practices. Stitch type 301 is the most commonly used stitch for apparel manufacturing because it provides tight seams with minimal thread.[44] Union Special Corp.'s *Garment Construction Guide* lists this particular combination of stitch and seam for several of the sewing steps in constructing a men's dress shirt.[45]

Thread manufacturers American & Efird,[46] Coats,[47] and Gütermann[48] recommend a polyester-wrapped, polyester-core thread for shirting applications.

For lockstitching men's shirts, Coats suggests 24 or 30 tex thread for both needle and bobbin.[4] American & Efird recommends 24 tex for "light" fabric weights and 30 tex for "medium" weights used to construct dress shirts.[46] Appropriate needle size is based on both fabric weight and sewing thread size. Most sources provided a range of needles suitable for the fabrics used in this study. Based on the recommendations listed in Table II, a sewing thread size of 27 tex and a size 70 needle was used for all experimental seams. A stitch length of 1.8 mm (14 stitches per inch) and a 1.3-cm (½-in) seam allowance was used for all seams.

TABLE II.

Sewing Thread and Needle Recommendations

Source	Fabric/End Use	Thread Size (tex)	Needle Size (metric)
American Apparel Manufacturers Association[25]	68-136 g/m² (2-4 oz/yd²)	16-24	–
	136-203 g/m² (4-6 oz/yd²)	24-30	–
	136-271 g/m² (4-8 oz/yd²)	30-40	–
	Shirts/Blouses	18-30	–
	Work shirts	35	–
	–	21	65
	–	24	70
	–	27	75
	–	30	75
American & Efird Inc.[46]	68-136 g/m² (2-4 oz/yd²)	16-21	–
	136-203 g/m² (4-6 oz/yd²)	24-30	–
	203-271 g/m² (6-8 oz/yd²)	30-50	–
American & Efird[49]	Shirts	–	65-75
Coats Thread Recommendations[47]	Men's shirts (lockstitch)	24 or 30	70
Coats Epic Datasheet[50]	–	24	70-90
	–	30	80-100
Gunzetal[51]	Dress shirts (lockstitch)	18-27	60-80
	Casual shirts (lockstitch)	21-27	65-90
Gütermann[48]	Shirts and blouses	25	–

An attempt was made to evaluate specimens with unpressed seams to eliminate additional variables from the heat, pressure, or steam of pressing; however, it was found that measurements were not repeatable. Seams were pressed flat before the original measurement with the hand iron at "cotton" setting with no steam. At this setting, the temperature cycled between 163°C and 177°C (325°F and 350°F) at the center. A Black & Decker Press 'n Go S220 iron was used for all hand pressing. The mass of the iron with no water was 797 g. The surface area of the heated plate was 161 cm^2, giving a vertical pressure of just under 5g/cm^2. Vertical pressure for initial pressing was equal only to the weight of the dry iron, with no movement in the plane of the fabric

Testing of seamed and control fabric was based on standardized test methods for flat fabrics and garments. TM135 is specifically for evaluating flat fabric (or tubular fabric in the case of circular knitted fabrics produced on body-width machines)[6] by measuring the distance between sets of benchmarks before and after laundering.

TM150 uses essentially the same benchmark technique to evaluate fabric that has been assembled into garments. An option is provided for measuring the actual length and width of garment panels. “Benchmarks across garment panels are sometimes used, such as, from side seam-to-side seam, the full length or width of a garment and in other selected garment locations.”[18] ISO 3759 *requires* these types of measurements on garments (benchmarks are used for flat fabrics). “Measure between specific points, preferably at seams or between points where seams meet.”[52]

Since the purpose of this study was to differentiate between fabric and sewn item dimensional change, seams were incorporated into the measurements. Flat (control) specimens were benchmarked three times in the warp direction and three times in the weft direction. Each seamed (experimental) specimen was benchmarked once along the seam and three times across the seam. Each set of original benchmarks were approximately 254 cm (10 in) apart.

For each fabric (A, B, C, D), the control, warp seam, and weft seam specimens were laundered together. Specimens for the fabric compatibility were also included in the load. For the first wash of Fabric A specimens, preliminary fusing specimens were included.

Specimens were washed in a normal cycle with warm water (40C/105F) and dried at the normal setting, as defined by the AATCC monograph, “Standardization of Home Laundry Test Conditions.”[53] Ballast was used to make a total load of 1800 ±100 g. The load was weighed (unconditioned) prior to the first cycle. The same specimens and ballast sheets were used for successive loads although there was some decrease in weight from loss of lint and removal of loose threads. Loose threads were cut off after each wash cycle to prevent tangling or snagging. All loads were laundered with AATCC 1993 Standard Reference Detergent.

The dryer was run for a total of 25 minutes per cycle to dry all specimens and ballast. After cycles two and four, the load was transferred directly from the dryer to the washing machine to begin cycles three or five, respectively.

After laundering, there was some wrinkling and creasing, and puckering along seams, particularly of Fabric C. Measurements were initially taken without pressing to avoid introducing the additional variables of heat, steam, and pressure. After the fifth wash and corresponding measurements, all specimens were pressed with the same hand iron used to initially press open the seams. The iron was set to "cotton," with steam. With water for steam, the total iron mass ranged from 803 g ("Min" fill line) to 905 g ("Max" fill line). This provided an initial pressure of 5.0–5.6 g/cm^2. Some pressure and movement was required to smooth the laundered specimens.

Fusing Experiment

No standardized tests exist for fusing, welding, or cementing. For operations involving fusing, it has been recommended that "production garments should be subjected to the appropriate cleaning methods on a regular basis. One garment in each cloth and fusible combination should be tested at least every two working weeks."[24] The American Apparel Manufacturers Association suggests "each lot of [interfacing] and fabric to be bonded should be tested for thermal and wash shrinkage."[25]

Because of the widespread use of fusible interfacing in sewn items,[54] interfaced specimens were included in this study. Other joining methods are less common and were not addressed.

A medium-weight (126 g/m², 3.7 oz/yd²) fusible interfacing (Pellon ShirTailor 950F) was used. The interfacing is promoted for use in "collars and cuffs of all shirtings."[55] The interfacing manufacturer's instructions for fusing were "Cover with a DAMP press cloth…With iron at medium permapress steam setting, press FIRMLY for a full 15 seconds…Repeat, lifting and slightly overlapping iron until all interfacing is fused. Steam press on right side."[56]

Fabric specimens (400 × 400 mm) and interfacing specimens (380 × 380 mm) were initially fused with the steam iron set at medium (cotton blends) for 15 seconds, first to the interfacing side, and then to the fabric face,

as recommended. Only the mass of the iron plus water was used as pressure. The corners of each specimen were stitched across diagonally to secure the interfacing to the fabric.

After the first laundering cycle of Fabric A, the interfacing was completely delaminated from the fabric and held in place only by the stitching. It was assumed that this was due to insufficient pressing, the large area, and unsecured edges of the specimen. In garment applications, interfacing is generally secured by seams on most or all sides. It is often enclosed between layers of fabric and protected from the rigors of laundering. In addition, interfacing is not used for large open areas as represented by the 400-mm squares. In a typical man's shirt, the widest section of interfacing is at the front edges of the collar or the cuff. Neither is usually more than 100 mm (4 in) at the widest point and both are secured by seams on all edges, fabric layers on both sides, and usually at least one row of topstitching.

To determine a suitable method for evaluating fusing, specimens of varying sizes were prepared by stitching a fused square to an un-fused square and laundering. None delaminated as in the preliminary trial, so it was determined that with more pressing and secured edges, specimens up to 380 × 380 mm could be used. The largest possible specimen size was desirable to avoid the appearance of changes due to slight variations in measuring.

Specimens (380 × 380 mm) were cut and benchmarked in warp and weft directions. One quarter of the specimens were fused to an equal-sized piece of interfacing. The damp press cloth was not used. Instead, the hand iron was set to high (cotton) with steam and used to press the interfacing side of the composite. Pressure and movement of the iron was necessary to remove any bubbles and ensure a secure fuse. The fabric side was also steam-pressed on high.

It is impossible to separate the heat and steam of the fusing process from the fusion itself. Instead, a separate sample was prepared to represent only the heat/steam component. This treatment was called "hand-pressing" to

differentiate it from the machine-pressing treatment described in the Pressing experiment. Un-fused specimens were hand-pressed on both sides in the same manner as described above.

Half of the specimens were considered controls and were not fused or pressed prior to laundering.

Each fused specimen was placed, right sides together, with a control specimen in the same orientation. The pair was stitched along three edges (stitching parameters are described in the Seam Methodology section). Corners were cut and the pair was turned right side out. The seamed edges were pressed lightly to flatten them, taking care to keep the iron from benchmarked areas. Finally, the fourth side was stitched across.

Pressed and control specimen pairs were sewn together in the same manner. Six examples of each condition were prepared for Fabrics A and B. Due to limited sample size, fewer specimens of Fabrics C and D were prepared.

Original benchmarks were approximately 200 mm (8 in.) apart. Specimens were conditioned for at least four hours before each measurement. Measurements were taken before any treatment and after hand-pressing/fusing and sewing, as well as after one, three, and five laundering cycles. A final measurement was taken after five washes plus a final press with the hand iron.

All test and control specimens of Fabric A and B were washed in a single load with ballast. Fabrics C and D (with ballast) were washed in a second load. To further ensure that interfacing would not delaminate from the fabric during laundering, the delicate wash setting and cold water were used.[53] Specimens were hand-pressed after the fifth wash and corresponding measurements, using an iron set to “cotton,” with steam. Some pressure and movement of the iron was required to smooth the laundered specimens.

Fabric Compatibility Experiment

Three squares (400 × 400 mm) of each fabric were cut in half, parallel to the warp. Three squares of the same fabric were split parallel to the weft. The cut edge of each warp specimen was joined to the cut edge of a weft specimen. Fig. 3 illustrates this process. A total of six compatibility specimens were prepared for each fabric. Seams were sewn with the same thread, needle, stitch type, and stitch length as described for the Seam experiment. Seams were lightly pressed open to allow more consistent measurements.

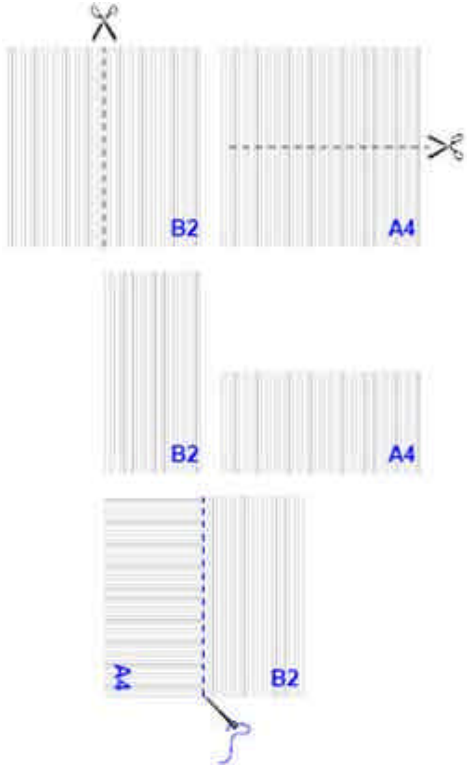


Fig. 3. Construction of test specimen for fabric compatibility test.

Compatibility specimens of each fabric (A, B, C, and D) were laundering with the corresponding control and seamed specimens. The same control specimens were used for the Seam and Compatibility experiments.

Compatibility specimens were benchmarked once along the seam and three times across the seam. Each set of original benchmarks were approximately 254 cm (10 in) apart. Benchmarks were measured with a steel ruler

after one, three, and five launderings, as well as after a final hand pressing. Specimens were conditioned for at least four hours prior to each measurement.

As in the Seam experiment, all specimens were hand-pressed only before the initial measurement and after the fifth wash and corresponding measurements. The iron was set to "cotton," with steam. Some pressure and iron movement was required to smooth the laundered specimens.

Pressing Experiment

Test methods have been developed to replicate steaming and pressing conditions for the evaluation of properties other than dimensional change. AATCC TM131-2005[57] and ISO 105-P02:2002,[58] Colorfastness [Colour fastness] to Pleating: Steam Pleating, use a jacketed steamer or a home pressure-cooker to simulate "the action of steam pleating processes." Three levels of steaming severity are outlined (Table III). The method advises that "the severe test is intended primarily for wholly manufactured textiles such as those made from polyamide and polyester fibers. It should not be used for textiles containing wool." No precision or bias data is reported.

TABLE III.

Steaming Conditions for AATCC TM131[57]

Test	Duration	Pressure (Gauge)	Temperature
I. Mild	5 min.	0.35 kg/cm^2 (5 lb/in^2)	108°C (226°F)
II. Intermediate	10 min.	0.70 kg/cm^2 (10 lb/in^2)	115°C (239°F)
III. Severe	20 min.	1.76 kg/cm^2 (25 lb/in^2)	130°C (266°F)

AATCC TM133-2004, Colorfastness to Heat: Hot Pressing,[54] and ISO 105-X11:1994, Colour fastness to hot pressing,[59] use heat and pressure with varying degrees of moisture. The tests can be performed dry, damp, or wet. Specimens are subjected to temperatures of 110°C, 150°C, or 200°C for 15 seconds. The textile end use determines the level of moisture while fiber content is used to select the pressing temperature. No precision or bias data is given.[54]

All of the above methods are designed to evaluate color change and require specialized equipment. For this study, a Hoffman utility press, operated by an experienced employee of a drycleaning establishment, was used to press specimens. Two seconds of steam were followed by two seconds of vacuum for each specimen. The temperature was approximately 150°C (300°F) and “Medium/High” pressure was used.

While this treatment is not representative of all steaming and pressing operations in sewn-item production, it was intended to test the theory that residual shrinkage taken up in production will reduce the shrinkage experienced in laundering.

For consistency with other portions of the study, six 400- × 400-mm experimental specimens were cut from across the width and along the length of each fabric.

Control and test specimens were benchmarked three times each in warp and weft directions. Original benchmarks were approximately 254 cm apart. Measurements were taken before and after pressing, as well as after one, three, and five laundering cycles. Specimens were conditioned for at least four hours before each measurement.

All test specimens (Fabrics A, B, C, and D) were laundered in the same load. Normal agitation and warm wash water were used. The load was dried for 25 minutes on the normal cycle. Control specimens were washed and dried with seamed specimens as described in that section. Specimens were pressed with a hand iron set to “cotton” with steam only after the fifth wash and corresponding measurements.

Calculations

Dimensional change may be reported as the actual change in length (warp direction) or width (weft direction) as measured in centimeters, inches, or other linear units. More often, changes are reported as a percentage of the

original measurement (see Eq. 1). This makes it easier to make valid comparisons among different measurements.

$[(B - A)/A] \times 100\%$ Eq. 1.

where A is the original measurement (before laundering) and B is the final measurement (after the specified number of home launderings).

Warp and weft measurements were treated separately as the fabric construction parameters (e.g., fiber, yarn size, weave pattern) are rarely identical in both directions. Percent change was calculated for each measurement. Average changes and standard deviations were calculated for individual specimens and for the grand average of all six specimens for a particular condition. The grand average and standard deviation was used for statistical and graphical comparison of various conditions.

The only other statistical analyses were comparisons of sample means using student t-tests to compare condition averages (e.g., experimental and control). All calculations were performed in Excel spreadsheets.

RESULTS

Seam Results

Potential sources of difference between seamed and control samples are cut seam allowances and the stitching itself. Cut edges may be more prone to shrinkage, particularly across the seam, if weaving tensions are more readily released. Stitching would have the opposite effect, jamming the structure and securing threads to prevent shrinkage.

All dimensional change observed for control and seamed specimens was negative (shrinkage). Measurements and percent change for all specimens are reported in Appendix A.

Changes were compared according to the fabric direction, regardless of the seam direction. For example, changes in the warp direction of the control specimens were compared to changes along the warp seam and across the weft seam of the experimental specimens.

It was necessary to determine whether the differences observed for control and seamed specimens after laundering were due to actual, permanent differences in dimensional change or simply to variations in wrinkling and puckering. By pressing all specimens (control and seamed), the influence of wrinkles was minimized. Puckering was also reduced, but could be not completely eliminated (see Fig. 4).



Fig. 4. Wrinkling and puckering after laundering was reduced by pressing.

A second trial was performed with Fabrics A and B. There was insufficient sample to retest Fabrics C and D. Seams in the first trial were initially pressed open only enough to allow repeatable measurements. After the final wash, seamed and control specimens were pressed flat on high. In the second trial, all specimens were pressed on high before the initial measurement and after the fifth wash. Except for the first wash of Fabric A, the results of both trials were similar.

Fabric A (Fig. 5) exhibited more shrinkage in the weft direction than in the warp. All other fabrics had greater shrinkage in the warp direction, as expected, due to relaxation of weaving tensions (Figs. 5-8).

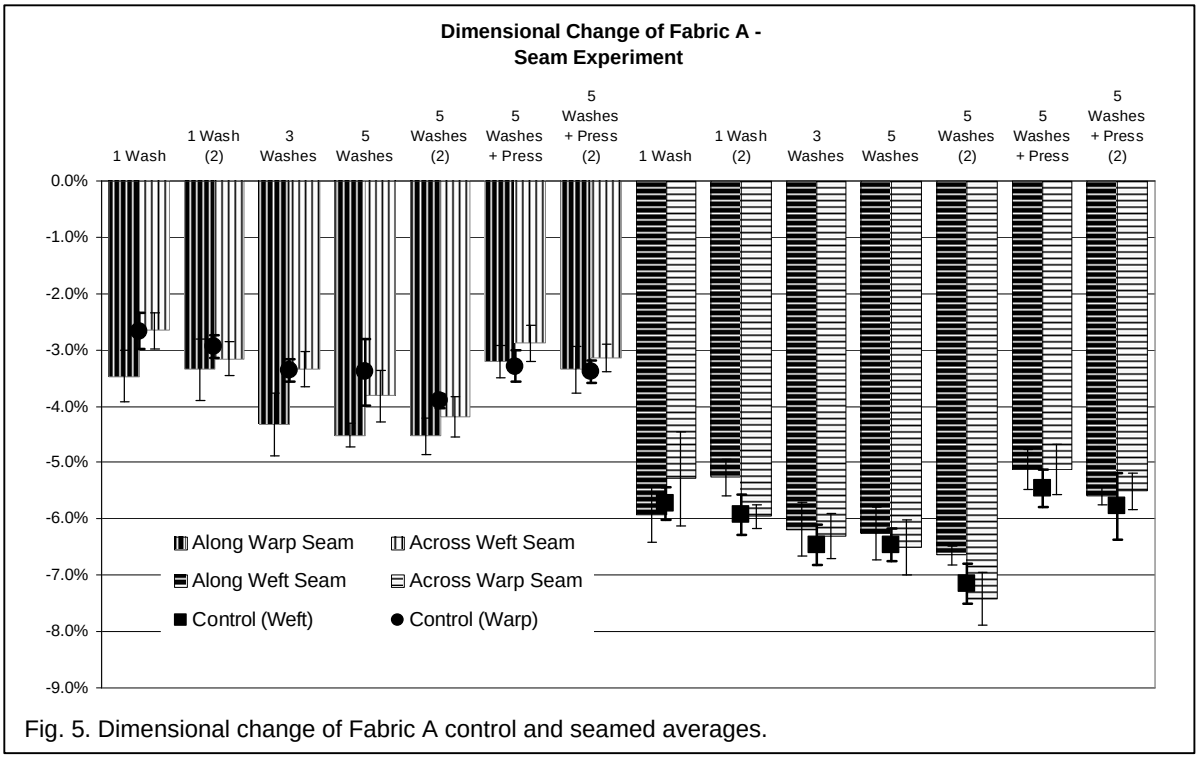


Fig. 5. Dimensional change of Fabric A control and seamed averages.

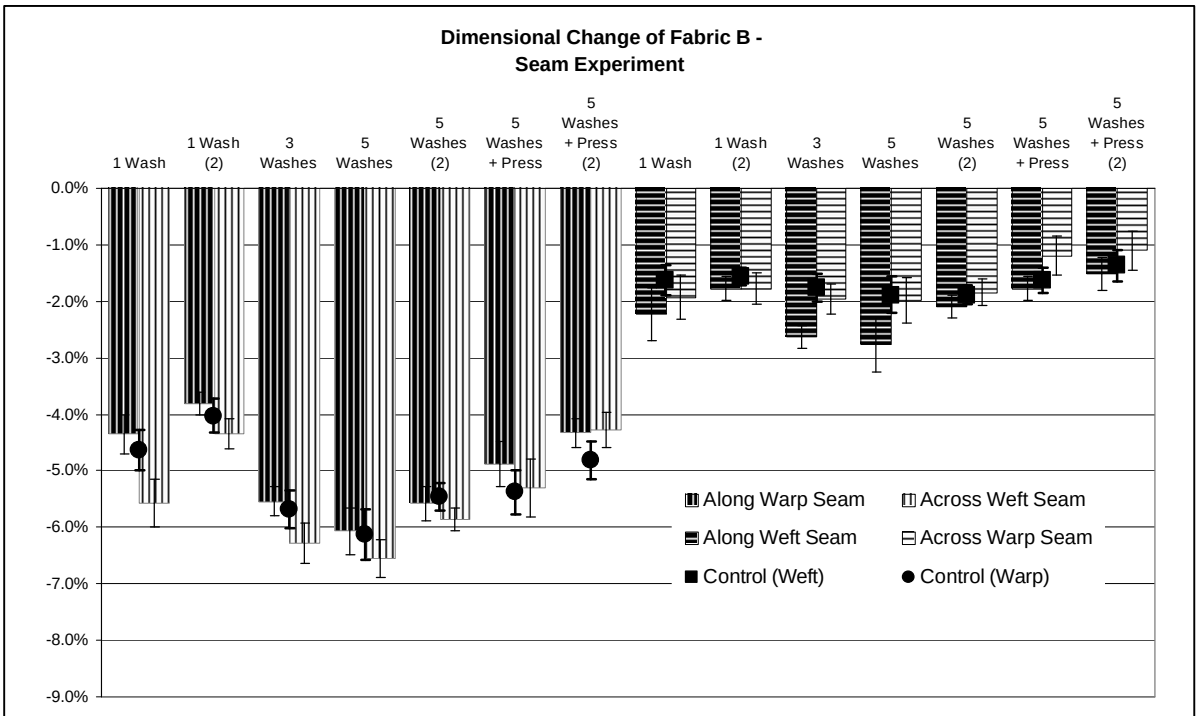


Fig. 6. Dimensional change of Fabric B control and seamed averages.

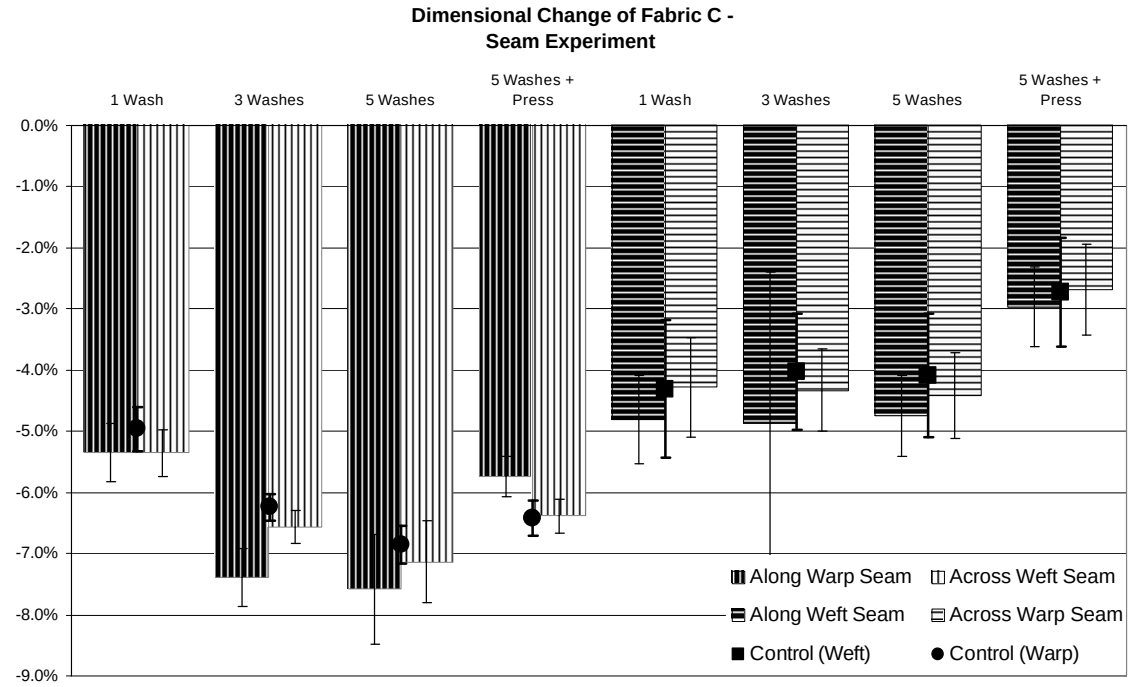


Fig. 7. Dimensional change of Fabric C control and seamed averages.

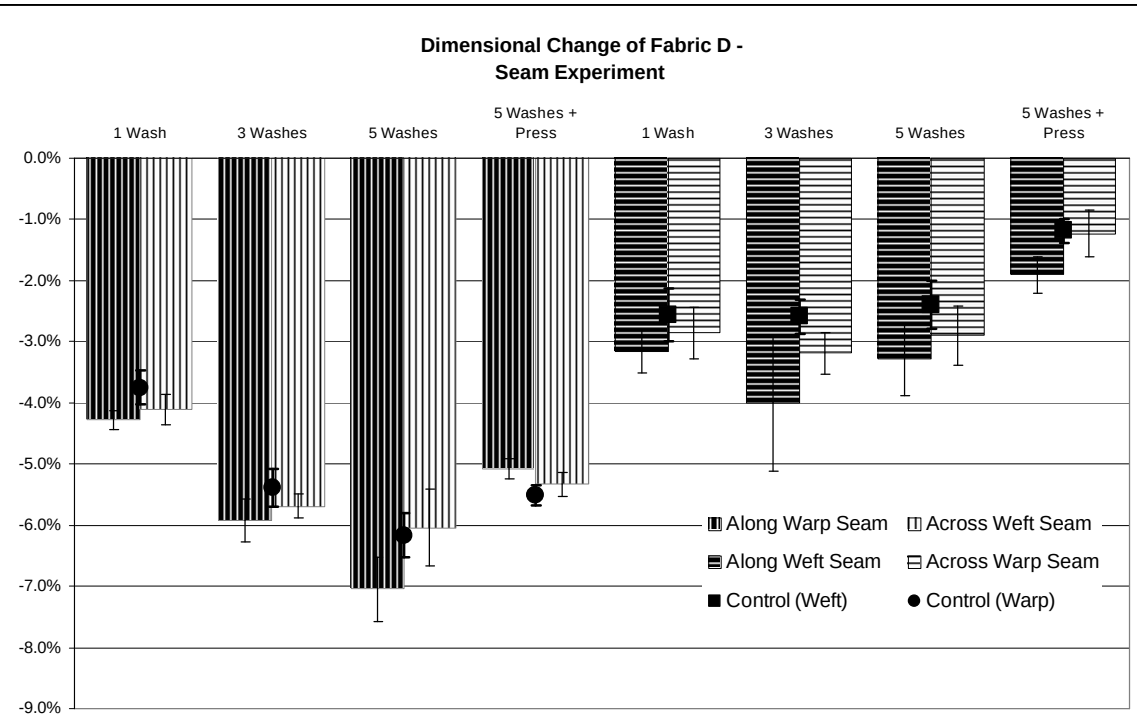


Fig. 8. Dimensional change of Fabric D control and seamed averages.

Along-Seam v. Across-Seam

After one, three, and five washes, dimensional changes along the seams were generally greater than across seams or control specimens in the same direction. There were two exceptions: in the warp direction, Fabric B exhibited the most dimensional change across the weft seam; the trend for the weft direction of Fabric A was unclear.

Table IV is the t-test data for comparison of dimensional change along and across seams in comparable directions. Values in bold indicate more dimensional change along seams with > 90% certainty. Italics indicate more change across seams with > 90% certainty. Of these 25 statistically significant differences, 15 had more dimensional change along a seam than across. As indicated above, there were instances in which across-seam measurements changed more than along-seam measurements. Most of these were in the warp direction of Fabric B (along warp seam/across weft seam) or the weft direction of Fabric A (along weft seam/across warp seam). It was not clear why these measurements reacted differently from the others although Fabric B was a twill weave and significantly heavier than the other fabrics tested. Fabric A was the only fabric in this experiment that had more dimensional change in the weft direction than in the warp direction.

TABLE IV.

t-Test for Along-Seam Averages versus Across-Seam Averages

Along	Across	Wash	t*	?	1-a/2
Warp A	Weft A	1	-4.004	7	**0.995**
		1 (2)	-0.823	7	0.558
		3	-4.137	6	**0.994**
		5	-5.058	22	**> 0.999**
		5 (2)	-2.171	11	**0.947**
		5 + Press	-2.297	11	**0.958**
		5 + Press (2)	-1.200	7	0.725
Warp B	Weft B	1	7.060	12	*> 0.999*
		1 (2)	5.160	13	*> 0.999*
		3	5.668	15	*> 0.999*
		5	2.641	8	*0.970*
		5 (2)	2.147	7	*0.931*
		5 + Press	2.074	13	*0.940*
		5 + Press (2)	-0.429	13	0.325
Warp C	Weft C	1	0.065	8	0.050
		3	-4.077	7	**0.993**
		5	-1.117	8	0.699
		5 + Press	4.372	9	*0.998*
Warp D	Weft D	1	-2.022	16	**0.939**
		3	-1.592	7	0.838
		5	-3.866	12	**0.998**
		5 + Press	3.234	13	*0.993*
Weft A	Warp A	1	-2.160	18	**0.955**
		1 (2)	4.898	7	*0.998*
		3	0.564	9	0.412
		5	1.076	11	0.695
		5 (2)	6.036	24	*> 0.999*
		5 + Press	-0.034	13	0.027
		5 + Press (2)	-0.812	20	0.574
Weft B	Warp B	1	-1.401	8	0.801
		1 (2)	0.028	13	0.022
		3	-6.255	13	**> 0.999**
		5	-3.477	8	**0.992**
		5 (2)	-2.627	12	**0.976**
		5 + Press	-4.820	17	**> 0.999**
		5 + Press (2)	-2.840	12	**0.984**
Weft C	Warp C	1	-1.492	11	0.836
		3	-0.537	5	0.385
		5	-1.038	11	0.676
		5 + Press	-0.902	11	0.613
Weft D	Warp D	1	-1.769	12	0.898
		3	-1.823	5	0.872
		5	-1.473	8	0.821
		5 + Press	-4.535	13	**0.999**

Note: Bold indicates more dimensional change along seams with > 90% certainty.
Italics indicate more dimensional change across seams with > 90% certainty.

Control v. Seam

After most laundering cycles, the control samples had the least dimensional change among comparable measurements. Final hand-pressing reversed this trend; control averages showed *more* shrinkage than seam averages after pressing.

Practical differences between control and seamed averages are visible in Figs. 5-8. A t-test was performed to identify statistical differences (Tables V-VIII). Not all the differences observed in the charts were deemed to be statistically significant. More significant differences were noted in the warp direction, perhaps because this was the direction of greater change for most of the fabrics tested. For the small changes in the weft direction, it was difficult to separate random error from actual differences.

For Fabric A, nine of the 14 seam averages in the warp direction were statistically significant (95% certainty) from control averages (Table V). All but two significant differences supported the general trends observed: seamed samples showed more shrinkage than controls after laundering, but less after final hand-pressing. Only three seam averages were statistically different from controls in the weft direction.

TABLE V.

t-Test for Fabric A Control Averages versus Seamed Averages

Control	Seamed	Wash	t*	***?***	1-a/2
Warp	Along Warp Seam	1	3.940	8	*0.994*
		1 (2)	1.810	6	0.870
		3	4.155	6	*0.991*
		5	6.721	23	*> 0.999*
		5 (2)	4.585	6	*0.994*
		5 + Press	-0.452	9	0.338
		5 + Press (2)	-0.180	6	0.137
	Across Weft Seam	1	-0.048	35	0.038
		1 (2)	2.538	31	*0.984*
		3	-0.233	31	0.183
		5	2.374	32	*0.976*
		5 (2)	3.143	22	*0.995*
		5 + Press	-3.857	34	**> 0.999**
		5 + Press (2)	-3.207	34	**0.997**
Weft	Along Weft Seam	1	0.914	7	0.604
		1 (2)	-4.269	11	**0.999**
		3	-1.272	8	0.761
		5	-1.020	7	0.658
		5 (2)	-4.721	22	**> 0.999**
		5 + Press	-1.908	10	0.915
		5 + Press (2)	-1.178	23	0.749
	Across Warp Seam	1	-1.947	19	0.934
		1 (2)	0.210	29	0.165
		3	-1.115	31	0.726
		5	0.250	26	0.195
		5 (2)	1.912	34	0.935
		5 + Press	-2.327	30	**0.973**
		5 + Press (2)	-1.670	27	0.894

Note: Bold indicates more dimensional change of control sample with > 95% certainty.
Italics indicate more dimensional change of seamed sample with > 95% certainty.

Eight of 14 Fabric B seam averages in the warp direction and nine in the weft direction were significantly different from control averages at 95% confidence (Table VI). The clearest trend for Fabric B seams was observed across weft seams. After one, three, and five washes, across-weft averages were calculated to have greater dimensional change than the weft averages of control samples. This was true for the initial experiment as well as the second experiment. After final hand-pressing, the across-weft averages showed less dimensional change than control weft averages. The difference was not statistically significant for the first experiment (38%

confidence of real difference), but for the second experiment, the difference was quite significant (> 99.9% confidence).

TABLE VI.

t-Test for Fabric B Control Averages versus Seamed Averages

Control	Seamed	Wash	t*	***?***	1-a/2
Warp	Along Warp Seam	1	-1.726	10	0.885
		1 (2)	-1.997	16	0.936
		3	-1.163	14	0.734
		5	-0.312	11	0.239
		5 (2)	0.911	8	0.611
		5 + Press	-2.633	9	**0.973**
		5 + Press (2)	-3.783	14	**0.998**
	Across Weft Seam	1	7.273	35	*> 0.999*
		1 (2)	3.329	35	*0.998*
		3	5.242	36	*> 0.999*
		5	3.216	33	*0.997*
		5 (2)	5.332	34	*> 0.999*
		5 + Press	-0.493	33	0.375
		5 + Press (2)	-5.042	36	**> 0.999**
Weft	Along Weft Seam	1	2.980	6	*0.975*
		1 (2)	2.235	8	0.939
		3	8.532	12	*> 0.999*
		5	4.040	7	*0.995*
		5 (2)	2.347	8	*0.953*
		5 + Press	1.451	11	0.823
		5 + Press (2)	1.091	9	0.697
	Across Warp Seam	1	2.741	31	*0.990*
		1 (2)	2.858	29	*0.992*
		3	2.427	36	*0.980*
		5	0.822	34	0.583
		5 (2)	-0.668	33	0.491
		5 + Press	-4.365	31	**> 0.999**
		5 + Press (2)	-2.520	34	**0.983**

Note: Bold indicates more dimensional change of control sample with > 95% certainty.
Italics indicate more dimensional change of seamed sample with > 95% certainty.

Four significantly different averages were calculated for Fabric C, all in the warp direction (Table VII). Dimensional change along warp seams was greater than along the warp grain of control after three washes. More dimensional change was also noted across weft seams after one and three washes. Less dimensional change was observed along warp seams after five washes plus final pressing than on comparable control samples.

TABLE VII.

t-Test for Fabric C Control Averages versus Seamed Averages

Control	Seamed	Wash	t*	***?***	1-a/2
Warp	Along Warp Seam	1	1.782	8	0.882
		3	5.816	6	*0.999*
		5	1.945	6	0.891
		5 + Press	-4.499	9	0.998
	Across Weft Seam	1	3.152	36	*0.997*
		3	3.973	34	*> 0.999*
		5	1.638	24	0.886
		5 + Press	-0.246	36	0.193
Weft	Along Weft Seam	1	1.265	16	0.776
		3	0.822	6	0.552
		5	1.811	16	0.911
		5 + Press	0.713	14	0.511
	Across Warp Seam	1	-0.081	33	0.064
		3	1.113	32	0.726
		5	1.116	32	0.727
		5 + Press	-0.171	35	0.135

Note: Bold indicates more dimensional change of control with > 95% certainty. *Italics* indicate more dimensional change of seamed sample with > 95% certainty.

Most seamed measurements of Fabric D were statistically different from control measurements in the warp direction (Table VIII). The only exception was across the weft seam after five washes, when the change in the seam sample was actually less than the change in the control sample.

There were also several statistically-significant differences among seamed and control samples in the weft direction of Fabric D. In all cases of significant difference in this direction, including after hand-pressing, dimensional change of seamed samples was greater than dimensional change of control samples.

TABLE VIII.

t-Test for Fabric D Control Averages versus Seamed Averages

Control	Seamed	Wash	t*	?	1-a/2
Warp	Along Warp Seam	1	5.672	18	*> 0.999*
		3	3.404	9	*0.991*
		5	3.809	7	*0.993*
		5 + Press	-5.730	10	**> 0.999**
	Across Weft Seam	1	4.060	35	*> 0.999*
		3	3.571	30	*0.999*
		5	-0.758	28	0.545
		5 + Press	-2.830	34	**0.992**
Weft	Along Weft Seam	1	3.371	13	*0.994*
		3	3.133	5	*0.974*
		5	3.474	7	*0.990*
		5 + Press	5.627	7	*0.999*
	Across Warp Seam	1	1.987	36	0.945
		3	5.689	35	*> 0.999*
		5	3.404	34	*0.998*
		5 + Press	0.430	26	0.329

Note: Bold indicates more dimensional change of control with > 95% certainty. *Italics* indicate more dimensional change of seamed sample with > 95% certainty.

After five washes plus final hand-pressing, control samples had more dimensional change than seamed samples in the warp direction for all fabrics and all trials. In eight of these 12 cases, there was a statistically significant difference (see Tables V-VIII). This is important since most garment seams are sewn generally in the warp direction (though rarely exactly along the grain line).

In the weft direction, control samples of Fabric A had the most dimensional change in both trials. All other fabrics experienced the most weft-wise dimensional change along the weft seams and the least across warp seams.

Only three differences between control and seamed dimensional change after final pressing were determined to be statistically significant in the weft direction. For both trials of Fabric B (Table VI), there was more

dimensional change in the weft direction of the control sample than across the warp seam of the experimental sample. For Fabric D (Table VIII), there was significantly less change in the control than along the weft seam.

Effect of Final Hand-Pressing

The most unexpected outcome of the Seam experiment was that while laundering generally caused greater dimensional change in seamed specimens than in control specimens, hand-pressing after laundering reversed this relationship.

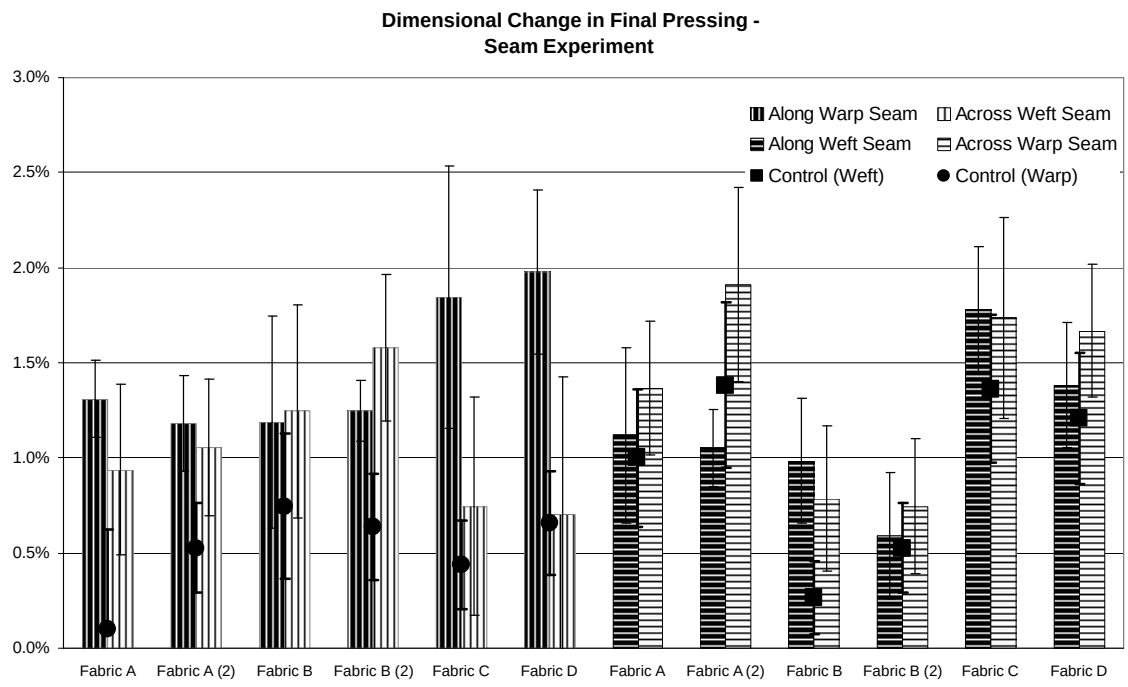


Fig. 9. Dimensional change of control and seamed during final pressing. Error bars represent one standard deviation above and below the mean.

It was assumed that more folding, wrinkling, and puckering occurred on the seamed specimens than on control specimens, giving the impression of more shrinkage. It can be seen in Fig. 9 that positive change (growth) occurred for all samples between the fifth wash and final hand-pressing due to flattening of wrinkles.

In all but one of 24 cases, there was more growth of seamed samples (along and across seams) than of comparable control samples. Nineteen of the differences were statistically significant at greater than 95% confidence (Table IX). This supported the hypothesis that wrinkling had a greater impact on seamed samples than control samples.

TABLE IX.

t-Test for Control Averages versus Seamed Averages during Final Pressing

Control	Seamed	t*	***?***	1-a/2
Warp A	Along Warp	-7.950	23	**> 0.999**
	Across Weft	-5.058	33	> 0.999
Warp A (2)	Along Warp	-5.632	9	> 0.999
	Across Weft	-5.213	31	> 0.999
Warp B	Along Warp	-1.796	7	0.884
	Across Weft	-3.120	31	**0.996**
Warp B (2)	Along Warp	-6.584	18	> 0.999
	Across Weft	-8.449	33	> 0.999
Warp C	Along Warp	-4.899	6	**0.996**
	Across Weft	-2.109	23	**0.953**
Warp D	Along Warp	-7.010	7	**> 0.999**
	Across Weft	-0.241	22	0.188
Weft A	Along Weft	-0.556	9	0.407
	Across Warp	-2.865	31	**0.992**
Weft A (2)	Along Weft	2.505	22	*0.979*
	Across Warp	-3.331	35	**0.998**
Weft B	Along Weft	-5.194	7	**0.998**
	Across Warp	-5.187	26	**> 0.999**
Weft B (2)	Along Weft	-0.443	7	0.329
	Across Warp	-2.181	31	**0.963**
Weft C	Along Weft	-2.551	12	**0.973**
	Across Warp	-2.417	33	**0.978**
Weft D	Along Weft	-1.110	10	0.707
	Across Warp	-3.987	36	**> 0.999**

Note: Bold indicates more dimensional change of control with > 95% certainty. *Italics* indicate more dimensional change of seamed sample with > 95% certainty.

Effect of Initial Hand-Pressing

The second trial on Fabrics A and B was designed to ensure that the initial pressing with a hand iron did not affect the final results. Seams in the first trial were minimally pressed before the initial measurement; control

specimens were not pressed. The seams for the second trial were thoroughly pressed before the first measurement. Standard deviation was expected to be lower for the second trial since variation in initial measurements was presumably reduced. Table X is a summary of averages and standard deviations for seamed samples in the two trials. For each pair of data, the smaller deviation is in bold type. Nineteen of the 24 pairs had lower deviation on the second trial, as predicted.

TABLE X.

Comparison of Seamed Samples from Trial 1 and Trial 2

	Along Warp Seam		Across Weft Seam		Along Weft Seam		Across Warp Seam	
Fabric A	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
1 Wash	-3.5%	**0.46%**	-2.7%	0.32%	-5.9%	0.50%	-5.3%	0.83%
1 Wash (2)	-3.4%	0.54%	-3.2%	**0.30%**	-5.3%	**0.32%**	-5.9%	**0.21%**
5 Washes	-4.5%	**0.21%**	-3.8%	0.46%	-6.3%	0.47%	-6.5%	0.49%
5 Washes (2)	-4.5%	0.33%	-4.2%	**0.36%**	-6.6%	**0.17%**	-7.4%	**0.46%**
5 Washes + Press	-3.2%	**0.29%**	-2.9%	0.33%	-5.1%	0.36%	-5.1%	0.45%
5 Washes + Press (2)	-3.4%	0.41%	-3.1%	**0.25%**	-5.6%	**0.17%**	-5.5%	**0.32%**
Fabric B								
1 Wash	-4.4%	0.35%	-5.6%	0.42%	-2.2%	0.48%	-1.9%	0.39%
1 Wash (2)	-3.8%	**0.20%**	-4.3%	**0.27%**	-1.8%	**0.22%**	-1.8%	**0.28%**
5 Washes	-6.1%	0.41%	-6.6%	0.33%	-2.8%	0.49%	-2.0%	0.39%
5 Washes (2)	-5.6%	**0.30%**	-5.9%	**0.20%**	-2.1%	**0.20%**	-1.8%	**0.23%**
5 Washes + Press	-4.9%	0.41%	-5.3%	0.51%	-1.8%	**0.21%**	-1.2%	**0.34%**
5 Washes + Press (2)	-4.3%	**0.25%**	-4.3%	**0.31%**	-1.5%	0.30%	-1.1%	0.35%

Note: Standard deviation values in bold are the smaller of each pair.

Difference between trials one and two could be attributed to dimensional change caused by the initial pressing process itself. In this case, seamed specimens for Trial 2 (which were pressed more aggressively) would show less negative dimensional change (shrinkage). Relaxation shrinkage would be taken up by the pressing process, leaving less to be experienced in laundering.

In fact, Trial 2 fabrics were about as likely to have more shrinkage in laundering (9 of 24 pairs listed in Table X) as less (14 of 24 pairs). Of the 15 differences considered statistically significant (95% certainty), trial two had more shrinkage in seven cases; trial one had more shrinkage in eight cases. This near-equal division provided no clear evidence that initial hand-pressing affected the final dimensional change of seamed samples.

Further study of more fabrics is required as it appeared that the results were fabric-dependent. For Fabric A, dimensional change in Trial 2 was generally greater than in Trial 1. The opposite was true for Fabric B.

Fusing Results

Measurements after laundering were compared to treated (hand-pressed/fused and sewn) measurements. Dimensional changes between original and treated measurements are shown in Figs. 10-13 as stacked columns.

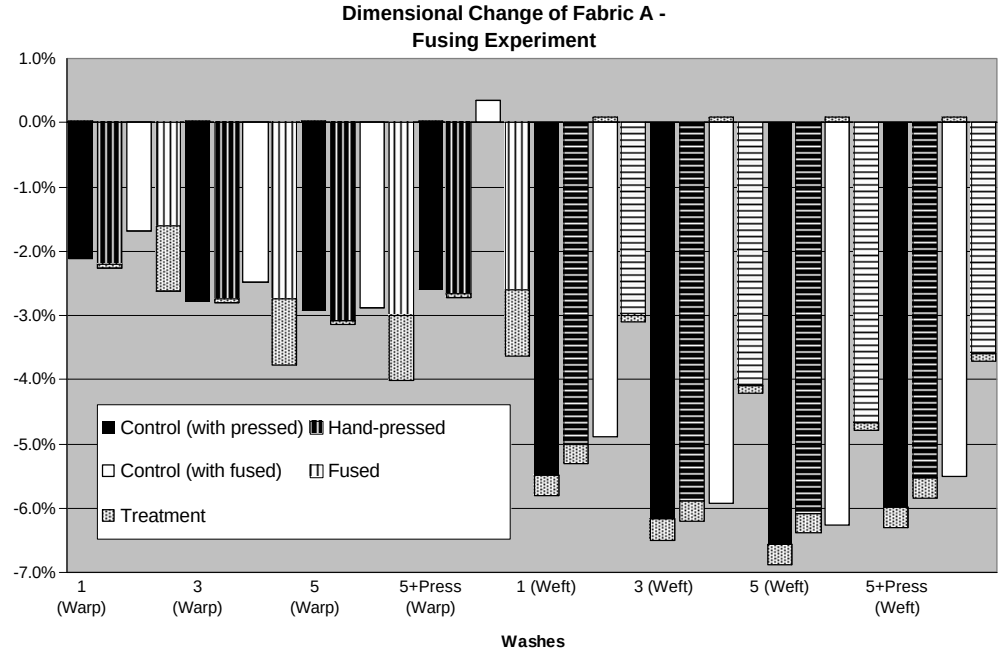


Fig. 10. Dimensional change of fused and control specimens of Fabric A.

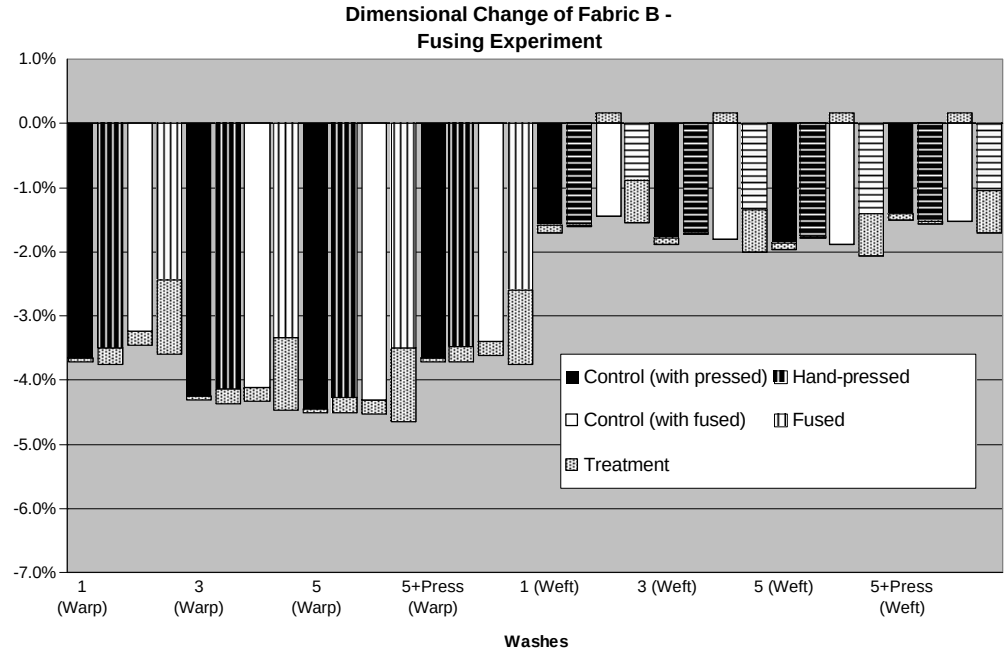


Fig. 11. Dimensional change of fused and control specimens of Fabric B.

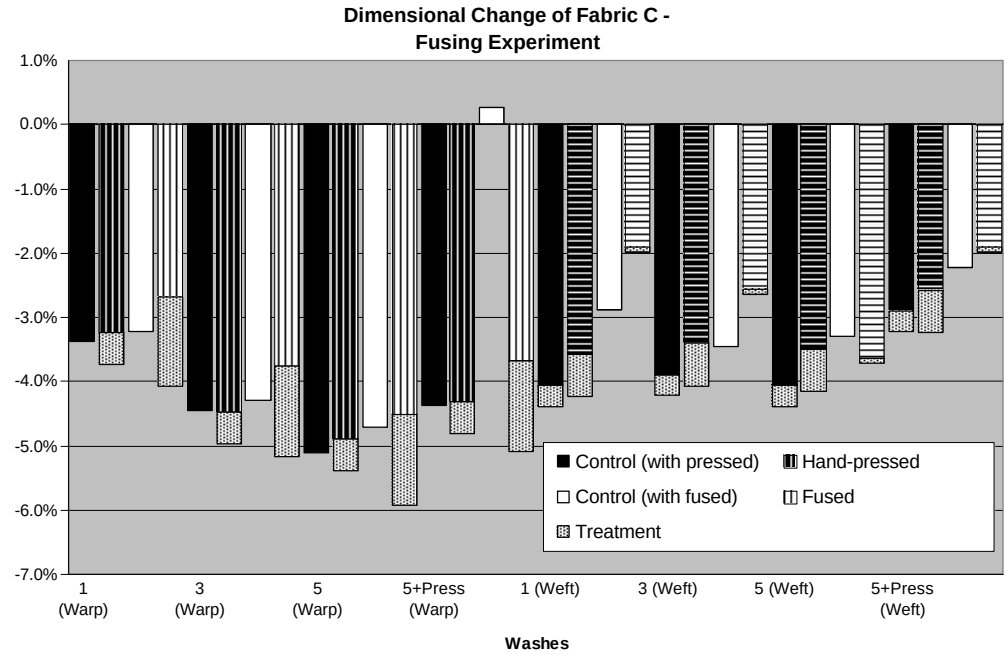


Fig. 12. Dimensional change of fused and control specimens of Fabric C.

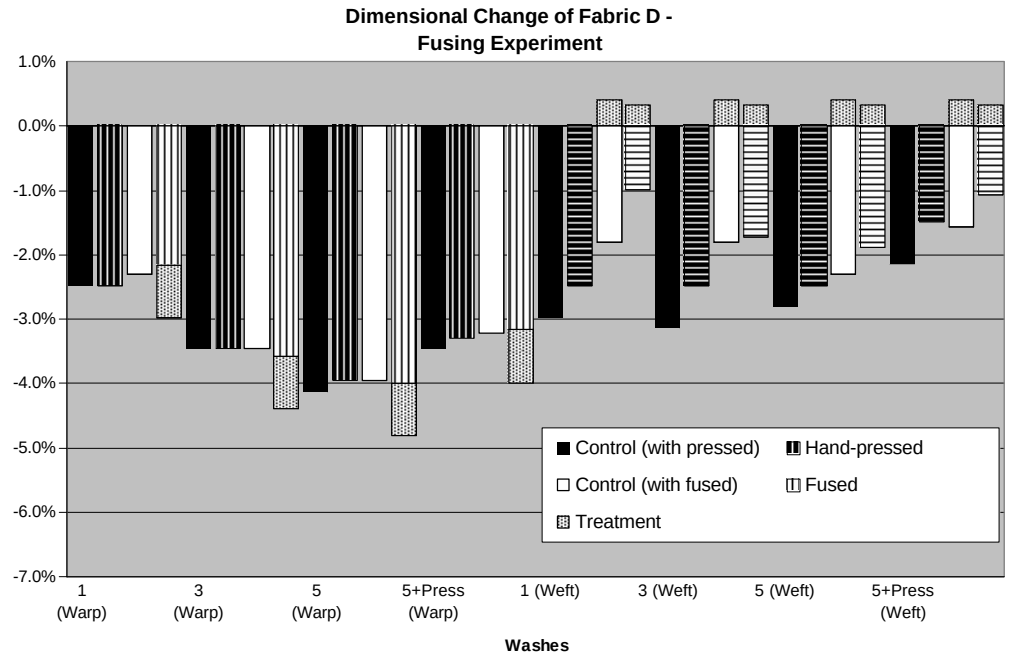


Fig. 13. Dimensional change of fused and control specimens of Fabric D.

Dimensional Change in Laundering

For dimensional change in laundering only (disregarding the initial change due to preparation of the specimens), fused samples appeared to have less change than hand-pressed samples. This is not surprising as the function of the fused interfacing is to stabilize the fabric.

A t-test was performed to confirm the statistical importance of differences between fused and hand-pressed samples (Table XI). The analysis confirmed that fused samples experienced significantly less dimensional change, with the exception of Fabrics A and D in the warp direction. Nearly all other differences were significant at 95% certainty.

The control specimens did not all behave in the same manner. Most of the control fabrics sewn to fused fabrics had less change than comparable control fabrics sewn to hand-pressed fabrics. There were only three cases in which this was not true and 19 of the 32 cases showed a statistically significant difference (Table XII).

TABLE XI.

t-Test for Fused Averages versus Hand-pressed Averages

	Wash	t*	?	1-a/2
Warp A	1	5.647	32	*> 0.999*
	3	0.002	35	0.002
	5	0.586	34	0.438
	5 + Press	0.454	35	0.348
Warp B	1	9.645	28	*> 0.999*
	3	6.380	26	*> 0.999*
	5	6.808	29	*> 0.999*
	5 + Press	7.411	22	> 0.999
Warp C	1	6.316	36	*> 0.999*
	3	5.807	17	*> 0.999*
	5	3.262	35	*0.997*
	5 + Press	5.5777	30	*> 0.999*
Warp D	1	3.255	17	*0.995*
	3	-0.968	17	0.653
	5	-0.313	17	0.242
	5 + Press	1.538	36	0.867
Weft A	1	11.971	30	*> 0.999*
	3	11.591	29	*> 0.999*
	5	10.040	31	*> 0.999*
	5 + Press	10.697	26	*> 0.999*
Weft B	1	6.568	35	*> 0.999*
	3	3.137	30	*0.996*
	5	2.881	32	*0.993*
	5 + Press	3.757	33	*0.999*
Weft C	1	10.359	30	*>0.999*
	3	6.825	36	*> 0.999*
	5	-1.188	34	0.757
	5 + Press	4.675	22	*> 0.999*
Weft D	1	20.369	17	*> 0.999*
	3	6.163	17	*> 0.999*
	5	6.719	17	*> 0.999*
	5 + Press	4.756	17	*> 0.999*

Note: *Italics* indicate more dimensional change of hand-pressed samples with > 95% certainty.

TABLE XII.

t-Test for Control Fabrics Sewn to Fused versus Controls Sewn to Hand-pressed

	Wash	t*	?	1-a/2
Warp A	1	4.519	36	*> 0.999*
	3	3.047	33	*0.995*
	5	0.221	36	0.173
	5 + Press	1.731	36	0.908
Warp B	1	4.202	36	*> 0.999*
	3	1.608	34	0.883
	5	1.500	36	0.857
	5 + Press	2.257	33	*0.969*
Warp C	1	1.519	33	0.861
	3	2.739	17	*0.986*
	5	4.697	36	*> 0.999*
	5 + Press	0.000	36	0.000
Warp D	1	2.739	17	*0.986*
	3	-	-	< 0.001
	5	2.449	17	*0.975*
	5 + Press	3.873	17	*0.999*
Weft A	1	2.593	35	*0.986*
	3	1.228	36	0.772
	5	1.711	33	0.903
	5 + Press	2.371	36	*0.977*
Weft B	1	1.311	33	0.801
	3	-0.293	34	0.229
	5	-0.306	36	0.238
	5 + Press	-1.689	36	0.900
Weft C	1	1.519	33	*> 0.999*
	3	2.739	17	*0.993*
	5	4.697	36	*> 0.999*
	5 + Press	0.000	36	*> 0.999*
Weft D	1	19.538	17	*> 0.999*
	3	13.985	36	*> 0.999*
	5	5.622	35	*> 0.999*
	5 + Press	5.310	34	*> 0.999*

Note: *Italics* indicate more dimensional change of control fabrics sewn to hand-pressed fabrics with > 95% certainty.

Analysis of the charts (Figs. 10-13) suggests that there was some relationship between sewn pairs (i.e., fused fabrics and the control fabrics sewn to them, hand-pressed fabrics and the control fabrics sewn to them). Table XIII contains t-test data for a comparison of paired fabrics. The fact that there were not fewer significant differences is interesting.

TABLE XIII.

t-Test for Sewn Pairs

		Fused v. Control			Hand-pressed v. Control		
	Wash	t*	***?***	1-a/2	t*	***?***	1-a/2
Warp A	1	0.597	35	0.446	-0.938	36	0.646
	3	-2.386	36	**0.977**	0.282	34	0.220
	5	-0.837	34	0.592	-1.357	36	0.817
	5 + Press	-1.550	35	0.870	-0.502	36	0.381
Warp B	1	6.673	33	*> 0.999*	1.757	34	0.912
	3	6.301	26	*> 0.999*	1.456	34	0.845
	5	6.960	31	*> 0.999*	2.023	35	0.949
	5 + Press	6.210	29	*> 0.999*	1.906	24	0.931
Warp C	1	6.151	36	*> 0.999*	1.369	33	0.820
	3	3.843	26	*0.999*	-1.597×10^{6}	17	**> 0.999**
	5	1.901	35	0.934	2.089	32	*0.955*
	5 + Press	9.026	34	*> 0.999*	0.572	26	0.428
Warp D	1	1.300	30	0.796	0.000	36	0.000
	3	-0.968	17	0.653	—	—	< 0.001
	5	-0.313	17	0.242	2.449	17	*0.975*
	5 + Press	0.644	36	0.476	2.449	17	*0.975*
Weft A	1	9.149	36	*> 0.999*	2.370	26	*0.974*
	3	9.363	36	*> 0.999*	1.716	28	0.902
	5	8.564	35	*> 0.999*	3.583	33	*0.999*
	5 + Press	8.992	35	*> 0.999*	2.749	29	*0.990*
Weft B	1	5.425	33	*> 0.999*	0.082	34	0.064
	3	4.152	29	*> 0.999*	0.881	35	0.616
	5	4.211	29	*> 0.999*	1.137	35	0.737
	5 + Press	4.142	27	*> 0.999*	-1.410	34	0.832
Weft C	1	6.072	30	*> 0.999*	3.945	36	*> 0.999*
	3	10.214	17	*> 0.999*	2.971	30	*0.994*
	5	-2.960	30	*0.994*	6.438	31	*> 0.999*
	5 + Press	4.114	33	*> 0.999*	1.793	35	0.918
Weft D	1	8.708	35	*> 0.999*	4.943×10^{15}	17	**> 0.999**
	3	0.569	28	0.426	9.798	17	*> 0.999*
	5	3.882	32	*0.999*	4.899	17	*> 0.999*
	5 + Press	3.983	36	*> 0.999*	9.798	17	*> 0.999*

Note: Bold indicates more dimensional change of treated (fused/pressed) samples with > 95% certainty. *Italics* indicate more dimensional change of control samples with > 95% certainty.

Visual inspection of the sewn pairs supported the hypothesis that the paired fabrics had some influence on each other. The fused/control pairs in particular, appeared bowed toward the control fabric after laundering (Fig. 14). This suggested that, while the control specimens obviously experienced more shrinkage than the fused, they may have been stretched between the seams and stabilized at the seams by the fused fabric. Presumably, un-paired control samples would have even more dimensional change. Control fabrics paired with hand-pressed fabrics were not stretched as tightly and did have more dimensional change. It is not clear whether the dimensional changes of fused and hand-pressed samples were affected by being sewn to control fabrics.



Fig. 14. Curling of fused/control specimen. Control fabric is on top; fused fabric is on the bottom.

Total Dimensional Change

Dimensional change in laundering-only is more representative of the results expected for lab tests or consumer experiences; however, the total dimensional change due to laundering and initial treatment provides some understanding of the forces at work. There were fewer obvious differences among the conditions when total dimensional change was considered.

Total dimensional change of fused samples of Fabric A was greater than that of comparable hand-pressed or control samples in the warp direction.

All conditions of Fabric B had nearly equal total dimensional change in the warp direction. Fused changes were similar to hand-pressed changes in the weft direction. The control fabrics sewn to fused fabrics had less change than controls sewn to pressed fabrics.

Since there was no change to control samples of Fabric C in the warp direction and all change to experimental samples was negative, the differences between control and experimental samples were accentuated. Hand-pressed samples had slightly more total dimensional change than fused samples. In the weft direction, hand-pressed and corresponding control samples had little difference in total dimensional change. There was slightly less difference in total dimensional change between fused and corresponding controls than in dimensional change in laundering only.

Fabric D had the least dimensional change due to treatment. In the warp direction, the total change to fused averages became greater than the total change to other averages in the warp direction. In the weft direction, the difference between hand-pressed and paired control samples, and fused and paired controls was more pronounced than when laundering only was considered because treatment of fused and paired controls provided positive dimensional change.

Compatibility Results

Dimensional change of compatibility specimens generally fell between the change of control warp and weft measurements. For most fabrics in the Seam experiment, the relationship between dimensional change of control and test specimens after laundering was reversed after the final press. This phenomenon was not generally observed in the Compatibility experiment. For Fabric A (Fig. 15), test specimens shrank more than controls in the warp direction and less than controls in the weft direction.

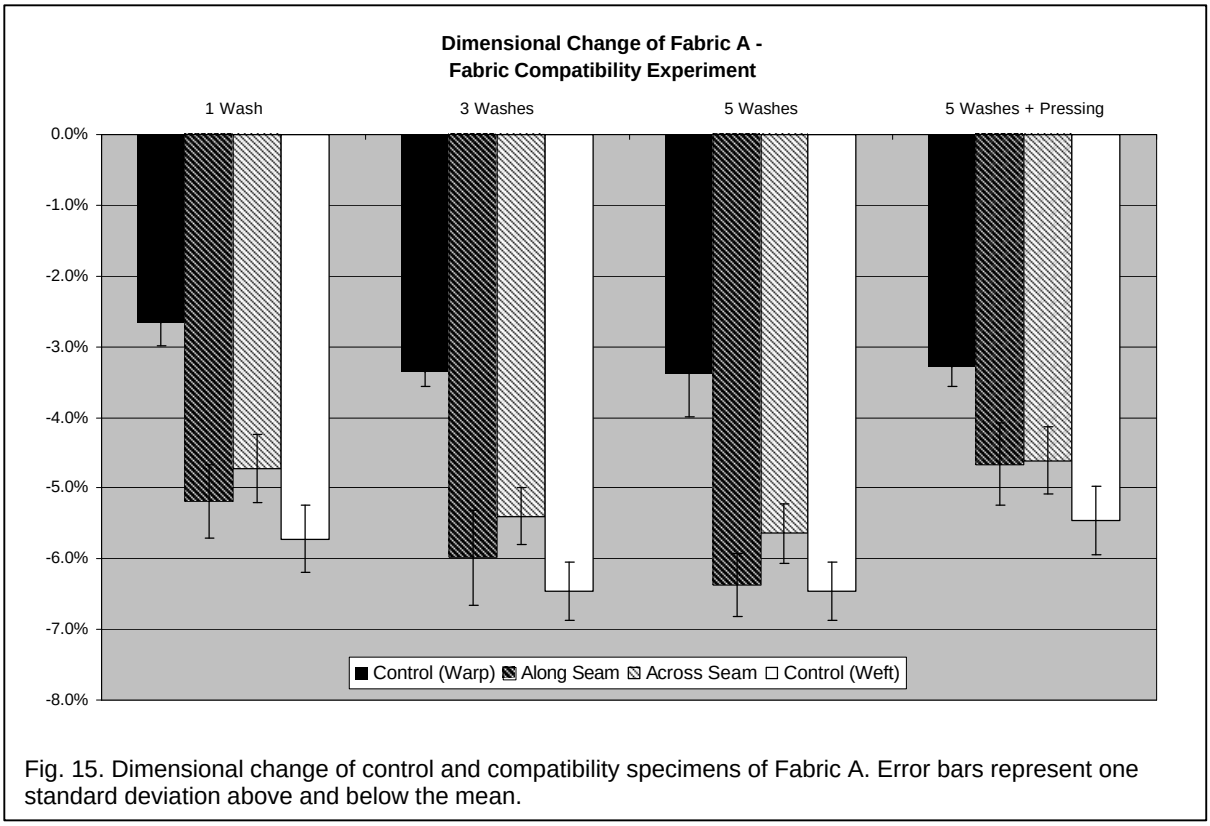


Fig. 15. Dimensional change of control and compatibility specimens of Fabric A. Error bars represent one standard deviation above and below the mean.

The opposite was true for Fabrics B (Fig. 16), C (Fig. 17), and D (Fig. 18). There were a few exceptions to this rule. Fabric C compatibility specimens had slightly more shrinkage along the seam than both warp and weft control measurements after one, three, and five washes. Fabric D compatibility specimens had slightly more shrinkage along the seam after one wash. In all cases, dimensional change along the seam was greater than dimensional change across the same seam.

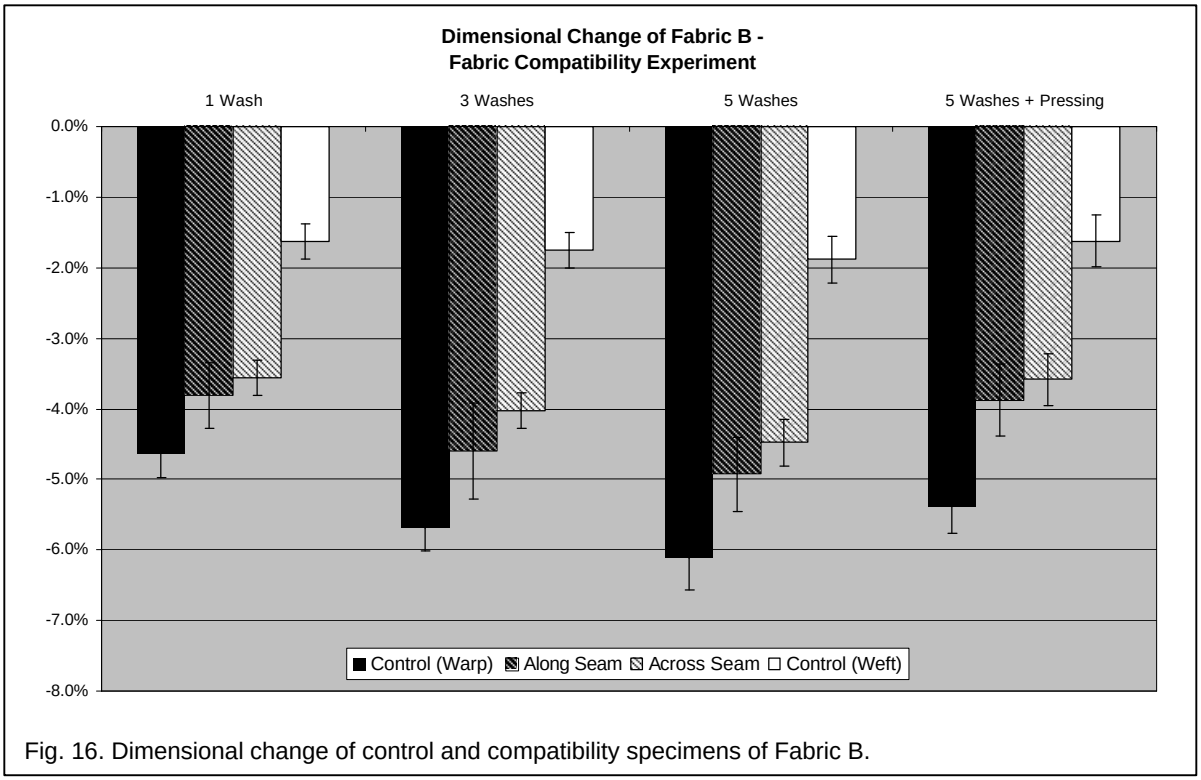


Fig. 16. Dimensional change of control and compatibility specimens of Fabric B.

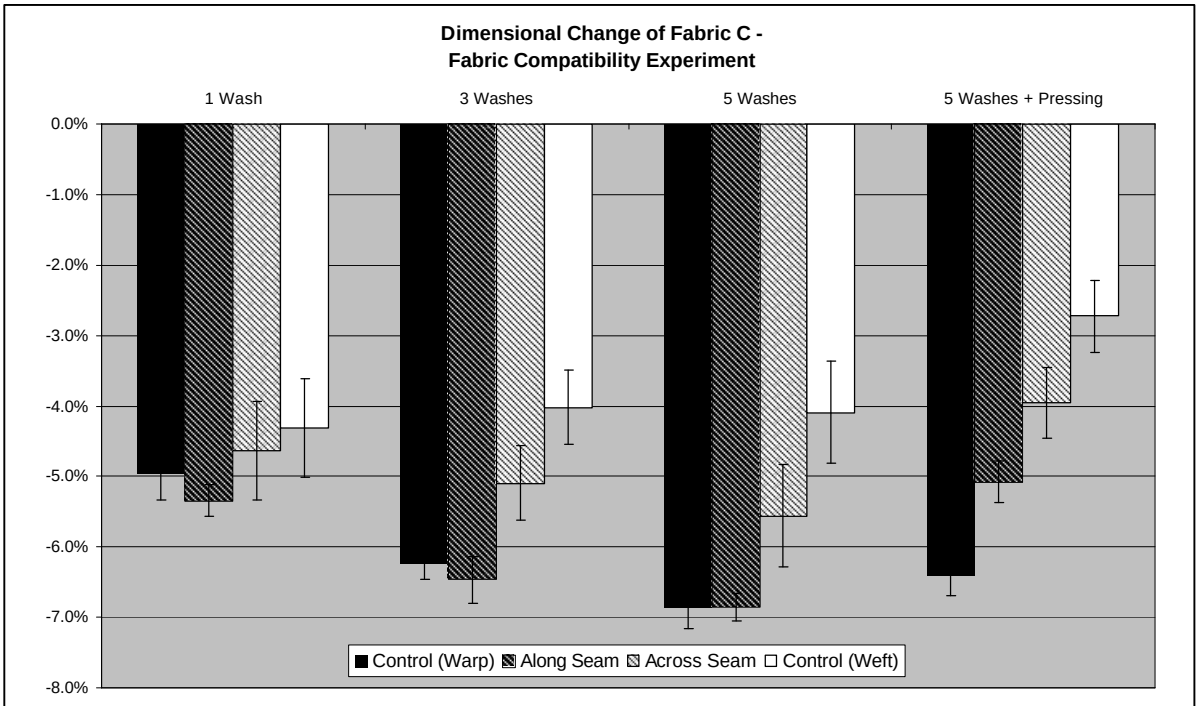


Fig. 17. Dimensional change of control and compatibility specimens of Fabric C.

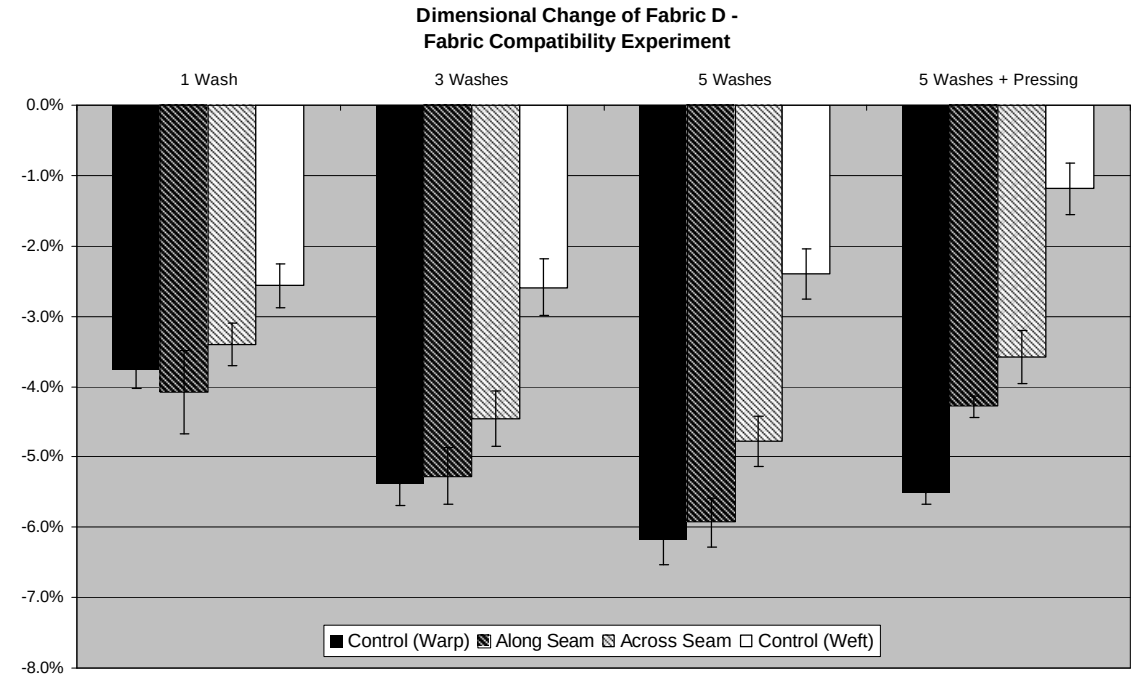


Fig. 18. Dimensional change of control and compatibility specimens of Fabric D.

The incompatibility of the two directions was visible at the seam interface (see Fig. 19). Pressing after the fifth wash reduced some of the puckering, but could not completely smooth the seam because of the differential in dimensional change between the fabrics on each side.



Fig. 19. Differential dimensional change of compatibility specimens (Fabric A).

The left side of the specimen pictured in Fig. 19 is stitched along the warp grain. The right side is stitched along the weft. For Fabric A, there was more dimensional change in the weft direction on control specimens (Fig. 15). This is confirmed by the photos. The left side of the specimen is severely puckered because, although the warp edge did not shrink as much as the weft edge, it was forced to match the weft length at the seam.

Across Seam

Measurements across seams are approximately one half along a warp grain and one half along a weft grain. The Seam experiment found that most cross-seam measurements were not significantly affected by the existence of the seam. If a seam was exactly in the middle of the benchmarks, the dimensional change across the seam may be expected to represent an average of the change experienced by the fabrics on each side of the seam.
For this experiment, no attempt was made to control or determine the exact fraction of a benchmarked measurement on each side of the seam; however the dimensional change values do represent a middle ground between warp and weft dimensional change values.

Along Seam

Dimensional change along the warp/weft compatibility seam was also expected to be somewhere between true warp and true weft dimensional change, but in less predictable proportions. This appears to be the case for all but the exceptions listed in Compatibility Results (Fabric C after one, three, and five washes; and Fabric D after

one wash). The direction prone to greater shrinkage causes puckering while the direction with lower propensity to shrink may stabilize the seam to some extent, limiting dimensional change.

Results of the Seam experiment suggested that there may be more dimensional change along seams than across seams in the same direction. Table XIV is the data for t-tests of measurements along and across the compatibility seams. The statistical analysis strongly supports the hypothesis that more change occurs along seams than across.

TABLE XIV.

t-Test for Along-Seam Averages versus Across-Seam Compatibility Averages

Fabric	Wash	t*	*?*	1-a/2
A	1	-1.694	9	**0.919**
	3	-1.995	7	**0.907**
	5	-3.504	9	**0.993**
	5 + Press	-0.199	8	0.153
B	1	-1.248	6	0.741
	3	-2.055	6	**0.905**
	5	-1.962	7	**0.903**
	5 + Press	-1.291	8	0.762
C	1	-3.771	24	**0.999**
	3	-7.446	17	> **0.999**
	5	-6.909	23	> **0.999**
	5 + Press	-6.639	17	> **0.999**
D	1	-2.710	6	**0.965**
	3	-4.304	10	**0.998**
	5	-6.874	10	> **0.999**
	5 + Press	-6.565	23	> **0.999**

Note: Bold indicates more dimensional change along seams with > 90% certainty.

Pressing Results

Dimensional Change due to Pressing

After pressing, each fabric exhibited slight, but relatively consistent, dimensional change. Fig. 20 is a graphic illustration of the average change and standard deviation for all fabrics.

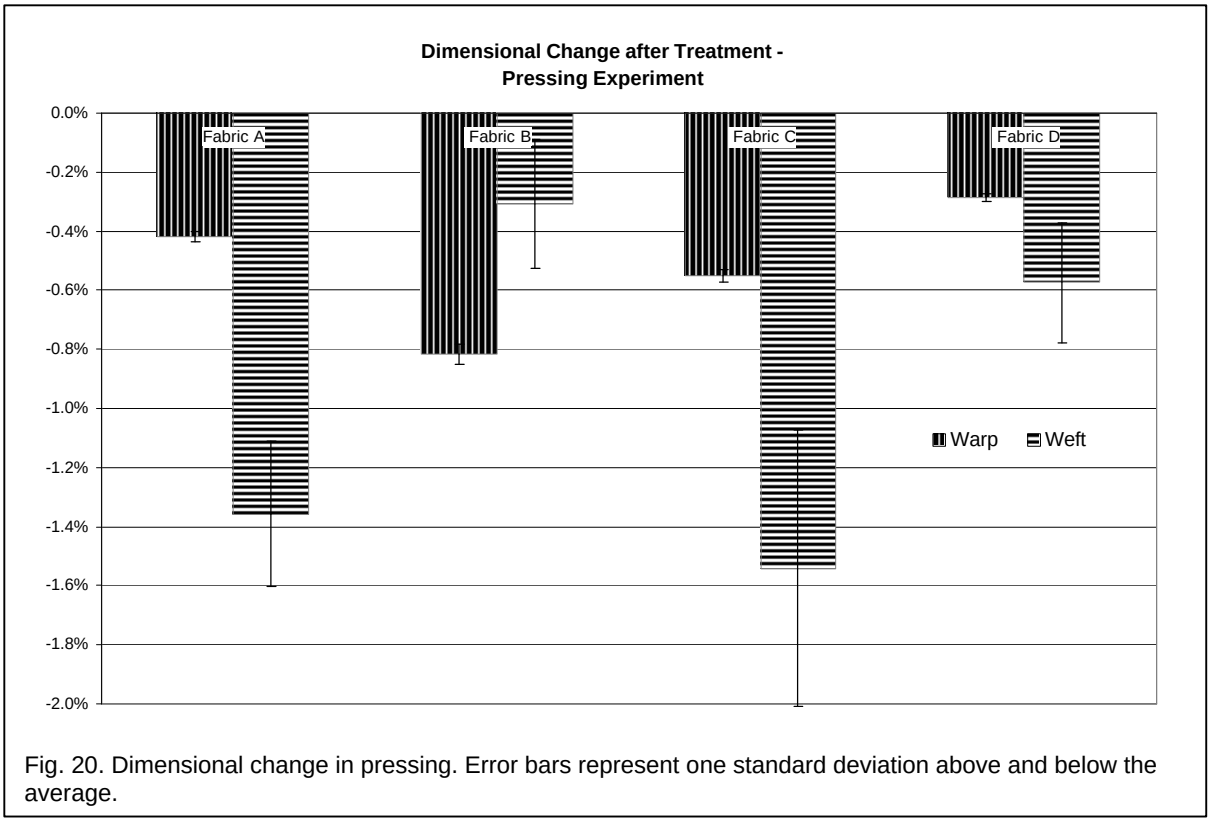


Fig. 20. Dimensional change in pressing. Error bars represent one standard deviation above and below the average.

Fabrics A, C, and D had more dimensional change in the weft direction. Fabric B, the only twill fabric, had more dimensional change in the warp direction.

Dimensional Change due to Laundering

Measurements after laundering were compared to both the treated (pressed) and untreated measurements. Complete data is listed in Appendix D. The average dimensional changes of each fabric are displayed graphically in Figs. 21-24. In the graphs, the changes due to laundering only are shown as striped columns (vertical stripes for warp measurements; horizontal stripes for weft measurements). The dimensional changes due to initial pressing are shown as dotted portions stacked on the striped columns. The combined columns represent the total changes due to pressing and laundering. There is only one segment for each control column since there was no initial pressing of these specimens.

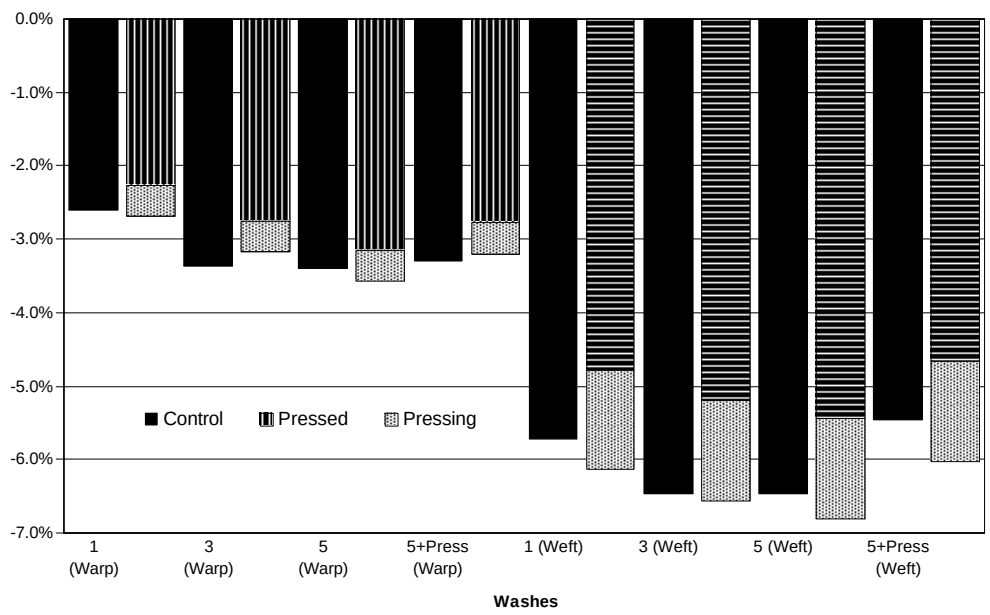


Fig. 21. Dimensional change of Fabric A, pressed versus control.

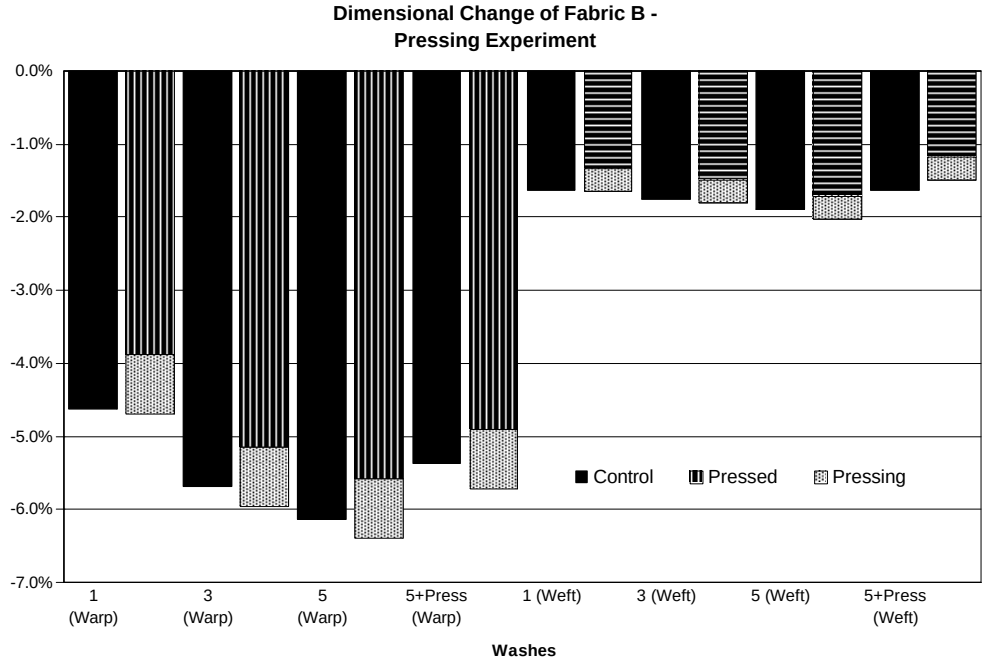


Fig. 22. Dimensional change of Fabric B, pressed versus control.

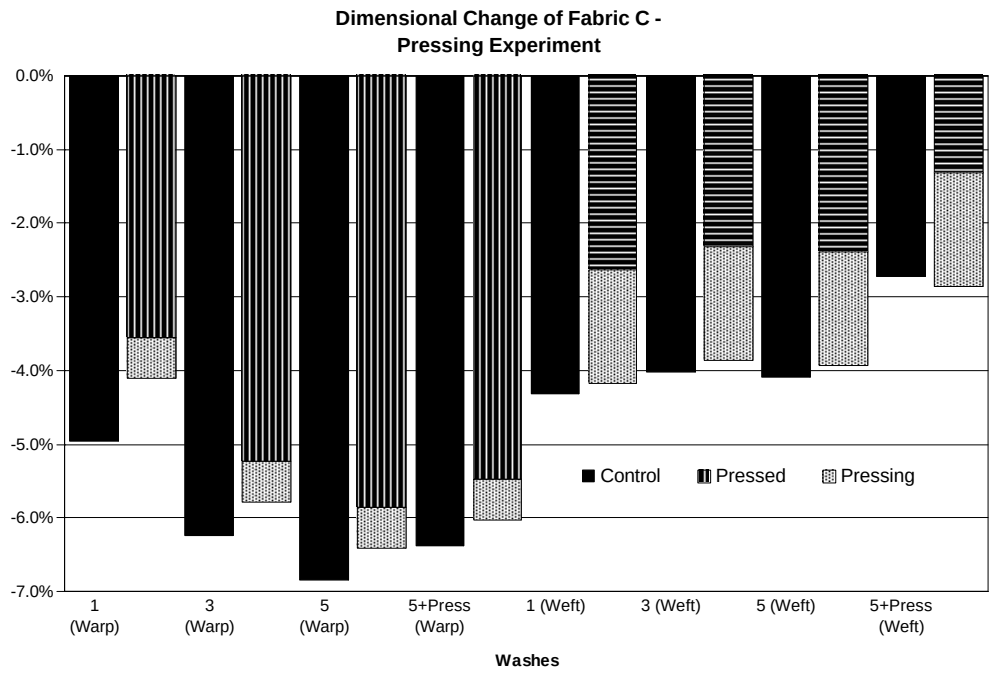


Fig. 23. Dimensional change of Fabric C, pressed versus control.

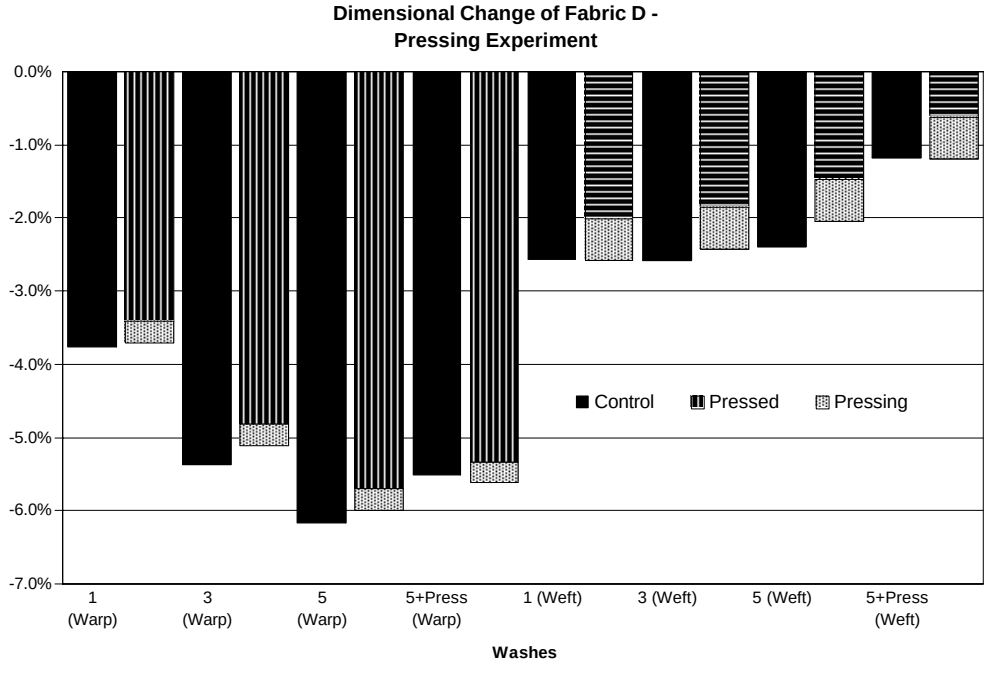


Fig. 24. Dimensional change of Fabric D, pressed versus control.

As expected, dimensional change generally increased with each wash. Dimensional change after five washes plus hand-pressing was slightly less than immediately after five washes for all fabrics in both directions. This was also expected due to flattening of wrinkles. Unlike the seam experiment, the relationship between control change and test specimen change remained relatively constant. Seams allowed for puckering and folding that did not occur on flat specimens; in this experiment, wrinkling was approximately equal on control and test specimens.

A t-test of the data illustrated in Figs. 21-24 shows that there are significant differences in the dimensional changes of pressed and unpressed samples due to laundering. There are fewer differences when the total dimensional change is considered. Table XV is the data for dimensional change calculated with the pressed condition as the "original." This represents the laundering-only change that consumers or labs see from a finished item that had been steamed or pressed in the manufacturing process. Table XVI is calculated for the pre-pressed condition as "original." This is the total dimensional change from pressing and laundering.
In the first comparison, all data pairs showed less dimensional change of the pressed sample than of the control. Even the least significant difference was 88.5% probable. All others were well over 90%. The second comparison had more varied results. Of the 48 data pairs, the pressed sample had significantly less (90% certainty) dimensional change than the control in eight cases. The opposite was true in six cases.

TABLE XV.

t-Test for Control and Pressed Averages (Pressed as "Original")

Fabric	Wash	t*	?	1-a/2
Warp A	1	-3.340	24	**0.997**
	3	-10.835	25	> **0.999**
	5	-1.660	17	0.885
	5 + Press	-6.061	34	> **0.999**
Warp B	1	-7.253	31	> **0.999**
	3	-5.657	29	> **0.999**
	5	-4.500	24	> **0.999**
	5 + Press	-4.155	32	> **0.999**
Warp C	1	-5.562	22	> **0.999**
	3	-8.967	23	> **0.999**
	5	-10.123	32	> **0.999**
	5 + Press	-9.068	34	> **0.999**
Warp D	1	-3.661	35	**0.999**
	3	-5.735	31	> **0.999**
	5	-4.154	31	> **0.999**
	5 + Press	-2.973	34	**0.995**
Weft A	1	-6.968	30	> **0.999**
	3	-7.751	22	> **0.999**
	5	-8.154	31	> **0.999**
	5 + Press	-5.903	33	> **0.999**
Weft B	1	-3.409	27	**0.998**
	3	-3.106	30	**0.996**
	5	-1.840	23	**0.921**
	5 + Press	-5.021	33	> **0.999**
Weft C	1	-5.054	23	> **0.999**
	3	-5.762	26	> **0.999**
	5	-5.708	23	> **0.999**
	5 + Press	-5.475	23	> **0.999**
Weft D	1	-3.843	31	**0.999**
	3	-6.266	28	> **0.999**
	5	-7.948	22	> **0.999**
	5 + Press	-7.476	33	> **0.999**

Note: Bold indicates less dimensional change of pressed sample than control with > 90% certainty.

TABLE XVI.

t-Test for Control and Pressed Averages (Pre-Pressed as "Original")

Fabric	Wash	t*	?	1-a/2
Warp A	1	0.801	23	0.569
	3	-3.140	31	**0.996**
	5	1.156	16	0.735
	5 + Press	-1.547	20	0.862
Warp B	1	0.291	22	0.226
	3	2.331	27	*0.973*
	5	1.917	19	*0.930*
	5 + Press	2.760	25	*0.989*
Warp C	1	-3.393	22	**0.997**
	3	-5.897	30	> **0.999**
	5	-5.994	23	> **0.999**
	5 + Press	-4.608	24	> **0.999**
Warp D	1	-0.799	30	0.569
	3	-3.198	28	**0.997**
	5	-1.956	26	**0.938**
	5 + Press	1.663	34	0.895
Weft A	1	3.093	33	*0.996*
	3	-0.059	28	0.047
	5	2.212	33	*0.966*
	5 + Press	4.101	32	> *0.999*
Weft B	1	0.237	27	0.186
	3	0.437	29	0.334
	5	1.312	26	0.799
	5 + Press	-1.403	32	0.830
Weft C	1	-0.538	30	0.406
	3	-0.657	30	0.484
	5	-0.667	30	0.490
	5 + Press	0.290	31	0.226
Weft D	1	-0.001	26	0.001
	3	-1.661	30	0.893
	5	-3.259	18	**0.995**
	5 + Press	-0.002	33	0.002

Note: Bold indicates less dimensional change of pressed sample with > 90% certainty. *Italics* indicate more dimensional change of pressed sample with > 90% certainty.

DISCUSSION

Seam Experiment

Shrinkage was expected along seams due to puckering, but it was discovered that for the seam assemblies tested, most puckering could be eliminated by hand-pressing. After final hand-pressing, seamed samples generally had less dimensional change than control samples. These results confirm research at University of Ljubljana in Slovenia, which found that seams acted to stabilize sewn items, reducing dimensional change.[12]

If appropriate sewing thread and stitch count is used, puckering may not be a significant factor in sewn-item dimensional change although future research is needed to verify this for other seam types.

It appeared that measurements along seams experienced more shrinkage than measurements across seams, even after final hand-pressing, but not all fabrics reliably followed this pattern.

Measurements across seams differ from control measurements only at the point where they intersect the seam. Such measurements were not expected to be significantly affected by the seams; however, they were affected by the lack of pressing between washes in this study.

Hand-pressing after laundering had a considerable impact on the results of this study, reversing some trends noted after laundering alone. This fact must be considered when developing protocols and standards for dimensional change in home laundering. AATCC TM135 notes that “reproducibility of dimensional change results after hand ironing has been found to be extremely poor” and advises hand ironing of specimens only “if the specimens are extremely wrinkled and the customer would ALWAYS expect to iron a garment made from the fabric.”[6]

This experiment showed that wrinkles and puckering add apparent shrinkage to the permanent changes in the dimensions of the fabric or sewn item. This is especially true for measurements along or across seams. For this

reason, values after hand-pressing were believed to be more accurate representations of true dimensional change. Since the heat and steam of hand-pressing did not appear to have a significant effect on dimensional change, future experiments should include pressing before each measurement.

If a fabric and resulting sewn item are both evaluated without hand-pressing, the sewn item may exhibit more negative dimensional change, even if no real difference exists. While it is true that there is no standard test method for hand-pressing, specifiers should consider the realistic likelihood that consumers will press items at home when determining whether to include hand-pressing in standard laundering protocols. Allowable dimensional change limits should also be developed with an understanding of whether specimens will be pressed. In this study, hand-pressing decreased the apparent shrinkage by an average of 1.1%. For a retailer that requires less than 3% dimensional change, this could easily account for the difference between passing and failing a sample.

Fusing Experiment

Due to a very limited data set for Fabrics C and D, conclusions based on these averages must be regarded with caution. Despite limited sample, fusing appears to stabilize fabrics, reducing dimensional change.

Differences among conditions due only to dimensional change in laundering are greater than differences in total dimensional change. For sewn products, this means that if dimensional change occurs during the making up process, there is likely to be less dimensional change in laundering of the item than of the flat fabric. This is discussed further in the Pressing experiment.

Treated and control fabrics were sewn together for the purpose of protecting the interfacing from delamination. It was discovered in the course of the experiment that dimensional change of the control, and possibly the treated fabric, was affected by being sewn to an unlike fabric. When controls were sewn to fused samples with little shrinkage, the controls themselves experienced less shrinkage. This is confirmed by results of the

Compatibility experiment, which also showed that when two unlike fabrics are sewn together, the overall dimensional change is between the expected change for each fabric individually.

Compatibility Experiment

Dimensional change of flat fabric provides useful information relevant to sewn item dimensional change. If two component fabrics are joined, the overall dimensional change of the item may be expected to be somewhere between the two. More importantly, there are appearance issues if the fabrics vary too greatly. Further study is required to determine the maximum degree of difference for acceptable appearance, although two percent has been suggested.[26] Specifiers should consider the dimensional change of fabric components to be used in the same item in relation to each other as well as to established quality standards.

The results of this experiment confirmed that there is more dimensional change along seams than across seams, as suggested by the Seam experiment.

Pressing Experiment

Pressing caused initial shrinkage of all fabrics (Fig. 20), but after laundering, the effect was greatly diminished except for on Fabric C in the warp direction. This suggests that the heat and moisture of pressing simply accelerates the expected relaxation of weaving tensions.

The real-world implication of this is that pressing and other processes involving heat or steam in the making-up of sewn items influences the dimensional change in laundering of the finished items. Sewn items can be expected to shrink less than the component flat fabrics because some of the relaxation shrinkage has already been taken up by pressing.

For this study, the most significant change due to pressing was in the weft direction of Fabric C (-1.5%). The greatest total shrinkage for the same fabric was -4.1%. This means pressing accounted for almost 37% of the

total dimensional change. Table XVII includes data comparing pressing shrinkage to total shrinkage for all fabrics.

TABLE XVII.

Pressing Dimensional Change versus Total Dimensional Change

Fabric	Dimensional Change after Pressing	Total Dimensional Change after Laundering (Max.)	Pressing DC/ Total DC
A (Warp)	-0.4%	-3.4% (3&5 Washes)	12%
A (Weft)	-1.4%	-6.5% (3&5 Washes)	22%
B (Warp)	-0.8%	-6.1% (5 Washes)	13%
B (Weft)	-0.3%	-1.9% (5 Washes)	16%
C (Warp)	-0.6%	-6.9% (5 Washes)	9%
C (Weft)	-1.5%	-4.3% (1 Wash)	35%
D (Warp)	-0.3%	-6.2% (5 Washes)	5%
D (Weft)	-0.6%	-2.6% (1&3 Washes)	23%

For all the fabrics tested, pressing accounted for at least 15% of total shrinkage in at least one direction. While the measurements and percentages are small and therefore prone to error, standard deviation for all samples was low, and patterns were consistent across washes and fabrics.

Specifiers may wish to set slightly wider tolerances for dimensional change of flat fabric to prevent rejection of fabric that would result in acceptable dimensional change as a sewn item; however, this assumes that the differential shrinkage can be accommodated in the making-up process. This may be an invalid assumption since a past study showed that the amount of dimensional change experienced in making-up can not be accurately predicted.[22] The current study also showed that dimensional change under controlled circumstances varied considerably across fabrics of similar content and construction (Fig. 20). Actual production conditions and fabrics would vary further.

CONCLUSIONS

Seams

Seams are the most visible difference between flat fabric and sewn items. Empirical evidence from a preliminary study and general observation suggests that seams pucker in laundering, resulting in more negative dimensional change (shrinkage) along the seam than in open areas of fabric. This study confirmed this for the fabrics tested when seams were not pressed after laundering. Dimensional change along seams was more important than across seams whether the sewn panels are of the same or different fabrics, and unpressed or pressed.

The cotton fabrics used in this study were prone to wrinkling and it is likely that consumers washing sewn items of these fabrics would press them with a hand-iron. Results showed that hand-pressing after laundering resulted in less dimensional change along some seams than on comparable control samples (unseamed fabric). The seams served to stabilize the areas immediately adjacent to the stitching.

The difference between unpressed and pressed dimensional change is very important in determining a test protocol for fabrics and sewn items. It must first be determined whether a particular fabric, seam, or item can be reliably measured without pressing. It is also important to know whether consumers are likely to press the end product. If hand-pressing is necessary for accurate and reproducible measurements, or to mirror consumer behavior, this should be specified in the test protocol and dimensional change requirements should be established accordingly. Based on the results of this study, the same requirements are probably appropriate for pressed fabric and sewn items. If items will not be pressed, a tighter tolerance may be advisable for flat fabric to ensure that sewn items of the same fabric meet the desired dimensional change specifications.

Fusing

Fusing, another joining method, had the same stabilizing effect as seams. The fused fabrics had less

dimensional change than comparable control fabrics. The act of fusing with heat and steam did cause some change, but the Pressing experiment showed that this is likely due to relaxation shrinkage that will occur *either* in fusing *or* in laundering. The initial change observed in fused samples happens in laundering of control samples.

Compatibility

Not surprisingly, when fabrics with different propensities to dimensional change are sewn together, the dimensional change of the resulting item is between that of the individual fabrics. At the seam, fabrics with less dimensional change stabilize those with more. This was seen in the Compatibility experiment as well as in the Fusing experiment. Control fabrics sewn to fused panels had less overall change even though measurements were not taken at the seam. Since the specimens were stitched on all four sides, the fused sample actually held the control taut between the seams.

For the sake of appearance, sewn items should use fabrics with similar dimensional change profiles. Poorly matched fabrics result in puckered and unattractive seams even if the overall measurements meet the stated specifications. Panels that are fused or otherwise stabilized should be considered separate fabrics for the sake of determining compatibility. If all fabrics meet the standard ASTM requirement of less than 2% dimensional change in laundering, compatibility is unlikely to be an issue, but the existence of seams must still be considered as discussed above. A tolerable spread for the dimensional change values of fabrics to be incorporated in a sewn item was not established and will likely vary with the values themselves.

Pressing

Commercial pressing as well as hand pressing in the Fusing experiment caused initial shrinkage of most fabrics. As mentioned in the Fusing discussion, the total dimensional change of a laundered fabric is not significantly affected by initial pressing. This also means that total dimensional change is more likely to be affected by final pressing after an initial wash—before relaxation shrinkage is complete—than after five or more washes. The

fact that the initial change occurs before laundering is important for laboratory testing and consumer experience. Neither the lab nor the consumer sees the total dimensional change.

Items that have been pressed or otherwise steamed in the making-up process exhibit less dimensional change in laundering. Most sewn items experience some form of pressing or steaming during production, so these items will have less dimensional change than the flat fabric (which has not been pressed) from which they are made. Specifiers using the same dimensional change tolerances for fabric and sewn items should have few failures of sewn items made from passing fabrics.

General

The components and processes involved in converting flat fabric to a finished item do affect the dimensional change of that item. Seams, fusing, and initial pressing all serve to stabilize the sewn item. This is in agreement with several unscientific observations by those involved in textile testing and specification. ("We usually see similar results, but garments tend to [have] a little less shrinkage;" "Less change in garment than in the fabric.")[10] A pass in the fabric stage is likely to be a good indication of passing in the finished item stage, but it is not practical to skip testing at the finished stage because other appearance issues must be evaluated.

The difference between dimensional changes of fabric and sewn items varies with the type of fabric, seam, and other details. It is impractical to try to establish a general rule for the difference between dimensional change of a fabric and a resulting sewn item, but manufacturers and specifiers should be aware of the factors involved so that any problems can be corrected efficiently, without resorting to trial-and-error attempts.

Fabric testing is used to eliminate nonconforming fabrics before investing large sums of time and money. This purpose may be better served with a test method that incorporates some of the components included in this study .

FUTURE RESEARCH

This study constitutes an initial investigation into the factors that affect the dimensional change of sewn items in laundering. Some basic trends were suggested, but additional studies are necessary to verify these trends for all types of fabric and processing. Future testing must include samples of fabrics with various fiber contents and construction parameters. Before reliable recommendations can be made, a larger and more diverse body of data is needed.

Combined effects of sewing, fusing, and pressing were not examined in this study. Construction of sewn items involves all or most of these operations, so any interaction among variables is important in developing recommendations or predictions for real-world use.

To better represent industrial production techniques, a different seam type might be used. A true fusing press could also be used. Better fusing may eliminate the need for a facing fabric and reduce the number of variables in the test. Actual production specimens, taken at various points in the construction process, would provide the most realistic scenario, but require the cooperation of a manufacturer and introduce more variables than specially-prepared lab specimens.

The effects of specific seam parameters could be studied in more detail. Understanding how various threads, stitch counts, and seam types impact dimensional change would be beneficial to manufacturers trying to design items with minimal dimensional change in laundering. Different types of fusing and various weights of interfacing could also be compared.

Future research may also cover those components not addressed in this study, including spreading, cutting, embroidery, garment finishing and washing, and packing and storage.

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APPENDICES

Appendix A: Seam Experiment

Fabric A Original									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253	A1	252	252	253	252
B2	254	254	254	254	B2	253	253	253	253
C3	253	253	253	253	C3	253	253	253	253
D4	253	253	253	253	D4	253	253	253	253
E5	253	253	253	253	E5	253	253	253	253
A7	253	252	254	253	A7	252	253	252	252
Average				253	Average				253
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	255			255	B1	254	254	254	254
C2	255			255	C2	252	254	254	253
D3	254			254	D3	254	254	254	254
E4	254			254	E4	254	254	252	253
A6	254			254	A6	255	254	254	254
B7	255			255	B7	252	253	253	253
Average				255	Average				254
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	255	254	254	254	C1	253			253
D2	255	255	254	255	D2	253			253
E3	255	255	254	255	E3	253			253
A5	255	255	255	255	A5	253			253
B6	255	255	253	254	B6	254			254
C7	255	254	255	255	C7	254			254
Average				255	Average				253

Fabric A After 3 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244	A1	236	237	237	237
B2	245	245	246	245	B2	235	237	237	236
C3	245	244	244	244	C3	237	237	238	237
D4	245	245	245	245	D4	237	237	236	237
E5	245	245	245	245	E5	235	236	236	236
A7	244	243	-	244	A7	-	-	-	N/A
Average				245	Average				237
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	246			246	B1	239	238	239	239
C2	244			244	C2	238	238	239	238
D3	243			243	D3	237	237	237	237
E4	244			244	E4	238	236	236	237
A6	242			242	A6	-	238	237	238
B7	242			242	B7	-	237	238	238
Average				244	Average				238
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	247	245	247	246	C1	239			239
D2	246	247	246	246	D2	238			238
E3	247	247	246	247	E3	236			236
A5	245	246	246	246	A5	236			236
B6	246	246	244	245	B6	238			238
C7	246	247	246	246	C7	239			239
Average				246	Average				238

Fabric A After 1 Wash									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	245	245	247	246	A1	237	238	238	238
B2	247	247	247	247	B2	239	239	239	239
C3	245	245	246	245	C3	239	239	240	239
D4	247	247	247	247	D4	238	239	238	238
E5	247	247	247	247	E5	237	238	238	238
A7	247	245	-	246	A7	-	-	-	N/A
Average				246	Average				238
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	248			248	B1	239	239	239	239
C2	245			245	C2	239	239	239	239
D3	246			246	D3	239	239	239	239
E4	244			244	E4	244	243	244	244
A6	245			245	A6	-	241	241	241
B7	246			246	B7	-	239	240	240
Average				246	Average				240
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	249	248	248	248	C1	239			239
D2	248	249	248	248	D2	239			239
E3	248	249	247	248	E3	237			237
A5	248	248	249	248	A5	236			236
B6	247	247	246	247	B6	239			239
C7	247	248	247	247	C7	240			240
Average				248	Average				238

Fabric A After 5 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244	A1	236	237	237	237
B2	244	244	244	244	B2	237	237	237	237
C3	243	243	244	243	C3	237	237	237	237
D4	246	247	246	246	D4	237	236	236	236
E5	246	247	246	246	E5	236	235	236	236
A7	243	243	-	243	A7	-	-	-	N/A
Average				245	Average				237
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	244			244	B1	236	237	238	237
C2	243			243	C2	237	237	238	237
D3	243			243	D3	237	237	236	237
E4	243			243	E4	235	236	235	235
A6	242			242	A6	-	239	239	239
B7	243			243	B7	-	237	238	238
Average				243	Average				237
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	245	245	247	246	C1	238			238
D2	245	246	245	245	D2	236			236
E3	244	244	245	244	E3	236			236
A5	245	245	244	245	A5	237			237
B6	243	245	243	244	B6	240			240
C7	245	246	246	246	C7	238			238
Average				245	Average				238

Fabric A After 5 Washes + Pressing									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244	A1	238	238	238	238
B2	245	245	245	245	B2	239	240	241	240
C3	245	244	244	244	C3	239	240	240	240
D4	245	244	245	245	D4	239	239	240	239
E5	246	245	246	246	E5	239	238	238	238
A7	245	244	-	245	A7	-	-	-	N/A
Average				245	Average				239
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	247			247	B1	240	241	241	241
C2	246			246	C2	240	241	242	241
D3	246			246	D3	240	240	239	240
E4	247			247	E4	241	239	238	239
A6	245			245	A6	-	242	241	242
B7	247			247	B7	-	241	242	242
Average				246	Average				241
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	247	246	248	247	C1	240			240
D2	247	248	247	247	D2	239			239
E3	248	249	248	248	E3	239			239
A5	247	248	248	248	A5	241			241
B6	246	248	245	246	B6	241			241
C7	247	247	247	247	C7	242			242
Average				247	Average				240

Fabric B Original									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253	A1	253	253	254	253
C4	253	253	254	253	C4	253	254	254	254
B6	253	253	253	253	B6	253	253	253	253
A8	252	253	253	253	A8	254	253	253	253
C10	253	253	253	253	C10	253	253	253	253
B12	253	253	253	253	B12	253	253	254	253
Average				253	Average				253
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	253			253	B1	255	255	255	255
A3	253			253	A3	255	256	255	255
C6	253			253	C6	255	255	254	255
B8	253			253	B8	254	255	255	255
A9	254			254	A9	255	255	255	255
C12	251			251	C12	254	255	254	254
Average				253	Average				255
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	255	255	253	254	C1	254			254
B3	253	253	254	253	B3	254			254
A5	255	255	255	255	A5	253			253
C8	254	255	254	254	C8	254			254
B9	254	255	255	255	B9	255			255
A11	255	256	254	255	A11	254			254
Average				254	Average				254

Fabric B After 1 Wash									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	243	242	242	242	A1	249	249	250	249
C4	242	241	241	241	C4	249	249	249	249
B6	241	241	241	241	B6	250	249	249	249
A8	242	241	242	242	A8	250	250	249	250
C10	240	240	241	240	C10	248	248	250	249
B12	241	241	241	241	B12	249	249	249	249
Average				241	Average				249
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	241			241	B1	251	250	250	250
A3	242			242	A3	250	253	251	251
C6	241			241	C6	250	250	248	249
B8	243			243	B8	248	248	250	249
A9	243			243	A9	250	249	251	250
C12	241			241	C12	249	250	250	250
Average				242	Average				250
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	239	241	239	240	C1	246			246
B3	237	238	239	238	B3	249			249
A5	241	241	241	241	A5	248			248
C8	241	241	240	241	C8	249			249
B9	239	242	243	241	B9	249			249
A11	242	242	239	241	A11	249			249
Average				240	Average				248

Fabric B After 3 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	240	240	239	240	A1	249	249	250	249
C4	238	238	238	238	C4	248	249	249	249
B6	239	239	239	239	B6	249	248	248	248
A8	239	238	239	239	A8	249	250	249	249
C10	238	238	239	238	C10	248	248	249	248
B12	238	238	238	238	B12	249	249	249	249
Average				239	Average				249
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	238			238	B1	250	249	250	250
A3	239			239	A3	250	253	251	251
C6	239			239	C6	250	250	249	250
B8	240			240	B8	249	249	250	249
A9	240			240	A9	250	250	250	250
C12	237			237	C12	248	250	249	249
Average				239	Average				250
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	239	238	236	238	C1	247			247
B3	238	239	238	238	B3	248			248
A5	240	239	238	239	A5	246			246
C8	237	239	238	238	C8	247			247
B9	237	239	240	239	B9	249			249
A11	240	240	237	239	A11	247			247
Average				238	Average				247

Fabric B After 5 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	240	239	238	239	A1	248	248	250	249
C4	237	236	236	236	C4	248	248	249	248
B6	237	237	237	237	B6	249	247	248	248
A8	238	238	238	238	A8	250	250	249	250
C10	237	237	237	237	C10	248	248	249	248
B12	237	238	238	238	B12	248	248	248	248
Average				238	Average				249
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	236			236	B1	250	249	250	250
A3	239			239	A3	250	254	251	252
C6	237			237	C6	250	250	248	249
B8	238			238	B8	248	249	250	249
A9	239			239	A9	250	249	249	249
C12	236			236	C12	249	250	250	250
Average				238	Average				250
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	239	238	235	237	C1	248			248
B3	237	237	237	237	B3	246			246
A5	238	238	237	238	A5	248			248
C8	236	239	238	238	C8	246			246
B9	237	239	240	239	B9	247			247
A11	239	239	237	238	A11	247			247
Average				238	Average				247

Fabric B After 5 Washes + Pressing									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	241	240	239	240	A1	249	249	250	249
C4	239	238	239	239	C4	249	249	249	249
B6	240	240	240	240	B6	249	248	249	249
A8	240	240	240	240	A8	250	250	250	250
C10	239	239	240	239	C10	249	249	249	249
B12	239	238	238	238	B12	249	249	249	249
Average				239	Average				249
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	241			241	B1	252	252	252	252
A3	240			240	A3	251	254	253	253
C6	239			239	C6	251	251	250	251
B8	241			241	B8	250	251	252	251
A9	243			243	A9	251	252	253	252
C12	239			239	C12	252	253	252	252
Average				241	Average				252
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
C1	240	240	237	239	C1	250			250
B3	240	240	241	240	B3	249			249
A5	240	241	242	241	A5	249			249
C8	242	243	240	242	C8	249			249
B9	243	243	242	243	B9	250			250
A11	241	242	240	241	A11	250			250
Average				241	Average				250

Fabric C Original									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253	A1	253	253	253	253
B3	253	253	253	253	B3	253	253	253	253
A6	253	253	253	253	A6	253	253	253	253
B8	253	253	253	253	B8	253	252	252	252
A11	253	253	253	253	A11	253	253	253	253
B13	253	253	253	253	B13	252	252	252	252
Average				253	Average				253
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	252			252	B1	252	253	253	253
A4	253			253	A4	253	253	253	253
B6	252			252	B6	253	253	253	253
A9	253			253	A9	253	253	253	253
B11	253			253	B11	253	253	253	253
A14	253			253	A14	252	253	253	253
Average				253	Average				253
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	254	253	253	253	A2	253			253
B4	253	253	253	253	B4	253			253
A7	253	253	253	253	A7	253			253
B14	253	253	253	253	B14	252			252
A16	253	253	253	253	A16	253			253
B16	253	253	253	253	B16	253			253
Average				253	Average				253

Fabric C After 1 Wash									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	242	241	242	242	A1	244	244	244	244
B3	240	241	241	241	B3	240	239	239	239
A6	240	241	240	240	A6	245	245	245	245
B8	239	239	239	239	B8	237	237	240	238
A11	241	241	241	241	A11	245	245	245	245
B13	240	240	240	240	B13	239	240	240	240
Average				240	Average				242
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	240			240	B1	240	240	241	240
A4	238			238	A4	244	245	244	244
B6	239			239	B6	239	240	241	240
A9	240			240	A9	245	245	245	245
B11	238			238	B11	240	241	241	241
A14	240			240	A14	242	242	242	242
Average				239	Average				242
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	238	240	240	239	A2	243			243
B4	240	240	240	240	B4	242			242
A7	239	239	240	239	A7	242			242
B14	240	240	237	239	B14	239			239
A16	240	239	239	239	A16	240			240
B16	240	240	240	240	B16	238			238
Average				240	Average				241

Fabric C After 3 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238	A1	244	244	244	244
B3	237	237	238	237	B3	240	240	241	240
A6	237	237	236	237	A6	245	245	246	245
B8	237	237	237	237	B8	240	239	240	240
A11	237	237	237	237	A11	245	247	245	246
B13	237	237	238	237	B13	240	240	241	240
Average				237	Average				243
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	234			234	B1	241	241	241	241
A4	233			233	A4	246	244	244	245
B6	235			235	B6	240	241	242	241
A9	234			234	A9	244	244	242	243
B11	233			233	B11	240	240	241	240
A14	235			235	A14	241	241	242	241
Average				234	Average				242
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	237	236	237	237	A2	242			242
B4	237	237	237	237	B4	240			240
A7	236	236	235	236	A7	245			245
B14	237	236	237	237	B14	230			230
A16	237	236	237	237	A16	249			249
B16	237	236	235	236	B16	237			237
Average				236	Average				241

Fabric C After 5 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	236	236	237	236	A1	245	244	244	244
B3	237	236	236	236	B3	240	239	240	240
A6	236	236	236	236	A6	246	247	247	247
B8	235	235	235	235	B8	240	239	240	240
A11	235	234	235	235	A11	243	244	244	244
B13	235	236	236	236	B13	240	240	241	240
Average				236	Average				243
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	237			237	B1	240	241	242	241
A4	233			233	A4	245	245	242	244
B6	233			233	B6	241	239	239	240
A9	234			234	A9	243	242	243	243
B11	233			233	B11	240	241	240	240
A14	231			231	A14	243	243	242	243
Average				234	Average				242
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	235	235	236	235	A2	243			243
B4	234	234	234	234	B4	240			240
A7	235	235	233	234	A7	243			243
B14	240	238	235	238	B14	238			238
A16	234	234	233	234	A16	241			241
B16	235	235	235	235	B16	240			240
Average				235	Average				241

Fabric C After 5 Washes + Pressing									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238	A1	246	246	247	246
B3	237	237	236	237	B3	243	243	243	243
A6	237	237	237	237	A6	249	250	250	250
B8	236	236	236	236	B8	245	244	244	244
A11	236	236	236	236	A11	247	248	248	248
B13	237	237	237	237	B13	244	244	244	244
Average				237	Average				246
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	239			239	B1	245	245	245	245
A4	239			239	A4	249	249	249	249
B6	237			237	B6	244	243	245	244
A9	238			238	A9	248	248	248	248
B11	238			238	B11	245	244	246	245
A14	238			238	A14	245	246	246	246
Average				238	Average				246
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	238	238	237	238	A2	247			247
B4	237	237	237	237	B4	244			244
A7	237	236	236	236	A7	247			247
B14	238	237	238	238	B14	243			243
A16	236	236	236	236	A16	247			247
B16	237	237	236	237	B16	244			244
Average				237	Average				245

Fabric D Original									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	253	254	253	253	A1	253	253	253	253
B3	253	253	253	253	B3	253	253	253	253
A6	253	253	253	253	A6	253	253	253	253
B8	253	253	253	253	B8	253	253	253	253
A11	253	253	253	253	A11	253	253	253	253
B13	253	253	253	253	B13	253	254	254	254
Average				253	Average				253
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	253			253	B1	253	253	253	253
A4	253			253	A4	253	253	253	253
B6	253			253	B6	254	254	254	254
A9	253			253	A9	253	253	253	253
B11	253			253	B11	253	253	253	253
A14	253			253	A14	253	254	253	253
Average				253	Average				253
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	253	253	253	253	A2	253			253
B4	253	253	253	253	B4	254			254
A7	253	253	253	253	A7	254			254
B9	253	253	253	253	B9	253			253
A12	253	253	253	253	A12	253			253
B14	253	253	253	253	B14	253			253
Average				253	Average				253

Fabric D After 1 Wash									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244	A1	246	246	247	246
B3	243	243	242	243	B3	247	248	249	248
A6	244	243	244	244	A6	245	245	245	245
B8	244	244	244	244	B8	247	247	248	247
A11	243	243	243	243	A11	246	246	246	246
B13	243	244	244	244	B13	246	248	247	247
Average				244	Average				247
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	242			242	B1	245	245	246	245
A4	242			242	A4	246	246	246	246
B6	242			242	B6	245	245	245	245
A9	243			243	A9	246	246	247	246
B11	242			242	B11	247	247	247	247
A14	242			242	A14	246	246	247	246
Average				242	Average				246
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	242	242	243	242	A2	245			245
B4	242	242	242	242	B4	245			245
A7	242	243	243	243	A7	245			245
B9	243	243	244	243	B9	246			246
A12	242	242	243	242	A12	245			245
B14	243	243	243	243	B14	246			246
Average				243	Average				245

Fabric D After 3 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	241	241	240	241	A1	246	245	246	246
B3	239	239	238	239	B3	247	247	248	247
A6	238	239	240	239	A6	246	247	246	246
B8	240	240	240	240	B8	247	246	247	247
A11	239	239	240	239	A11	246	246	246	246
B13	239	239	239	239	B13	247	248	247	247
Average				239	Average				247
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	238			238	B1	244	244	245	244
A4	239			239	A4	246	245	245	245
B6	237			237	B6	245	245	245	245
A9	237			237	A9	246	246	247	246
B11	238			238	B11	245	245	245	245
A14	239			239	A14	245	245	245	245
Average				238	Average				245
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	239	239	239	239	A2	244			244
B4	239	239	238	239	B4	246			246
A7	239	239	238	239	A7	242			242
B9	238	238	238	238	B9	238			238
A12	239	239	238	239	A12	245			245
B14	239	238	239	239	B14	244			244
Average				239	Average				243

Fabric D After 5 Washes									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	239	239	239	239	A1	246	246	246	246
B3	237	237	237	237	B3	248	248	249	248
A6	237	237	238	237	A6	246	246	247	246
B8	238	238	238	238	B8	248	248	248	248
A11	236	236	236	236	A11	246	246	246	246
B13	237	237	238	237	B13	247	248	248	248
Average				237	Average				247
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	234			234	B1	243	244	244	244
A4	236			236	A4	247	247	247	247
B6	236			236	B6	247	246	246	246
A9	237			237	A9	246	247	247	247
B11	234			234	B11	245	247	246	246
A14	234			234	A14	245	246	246	246
Average				235	Average				246
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	237	236	237	237	A2	245			245
B4	237	237	237	237	B4	246			246
A7	241	242	240	241	A7	243			243
B9	237	237	237	237	B9	246			246
A12	237	237	237	237	A12	244			244
B14	238	237	238	238	B14	246			246
Average				238	Average				245

Fabric D After 5 Washes + Pressing									
Control (Warp)	**1**	**2**	**3**	**Avg.**	**Control (Weft)**	**1**	**2**	**3**	**Avg.**
A1	240	240	240	240	A1	249	249	250	249
B3	239	239	239	239	B3	250	250	251	250
A6	239	239	239	239	A6	250	250	250	250
B8	239	239	239	239	B8	250	250	250	250
A11	239	238	239	239	A11	250	250	250	250
B13	239	239	239	239	B13	251	251	251	251
Average				239	Average				250
Along Warp Seam	**1**			**Avg.**	**Across Warp Seam**	**1**	**2**	**3**	**Avg.**
B1	240			240	B1	248	249	250	249
A4	240			240	A4	251	250	250	250
B6	240			240	B6	250	250	250	250
A9	241			241	A9	250	251	251	251
B11	240			240	B11	251	251	250	251
A14	240			240	A14	249	250	251	250
Average				240	Average				250
Across Weft Seam	**1**	**2**	**3**	**Avg.**	**Along Weft Seam**	**1**			**Avg.**
A2	239	239	240	239	A2	248			248
B4	239	240	240	240	B4	249			249
A7	239	239	239	239	A7	248			248
B9	240	240	240	240	B9	249			249
A12	239	239	239	239	A12	248			248
B14	240	240	240	240	B14	249			249
Average				240	Average				249

Appendix B: Fusing Experiment

Fabric A (Warp) Original				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	202	202	202	202
D10	202	202	202	202
C11	202	202	202	202
D12	202	202	203	202
C13	202	202	202	202
F13	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B10	202	202	202	202
F10	202	202	202	202
E11	202	202	202	202
B12	202	202	202	202
E12	203	202	203	203
B13	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	202	202	202	202
A11	202	202	203	202
D11	202	202	202	202
A12	202	202	202	202
F12	202	202	202	202
D13	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
E10	202	202	202	202
B11	202	202	202	202
F11	202	202	202	202
C12	202	202	202	202
A13	202	203	202	202
E13	202	202	202	202
Average				202

Fabric A (Weft) Original				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	202	202	203	202
D10	202	202	202	202
C11	202	202	202	202
D12	203	202	202	202
C13	203	203	202	203
F13	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B10	202	202	202	202
F10	202	202	203	202
E11	202	202	202	202
B12	202	202	203	202
E12	202	202	202	202
B13	203	203	204	203
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	202	202	202	202
A11	203	203	202	203
D11	203	203	203	203
A12	202	202	203	202
F12	202	202	202	202
D13	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
E10	202	202	202	202
B11	202	202	203	202
F11	202	202	202	202
C12	202	202	202	202
A13	202	202	202	202
E13	202	204	204	203
Average				202

Fabric A (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	202	202	203	202
D10	202	202	202	202
C11	202	202	203	202
D12	202	202	202	202
C13	202	202	202	202
F13	202	202	202	202
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B10	202	202	202	202
F10	202	201	202	202
E11	202	202	203	202
B12	202	202	202	202
E12	202	202	202	202
B13	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	202	203	202	202
A11	202	202	202	202
D11	202	202	202	202
A12	202	202	202	202
F12	202	202	202	202
D13	202	202	202	202
Average				202
Fused	**1**	**2**	**3**	**Avg.**
E10	200	200	200	200
B11	200	199	200	200
F11	200	200	201	200
C12	200	200	201	200
A13	200	200	200	200
E13	199	200	200	200
Average				200

Fabric A (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	202	202	202	202
D10	202	202	203	202
C11	202	202	202	202
D12	202	201	202	202
C13	201	201	201	201
F13	200	200	201	200
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B10	202	201	202	202
F10	202	202	201	202
E11	201	202	202	202
B12	201	201	202	201
E12	202	202	202	202
B13	201	202	203	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	202	202	202	202
A11	202	203	202	202
D11	203	203	203	203
A12	203	202	203	203
F12	203	203	203	203
D13	202	202	202	202
Average				203
Fused	**1**	**2**	**3**	**Avg.**
E10	202	202	202	202
B11	202	202	202	202
F11	201	201	202	201
C12	202	202	201	202
A13	202	201	201	201
E13	202	204	206	204
Average				202

Fabric A (Warp) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	198	198	198	198
D10	198	198	198	198
C11	199	198	198	198
D12	197	198	197	197
C13	197	198	198	198
F13	197	198	198	198
Average				198
Pressed	**1**	**2**	**3**	**Avg.**
B10	197	197	198	197
F10	198	197	198	198
E11	198	198	198	198
B12	197	197	197	197
E12	198	198	198	198
B13	198	197	197	197
Average				198
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	199	199	199	199
A11	199	199	199	199
D11	198	199	199	199
A12	198	198	198	198
F12	198	198	198	198
D13	200	199	199	199
Average				199
Fused	**1**	**2**	**3**	**Avg.**
E10	196	196	196	196
B11	196	196	197	196
F11	197	197	197	197
C12	197	197	197	197
A13	197	197	196	197
E13	197	198	198	198
Average				197

Fabric A (Weft) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	190	189	190	190
D10	190	190	191	190
C11	189	189	189	189
D12	192	191	191	191
C13	192	192	192	192
F13	190	191	191	191
Average				191
Pressed	**1**	**2**	**3**	**Avg.**
B10	191	191	191	191
F10	192	191	192	192
E11	191	191	191	191
B12	191	191	191	191
E12	192	193	193	193
B13	191	192	194	192
Average				192
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	191	191	191	191
A11	192	193	192	192
D11	193	193	193	193
A12	192	192	192	192
F12	193	192	193	193
D13	195	194	195	195
Average				193
Fused	**1**	**2**	**3**	**Avg.**
E10	196	196	195	196
B11	196	197	197	197
F11	194	197	196	196
C12	196	195	194	195
A13	194	193	194	194
E13	197	200	201	199
Average				196

Fabric A (Warp) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	197	197	197	197
D10	197	197	197	197
C11	197	197	197	197
D12	196	196	196	196
C13	196	196	196	196
F13	196	196	196	196
Average				197
Pressed	**1**	**2**	**3**	**Avg.**
B10	197	197	197	197
F10	197	196	197	197
E11	197	197	197	197
B12	196	196	196	196
E12	196	196	196	196
B13	197	196	195	196
Average				196
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	198	198	198	198
A11	198	197	198	198
D11	197	197	197	197
A12	196	197	196	196
F12	196	197	196	196
D13	197	197	197	197
Average				197
Fused	**1**	**2**	**3**	**Avg.**
E10	194	193	194	194
B11	194	194	195	194
F11	195	196	196	196
C12	195	195	195	195
A13	194	194	194	194
E13	194	194	195	194
Average				195

Fabric A (Weft) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	189	188	188	188
D10	189	189	190	189
C11	188	188	188	188
D12	190	190	190	190
C13	190	190	190	190
F13	189	189	189	189
Average				189
Pressed	**1**	**2**	**3**	**Avg.**
B10	189	188	189	189
F10	190	190	190	190
E11	190	190	190	190
B12	189	189	190	189
E12	190	191	191	191
B13	189	190	192	190
Average				190
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	189	189	189	189
A11	190	191	190	190
D11	191	191	192	191
A12	190	190	190	190
F12	190	190	190	190
D13	193	192	192	192
Average				191
Fused	**1**	**2**	**3**	**Avg.**
E10	193	193	194	193
B11	194	194	194	194
F11	194	193	195	194
C12	195	193	192	193
A13	191	191	192	191
E13	195	197	198	197
Average				194

Fabric A (Warp) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	196	197	197	197
D10	197	197	197	197
C11	197	197	197	197
D12	196	196	196	196
C13	195	195	195	195
F13	195	196	196	196
Average				196
Pressed	**1**	**2**	**3**	**Avg.**
B10	196	196	196	196
F10	197	196	196	196
E11	196	197	196	196
B12	195	195	195	195
E12	196	195	196	196
B13	196	195	195	195
Average				196
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	197	197	197	197
A11	197	197	197	197
D11	196	196	197	196
A12	195	195	195	195
F12	196	196	196	196
D13	196	196	196	196
Average				196
Fused	**1**	**2**	**3**	**Avg.**
E10	193	193	193	193
B11	194	193	195	194
F11	195	196	196	196
C12	194	195	194	194
A13	194	194	193	194
E13	193	194	193	193
Average				194

Fabric A (Weft) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	188	187	188	188
D10	189	188	189	189
C11	188	188	188	188
D12	189	189	189	189
C13	189	189	189	189
F13	187	188	188	188
Average				188
Pressed	**1**	**2**	**3**	**Avg.**
B10	190	188	189	189
F10	190	190	190	190
E11	190	190	190	190
B12	188	188	189	188
E12	189	190	190	190
B13	189	189	191	190
Average				189
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	188	188	189	188
A11	190	190	190	190
D11	191	191	191	191
A12	189	189	189	189
F12	189	189	190	189
D13	192	191	191	191
Average				190
Fused	**1**	**2**	**3**	**Avg.**
E10	192	194	193	193
B11	193	194	193	193
F11	191	192	192	192
C12	192	192	192	192
A13	191	190	190	190
E13	194	195	197	195
Average				193

Fabric A (Warp) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	197	197	197	197
D10	197	198	197	197
C11	198	197	197	197
D12	196	196	197	196
C13	197	197	197	197
F13	196	196	196	196
Average				197
Pressed	**1**	**2**	**3**	**Avg.**
B10	197	197	197	197
F10	197	197	197	197
E11	197	197	197	197
B12	196	196	196	196
E12	197	197	197	197
B13	196	196	195	196
Average				197
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	198	198	198	198
A11	198	198	198	198
D11	197	197	197	197
A12	196	196	196	196
F12	197	197	197	197
D13	197	197	197	197
Average				197
Fused	**1**	**2**	**3**	**Avg.**
E10	194	194	194	194
B11	195	195	196	195
F11	196	196	196	196
C12	195	195	195	195
A13	195	194	194	194
E13	194	194	194	194
Average				195

Fabric A (Weft) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A10	189	189	189	189
D10	190	190	191	190
C11	188	188	189	188
D12	190	190	190	190
C13	191	191	191	191
F13	188	188	189	188
Average				190
Pressed	**1**	**2**	**3**	**Avg.**
B10	191	190	191	191
F10	191	190	191	191
E11	191	191	192	191
B12	189	189	190	189
E12	190	191	191	191
B13	190	190	192	191
Average				191
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C10	189	189	191	190
A11	192	192	192	192
D11	191	191	192	191
A12	191	190	191	191
F12	192	191	192	192
D13	193	192	193	193
Average				191
Fused	**1**	**2**	**3**	**Avg.**
E10	196	196	195	196
B11	194	195	195	195
F11	194	195	195	195
C12	195	195	194	195
A13	192	191	191	191
E13	196	198	199	198
Average				195

Fabric B (Warp) Original						Fabric B (Weft) Original				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**		**Control (with Pressed)**	**1**	**2**	**3**	**Avg.**
A15	203	203	202	203		A15	203	203	203	203
B16	202	203	203	203		B16	203	203	203	203
C17	203	203	203	203		C17	203	202	203	203
A19	203	203	203	203		A19	203	203	203	203
B20	203	203	202	203		B20	203	203	203	203
C21	199	199	200	199		C21	203	202	202	202
Average				202		Average				203
(To Be) Pressed	**1**	**2**	**3**	**Avg.**		**(To Be) Pressed**	**1**	**2**	**3**	**Avg.**
B15	202	202	202	202		B15	203	203	202	203
C16	202	202	202	202		C16	203	202	203	203
A18	202	202	203	202		A18	202	202	203	202
B19	203	203	203	203		B19	202	203	203	203
C20	203	202	202	202		C20	203	202	202	202
A22	202	202	202	202		A22	202	202	202	202
Average				202		Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**		**Control (with Fused)**	**1**	**2**	**3**	**Avg.**
C15	203	203	203	203		C15	202	203	203	203
A17	203	203	203	203		A17	203	203	203	203
B18	203	203	203	203		B18	202	202	202	202
C19	203	202	202	202		C19	202	202	202	202
A21	203	203	203	203		A21	203	202	203	203
B22	203	202	203	203		B22	202	202	202	202
Average				203		Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**		**(To Be) Fused**	**1**	**2**	**3**	**Avg.**
A16	202	202	202	202		A16	203	202	203	203
B17	203	202	203	203		B17	203	202	203	203
C18	202	203	203	203		C18	202	202	203	202
A20	203	203	203	203		A20	203	203	203	203
B21	202	202	202	202		B21	202	202	202	202
C22	202	202	203	202		C22	202	202	203	202
Average				202		Average				203

Fabric B (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	202	203	202	202
B16	203	203	202	203
C17	203	203	203	203
A19	203	203	202	203
B20	203	203	202	203
C21	199	199	200	199
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B15	202	202	202	202
C16	201	201	201	201
A18	202	202	202	202
B19	202	202	202	202
C20	202	202	202	202
A22	202	201	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	203	202	202	202
A17	203	203	203	203
B18	202	202	202	202
C19	202	202	203	202
A21	203	202	202	202
B22	202	202	203	202
Average				202
Fused	**1**	**2**	**3**	**Avg.**
A16	200	201	201	201
B17	199	200	200	200
C18	199	199	199	199
A20	200	200	201	200
B21	200	200	200	200
C22	201	201	201	201
Average				200

Fabric B (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	203	203	203	203
B16	202	202	202	202
C17	203	203	203	203
A19	202	203	203	203
B20	203	203	202	203
C21	203	202	202	202
Average				203
Pressed	**1**	**2**	**3**	**Avg.**
B15	203	202	202	202
C16	203	202	203	203
A18	202	202	203	202
B19	202	202	203	202
C20	202	202	202	202
A22	203	203	202	203
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	202	202	203	202
A17	203	203	203	203
B18	203	202	203	203
C19	202	202	203	202
A21	203	203	203	203
B22	203	203	203	203
Average				203
Fused	**1**	**2**	**3**	**Avg.**
A16	201	200	200	200
B17	203	202	203	203
C18	202	202	202	202
A20	200	200	200	200
B21	202	202	202	202
C22	200	200	200	200
Average				201

Fabric B (Warp) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	195	195	195	195
B16	195	195	195	195
C17	195	195	196	195
A19	196	196	196	196
B20	195	195	195	195
C21	192	192	192	192
Average				195
Pressed	**1**	**2**	**3**	**Avg.**
B15	194	195	195	195
C16	194	194	194	194
A18	195	195	196	195
B19	195	194	195	195
C20	195	195	195	195
A22	-	-	-	N/A
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	196	196	196	196
A17	197	196	197	197
B18	196	196	196	196
C19	195	195	196	195
A21	196	196	196	196
B22	195	195	195	195
Average				196
Fused	**1**	**2**	**3**	**Avg.**
A16	196	195	195	195
B17	195	195	195	195
C18	195	195	195	195
A20	196	196	196	196
B21	195	195	195	195
C22	195	195	195	195
Average				195

Fabric B (Weft) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	199	199	199	199
B16	199	199	199	199
C17	199	199	199	199
A19	200	200	200	200
B20	200	200	199	200
C21	199	200	200	200
Average				199
Pressed	**1**	**2**	**3**	**Avg.**
B15	199	199	199	199
C16	200	200	199	200
A18	199	199	199	199
B19	199	199	199	199
C20	199	199	199	199
A22	-	-	-	N/A
Average				199
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	200	200	200	200
A17	200	200	200	200
B18	199	199	199	199
C19	199	200	200	200
A21	200	200	200	200
B22	200	200	200	200
Average				200
Fused	**1**	**2**	**3**	**Avg.**
A16	199	199	199	199
B17	200	200	200	200
C18	200	199	200	200
A20	199	199	198	199
B21	200	200	200	200
C22	199	199	199	199
Average				199

Fabric B (Warp) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	194	194	195	194
B16	194	194	194	194
C17	194	194	194	194
A19	194	194	194	194
B20	194	194	194	194
C21	190	191	191	191
Average				194
Pressed	**1**	**2**	**3**	**Avg.**
B15	193	194	193	193
C16	193	193	192	193
A18	194	194	194	194
B19	194	194	194	194
C20	194	193	193	193
A22	193	193	194	193
Average				193
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	194	194	194	194
A17	195	195	195	195
B18	194	194	193	194
C19	193	194	194	194
A21	194	194	194	194
B22	194	194	194	194
Average				194
Fused	**1**	**2**	**3**	**Avg.**
A16	193	193	193	193
B17	193	193	194	193
C18	194	194	194	194
A20	193	194	194	194
B21	193	193	193	193
C22	194	193	194	194
Average				193

Fabric B (Weft) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	199	199	198	199
B16	198	199	198	198
C17	199	199	199	199
A19	199	200	199	199
B20	199	200	199	199
C21	200	199	199	199
Average				199
Pressed	**1**	**2**	**3**	**Avg.**
B15	199	199	199	199
C16	199	199	199	199
A18	199	199	199	199
B19	199	199	199	199
C20	198	199	199	199
A22	199	199	199	199
Average				199
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	199	199	200	199
A17	199	199	199	199
B18	199	199	199	199
C19	199	199	199	199
A21	199	199	199	199
B22	199	199	199	199
Average				199
Fused	**1**	**2**	**3**	**Avg.**
A16	199	198	198	198
B17	199	199	199	199
C18	199	198	198	198
A20	198	198	198	198
B21	199	199	199	199
C22	198	198	198	198
Average				198

Fabric B (Warp) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	193	194	194	194
B16	193	193	194	193
C17	194	194	194	194
A19	194	194	194	194
B20	194	194	193	194
C21	189	190	191	190
Average				193
Pressed	**1**	**2**	**3**	**Avg.**
B15	193	193	193	193
C16	192	192	192	192
A18	194	194	194	194
B19	194	194	194	194
C20	193	193	193	193
A22	193	193	193	193
Average				193
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	194	193	194	194
A17	194	194	194	194
B18	194	194	194	194
C19	193	193	194	193
A21	194	194	194	194
B22	193	193	193	193
Average				194
Fused	**1**	**2**	**3**	**Avg.**
A16	192	192	193	192
B17	193	193	193	193
C18	193	193	193	193
A20	193	194	194	194
B21	193	193	193	193
C22	193	194	194	194
Average				193

Fabric B (Weft) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	199	199	199	199
B16	199	198	198	198
C17	198	199	199	199
A19	199	199	199	199
B20	199	199	199	199
C21	199	199	199	199
Average				199
Pressed	**1**	**2**	**3**	**Avg.**
B15	199	199	199	199
C16	199	199	199	199
A18	199	198	199	199
B19	199	198	198	198
C20	199	199	199	199
A22	199	199	199	199
Average				199
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	199	199	199	199
A17	199	199	199	199
B18	198	199	199	199
C19	198	199	199	199
A21	199	199	199	199
B22	199	199	199	199
Average				199
Fused	**1**	**2**	**3**	**Avg.**
A16	198	198	198	198
B17	198	199	199	199
C18	199	198	199	199
A20	198	197	198	198
B21	199	199	199	199
C22	198	198	198	198
Average				198

Fabric B (Warp) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	196	196	196	196
B16	195	195	195	195
C17	195	195	195	195
A19	195	196	196	196
B20	195	195	194	195
C21	191	192	193	192
Average				195
Pressed	**1**	**2**	**3**	**Avg.**
B15	195	195	195	195
C16	194	194	194	194
A18	195	195	195	195
B19	195	195	195	195
C20	194	195	195	195
A22	195	195	195	195
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	195	195	195	195
A17	196	196	196	196
B18	196	195	196	196
C19	195	195	196	195
A21	196	196	196	196
B22	195	195	195	195
Average				196
Fused	**1**	**2**	**3**	**Avg.**
A16	194	194	194	194
B17	195	195	195	195
C18	195	195	195	195
A20	195	195	195	195
B21	194	195	195	195
C22	195	196	196	196
Average				195

Fabric B (Weft) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A15	200	200	200	200
B16	199	199	199	199
C17	200	200	200	200
A19	200	200	201	200
B20	199	200	199	199
C21	200	200	200	200
Average				200
Pressed	**1**	**2**	**3**	**Avg.**
B15	199	199	200	199
C16	199	199	199	199
A18	199	199	200	199
B19	199	199	200	199
C20	199	199	200	199
A22	199	199	200	199
Average				199
Control (with Fused)	**1**	**2**	**3**	**Avg.**
C15	199	199	200	199
A17	199	200	200	200
B18	199	199	199	199
C19	199	200	200	200
A21	200	200	200	200
B22	200	200	200	200
Average				200
Fused	**1**	**2**	**3**	**Avg.**
A16	199	199	199	199
B17	199	200	200	200
C18	199	199	199	199
A20	198	198	199	198
B21	199	200	200	200
C22	198	199	199	199
Average				199

Fabric C (Warp) Original				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
B19	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	202	202
A19	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B20	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
B18	202	202	202	202
A20	202	202	202	202
Average				202

Fabric C (Weft) Original				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
B19	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	201	202
A19	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B20	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
B18	202	202	202	202
A20	202	202	202	202
Average				202

Fabric C (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
B19	202	202	202	202
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B17	201	201	201	201
A19	201	201	201	201
Average				201
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B20	202	202	202	202
Average				202
Fused	**1**	**2**	**3**	**Avg.**
B18	199	199	199	199
A20	199	200	199	199
Average				199

Fabric C (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	201	201	201	201
B19	201	202	202	202
Average				201
Pressed	**1**	**2**	**3**	**Avg.**
B17	202	200	200	201
A19	201	200	200	200
Average				201
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B20	202	202	202	202
Average				202
Fused	**1**	**2**	**3**	**Avg.**
B18	202	202	202	202
A20	202	201	202	202
Average				202

Fabric C (Warp) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	195	195	194	195
B19	195	196	196	196
Average				195
Pressed	**1**	**2**	**3**	**Avg.**
B17	194	194	194	194
A19	195	195	195	195
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	195	195	195	195
B20	196	196	196	196
Average				196
Fused	**1**	**2**	**3**	**Avg.**
B18	194	194	193	194
A20	194	194	194	194
Average				194

Fabric C (Weft) After 1 Wash				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	192	193	193	193
B19	194	194	193	194
Average				193
Pressed	**1**	**2**	**3**	**Avg.**
B17	194	194	193	194
A19	193	193	193	193
Average				193
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	196	195	196	196
B20	197	197	196	197
Average				196
Fused	**1**	**2**	**3**	**Avg.**
B18	200	199	197	199
A20	198	196	198	197
Average				198

Fabric C (Warp) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	193	193	193	193
B19	193	193	193	193
Average				193
Pressed	**1**	**2**	**3**	**Avg.**
B17	192	192	192	192
A19	192	192	192	192
Average				192
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	194	193	193	193
B20	194	193	193	193
Average				193
Fused	**1**	**2**	**3**	**Avg.**
B18	193	192	192	192
A20	191	191	191	191
Average				192

Fabric C (Weft) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	192	192	193	192
B19	195	195	194	195
Average				194
Pressed	**1**	**2**	**3**	**Avg.**
B17	195	194	194	194
A19	193	193	193	193
Average				194
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	195	195	195	195
B20	195	195	195	195
Average				195
Fused	**1**	**2**	**3**	**Avg.**
B18	198	197	197	197
A20	197	195	196	196
Average				197

Fabric C (Warp) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	192	191	191	191
B19	192	192	192	192
Average				192
Pressed	**1**	**2**	**3**	**Avg.**
B17	191	191	190	191
A19	192	192	191	192
Average				191
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	192	192	192	192
B20	193	193	193	193
Average				193
Fused	**1**	**2**	**3**	**Avg.**
B18	191	190	190	190
A20	190	190	190	190
Average				190

Fabric C (Weft) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	193	192	193	193
B19	193	194	194	194
Average				193
Pressed	**1**	**2**	**3**	**Avg.**
B17	195	194	193	194
A19	193	193	193	193
Average				194
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	195	195	195	195
B20	196	196	195	196
Average				195
Fused	**1**	**2**	**3**	**Avg.**
B18	195	194	194	194
A20	196	194	194	195
Average				195

Fabric C (Warp) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	193	193	193	193
B19	193	193	194	193
Average				193
Pressed	**1**	**2**	**3**	**Avg.**
B17	192	191	192	192
A19	193	193	193	193
Average				192
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	193	193	193	193
B20	193	193	194	193
Average				193
Fused	**1**	**2**	**3**	**Avg.**
B18	192	192	191	192
A20	192	192	192	192
Average				192

Fabric C (Weft) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	194	194	195	194
B19	196	197	197	197
Average				196
Pressed	**1**	**2**	**3**	**Avg.**
B17	197	196	196	196
A19	194	195	194	194
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	197	198	198	198
B20	197	198	197	197
Average				198
Fused	**1**	**2**	**3**	**Avg.**
B18	199	198	198	198
A20	198	197	198	198
Average				198

Fabric D (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B19	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
B18	202	202	202	202
A19	202	202	202	202
Average				202

Fabric D (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
Average				202
(To Be) Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B19	202	202	202	202
Average				202
(To Be) Fused	**1**	**2**	**3**	**Avg.**
B18	202	202	202	202
A19	201	202	202	202
Average				202

Fabric D (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	202	202	202	202
B19	202	202	202	202
Average				202
Fused	**1**	**2**	**3**	**Avg.**
B18	201	200	200	200
A19	201	200	200	200
Average				200

Fabric D (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	202	202	202	202
Average				202
Pressed	**1**	**2**	**3**	**Avg.**
B17	202	202	202	202
Average				202
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	203	202	203	203
B19	203	203	203	203
Average				203
Fused	**1**	**2**	**3**	**Avg.**
B18	201	203	203	202
A19	202	203	203	203
Average				203

Fabric D (Warp) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	197	197	197	197
Average				197
Pressed	**1**	**2**	**3**	**Avg.**
B17	197	197	197	197
Average				197
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	198	197	197	197
B19	198	197	197	197
Average				197
Fused	**1**	**2**	**3**	**Avg.**
B18	196	195	195	195
A19	197	197	196	197
Average				196

Fabric D (Weft) After Treatment				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	196	196	196	196
Average				196
Pressed	**1**	**2**	**3**	**Avg.**
B17	197	197	197	197
Average				197
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	199	199	199	199
B19	199	199	200	199
Average				199
Fused	**1**	**2**	**3**	**Avg.**
B18	200	200	201	200
A19	200	201	201	201
Average				201

Fabric D (Warp) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	195	195	195	195
Average				195
Pressed	**1**	**2**	**3**	**Avg.**
B17	195	195	195	195
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	-	-	-	N/A
B19	195	195	195	195
Average				195
Fused	**1**	**2**	**3**	**Avg.**
B18	193	192	192	192
A19	195	194	193	194
Average				193

Fabric D (Weft) After 3 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	196	196	195	196
Average				196
Pressed	**1**	**2**	**3**	**Avg.**
B17	197	197	197	197
Average				197
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	-	-	-	N/A
B19	200	199	199	199
Average				199
Fused	**1**	**2**	**3**	**Avg.**
B18	199	198	199	199
A19	198	200	200	199
Average				199

Fabric D (Warp) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	193	194	194	194
Average				194
Pressed	**1**	**2**	**3**	**Avg.**
B17	194	194	194	194
Average				194
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	194	194	194	194
B19	194	194	194	194
Average				194
Fused	**1**	**2**	**3**	**Avg.**
B18	192	192	191	192
A19	194	193	192	193
Average				192

Fabric D (Weft) After 5 Washes				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	196	197	196	196
Average				196
Pressed	**1**	**2**	**3**	**Avg.**
B17	197	197	197	197
Average				197
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	198	198	199	198
B19	198	198	198	198
Average				198
Fused	**1**	**2**	**3**	**Avg.**
B18	198	198	200	199
A19	198	199	199	199
Average				199

Fabric D (Warp) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	195	195	195	195
Average				195
Pressed	**1**	**2**	**3**	**Avg.**
B17	195	195	196	195
Average				195
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	196	196	196	196
B19	195	195	195	195
Average				196
Fused	**1**	**2**	**3**	**Avg.**
B18	194	194	193	194
A19	195	194	194	194
Average				194

Fabric D (Weft) After 5 Washes + Press				
Control (with Pressed)	**1**	**2**	**3**	**Avg.**
A17	197	198	198	198
Average				198
Pressed	**1**	**2**	**3**	**Avg.**
B17	199	199	199	199
Average				199
Control (with Fused)	**1**	**2**	**3**	**Avg.**
A18	199	200	200	200
B19	200	199	200	200
Average				200
Fused	**1**	**2**	**3**	**Avg.**
B18	200	200	201	200
A19	199	201	201	200
Average				200

Appendix C: Compatibility Experiment

Fabric A Original				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B2	254	254	254	254
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	253	252	254	253
Average				253
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	252	252	253	252
B2	253	253	253	253
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	252	253	252	252
Average				253
Along Seam	**1**			**Avg.**
E1/A3	254			254
E1/A3	254			254
B4/C5	253			253
B4/C5	253			253
D6/E7	254			254
D6/E7	254			254
Average				254
Across Seam	**1**	**2**	**3**	**Avg.**
E1/A3	255	255	253	254
E1/A3	253	253	253	253
B4/C5	254	252	255	254
B4/C5	255	255	255	255
D6/E7	255	254	254	254
D6/E7	255	254	254	254
Average				254

Fabric A After 1 Wash				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	245	245	247	246
B2	247	247	247	247
C3	245	245	246	245
D4	247	247	247	247
E5	247	247	247	247
A7	247	245	-	246
Average				246
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	237	238	238	238
B2	239	239	239	239
C3	239	239	240	239
D4	238	239	238	238
E5	237	238	238	238
A7	-	-	-	N/A
Average				238
Along Seam	**1**			**Avg.**
E1/A3	240			240
E1/A3	240			240
B4/C5	242			242
B4/C5	241			241
D6/E7	240			240
D6/E7	240			240
Average				241
Across Seam	**1**	**2**	**3**	**Avg.**
E1/A3	242	240	241	241
E1/A3	242	242	243	242
B4/C5	241	240	243	241
B4/C5	243	242	242	242
D6/E7	242	243	242	242
D6/E7	245	242	243	243
Average				242

Fabric A After 3 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B2	245	245	246	245
C3	245	244	244	244
D4	245	245	245	245
E5	245	245	245	245
A7	244	243	-	244
Average				245
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	236	237	237	237
B2	235	237	237	236
C3	237	237	238	237
D4	237	237	236	237
E5	235	236	236	236
A7	-	-	-	N/A
Average				237
Along Seam	**1**			**Avg.**
E1/A3	237			237
E1/A3	238			238
B4/C5	241			241
B4/C5	238			238
D6/E7	238			238
D6/E7	239			239
Average				239
Across Seam	**1**	**2**	**3**	**Avg.**
E1/A3	240	240	240	240
E1/A3	240	241	241	241
B4/C5	239	239	242	240
B4/C5	241	240	240	240
D6/E7	240	241	241	241
D6/E7	241	240	241	241
Average				240

Fabric A (Warp) After 5 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B2	244	244	244	244
C3	243	243	244	243
D4	246	247	246	246
E5	246	247	246	246
A7	243	243	-	243
Average				245
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	236	237	237	237
B2	237	237	237	237
C3	237	237	237	237
D4	237	236	236	236
E5	236	235	236	236
A7	-	-	-	N/A
Average				237
Along Seam	**1**			**Avg.**
E1/A3	238			238
E1/A3	237			237
B4/C5	239			239
B4/C5	237			237
D6/E7	237			237
D6/E7	237			237
Average				238
Across Seam	**1**	**2**	**3**	**Avg.**
E1/A3	240	239	239	239
E1/A3	240	240	240	240
B4/C5	238	237	240	238
B4/C5	240	240	240	240
D6/E7	240	241	241	241
D6/E7	242	239	240	240
Average				240

Fabric A After 5 Washes + Press				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B2	245	245	245	245
C3	245	244	244	244
D4	245	244	245	245
E5	246	245	246	246
A7	245	244	-	245
Average				245
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B2	239	240	241	240
C3	239	240	240	240
D4	239	239	240	239
E5	239	238	238	238
A7	-	-	-	N/A
Average				239
Along Seam	**1**			**Avg.**
E1/A3	244			244
E1/A3	241			241
B4/C5	243			243
B4/C5	241			241
D6/E7	241			241
D6/E7	241			241
Average				242
Across Seam	**1**	**2**	**3**	**Avg.**
E1/A3	243	242	241	242
E1/A3	242	243	243	243
B4/C5	240	239	242	240
B4/C5	243	242	242	242
D6/E7	244	243	244	244
D6/E7	244	243	243	243
Average				242

Fabric B Original				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
C4	253	253	254	253
B6	253	253	253	253
A8	252	253	253	253
C10	253	253	253	253
B12	253	253	253	253
Average				253
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	253	253	254	253
C4	253	254	254	254
B6	253	253	253	253
A8	254	253	253	253
C10	253	253	253	253
B12	253	253	254	253
Average				253
Along Seam	**1**			**Avg.**
B2/A4	254			254
B2/A4	253			253
C5/B7	253			253
C5/B7	255			255
A10/C11	253			253
A10/C11	253			253
Average				254
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A4	255	255	253	254
B2/A4	254	254	255	254
C5/B7	253	254	254	254
C5/B7	253	254	254	254
A10/C11	253	254	255	254
A10/C11	255	255	254	255
Average				254

Fabric B After 1 Wash				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	243	242	242	242
C4	242	241	241	241
B6	241	241	241	241
A8	242	241	242	242
C10	240	240	241	240
B12	241	241	241	241
Average				241
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	249	249	249	249
B6	250	249	249	249
A8	250	250	249	250
C10	248	248	250	249
B12	249	249	249	249
Average				249
Along Seam	**1**			**Avg.**
B2/A4	245			245
B2/A4	244			244
C5/B7	243			243
C5/B7	243			243
A10/C11	244			244
A10/C11	244			244
Average				244
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A4	246	246	243	245
B2/A4	245	246	247	246
C5/B7	244	245	245	245
C5/B7	244	246	245	245
A10/C11	244	245	246	245
A10/C11	245	245	244	245
Average				245

Fabric B After 3 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	240	240	239	240
C4	238	238	238	238
B6	239	239	239	239
A8	239	238	239	239
C10	238	238	239	238
B12	238	238	238	238
Average				239
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	248	249	249	249
B6	249	248	248	248
A8	249	250	249	249
C10	248	248	249	248
B12	249	249	249	249
Average				249
Along Seam	**1**			**Avg.**
B2/A4	242			242
B2/A4	242			242
C5/B7	242			242
C5/B7	240			240
A10/C11	242			242
A10/C11	243			243
Average				242
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A4	244	244	242	243
B2/A4	244	244	245	244
C5/B7	243	244	244	244
C5/B7	244	245	244	244
A10/C11	243	244	245	244
A10/C11	244	244	243	244
Average				244

Fabric B After 5 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	240	239	238	239
C4	237	236	236	236
B6	237	237	237	237
A8	238	238	238	238
C10	237	237	237	237
B12	237	238	238	238
Average				238
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	248	248	250	249
C4	248	248	249	248
B6	249	247	248	248
A8	250	250	249	250
C10	248	248	249	248
B12	248	248	248	248
Average				249
Along Seam	**1**			**Avg.**
B2/A4	241			241
B2/A4	241			241
C5/B7	242			242
C5/B7	240			240
A10/C11	241			241
A10/C11	241			241
Average				241
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A4	243	243	241	242
B2/A4	243	243	244	243
C5/B7	243	243	243	243
C5/B7	242	244	243	243
A10/C11	242	243	243	243
A10/C11	242	243	241	242
Average				243

Fabric B After 5 Washes + Pressing				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	241	240	239	240
C4	239	238	239	239
B6	240	240	240	240
A8	240	240	240	240
C10	239	239	240	239
B12	239	238	238	238
Average				239
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	249	249	249	249
B6	249	248	249	249
A8	250	250	250	250
C10	249	249	249	249
B12	249	249	249	249
Average				249
Along Warp/Weft Seam	**1**			**Avg.**
B2/A4	244			244
B2/A4	243			243
C5/B7	244			244
C5/B7	243			243
A10/C11	243			243
A10/C11	245			245
Average				244
Across Warp/Weft Seam	**1**	**2**	**3**	**Avg.**
B2/A4	246	245	244	245
B2/A4	246	245	245	245
C5/B7	245	245	245	245
C5/B7	245	247	245	246
A10/C11	244	244	244	244
A10/C11	245	245	245	245
Average				245

Fabric C Original				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	252	252	252
A11	253	253	253	253
B13	252	252	252	252
Average				253
Along Seam	**1**			**Avg.**
B2/A5	253			253
B2/A5	252			252
B7/A10	253			253
B7/A10	253			253
B12/A15	253			253
B12/A15	252			252
Average				253
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	253	253	253	253
B2/A5	252	253	253	253
B7/A10	253	253	253	253
B7/A10	253	253	253	253
B12/A15	253	252	253	253
B12/A15	253	253	253	253
Average				253

Fabric C After 1 Wash				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	242	241	242	242
B3	240	241	241	241
A6	240	241	240	240
B8	239	239	239	239
A11	241	241	241	241
B13	240	240	240	240
Average				240
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B3	240	239	239	239
A6	245	245	245	245
B8	237	237	240	238
A11	245	245	245	245
B13	239	240	240	240
Average				242
Along Seam	**1**			**Avg.**
B2/A5	240			240
B2/A5	238			238
B7/A10	239			239
B7/A10	239			239
B12/A15	240			240
B12/A15	239			239
Average				239
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	243	243	243	243
B2/A5	242	242	243	242
B7/A10	238	239	241	239
B7/A10	239	239	240	239
B12/A15	242	239	240	240
B12/A15	243	243	242	243
Average				241

Fabric C After 3 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B3	237	237	238	237
A6	237	237	236	237
B8	237	237	237	237
A11	237	237	237	237
B13	237	237	238	237
Average				237
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B3	240	240	241	240
A6	245	245	246	245
B8	240	239	240	240
A11	245	247	245	246
B13	240	240	241	240
Average				243
Along Seam	**1**			**Avg.**
B2/A5	237			237
B2/A5	234			234
B7/A10	237			237
B7/A10	237			237
B12/A15	237			237
B12/A15	236			236
Average				236
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	240	240	241	240
B2/A5	239	241	242	241
B7/A10	238	237	240	238
B7/A10	241	241	241	241
B12/A15	239	237	240	239
B12/A15	241	241	241	241
Average				240

Fabric C After 5 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	236	236	237	236
B3	237	236	236	236
A6	236	236	236	236
B8	235	235	235	235
A11	235	234	235	235
B13	235	236	236	236
Average				236
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	245	244	244	244
B3	240	239	240	240
A6	246	247	247	247
B8	240	239	240	240
A11	243	244	244	244
B13	240	240	241	240
Average				243
Along Seam	**1**			**Avg.**
B2/A5	235			235
B2/A5	235			235
B7/A10	236			236
B7/A10	235			235
B12/A15	236			236
B12/A15	235			235
Average				235
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	240	237	237	238
B2/A5	239	240	242	240
B7/A10	237	239	239	238
B7/A10	235	237	238	237
B12/A15	239	238	239	239
B12/A15	241	241	241	241
Average				239

Fabric C After 5 Washes + Pressing				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B3	237	237	236	237
A6	237	237	237	237
B8	236	236	236	236
A11	236	236	236	236
B13	237	237	237	237
Average				237
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	246	246	247	246
B3	243	243	243	243
A6	249	250	250	250
B8	245	244	244	244
A11	247	248	248	248
B13	244	244	244	244
Average				246
Along Seam	**1**			**Avg.**
B2/A5	241			241
B2/A5	240			240
B7/A10	239			239
B7/A10	240			240
B12/A15	240			240
B12/A15	239			239
Average				240
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	243	242	243	243
B2/A5	243	243	245	244
B7/A10	241	241	242	241
B7/A10	242	242	242	242
B12/A15	243	243	243	243
B12/A15	245	244	245	245
Average				243

Fabric D Original				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	253	254	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	254	254	254
Average				253
Along Seam	**1**			**Avg.**
B2/A5	253			253
B2/A5	253			253
B7/A10	253			253
B7/A10	252			252
B12/A15	253			253
B12/A15	253			253
Average				253
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	253	253	253	253
B2/A5	253	253	253	253
B7/A10	253	254	253	253
B7/A10	253	253	253	253
B12/A15	253	253	254	253
B12/A15	253	253	253	253
Average				253

Fabric D After 1 Wash				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B3	243	243	242	243
A6	244	243	244	244
B8	244	244	244	244
A11	243	243	243	243
B13	243	244	244	244
Average				244
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	246	246	247	246
B3	247	248	249	248
A6	245	245	245	245
B8	247	247	248	247
A11	246	246	246	246
B13	246	248	247	247
Average				247
Along Seam	**1**			**Avg.**
B2/A5	243			243
B2/A5	244			244
B7/A10	242			242
B7/A10	243			243
B12/A15	243			243
B12/A15	240			240
Average				243
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	243	243	243	243
B2/A5	245	245	245	245
B7/A10	245	245	244	245
B7/A10	244	245	244	244
B12/A15	245	245	246	245
B12/A15	245	244	245	245
Average				245

Fabric D After 3 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	241	241	240	241
B3	239	239	238	239
A6	238	239	240	239
B8	240	240	240	240
A11	239	239	240	239
B13	239	239	239	239
Average				239
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	246	245	246	246
B3	247	247	248	247
A6	246	247	246	246
B8	247	246	247	247
A11	246	246	246	246
B13	247	248	247	247
Average				247
Along Seam	**1**			**Avg.**
B2/A5	240			240
B2/A5	240			240
B7/A10	240			240
B7/A10	240			240
B12/A15	239			239
B12/A15	238			238
Average				240
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	243	242	242	242
B2/A5	240	240	241	240
B7/A10	243	243	243	243
B7/A10	242	242	241	242
B12/A15	243	243	242	243
B12/A15	241	241	241	241
Average				242

Fabric D After 5 Washes				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	239	239	239	239
B3	237	237	237	237
A6	237	237	238	237
B8	238	238	238	238
A11	236	236	236	236
B13	237	237	238	237
Average				237
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	246	246	246	246
B3	248	248	249	248
A6	246	246	247	246
B8	248	248	248	248
A11	246	246	246	246
B13	247	248	248	248
Average				247
Along Seam	**1**			**Avg.**
B2/A5	239			239
B2/A5	237			237
B7/A10	239			239
B7/A10	237			237
B12/A15	237			237
B12/A15	238			238
Average				238
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	241	242	242	242
B2/A5	240	241	240	240
B7/A10	241	241	242	241
B7/A10	239	240	240	240
B12/A15	241	242	243	242
B12/A15	241	241	241	241
Average				241

Fabric D After 5 Washes + Pressing				
Control (Warp)	**1**	**2**	**3**	**Avg.**
A1	240	240	240	240
B3	239	239	239	239
A6	239	239	239	239
B8	239	239	239	239
A11	239	238	239	239
B13	239	239	239	239
Average				239
Control (Weft)	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
B3	250	250	251	250
A6	250	250	250	250
B8	250	250	250	250
A11	250	250	250	250
B13	251	251	251	251
Average				250
Along Seam	**1**			**Avg.**
B2/A5	242			242
B2/A5	242			242
B7/A10	242			242
B7/A10	242			242
B12/A15	242			242
B12/A15	242			242
Average				242
Across Seam	**1**	**2**	**3**	**Avg.**
B2/A5	243	243	243	243
B2/A5	243	244	243	243
B7/A10	244	244	244	244
B7/A10	244	245	243	244
B12/A15	245	244	245	245
B12/A15	246	245	245	245
Average				244

Appendix D: Pressing Experiment

Fabric A (Warp) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B2	254	254	254	254
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	253	252	254	253
Average				253
Pre-Pressed	**1**	**2**	**3**	**Avg.**
A2	253	253	253	253
B3	253	253	253	253
C4	253	253	253	253
D5	253	253	253	253
E6	253	253	253	253
A8	253	253	253	253
Average				253

Fabric A (Weft) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	252	252	253	252
B2	253	253	253	253
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	252	253	252	252
Average				253
Pre-Pressed	**1**	**2**	**3**	**Avg.**
A2	253	253	254	253
B3	253	253	254	253
C4	253	253	253	253
D5	253	253	254	253
E6	253	253	254	253
A8	253	253	253	253
Average				253

Fabric A (Warp) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B2	254	254	254	254
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	253	252	254	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A2	252	252	252	252
B3	252	252	252	252
C4	251	252	252	252
D5	252	252	252	252
E6	252	252	252	252
A8	252	252	252	252
Average				252

Fabric A (Weft) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	252	252	253	252
B2	253	253	253	253
C3	253	253	253	253
D4	253	253	253	253
E5	253	253	253	253
A7	252	253	252	252
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A2	250	249	250	250
B3	250	249	250	250
C4	249	249	249	249
D5	251	250	251	251
E6	250	250	250	250
A8	250	250	250	250
Average				250

Fabric A (Warp) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	245	245	247	246
B2	247	247	247	247
C3	245	245	246	245
D4	247	247	247	247
E5	247	247	247	247
A7	247	247	-	247
Average				247
Pressed	**1**	**2**	**3**	**Avg.**
A2	246	246	246	246
B3	246	246	247	246
C4	246	246	246	246
D5	246	246	246	246
E6	247	247	247	247
A8	246	246	246	246
Average				246

Fabric A (Weft) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	237	238	238	238
B2	239	239	239	239
C3	239	239	240	239
D4	238	239	238	238
E5	237	238	238	238
A7	-	-	-	N/A
Average				238
Pressed	**1**	**2**	**3**	**Avg.**
A2	238	238	238	238
B3	238	238	238	238
C4	239	239	239	239
D5	237	238	237	237
E6	238	238	238	238
A8	237	237	237	237
Average				238

Fabric A (Warp) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B2	245	245	246	245
C3	245	244	244	244
D4	245	245	245	245
E5	245	245	245	245
A7	244	243	-	244
Average				245
Pressed	**1**	**2**	**3**	**Avg.**
A2	245	245	245	245
B3	-	-	-	N/A
C4	244	245	245	245
D5	246	245	245	245
E6	245	245	245	245
A8	245	245	245	245

Fabric A (Weft) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	236	237	237	237
B2	235	237	237	236
C3	237	237	238	237
D4	237	237	236	237
E5	235	236	236	236
A7	-	-	-	N/A
Average				237
Pressed	**1**	**2**	**3**	**Avg.**
A2	237	237	236	237
B3	-	-	-	N/A
C4	238	239	238	238
D5	237	236	236	236
E6	237	236	236	236
A8	237	237	236	237

Fabric A (Warp) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B2	244	244	244	244
C3	243	243	244	243
D4	246	247	246	246
E5	246	247	246	246
A7	243	243	-	243
Average				245
Pressed	**1**	**2**	**3**	**Avg.**
A2	-	-	-	N/A
B3	244	244	244	244
C4	244	244	244	244
D5	244	244	244	244
E6	244	244	244	244
A8	244	244	244	244
Average				244

Fabric A (Weft) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	236	237	237	237
B2	237	237	237	237
C3	237	237	237	237
D4	237	236	236	236
E5	236	235	236	236
A7	-	-	-	N/A
Average				237
Pressed	**1**	**2**	**3**	**Avg.**
A2	236	236	236	236
B3	236	236	237	236
C4	237	238	237	237
D5	236	236	236	236
E6	236	235	236	236
A8	236	236	236	236
Average				236

Fabric A (Warp) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B2	245	245	245	245
C3	245	244	244	244
D4	245	244	245	245
E5	246	245	246	246
A7	245	244	-	245
Average				245
Pressed	**1**	**2**	**3**	**Avg.**
A2	245	245	245	245
B3	244	245	245	245
C4	245	245	245	245
D5	245	245	245	245
E6	245	245	245	245
A8	245	245	245	245
Average				245

Fabric A (Weft) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B2	239	240	241	240
C3	239	240	240	240
D4	239	239	240	239
E5	239	238	238	238
A7	-	-	-	N/A
Average				239
Pressed	**1**	**2**	**3**	**Avg.**
A2	238	237	238	238
B3	237	238	238	238
C4	239	240	239	239
D5	238	238	238	238
E6	238	238	238	238
A8	238	239	238	238
Average				238

Fabric B (Warp) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
C4	253	253	254	253
B6	253	253	253	253
A8	252	253	253	253
C10	253	253	253	253
B12	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
C2	254	254	253	254
B4	254	254	254	254
A6	254	254	254	254
C7	254	254	254	254
B10	254	254	254	254
A12	254	254	254	254
Average				254

Fabric B (Weft) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	254	253
C4	253	254	254	254
B6	253	253	253	253
A8	254	253	253	253
C10	253	253	253	253
B12	253	253	254	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
C2	253	254	254	254
B4	254	254	254	254
A6	254	254	253	254
C7	254	254	253	254
B10	253	253	253	253
A12	254	254	253	254
Average				254

Fabric B (Warp) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
C4	253	253	254	253
B6	253	253	253	253
A8	252	253	253	253
C10	253	253	253	253
B12	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
C2	253	252	252	252
B4	252	251	251	251
A6	252	252	252	252
C7	252	251	252	252
B10	252	252	252	252
A12	252	252	252	252
Average				252

Fabric B (Weft) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	254	253
C4	253	254	254	254
B6	253	253	253	253
A8	254	253	253	253
C10	253	253	253	253
B12	253	253	254	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
C2	253	253	253	253
B4	253	253	253	253
A6	253	253	253	253
C7	253	253	253	253
B10	253	252	252	252
A12	253	252	253	253
Average				253

Fabric B (Warp) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	243	242	242	242
C4	242	241	241	241
B6	241	241	241	241
A8	242	241	242	242
C10	240	240	241	240
B12	241	241	241	241
Average				241
Pressed	**1**	**2**	**3**	**Avg.**
C2	242	242	241	242
B4	242	242	242	242
A6	242	242	242	242
C7	242	242	242	242
B10	243	242	242	242
A12	242	243	243	243
Average				242

Fabric B (Weft) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	249	249	249	249
B6	250	249	249	249
A8	250	250	249	250
C10	248	248	250	249
B12	249	249	249	249
Average				249
Pressed	**1**	**2**	**3**	**Avg.**
C2	249	250	250	250
B4	249	250	250	250
A6	250	250	250	250
C7	249	250	249	249
B10	249	249	249	249
A12	249	249	249	249
Average				249

Fabric B (Warp) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	240	240	239	240
C4	238	238	238	238
B6	239	239	239	239
A8	239	238	239	239
C10	238	238	239	238
B12	238	238	238	238
Average				239
Pressed	**1**	**2**	**3**	**Avg.**
C2	239	239	238	239
B4	239	239	238	239
A6	240	239	239	239
C7	239	238	239	239
B10	240	239	239	239
A12	239	239	239	239
Average				239

Fabric B (Weft) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	248	249	249	249
B6	249	248	248	248
A8	249	250	249	249
C10	248	248	249	248
B12	249	249	249	249
Average				249
Pressed	**1**	**2**	**3**	**Avg.**
C2	249	250	249	249
B4	249	250	249	249
A6	249	249	250	249
C7	249	250	249	249
B10	249	249	248	249
A12	249	248	248	248
Average				249

Fabric B (Warp) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	240	239	238	239
C4	237	236	236	236
B6	237	237	237	237
A8	238	238	238	238
C10	237	237	237	237
B12	237	238	238	238
Average				238
Pressed	**1**	**2**	**3**	**Avg.**
C2	238	237	237	237
B4	238	238	238	238
A6	238	238	238	238
C7	238	237	238	238
B10	238	238	238	238
A12	238	238	238	238
Average				238

Fabric B (Weft) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	248	248	250	249
C4	248	248	249	248
B6	249	247	248	248
A8	250	250	249	250
C10	248	248	249	248
B12	248	248	248	248
Average				249
Pressed	**1**	**2**	**3**	**Avg.**
C2	249	249	249	249
B4	248	249	249	249
A6	249	249	249	249
C7	248	249	248	248
B10	248	248	248	248
A12	248	248	248	248
Average				249

Fabric B (Warp) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	241	240	239	240
C4	239	238	239	239
B6	240	240	240	240
A8	240	240	240	240
C10	239	239	240	239
B12	239	238	238	238
Average				239
Pressed	**1**	**2**	**3**	**Avg.**
C2	239	239	239	239
B4	240	240	240	240
A6	240	239	240	240
C7	239	239	239	239
B10	240	240	240	240
A12	239	240	240	240
Average				240

Fabric B (Weft) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
C4	249	249	249	249
B6	249	248	249	249
A8	250	250	250	250
C10	249	249	249	249
B12	249	249	249	249
Average				249
Pressed	**1**	**2**	**3**	**Avg.**
C2	250	251	250	250
B4	250	251	249	250
A6	250	250	251	250
C7	249	250	249	249
B10	249	249	250	249
A12	250	249	250	250
Average				250

Fabric C (Warp) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	253	253	253	253
B5	253	253	253	253
A8	253	253	253	253
B10	253	253	253	253
A13	253	253	253	253
B15	253	253	253	253
Average				253

Fabric C (Weft) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	252	252	252
A11	253	253	253	253
B13	252	252	252	252
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	253	253	253	253
B5	253	253	253	253
A8	253	253	253	253
B10	252	253	253	253
A13	253	252	252	252
B15	253	253	253	253
Average				253

Fabric C (Warp) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	252	252	252	252
B5	252	252	252	252
A8	252	251	252	252
B10	251	251	251	251
A13	251	251	251	251
B15	252	252	252	252
Average				252

Fabric C (Weft) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	252	252	252
A11	253	253	253	253
B13	252	252	252	252
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	251	251	251	251
B5	249	248	249	249
A8	250	249	250	250
B10	248	248	248	248
A13	248	249	249	249
B15	248	248	248	248
Average				249

Fabric C (Warp) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	242	241	242	242
B3	240	241	241	241
A6	240	241	240	240
B8	239	239	239	239
A11	241	241	241	241
B13	240	240	240	240
Average				240
Pressed	**1**	**2**	**3**	**Avg.**
A3	246	245	246	246
B5	241	241	241	241
A8	246	247	247	247
B10	241	241	241	241
A13	242	241	240	241
B15	240	241	241	241
Average				243

Fabric C (Weft) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B3	240	239	239	239
A6	245	245	245	245
B8	237	237	240	238
A11	245	245	245	245
B13	239	240	240	240
Average				242
Pressed	**1**	**2**	**3**	**Avg.**
A3	246	245	245	245
B5	240	241	241	241
A8	246	245	246	246
B10	241	240	240	240
A13	243	243	243	243
B15	240	240	239	240
Average				242

Fabric C (Warp) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B3	237	237	238	237
A6	237	237	236	237
B8	237	237	237	237
A11	237	237	237	237
B13	237	237	238	237
Average				237
Pressed	**1**	**2**	**3**	**Avg.**
A3	239	238	238	238
B5	237	238	238	238
A8	238	238	238	238
B10	239	239	239	239
A13	239	239	239	239
B15	238	239	239	239
Average				238

Fabric C (Weft) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	244	244
B3	240	240	241	240
A6	245	245	246	245
B8	240	239	240	240
A11	245	247	245	246
B13	240	240	241	240
Average				243
Pressed	**1**	**2**	**3**	**Avg.**
A3	247	245	245	246
B5	241	241	242	241
A8	245	244	246	245
B10	243	242	243	243
A13	245	245	244	245
B15	240	240	240	240
Average				243

Fabric C (Warp) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	236	236	237	236
B3	237	236	236	236
A6	236	236	236	236
B8	235	235	235	235
A11	235	234	235	235
B13	235	236	236	236
Average				236
Pressed	**1**	**2**	**3**	**Avg.**
A3	237	237	236	237
B5	237	236	237	237
A8	237	237	237	237
B10	237	237	237	237
A13	237	237	237	237
B15	237	237	237	237
Average				237

Fabric C (Weft) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	245	244	244	244
B3	240	239	240	240
A6	246	247	247	247
B8	240	239	240	240
A11	243	244	244	244
B13	240	240	241	240
Average				243
Pressed	**1**	**2**	**3**	**Avg.**
A3	247	245	245	246
B5	240	241	242	241
A8	245	245	245	245
B10	243	242	242	242
A13	244	244	244	244
B15	241	240	240	240
Average				243

Fabric C (Warp) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	238	238	238	238
B3	237	237	238	237
A6	237	237	237	237
B8	236	236	236	236
A11	236	236	236	236
B13	237	237	237	237
Average				237
Pressed	**1**	**2**	**3**	**Avg.**
A3	238	238	238	238
B5	238	237	237	237
A8	238	238	237	238
B10	238	238	238	238
A13	238	238	238	238
B15	238	238	238	238
Average				238

Fabric C (Weft) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	246	246	247	246
B3	243	243	243	243
A6	249	250	250	250
B8	245	244	244	244
A11	247	248	248	248
B13	244	244	244	244
Average				246
Pressed	**1**	**2**	**3**	**Avg.**
A3	250	248	248	249
B5	243	244	245	244
A8	248	247	248	248
B10	245	245	245	245
A13	246	246	245	246
B15	243	243	244	243
Average				246

Fabric D (Warp) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	254	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	253	253	253	253
B5	253	253	253	253
A8	253	253	253	253
B10	253	253	253	253
A13	253	253	253	253
B15	253	253	253	253
Average				253

Fabric D (Weft) Before Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	254	254	254
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	253	253	253	253
B5	253	253	253	253
A8	253	253	253	253
B10	253	253	253	253
A13	253	253	253	253
B15	253	254	254	254
Average				253

Fabric D (Warp) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	254	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	253	253	253
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	252	253	253	253
B5	252	252	252	252
A8	252	252	252	252
B10	253	252	252	252
A13	252	252	252	252
B15	252	253	253	253
Average				252

Fabric D (Weft) Original				
Control	**1**	**2**	**3**	**Avg.**
A1	253	253	253	253
B3	253	253	253	253
A6	253	253	253	253
B8	253	253	253	253
A11	253	253	253	253
B13	253	254	254	254
Average				253
Pressed	**1**	**2**	**3**	**Avg.**
A3	252	252	252	252
B5	251	251	252	251
A8	252	251	251	251
B10	252	252	252	252
A13	252	251	252	252
B15	251	252	252	252
Average				252

Fabric D (Warp) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	244	244	245	244
B3	243	243	242	243
A6	244	243	244	244
B8	244	244	244	244
A11	243	243	243	243
B13	243	244	244	244
Average				244
Pressed	**1**	**2**	**3**	**Avg.**
A3	243	243	243	243
B5	244	244	244	244
A8	244	244	244	244
B10	244	244	244	244
A13	243	243	243	243
B15	244	244	244	244
Average				244

Fabric D (Weft) After 1 Wash				
Control	**1**	**2**	**3**	**Avg.**
A1	246	246	247	246
B3	247	248	249	248
A6	245	245	245	245
B8	247	247	248	247
A11	246	246	246	246
B13	246	248	247	247
Average				247
Pressed	**1**	**2**	**3**	**Avg.**
A3	245	246	246	246
B5	247	247	247	247
A8	247	248	247	247
B10	247	247	247	247
A13	246	245	246	246
B15	247	247	247	247
Average				247

Fabric D (Warp) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	241	241	240	241
B3	239	239	238	239
A6	238	239	240	239
B8	240	240	240	240
A11	239	239	240	239
B13	239	239	239	239
Average				239
Pressed	**1**	**2**	**3**	**Avg.**
A3	240	240	240	240
B5	240	239	240	240
A8	241	240	240	240
B10	240	240	241	240
A13	240	240	240	240
B15	240	240	241	240
Average				240

Fabric D (Weft) After 3 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	246	245	246	246
B3	247	247	248	247
A6	246	247	246	246
B8	247	246	247	247
A11	246	246	246	246
B13	247	248	247	247
Average				247
Pressed	**1**	**2**	**3**	**Avg.**
A3	247	246	247	247
B5	247	246	248	247
A8	246	248	248	247
B10	247	247	247	247
A13	247	245	247	246
B15	247	248	248	248
Average				247

Fabric D (Warp) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	239	239	239	239
B3	237	237	237	237
A6	237	237	238	237
B8	238	238	238	238
A11	236	236	236	236
B13	237	237	238	237
Average				237
Pressed	**1**	**2**	**3**	**Avg.**
A3	238	238	237	238
B5	238	238	239	238
A8	238	237	237	237
B10	238	238	238	238
A13	238	238	238	238
B15	238	238	238	238
Average				238

Fabric D (Weft) After 5 Washes				
Control	**1**	**2**	**3**	**Avg.**
A1	246	246	246	246
B3	248	248	249	248
A6	246	246	247	246
B8	248	248	248	248
A11	246	246	246	246
B13	247	248	248	248
Average				247
Pressed	**1**	**2**	**3**	**Avg.**
A3	248	248	248	248
B5	248	248	248	248
A8	247	248	248	248
B10	248	248	248	248
A13	248	248	248	248
B15	248	248	248	248
Average				248

Fabric D (Warp) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	240	240	240	240
B3	239	239	239	239
A6	239	239	239	239
B8	239	239	239	239
A11	239	238	239	239
B13	239	239	239	239
Average				239
Pressed	**1**	**2**	**3**	**Avg.**
A3	239	239	239	239
B5	238	239	239	239
A8	239	238	239	239
B10	239	238	239	239
A13	239	239	239	239
B15	239	239	239	239
Average				239

Fabric D (Weft) After 5 Washes + Pressing				
Control	**1**	**2**	**3**	**Avg.**
A1	249	249	250	249
B3	250	250	251	250
A6	250	250	250	250
B8	250	250	250	250
A11	250	250	250	250
B13	251	251	251	251
Average				250
Pressed	**1**	**2**	**3**	**Avg.**
A3	250	250	251	250
B5	249	250	250	250
A8	250	251	250	250
B10	250	251	250	250
A13	250	250	250	250
B15	250	250	250	250
Average				250