THE EFFECTS OF PERMANENT CREASING ON TWO TYPES OF 65/35 POLYESTER-COTTON BLENDS AS MEASURED BY APPEARANCE, ABRASION RESISTANCE, AND BREAKING STRENGTH

by

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CHAPTER I

INTRODUCTION

Typical of science and industry is their constant search for improvements on newly created or developed products. Often times this occurs even before the products reach the market. This is especially true of the clothing and textile industry where many of the current fashions are dictating that certain garments be smartly and neatly creased and that this crease be able to display the ability to remain intact during the life of the garment. This stipulation attempts to lessen the burden of ironing for the housewife, since statistics show that ironing is one of the most disliked household duties (1).

Industry, aided by science and modern technology, has already given the housewife the 'wash-wear' fabrics even though they are far from being truly wash-wear in most cases. With most wash-wear fabrics, creases can be formed, but with no guarantee that they remain after repeated launderings.

But the past several years have brought about the advent of a new means of achieving more permanent creasing. This method is known by a number of names, the more popular ones being deferred cure, permanent-press and durable press. Many of the inherent problems common to wash-wear fabrics also appear in this new method of producing 'miracle' fabrics, thus research is being continued to try to overcome some of these. Permanent-press fabrics have the added problems of an inability to be altered, poor abrasion resistance, low strength and shrinkage along with poor chlorine retention, unpleasant odors, and yellowing it may share with wash-wear fabrics.

The purpose of this research is to evaluate the performance of a permanent-press fabric with a conventionally finished wash-wear fabric when new and after a first, third, and ninth laundering in relation to creasing. For purposes of statistical analysis the hypotheses are stated as null hypotheses.

H_1: There is no significant difference in the crease appearances of the permanent-press and wash-wear fabrics either when new or after nine launderings.

H_2: There is no significant difference in the abrasion resistance of the permanent-press and wash-wear fabrics whether creased or not creased either new or after nine launderings.

H_3: There is no significant difference in the breaking strength of the permanent-press and wash-wear fabrics whether creased or not creased either new or after nine launderings.

CHAPTER II

REVIEW OF LITERATURE

One of the elemental, but still distant, objectives of the textile industry is to engineer fabrics which exhibit those properties required for a specific end use, whether this be through the fabric finish or a blend of fibers (2). During the past decade, the progress with wash-wear fabrics in understanding the creaseproofing process has played a major part in developing the technology relating to permanent creasing of fabrics.

The whole approach to wash-wear was built on the idea of treating fabrics in such a way as to prevent the removal of creases and at the same time prevent the formation of wrinkles during the washing and wearing of a garment. Before the advent of permanent-press, the fabric was treated with a cross-linking chemical or resin which was immediately cured with heat. In this way, a 'memory' of the fabric's flat, finished state was imparted. Therefore, the resulting garment had a tendency to return to this smooth, flat state causing creases to disappear and seams to lose their flat, folded state. Some puckering also resulted due to yarn tensions and fabric displacement during fabrication (3).

A solution to these problems was found when pre-cure methods were replaced by post-cure or permanent-press methods. In this way, creases could be locked in and wrinkles locked out so that the garment would be permanently shaped as it was sewn and pressed. The promises made for wash-wear over eight years ago are now being fulfilled with permanent-press (3, 4).

With the advent of the permanent-press idea, new names for new processes, products, or techniques appeared. Such terms as post-cure, delayed cure, deferred cure, durable press, and durable crease, to name a few, were heard (5, 6). Also, processes termed Koratron, Super-Crease S, Cone-prest, Dan-Press, Sharp/Shape, Shape-Set, and Burmi-Crease were heard and were somewhat disconcerting to the consuming public as it tried to differentiate between all of these terms when, in actuality, many of them are synonymous (6).

History

The basic idea of deferred cure as a means of achieving permanent-press was proposed by Reid, Mazzeno, Reinhardt, and Markezich in 1956 (7, 8, 9). They reasoned that durable crease lines could be established in finished garments if the resin formulations applied to the yard goods were cured in this finished state (8). They also recognized the immediate problems that would be involved. First, a fabric and formulation possessing infinite shelf life after the fabric had been dried would be needed (10). Also, there was a need for a highly heat-sensitive catalyst, that is, one which would be completely stable to an activation temperature low enough for suitability on standard garment pressing equipment yet high enough for shelf storage of the fabric in the dry, uncured state. The trouble with the early catalysts was the fact that some fabrics cured over a short period of time and others over a longer period of time even at room temperature. This was detrimental to any subsequent curing procedure. In addition, sharp creases were impossible to obtain if the shelf life was sustained for a long period of time.

In the mid-fifties, Koret of California, a small San Francisco manufacturer of women's sportswear, experimented with curing ovens and completed garments. In 1961, this manufacturer obtained a patent for a deferred cure process and later formed the Koratron Company to market the process (3, 10, 11, 12, 13). At about the same time other interested parties were working on the same idea of improving the performance of wash and wear fabrics. The National Cotton Council and the Southern Regional Laboratory of the United States Department of Agriculture were directing their efforts toward upgrading the status of cotton in the face of many new synthetics appearing on the market (3, 8, 13, 14). Tesoro, of J. P. Stevens, was working on the concept of deferred cure with the use of sulfone chemicals (3, 13). Researchers at Cone Mills, Dan River, Burlington, and Wamsutta were also exploring the possibilities of permanent-press (3).

Encouraged by Bacharach of Levi Strauss and George Aufderheide from McCampbell Graniteville Company, Koret teamed with these companies and marketed the first permanent-press garments in February 1964 which were men's work pants. In this team, Koret provided the patented process; McCampbell Graniteville Company, the chemically impregnated fabric; and Levi Strauss manufactured the garments which included the oven-cure as the final finishing process.

These garments sold quickly, delighting customers with their freshly pressed appearance on emerging from home dryers (3, 10, 12). The idea of permanent-press began appearing in women's ready-made garments during late winter of 1964 and 1965.

Permanent-Press Problems to be Solved

Soon, many of these work pants were returned as defective. The most apparent defect to the customers was the excessive wear noted particularly at the knees, seat, and crease and cuff edges. The chemical finish that had given the cotton fibers the 'memory' of returning to their oven-cured position had weakened them. But there were other problems as well.

These early permanent-press garments were faced with the problem of fibrillation or frosting which is the lightening of a color that occurred after repeated launderings, especially in creased areas (3). This fibrillation was due to the increased abrasion incurred along the more exposed crease line which 'teased' out some of the fibrils in the fabric. Effective chemicals were needed to eliminate this problem and at the same time safeguard the existing strength or durability of the cotton in the garments (9, 10, 14).

Another problem to be eliminated was the discoloration or yellowing of white fabrics (3). This was caused, in some cases, by the necessity of prolonged heat periods (15). A related problem was that of objectionable shade changes. The cutters did not realize the importance of uniform temperature conditions for every part of the garment for uniform results (15, 16). Also, oil spots and lint on the garments would spot them during the oven-cure (16).

The reticence of the fabric finishers concerning shipping sensitized and uncured fabric needed to be corrected (11). These finishers wanted to know who was responsible for the fabric performance when the fabrics were shipped in this state; the finishers further wanted reasons for running the risk of having the fabric cure itself while in shipment.

The cutter was faced with the problem of storing piece goods in an air-conditioned warehouse. He was also faced with an extremely offensive odor problem, and loss of fabric strength and excessive shrinkage after the oven-cure (1). This excessive shrinkage problem created the necessity for the cutter to maintain a second set of patterns, oversized, in a complete size range and for all styles (1, 16).

The cutter was also faced with the problem of cutting and sewing the garments in a short period of time after shipment of the sensitized fabric.

In addition, there were problems of seam puckering, and over curing which resulted in tenderized cloth in the final oven-cure process (16). Heat-setting with hot-head presses had to be done with extreme care since any unwanted creases incurred while the fabric was still in this sensitized state were impossible to remove completely. Then after the garments had been oven-cured, the home sewer experienced difficulty to making necessary alterations, especially if the alterations involved changing a seam line or making trouser cuffs in permanently creased slacks (16).

Processes

There are several processes whereby permanent-press or durable press may be achieved and they are outlined briefly below.

(1) Delayed or Deferred Cure. This process is probably the most familiar and is the process for which the Koratron Company has a U. S. patent (10, 11, 13, 14). It is known at Koratron as "Press Free", at J. P. Stevens as "Super-Crease", at Dan River as "Dan-Press", at Burlington as "PCR", at Spring as "Springs-Set", and at Reeves as "Reeves-Set" (1). Blends of polyester/cotton, cotton/nylon, polynosic/-polyester, and 100% cotton are used in this process (3, 6, 13).

This is a post-cure process which means the fabric is impregnated with the appropriate reactant, catalyst, and finishing agent at the mill or finishing plant. The fabric is dried at a low temperature so as to prevent curing. After fabrication at the manufacturing plant, the sensitized garment is pressed on a hot-head press to set the shape after which it is oven-cured to cross-link the chemicals to the fabric and to set creases (4, 5, 6, 7, 9, 11, 13, 17). The oven-curing time-temperature combinations vary from one finisher to another. One source gave four such possible combinations: 370° F for two minutes, 340° F for four minutes, 320° F for eight minutes, and 300° F for fifteen minutes (3). If the fabric is of all cellulosic content, it is usually a heavy-weight fabric to offset the 35-50% reduction in tensile strength resulting from high temperatures and long periods of curing time (3). Due to shrinkage, especially in men's trousers, patterns must be oversized particularly in the waistband and inseam by one-fourth inch (3).

(2) Precure, Double Cure, or Recure. These processes include Cone's "Coneprest", Lowenstein's "Never Press", Erwin's "Dura-Crease", and McPike's "Everprest" (1). Deering-Milliken, Incorporated, and Klopman Mills also employ it. These processes do not require an oven, but they do depend on special garment pressing conditions. This is especially true in the precure or double cure process where garments are made from fully cured or partially cured fabric. These garments are pressed on a hot-head press to break and reform the cross-linking bonds in the creased position. Then the garments may or may not be oven-cured, depending on the temperature of the hot-head press (3, 5, 6, 16, 17).

The recure process was a 1957 discovery of Buck and Getchell (14, 17). Fabrication is carried out using fully cured fabric. The garments are lightly pressed for shaping and then an additional catalyst is sprayed or sponged on the creases, pleats, and seams. The catalyst solution 'uncures' and recures the fabric while the garment is held in the desired configuration with the aid of a hot-head press. The cross-links break with the application of heat and moisture, and reform as the fabric dries during the pressing (9, 13, 14). A modification of this process eliminates the need for spraying the garment with additional catalyst (13). One source merely states that the garment should be pressed for three minutes on a hot-head press (13) while another source indicates that the garments could be pressed on presses which generated temperatures above 325° F with steam gauge pressures ranging from 80 to 120 pounds (3). The pressing time could range from 25 seconds to 3 minutes depending on the fabric and type of press used (3).

There are several limitations to the recure process which prevents wide acceptance on an industrial scale. Stiffening usually occurs in the recured area with the application of additional catalysts (9). The delicate balance between a cross-linking rupture and a cross-linking formation is difficult to control. Water marks may appear on certain fabrics if this process is used. Also, where the catalyst solution causes the resin to migrate, scorching is likely to occur.

(3) Fiber Modification or Sulfone Process. This procedure is used by J. P. Stevens mostly on polyester/cotton fabrics (6). The fabric is treated with a symmetrical sulfone and an alkali which is allowed to react for some time in the wet state before the fabric is rinsed and dried. The cloth is treated next with a caustic which is allowed to react for a short period of time. After this reaction time, the fabric is neutralized and rinsed. This action completes the 'wet cross-linking' step (6, 13). After an alkaline catalyst has been padded on and the fabric dried, the cloth is ready for shipment. At this point, the cellulose fibers have been modified and all major changes have taken place which imparts all desirable properties

except dry crease recovery to the fabric. Dry crease recovery is imparted to the fabric only after an oven-cure or 'dry cross-linking' step. An oven-cure of 320° F for four to five minutes is believed to be sufficient according to one source (6) while another source states that these conditions may vary from ten to fifteen minutes at 260° to 280° F to three to six minutes at 300° to 330° F (9).

With this process, it is important to select a suitable chemical system to get uniformity of the treatment, stability of the treated fabric to storage, and the elimination of odors and an afterwash treatment. The amount of pressing required to set creases is less with this process than that for the delayed cure process because the lower amount of pressing is sufficient to impart a crease to the dried fabric and the chemical reaction is allowed to take place later in the oven, after fabrication. Chlorine retention, unpleasant odors, and spontaneous curing is usually eliminated in this process (9).

(4) High Energy or Pressure Cure. This procedure is known as the Everprest process. The garments are cut from post cured or pre-cured fabrics of polyester/cotton, cotton/nylon stretch, or 100% cotton. The garments are pressed and cured simultaneously (6, 13) using high temperatures of around 450° F for fifteen seconds with accompanying high pressures (5, 6). With this time/temperature relation, no oven-cure is necessary. Fabrics used in this procedure are always completely cured at the finishing plant (6).

(5) Resin-Latex or Garment Treatment Process. This is Williamson-Dickie's "Shape-Set" process in which the completed garments are

immersed in a conventional resin along with a very high concentration of a thermoplastic polymer (1, 5). After the excess liquor has been extracted, the damp garments are pressed into shape and cured in an oven (13). One source notes that the covering patent states that the garments show an approximate weight increase of 13% due to the resin and latex add-on (6).

One limitation to this procedure is that the treatment of the garments require such close control for satisfactory results that industrial acceptance on a wide scale is unlikely (9, 14). Also, this process requires a longer pressing time to set a crease because the process includes the extraction of excess liquid followed by a pressing to dry the garment and set crease lines (15).

(6) Resin-Fiber Process, or Fiber Blend. This process is used in Burlington's 'Burmi-Crease' and Wamsutta's 'Never-Press'. The major effect of this process is obtained through the engineering of fabric construction although some resins may be used in small amounts. Ideally, the fabric is woven with a 100% thermoplastic fiber in one direction, and 100% cellulose or a blend of cellulose/snythetic in the other direction (13). Garments made from this fabric are pressed on a hot-head press using high temperatures and pressures of around 90 pounds for five seconds which can impart the crease or pleat. This process results in about one percent residual shrinkage (3).

Another source specifies using 100% polyester yarn in the filling direction in order to capitalize on polyester's ability to accept and hold a crease. This source also suggests using blended polyester/-

acrylic fabrics where the two thermoplastic fibers only need a good pressing with pressure to obtain a sharp crease (6).

(7) Everprest's "Sharp/Shape". This process is effective with stretch fabrics and was adapted by Erwin Mills for Expandra stretch denim. A precure Sanforized blend of 75% cotton and 25% stretch nylon is used. Garments made from this fabric are pressed with a hot-head press to cure them (3).

(8) Vapor Process. This is known as the VP-3 Process and is used on 100% cotton fabric to achieve permanent-press garments. This process has not been developed for commercial use as yet. After fabrication from untreated cotton, the pressed garments are placed in a closed oven or vapor reacter chamber where vapors of cellulose cross-linking agents and catalysts are introduced into the chamber by an air or nitrogen stream. The reaction times and temperatures vary from room temperature to 120° C and 15 seconds to 120 minutes depending on reagents used. After the exposure time has elapsed, the unreacted chemicals from the garments are flushed from the chamber (18).

Since the vapor phase cross-linking is carried out under mild conditions and in the presence of moisture or non-restrictive swelling agents, the permanent-press cotton garments so produced have higher tensile strength, tear strength, and abrasion resistance than those produced in the resin-based high temperature curing system. There is no problem of storage stability for the fabric between the finishing plant operations and the manufacturing of the garments since the reactions are carried out on untreated cotton garments (18).

Fiber Properties of Polyester and Cotton Relating to Permanent Creasing

Polyester is a desirable component for wash-wear and permanent-press fabrics because, by itself, its chemical resistance is good in the presence of weak acids at boiling temperatures and strong acids in cold temperatures. Polyester's resistance is also good to weak alkalies but less so to strong alkalies. The good recovery from bending means polyester has power to lose wrinkles rapidly (19, 20).

Polyester's thermoplastic properties of softening and becoming pliable with heat means that heat-setting will dimensionally stabilize the fibers so that they will be completely immuned to subsequent treatments such as washing and drying actions at low temperatures (19, 20). Heat-setting of creases in the fabric imparted at a setting temperature of approximately 365° F, which is about 40° higher than any likely to be encountered in the life of the garment, are in for the life of the garment (19, 21). Any creases encountered during the laundering process are never severe and can be removed with a light pressing (19).

Dry and wet heat stability are reached at different heat-setting temperatures for at a given temperature, the percent of shrinkage may differ greatly from the washing to the ironing process (22). Heat-setting at 350° F during fabric finishing yields satisfactory results when laundering temperatures reach 212° F. Shrinkage is less than 0.6%. But when a blended fabric with this heat-setting treatment is exposed to high ironing temperatures of around 400° F, 3.0% shrinkage results (22). For dry-heat stability, heat-setting temperatures should exceed 380° F to reduce shrinkage to less than 1% (22).

In addition to dimensional stability, proper heat-setting of these fabrics minimizes pilling propensity and wrinkle resistance (22).

The heat-setting process stiffens the fabric but this is lost if heat-setting is done as early as possible in the process of finishing the fabric so that much of the processing will be utilized to break-down the stiffness (19). If heat-setting is done before drying, care must be taken to see that the heating is uniform so that the affinity for the dye will be regular to give level dyeing (19). A dry-heat set is often preferred because heat-setting done under steam and pressure causes some hydrolysis of the ester group in the polymer chain and the fiber is partly depolymerized with a loss in tenacity (19).

A blend level is carefully selected with respect to the resulting over-all fabric properties and desired performance. To obtain the proper blend level for any fabric, all the end fabric characteristics desired plus all economic factors must be taken into consideration. A fabric designed for a specific end-use must meet or exceed the minimum specifications required for that particular use (22). For example, by increasing the polyester content in a cellulosic blend, the fabric strength and elongation is increased. In a 50/50 polyester/-cotton blend, the yarn elongation is 43% lower than for the same yarn count in a 65/35 blend (22). This is especially important for batiste and broadcloth fabrics. In coarser yarn counts and heavier weights of fabric, this elongation is less noticeable since the actual fabric strength is usually more than enough to meet end-use specifications (22). An increase in the polyester content also improves the wrinkle recovery. Laundered appearance and pressed crease retention increases even with a blend of 35% polyester (22). As the percent of polyester fiber increases, a point is reached when the cotton fibers have only a limited effect on the spun yarn characteristics (22).

Cotton has a moderate abrasion resistance compared to polyester and has a low elasticity, which means wrinkles will not hang out. The elongation of cotton when stretched to the breaking point, ranges from 3% to 10%. By itself, cotton has poor crease recovery. Cotton has a medium tensile strength compared to polyester, but when wet, its strength may increase as much as 30% (20). In blends, the cotton gives an opacity to the fabric, greater moisture absorbency, and improved hand (19).

Cotton is decomposed by hot or cold strong acids and is deteriorated by weak, hot acids. Weak alkalies have little or no effect on cotton, whereas strong alkalies (sodium hydroxide solution) are used in the mercerization of cotton to increase its strength and luster (20, 23).

Finishes used to impart creases to cottons are resins of a synthetic high-polymer nature. These cause cross-linking between the molecular chains which results in fiber stiffness. Synthetic resin compounds are used in place of starches and gums to attain durable crispness in cotton fabrics (20).

In polyester/cotton blends, finishing agents are added to impart a desirable hand, increase wrinkle recovery, and improve the wash-wear properties. In a normal, balanced construction, polyester/cotton blends are finished for desired fabric properties with little or no loss of tensile strength due to resin application, provided the fabric contains at least 50% polyester fibers (22).

Tear strength can be degraded on polyester/cotton blends through the use of finishing agents. Any finishing agent applied to the fabric that restricts the yarn or fiber mobility will result in a reduction of tear strength. This can be lessened by using softeners which will provide lubrication for the yarns. Softeners with polyethylene have shown the greatest effect on improving and maintaining tear strength (22).

Summary

As far as research is concerned, permanent-press is still relatively new. Only a few studies are available that compare conventional wash-wear fabrics with permanent-press fabrics. The majority of the articles deal only with cottons instead of the blends and these cottons were studied only for particular qualities. A possible reason for using only cotton fabrics in the studies may have been to hold the number of variables to a minimum.

In general, these permanent-press studies are related to the performance qualities of the fabric or garment. For example, various means of achieving permanent creasing were studied (6, 7, 8, 24, 25). Some of these methods included the use of unsymmetrical sulfones, sulfone in the presence of water, and the use of sulfones under anhydrous conditions. These sulfones were also used to study the water holding capacity of fabrics (9, 25, 26, 27) since these chemicals affect the drying time of the fabric. This sometimes results in finishing agents used as water repellents.

There is evidence that more and more research is being carried out on blends and in the future, permanent-press fabric claims will be more substantiated because of new and better processes for curing as well as the increased knowledge of fiber blends.

CHAPTER III

PROCEDURE

Fabric Selection and Analysis

The fabrics used in this study were donated by Klopman Mills, Burlington Industries. The two broadcloth fabrics were of 65% polyester and 35% cotton by weight. The pink wash-wear fabric had been finished by a conventional pre-cure process while the white fabric had been given a permanent-press finish requiring a final oven-cure after fabrication. The new fabrics were subjected to a battery of tests to determine the fabric characteristics. These tests were conducted according to ASTM Designation D1910-64 (28) and AATCC Designation 20-1963T specifications (29). The results appear in Table 1 in Results and Discussion.

Pretesting of the Fabrics

Literature states that polyester sticks at 445° F, melts at 482° F (30) and is safely ironed at 325° F (21) while cotton is safely ironed at 425° F (21). Because curing temperature is important in permanent-press, the maximum ironing temperature was determined, using a home-type hand iron, to which the two 65/35 polyester/cotton fabrics could be subjected before reaching the beginning stages of deterioration.

Since temperature ranges vary from one home-type hand iron to another, a hand iron was selected for use in the pretesting of the two fabrics and the temperature range from the linen setting to the synthetic setting was determined.

Using a pyrometer and stop watch, the linen setting on the hand iron registered 430° F in two minutes, six seconds and remained for an additional one minute, seven seconds. Note was taken that at each setting, the iron reached a peak temperature, remained there for a short period of time and then cooled off before repeating the cycle. The area between the cotton and wool setting registered 360° F; the wool setting registered 320° F; and the synthetic setting registered 180° F.

Fourteen 7" x 15" samples, six from the wash-wear (pink) fabric and eight from the permanent-press (white) fabric, were creased in the warp direction using the linen setting (430° F) of the hand iron. The iron touched only the creased area and not the body of the fabric. This high temperature was used to establish the reaction of the two fabrics under severe conditions. A heat-setting treatment with a hand iron at a local garment manufacturing plant followed with the maximum ironing temperatures ranging from 200° F to 220° F with the use of steam. Hand irons were used instead of the hot-head presses for heat-setting treatments at this garment factory. Therefore, the hand irons were used in the pretest. Four of the eight white permanent-press samples were cured in a conveyor belt oven for six minutes at 300° F and the remaining four were cured for fifteen minutes at 300° F. Keeping one wash-wear sample and one fifteen-minute cured permanent-press sample as controls, the remaining twelve pretest samples were laundered according to AATCC Designation 88A-1964T (31) and AATCC 88C-1964T, Method II-C (32). The number of laundering cycles was arbitrarily chosen for evaluation after the first, third, and ninth launderings with one wash-wear sample and one six- and one fifteen-minute cured permanent-press sample. One wash-wear sample and one six-minute permanent-press sample were removed after the sixth laundering. The crease of the one wash-wear sample remaining after the nine launderings was pressed open with a hand iron for later use in evaluation.

All fourteen samples were evaluated empirically for appearance and sharpness of crease. No differences were evident among the fourteen pretest samples creased under severe conditions. This suggested that no differences would be evident between samples of the two fabrics creased under more favorable conditions. Since there were no differences under the severe creasing conditions as would be expected, it was decided to search for indications of fabric differences when subjected to varied amounts of abrasion, yet creased under normal conditions. The Accelerator abrasion test was used in a previous study of a similar nature (33). The 4-1/2 inch pitched blade, the fine #250 abrasive liner, and 3,000 revolutions per minute as recommended in this earlier study were accepted for this pretest as the same fabrics were tested in both studies. The abrasion time periods were chosen on the basis of the least amount of time that would cause an appreciable percent weight loss and the maximum amount of time that could be allowed before the cloth had shredded. Samples tested at one-half minute showed no appreciable weight loss. The original samples even retained their original crisp hand. At one minute, the abraded samples still had a small, but sufficient, percent weight loss so as to make this time period acceptable as a minimum abrasion period.

At 2-1/2 minutes, the abraded samples were in shreds rendering the samples as worthless, but at two minutes, the samples showed severe abrasion while remaining intact. With these two time periods as extremes established, the midpoint of 1-1/2 minutes was chosen as a medium abrasion time period.

Preparation of Test Specimens

From each test fabric, seventy-two 7" x 7" squares were cut according to AATCC 93-1959T (33) and twenty-four 7" x 15" samples were cut from each fabric instead of the 15" x 15" squares specified by AATCC 88C-1964T (32).

Thirty-six of the 7" x 7" square samples and twelve of the 7" x 15" samples for each fabric were carefully folded warpwise and creased slightly with a hand iron at approximately 180° F which was the synthetic setting. The remaining uncreased samples for both fabrics were given a light pressing with the hand iron set at the same temperature in order to keep the treatments of the two fabrics constant.

Heat-Setting Treatment

All of the samples from both fabrics were subjected to a heat-setting treatment with a hot-head press at the University Laundry. The manufacturer's instructions stated that the permanent-press fabric should be heat-set with a hot-head press at 320° F for fifteen seconds. On the equipment used in the study, this was not possible. The head of the press was allowed to remain on the samples until the temperature of 320° F was reached and held for fifteen seconds, giving a total heat-setting time of approximately two minutes.

Curing Process

The manufacturer's directions stated that the permanent-press fabric should be oven-cured at 300° F for fifteen minutes after the heat-setting treatment, but due to fluctuations in the temperatures and timing of the conveyor-belt oven used for the cure, all of the creased and uncreased permanent-press samples were cured for fourteen minutes, forty-five seconds at an average temperature of 298.9° F.

Randomization and Coding of Test Samples

All samples for both fabrics were randomized and coded in order to distinguish between original specimens and those of the first, third, and ninth launderings. Since the two fabrics were distinguishable in appearance by their color, there was no need to code the samples with regards to wash-wear and permanent-press. The samples were coded as follows:

1. 0 denoted original samples. Roman numerals I, III, and IX denoted samples of the first, third, and ninth launderings respectively.
2. Arabic numbers 1, 2, and 3 were used to denote the three samples in each of the four groups defined above.

Using the preceding coding system, a sample was distinguished from the rest by first a letter (0) or Roman numeral, then an Arabic number. Example: 01, I2, IX3.

Laundering Procedure

All samples from both fabrics to be laundered were laundered together according to specifications in AATCC Designation 88A-1964T (31) and AATCC 88C-1964T, Method II-C (32). A 1966 Maytag automatic agitator washer and tumble dryer were used. The recommended four-pound load was obtained with the use of dummy pieces and kept constant during the nine launderings by adding dummy pieces when test samples were removed after the first and third launderings.

Testing and Evaluation

The two fabrics were tested when new and after the first, third, and ninth launderings. Crease appearance, abrasion resistance, and breaking strength were tested.

The three creased 7" x 15" samples from each of the four groups (original and three launderings) for both fabrics were randomized, conditioned four hours at 70° F and 65% relative humidity, and evaluated twice according to AATCC Designation 88C-1964T (32) using a panel of three judges.

The seventy-two 7" x 7" samples, original and laundered, creased and uncreased, for both fabrics were prepared for the Accelerator abrading testing according to AATCC Designation 93-1959T (33). For each of three magnitudes of abrasion, original and after first, third, and ninth launderings, for each fabric, three uncreased and three creased samples were abraded. The three magnitudes of abrasion were chosen on the basis of a pretest and previous study of a similar nature (33). The abrader was run 3,000 revolutions per minute for one minute, one and one-half minutes, and two minutes. The fine #250 abrasive liner was changed after each 24 minutes of testing time.

The 7" x 7" abraded specimens and non-abraded specimens and the 7" x 15" samples were prepared for ravelled strip breaking strength tests according to ASTM Designation D1682-64, Method 1R-T (35). The breaking strength results for each test condition were based on the average of nine breaking strengths of which three ravelled strips were cut from each abraded or non-abraded piece.

The 1" ravelled strips were cut in the filling direction crossing the crease line of the creased samples which was in the warp direction. All samples were conditioned at 70° F and 65% relative humidity before being tested in order to allow the samples to reach moisture equilibrium with the surrounding atmosphere. The constant-rate-of-extension Scott-Tester was used.

CHAPTER IV

RESULTS AND DISCUSSION

Fabric Analysis

The fabrics for this study were donated by Klopman Mills, Burlington Industries. The physical properties of the two test fabrics under investigation were determined and the results are recorded in Table 1. Similar test fabrics were obtained so that the two finishing procedure effects could be studied. The wash-wear fabric was finished by a conventional pre-cure method and the permanent-press by a post-cure method.

The two fabrics were somewhat distorted due to fabric finishing for the permanent-press fabric was skewed off-grain 2.3% while the wash-wear fabric was skewed 0.6% and bowed off-grain 1.7%.

The yarn twist for the wash-wear fabric was 11.9 turns per inch higher in the warp direction and 10.1 turns per inch higher in the filling direction than the corresponding turns per inch in the permanent-press fabric. This may be of some significance in crease appearances, abrasion resistances, and breaking strengths between the two fabrics. It is generally considered that lower amounts of yarn twist contribute to better wrinkle resistance.

The permanent-press fabric was white and the wash-wear fabric was pink. This color difference was a deterrent to a statistical analysis of the empirical visual evaluation of the creases for both fabrics.

Table 1. Physical Properties of Test Fabrics

Fabric	Color	Weave	Yarn Count (Per Sq. In.)			Yarn Twist and Designation		Percent Bow or Skew		Weight (Oz. Per Sq. Yd.)
			W	F	Total	W	F			
Permanent-Press	White	Plain	136	71	207	22.2/Z	24.8/Z	0	2.3%	3.0209
Wash-Wear	Pink	Plain	135	70	205	34.1/Z	34.9/Z	1.7%	0.6%	3.0303

Crease Appearance

In preparing the three judges for evaluating the creases of the two fabrics, they were instructed to compare the appearance of the test specimens with the photographic standard placed alongside the test specimen under the prescribed lighting arrangement. Each judge was instructed to visually compare the width of the shadow cast by the crease of each specimen against a comparable shadow width on the photographic standard. They were to confine their observations to the crease itself.

The photographic standard ranked creases from one to five, in whole numbers. A rank of five indicated the sharpest crease and a rank of one, the poorest level of crease appearance. Since most of the creases in the test specimens seemed to fall between the standard whole numbers on the photographic standard, the judges were allowed to rank the test specimens between the standard whole numbers.

The crease appearance or retention ratings for both fabrics appear in Table 2. Under each of the four groups in the table are three specimens for the two fabrics. The values recorded for each of the twelve specimens represent the average of two observations made by each judge. The ratings for each sample were averaged and the overall mean value for the three samples of each group was determined.

As indicated in Table 2, the overall mean values after the first laundering for both the permanent-press fabric and the wash-wear fabric are the same. Further laundering did not yield consistent results.

Table 2. Crease Appearance Ratings for Original Test Fabrics and Specimens Laundered One, Three, and Nine Times*

	Original			1st Laundry			3rd Laundry			9th Laundry		
	01	02	03	I4	I5	I6	III7	III8	III9	IX10	IX11	IX12
Permanent Press:												
Judge 1	3.8	3.5	3.5	3.8	4.0	3.8	3.5	3.3	3.8	4.0	3.5	3.5
Judge 2	3.5	3.5	3.5	3.8	3.7	3.7	3.6	3.6	3.6	3.7	3.5	3.5
Judge 3	3.5	3.3	3.3	3.3	3.3	3.3	3.3	3.0	3.8	3.3	3.0	3.0
Average	3.6	3.4	3.4	3.6	3.7	3.6	3.5	3.3	3.7	3.7	3.3	3.3
Overall Mean		3.5			3.6			3.5			3.4	
Wash Wear:												
Judge 1	3.3	3.3	3.0	3.5	3.8	3.3	3.8	3.0	3.3	3.5	3.5	3.3
Judge 2	3.3	3.4	3.4	3.7	3.6	3.3	3.5	3.5	3.4	3.5	3.4	3.8
Judge 3	3.3	3.0	2.8	3.5	3.8	3.5	3.0	3.3	3.3	3.8	3.3	4.0
Average	3.3	3.2	3.1	3.6	3.7	3.4	3.4	3.3	3.3	3.6	3.4	3.7
Overall Mean		3.2			3.6			3.3			3.6	

A rating of 5 represents the best level of appearance and 1 the poorest appearance (ratings between the standard whole numbers were allowed).

* Represents an average of 2 observations for each sample for each of the 3 judges.

After the first laundering, the sharpness of the permanent-press creases seemed to lessen slightly as indicated by the overall mean value for the ninth laundering when compared with the other three groups. For the wash-wear creases, the judges deemed the creases to be the same after the ninth laundering when compared with the first laundering versus the lower crease rating of the originals. The third laundering rating was lower than the first and ninth.

If only whole numbers are considered in the overall mean values, the ratings given by the judges indicate that the creases were about the same for both fabrics in the original state and throughout the nine launderings. This may indicate a fairly stable fabric finish for both fabrics that lasted through nine launderings. The permanent-press creases were expected to be sharper than the wash-wear creases as the wash-wear fabric had more yarn twist per inch in both directions, but the only way this could be indicated is to compare each value in the table which shows a slight trend in this direction except for the ninth laundry ratings where the wash-wear creases are 0.2 of a rating higher.

An interesting fact for all of the observations is that none of the judges ever gave the highest rating of five to any of the specimens, even the originals. This suggests that the fabric finishes were not good enough to support creases equal to a five rating even though the creases after the ninth laundering were fairly consistent with those of the original samples for both fabrics. The reactions of the judges indicate a need for a more sensitive photographic standard.

For example, a photographic standard designed to allow deviations from the standard whole numbers or a standard with ten crease ratings instead of the five.

A statistical analysis of the crease appearance ratings was of no value due to the bias of the three judges to the colors of the two fabrics even though the two fabrics were not compared with each other, but to a photographic standard and because the ratings of one judge were consistently lower than those of the other two judges.

Abrasion Resistance

Samples from the two fabrics were abraded while in the original state and after the first, third, and ninth launderings. Samples from all four groups were abraded for one minute, one and one-half minutes and two minutes.

The percent loss of weight from abrasion was tabulated (Table 3) according to the following formula:

$$\frac{\text{Original weight - Final Weight}}{\text{Original Weight}} \times 100 = \text{Percent Loss}$$

The loss in weight of the test specimens is a means of indicating the abrasion resistance of the specimens. The more abrasion resistant samples lose less weight than do less abrasion resistant samples.

On the average, the data indicates that the regular wash-wear fabric had considerably lower abrasion resistance than the permanent-press fabric, that is, the wash-wear fabric had the higher percent weight loss as compared with the permanent-press fabric at each abrasion level and for each of the four groups.

Table 3. Percent Loss of Specimen Weight Caused by Abrasion

	Abrasion Time Periods		
	1 Minute	$1\frac{1}{2}$ Minutes	2 Minutes
Permanent-Press			
Original	5.9%	10.0%	15.1%
Laundry 1	2.8%	5.4%	8.0%
Laundry 3	3.8%	5.4%	9.4%
Laundry 9	2.1%	3.9%	4.4%
Wash-Wear			
Original	14.1%	17.9%	20.8%
Laundry 1	10.0%	13.1%	16.0%
Laundry 3	11.5%	13.1%	16.0%
Laundry 9	6.8%	11.6%	11.8%

Note: Each number represents 18 averages, 9 creased and 9 non-creased.

Both fabrics demonstrated a trend of improving in abrasion resistance as the number of launderings increased. Some of the detritus from the original fabric samples could have been sizing which caused a higher percent of weight loss for these samples.

Although the creased samples from both fabrics had a lower abrasion resistance than the non-creased samples, this difference was only slight as compared with the abraded flat samples in the study by Helms (33). In the present study, the creased and non-creased samples are combined for percentages while in the study by Helms, only non-creased samples were abraded.

Breaking Strength

The breaking strength values for the two fabrics under all conditions tested appear in Table 4. From this data, graphs were plotted to more clearly indicate the relationships between the two fabrics. The most apparent difference between the two fabrics is the greater average strength exhibited by the wash-wear fabric. Since it is known that the increased cross-linking of cotton that occurs in both permanent-press and wash-wear fabrics decreases the strength of the fabric, the greater strength of the wash-wear fabric may be caused by the greater twist of the yarn or the wash-wear finish may have had less tendency to decrease the fabric strength. It is possible that the strength of the two fabrics may be directly related to the effect of the finishes on the cotton. Part of the decreased strength of the permanent-press may have been due to the unstable storage

Table 4. Breaking Strengths of Creased and Non-Creased Specimens of Permanent-Press and Wash-Wear Fabrics with Varying Amounts of Abrasion*

Fabric	No Abrasion		Minimum Abrasion (1 minute)		Medium Abrasion (1-1/2 minutes)		Maximum Abrasion (2 minutes)	
	Creased	Non-Creased	Creased	Non-Creased	Creased	Non-Creased	Creased	Non-Creased
	lbs./in.	lbs./in.	lbs./in.	lbs./in.	lbs./in.	lbs./in.	lbs./in.	lbs./in.
Permanent-Press								
Original	29.3	32.1	19.3	23.7	16.7	23.1	18.4	25.2
Laundry 1	29.2	29.3	14.6	25.3	12.1	23.8	11.2	20.3
Laundry 3	27.3	29.3	13.7	20.1	13.6	20.3	12.7	19.1
Laundry 9	26.9	27.1	13.7	20.6	13.1	18.4	13.4	16.1
Wash-Wear								
Original	30.6	34.0	17.2	27.1	14.7	22.3	13.0	24.3
Laundry 1	29.6	28.5	17.8	23.7	13.3	20.6	15.0	19.4
Laundry 3	30.3	32.1	15.4	23.7	16.9	20.8	14.3	17.3
Laundry 9	28.8	27.3	18.0	19.2	15.8	19.7	12.5	20.1

* Each number in the table represents a mean of 9 values

Figure 1. Breaking Strengths for Permanent-Press Creased Samples

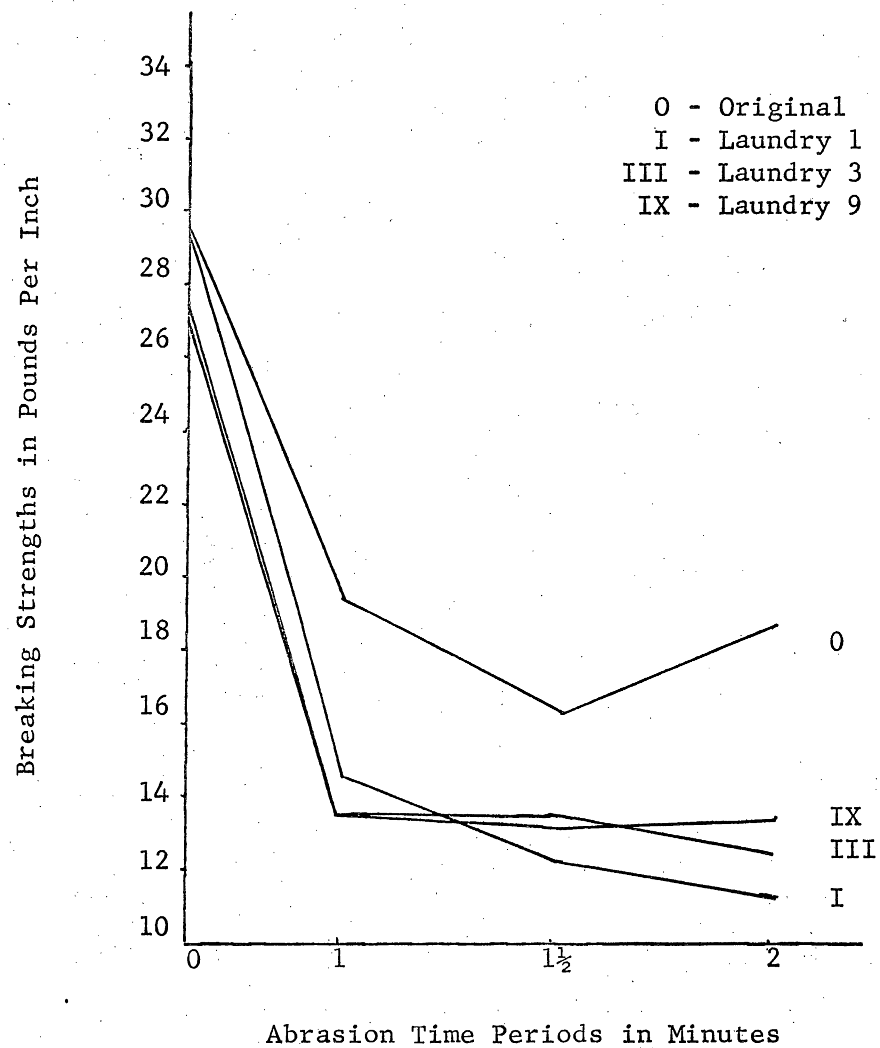


Figure 2. Breaking Strengths for Wash-Wear Creased Samples

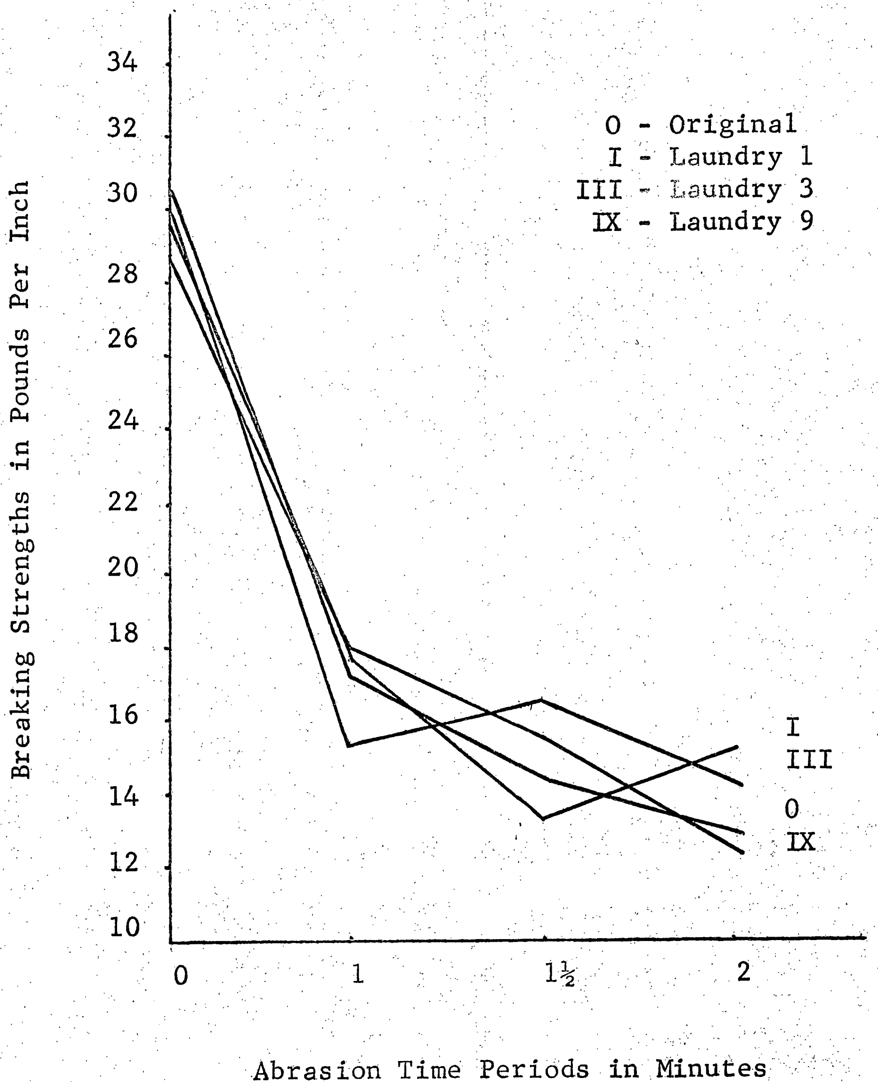


Figure 3. Breaking Strengths for Permanent-Press Non-Creased Samples

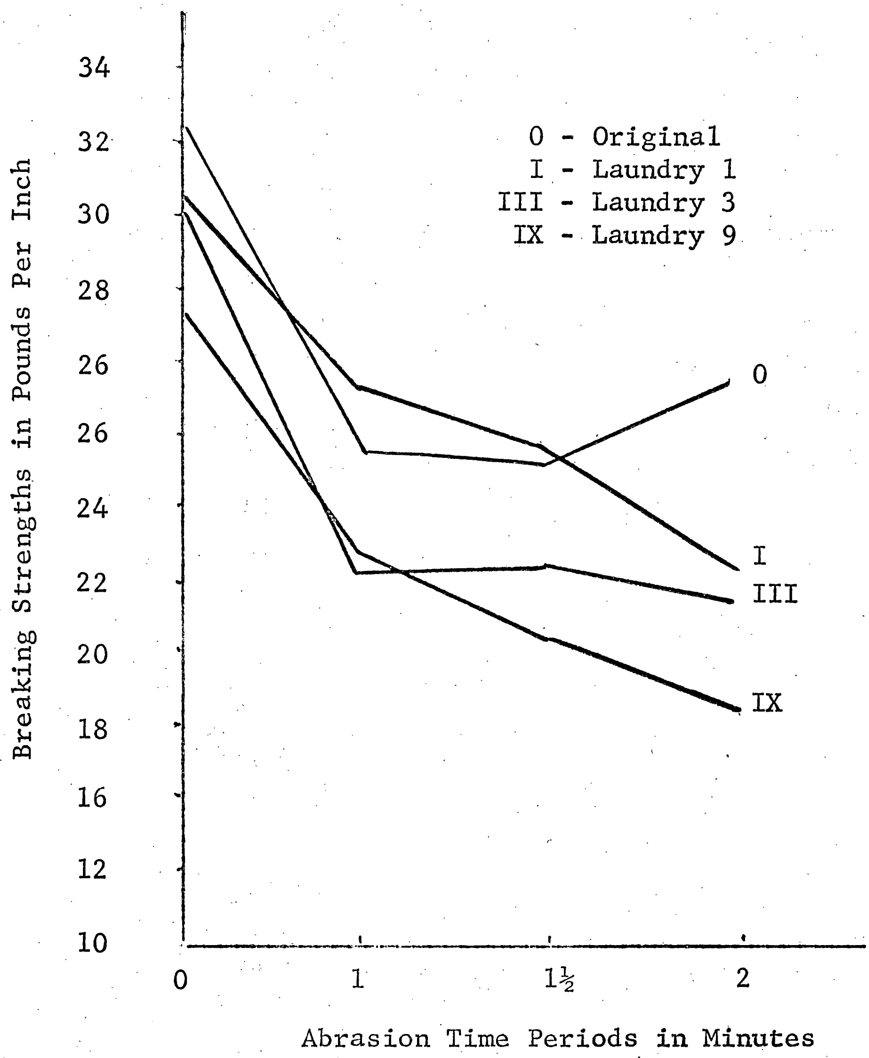
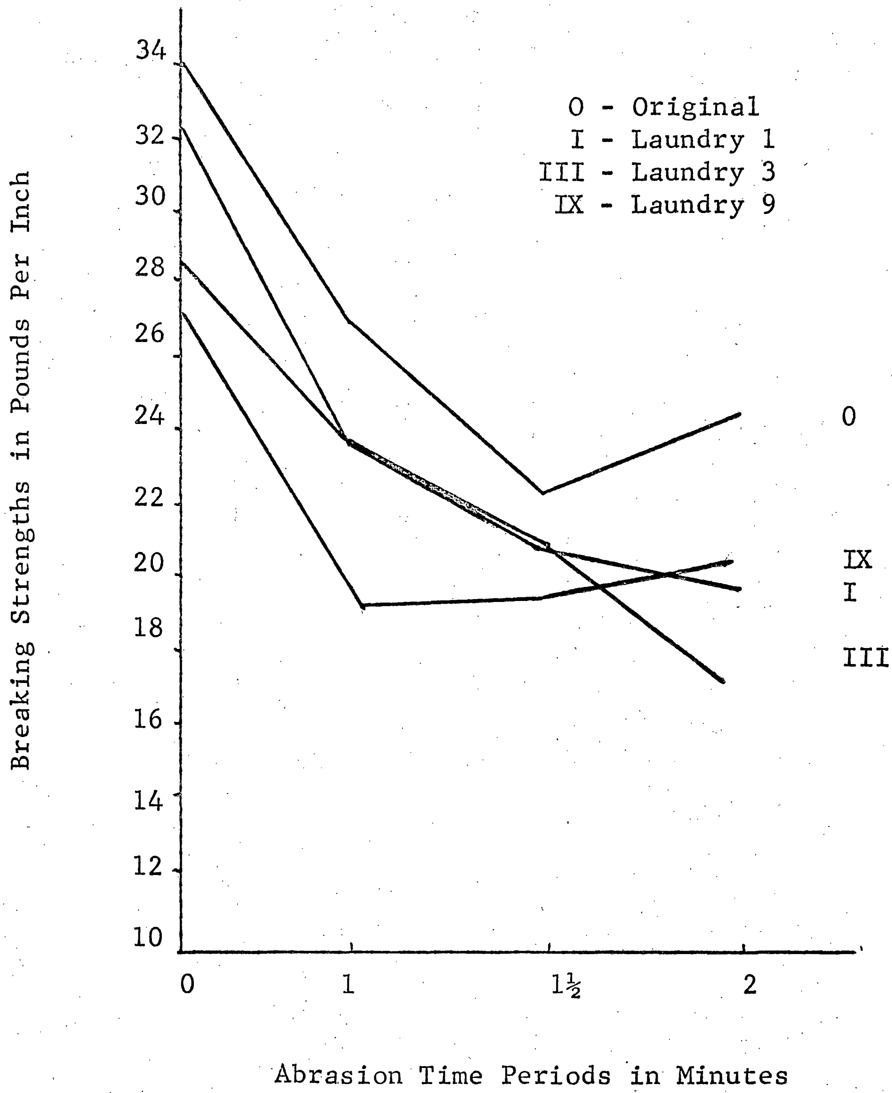


Figure 4. Breaking Strengths for Wash-Wear Non-Creased Samples



conditions and the severity of the oven-curing. During the two-month shelf life of the permanent-press fabric, where the temperature and humidity conditions varied greatly, some self-curing may have occurred. The permanent-press samples were oven-cured by means of a conveyor belt which slowly moved through a heated chamber opened at both ends. The temperature, though sufficient for the purposes of the garment industry, was not strictly controlled throughout the curing of the test samples and the strong air currents in the oven chamber may have caused not only uneven cure of the samples but also over cure to some of them. The heat-setting treatment of the permanent-press samples may have been detrimental to the strength of this fabric. The manufacturer recommended a heat-setting treatment of 320° F for fifteen seconds on a hot-head press. As a result of the necessity to leave the samples under the press for approximately two minutes in order for the press to reach and maintain a temperature of 320° F for fifteen seconds, the white permanent-press samples yellowed or scorched which also may have affected their strength. In order to compensate this condition, the wash-wear fabric samples were given the same heat-setting treatment.

The data points up differences between the creased and non-creased samples of the two fabrics. As would be expected, the creased samples of the two fabrics tended to have considerably lower breaking strength than did the non-creased samples. All of the creased samples were most vulnerable in the creased area when tested for breaking strength. This would be expected as creasing causes the cross-links to break in these areas. This was supported by the fact that frosting occurred in the creased area with launderings. This lightening or color change in the creased area indicated that the abrasive action of the wash cycles aggravated the broken fibers in the creased area causing them to "tease" out. This frosting may suggest the extent to which the polyester and cotton were blended.

The frosting of the creased areas in the creased samples of the two fabrics as a result of the launderings was magnified by the three magnitudes of abrasion. The abrasion time periods had a greater effect on the cotton fiber content than on the polyester because of polyester's inherent strength and tenacity. Dry, cross-linked cotton fibers are brittle and tend to be easily broken by abrasive forces. With each increase in abrasion time, the loss of cotton in the creased area of the samples from both fabrics appeared to increase somewhat proportionately. This idea may be supported by holding a flame close to the long fibers remaining after abrasion which were sparsely distributed throughout the creased area. These fibers melted, thus indicating the presence of only the thermoplastic polyester fibers.

For all samples of both fabrics, the graphs show a marked decrease in breaking strength between the non-abraded samples and those abraded for one minute. This marked difference is noted in the originals and throughout the nine launderings. Even though the effects of laundering softened the crisp hand of the new fabrics, the original and laundered samples had enough body in them to allow severe abrasion in some areas as this fabric stiffness or rigidity still present prevented the entire surface area of the samples from being abraded evenly. These areas were then vulnerable to subsequent breaking strength tests. A proportionately less effect from abrasion may be expected when abrasion time periods are increased. The first part of the time had a great softening effect so that the fabric samples could more easily withstand additional abrasive forces. The fibers could move more with the abrasive forces and therefore were not broken down as rapidly.

With increased launderings, the graphs suggest increased fiber movement. Between the first and third launderings, fiber swelling could have caused the fabric to shrink. A decrease in torsional strain could have occurred as the fibers began to relax and untwist to some extent. This should not have caused a decrease in fabric strength and may have even added to the overall fabric strength. This may explain the increase in breaking strength resistance that appears occasionally in the graphs. The abrasive action of laundering also may have caused some fiber movement which may have delayed fiber breakdown and thus allowed the fabric samples to retain their strength during the early launderings.

From the raw data in Table 4, the percent of loss of breaking strength caused by the varying amounts of abrasion was calculated for each fabric by the following formula:

$$\frac{\text{Original Strength} - \text{Final Strength}}{\text{Original Strength}} \times 100 = \text{Percent Loss}$$

The loss in strength of the test specimens is a means of indicating the breaking strength resistance of the specimen (Table 5). The more breaking strength resistant samples lose less weight than do less breaking strength resistant samples.

For both fabrics under all conditions tested, the wash-wear fabric tended to be the stronger of the two fabrics. But with the original creased samples of both fabrics, the permanent-press had a smaller percent of loss of breaking strength than the wash-wear at all three abrasion periods. The reverse held true, however, throughout all nine launderings. That is, the wash-wear fabric had the smaller percent loss in breaking strength for each abrasion period.

With the non-creased samples for both fabrics, the wash-wear was stronger in the original samples and for the third and ninth launderings but the permanent-press had a smaller percent loss of breaking strength for the first laundering.

This general trend of the greater strength belonging to the wash-wear fabric could indicate a finish that is less degradating to the fabric as well as demonstrate the effect of more turns per inch of twist in the warp and filling yarns of the wash-wear fabric.

The breaking strength data was analyzed statistically using Analysis of Variance and Duncan's New Multiple Range Test. The results of the Analysis of Variance appear in Table 6.

As would be expected with study of the raw data, the analysis of variance of the abrasion time periods was highly significant.

Table 5. Percent Loss in Breaking Strength Caused by Abrasion

Fabric	Minimum Abrasion (1 minute)		Medium Abrasion (1-1/2 minutes)		Maximum Abrasion (2 minutes)	
	Creased	Non-Creased	Creased	Non-Creased	Creased	Non-Creased
Permanent-Press						
Original	34.13	26.17	43.00	28.04	37.20	21.50
Laundry 1	50.00	13.65	58.56	18.77	61.64	30.72
Laundry 3	49.82	31.40	50.18	30.72	53.48	34.81
Laundry 9	49.07	23.99	51.30	32.10	50.19	40.59
Wash-Wear						
Original	43.79	20.29	51.96	34.41	57.52	28.53
Laundry 1	39.86	16.84	55.07	27.72	49.32	31.93
Laundry 3	49.17	26.17	44.22	35.20	52.81	46.12
Laundry 9	37.50	29.67	45.14	27.84	56.60	26.37

Figure 5. Percent Loss in Breaking Strength Caused by Abrasion for Permanent-Press Creased Samples

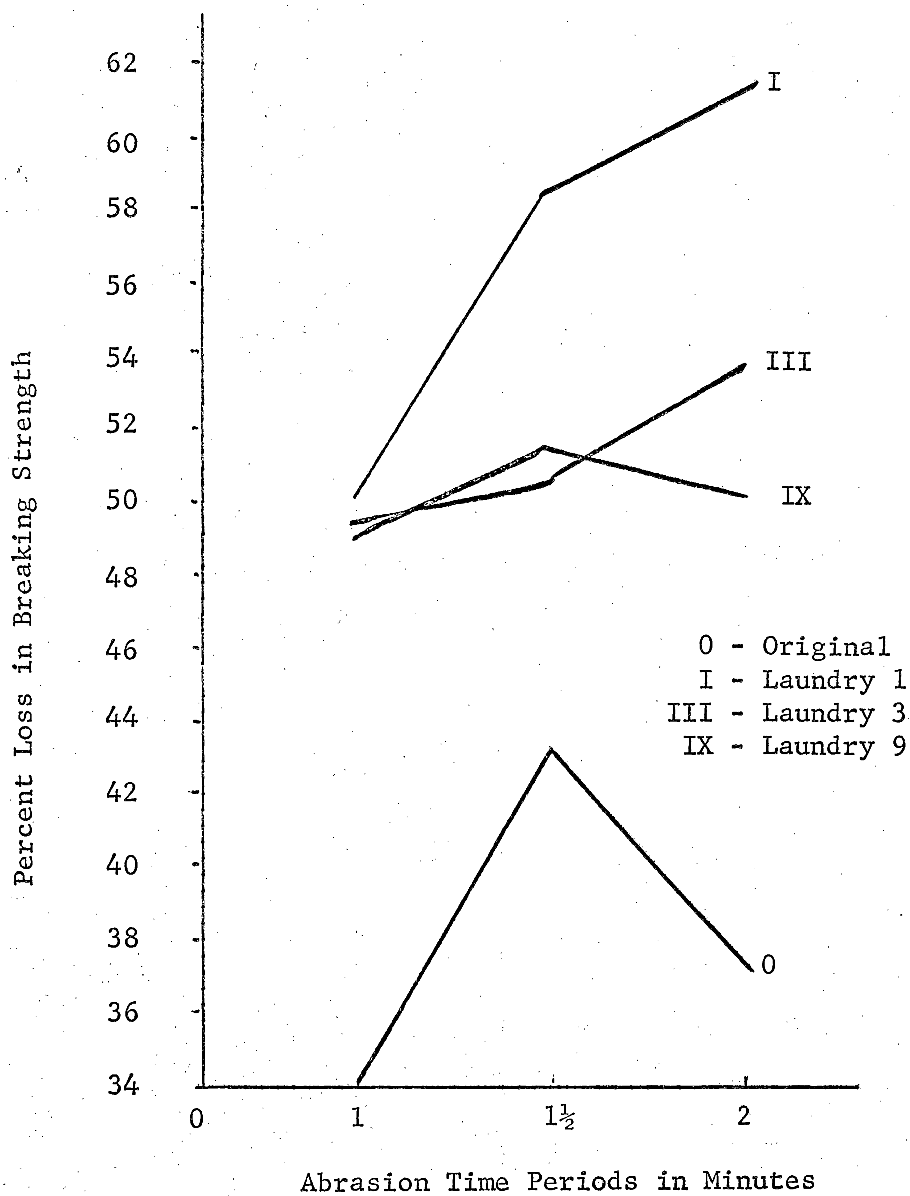


Figure 6. Percent of Loss in Breaking Strength Caused by Abrasion for Wash-Wear Creased Samples

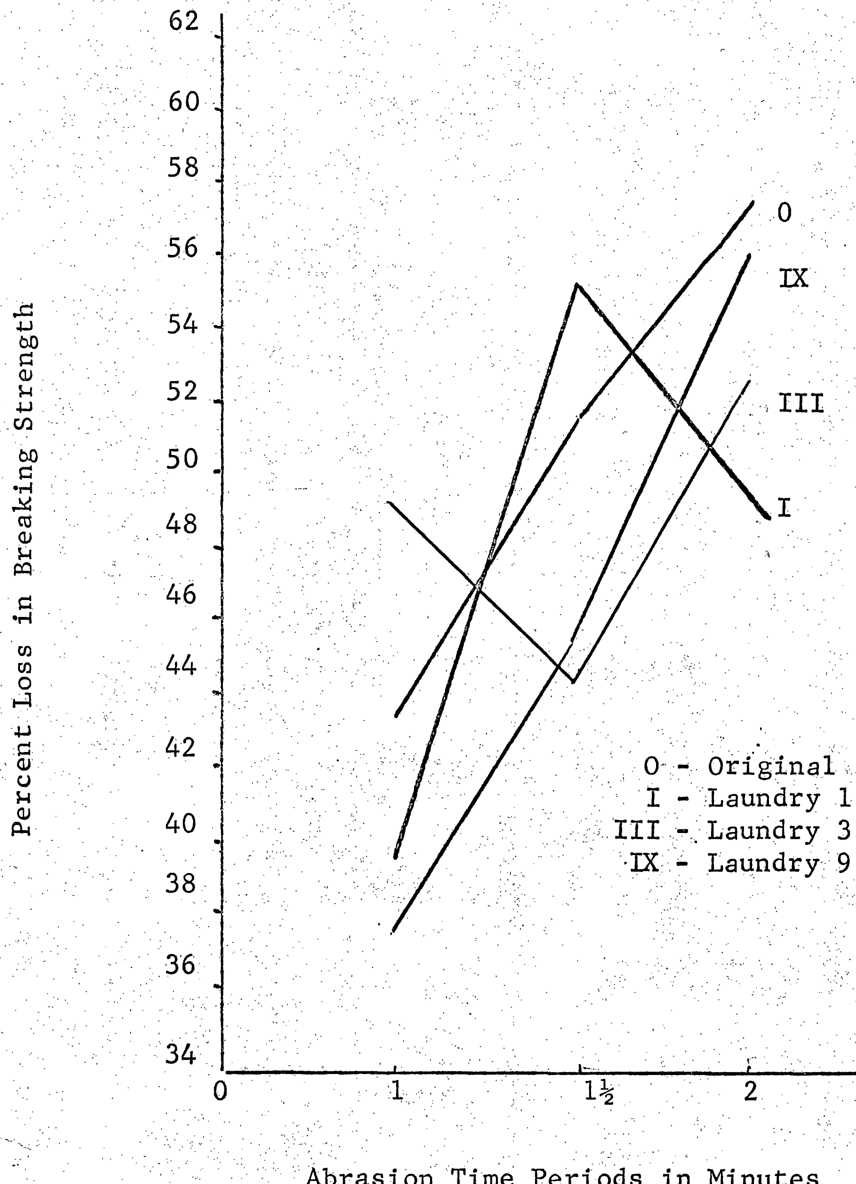


Figure 7. Percent Loss in Breaking Strength Caused By Abrasion for Permanent-Press Non-Creased Samples

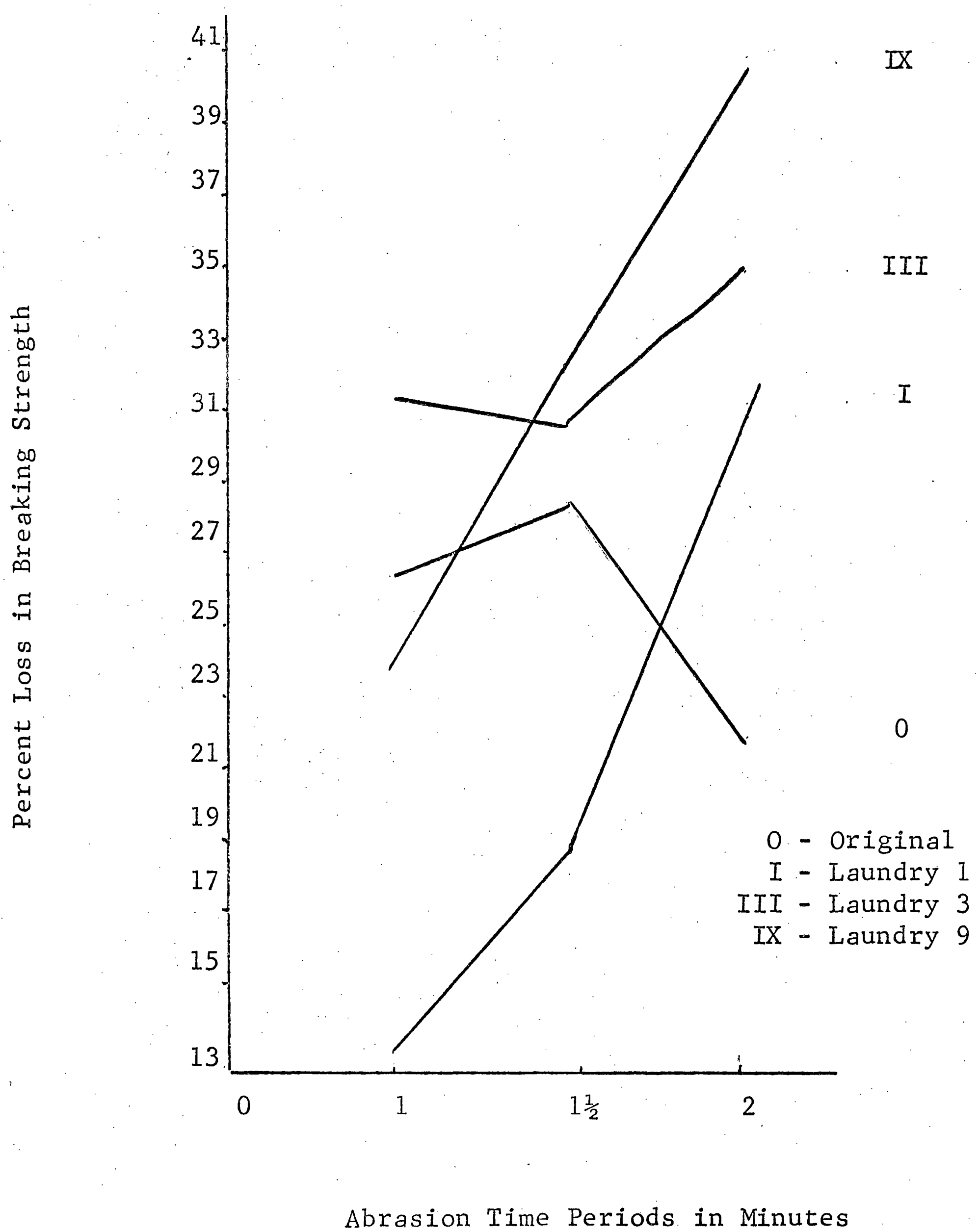


Figure 8. Percent Loss in Breaking Strength Caused by Abrasion for Wash-Wear Non-Creased Samples

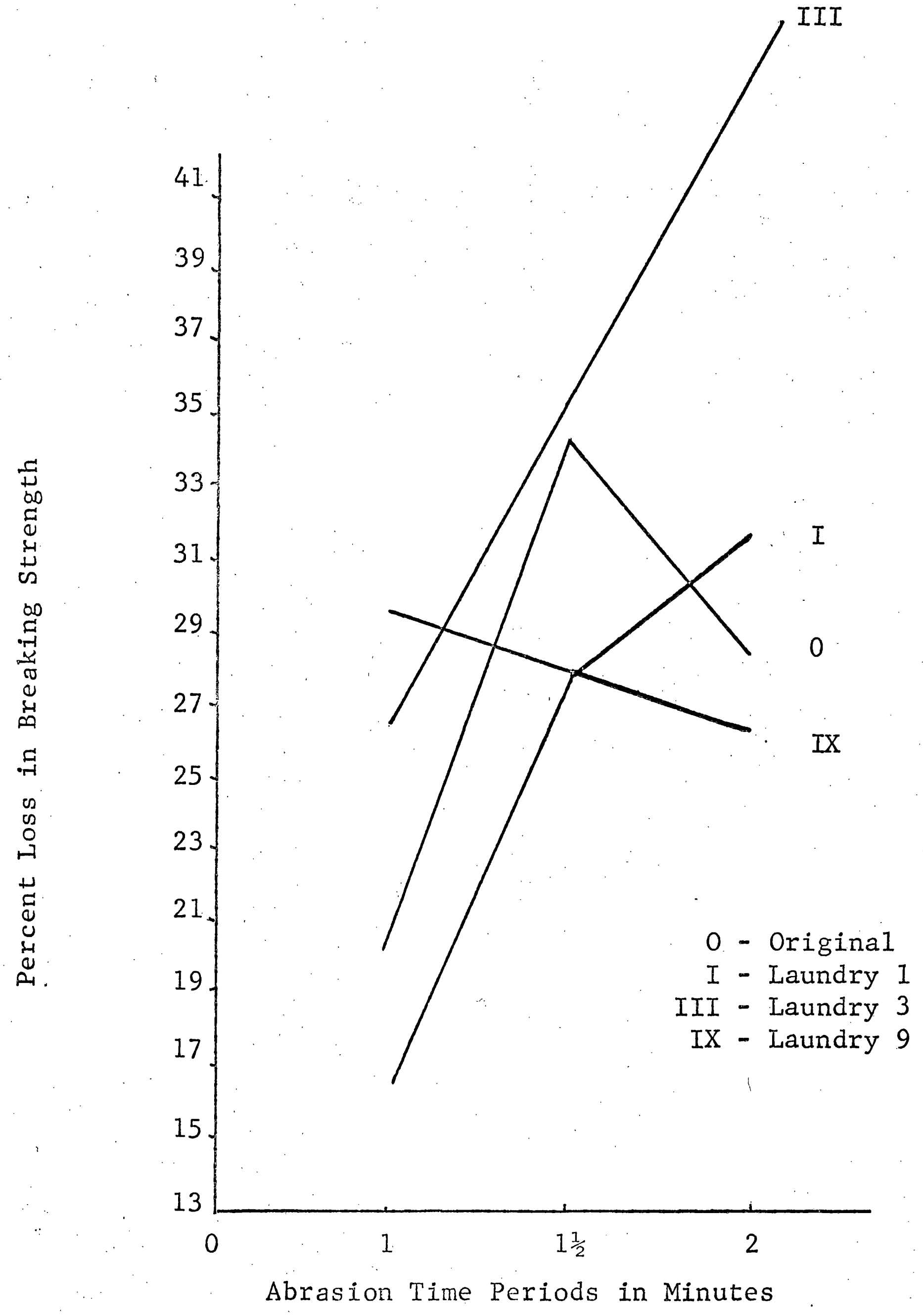


Table 6. Analysis of Variance for Breaking Strength Values

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F-Value
2	3	14381.65	4793.88	344.54**
3	3	1096.55	365.52	26.27**
4	1	85.18	85.18	6.12*
5	1	3849.68	3849.68	276.68**
2x3	9	193.21	21.47	1.54
2x4	3	56.11	18.70	1.34
2x5	3	863.18	287.73	20.68**
3x4	3	135.57	45.19	3.25*
3x5	3	228.84	76.28	5.48**
4x5	1	18.74	18.74	1.35
2x3x4	9	150.65	16.74	1.20
2x3x5	9	188.71	20.97	1.51
2x4x5	3	20.79	6.93	0.50
3x4x5	3	202.87	67.62	4.86**
2x3x4x5	9	212.26	23.58	1.69
Within Replicates	384	3612.99	9.41	0.68
Experimental Error	128	1781.00	13.91	
Total	575	27077.99		

Variables:

2	Abrasion Time Periods in Minutes
3	Laundering Cycles
4	Fabrics
5	Fabric Condition: Non-Creased, Creased
2x3	Interaction between Abrasion Periods and Launderings
**	Significant at .01 level
*	Significant at .05 level

By using the Duncan's Multiple Range Test, the abrasion period means were tested to discover which of the abrasion periods were significantly different. As indicated in Table 7, the breaking strength specimens for the 1-1/2 minute and 2 minute abrasion periods were not significantly different from each other, but were significantly lower than the breaking strength specimens for the 0 and 1 minute abrasion periods which were significantly different from each other.

Further abrasion beyond the 1-1/2 minute time period to 2 minutes may not have produced significantly different results because, by that time, the fabric was supple enough to allow the abrasive effect to be spread out more evenly over the samples and thereby avoiding severe abrasion in concentrated areas.

Abrasion up to 1-1/2 minutes took place on fabric samples with a crisp hand, fabric that exposed sharp folds to be abraded. It was often necessary to stop the Accelerator and re-crumple the sample being abraded as the crisp fabric would entangle itself with the rotor blade. This re-crumpling exposed new areas to the abrasive action of the machine and it was rarely necessary to re-adjust the fabric samples being abraded for two minutes after one minute and never after 1-1/2 minutes. This type of necessary adjustment decreased with increased laundering. The abrasive action of the launderings probably rendered the fabric samples soft enough to be abraded in the Accelerator without any severe abrasion to any one area.

The laundering variable was also found to be highly significant. With the application of the Duncan's Test in Table 8, the first and

Table 7. Duncan's New Multiple Range Test of Abrasion Period Breaking Strengths.

Standard error of a treatment mean: 0.3108

Means ranked in order:

Abrasion Times

T_4	T_3	T_2	T_1
17.03194	17.81319	19.56667	29.48055

Note: Any two means underlined by the same line are not significantly different at .05 level.

T_1 Without Abrasion

T_2 One Minute Abrasion

T_3 One, One-Half Minutes Abrasion

T_4 Two Minutes of Abrasion

Table 8. Duncan's New Multiple Range Test of Laundry Cycle Breaking Strengths.

Standard error of a treatment mean: 0.3108

Means ranked in order:

Laundry Cycles

L_4	L_3	L_2	L_1
19.41597	20.42847	20.86528	23.18264

Note: Any two means underlined by the same line are not significantly different at .05 level.

L_1 Original

L_2 Laundry 1

L_3 Laundry 3

L_4 Laundry 9

third laundering breaking strengths were not found to be significantly different, but original breaking strength samples were significantly stronger than all the other specimens. The ninth laundering breaking strength specimens were significantly weaker than the other specimens.

Since samples were not evaluated between the fourth laundering and the ninth laundering, it could not be determined as to the minimum number of launderings actually necessary to cause fabric samples to lose an appreciable amount of finishing effect. The original samples were significantly stronger than all laundered samples suggesting that as a result of laundering, there occurred a certain amount of abrasion, fiber movement and finish removal which contributed to the frosting effect.

The wash-wear fabric was significantly stronger only at the .05 level than the permanent-press fabric. This suggests that the popular belief of permanent-press fabrics being much weaker than regular wash-wear fabrics is based on a false premise. The major differences between the two fabrics may lie in the clothing construction techniques employed and not in the fabrics themselves.

Duncan's Test (Table 9) indicates no significant difference between the two fabrics in their original state or after the first laundering. The permanent-press fabric was significantly lower than the wash-wear fabric after the third and ninth launderings. It appears that with increased launderings the effect is greater on the permanent-press perhaps because of the severity of the curing conditions required by the permanent-press finish. The effect may be balanced upon further

Table 9. Duncan's New Multiple Range Test of the Interaction of Laundry Cycles and the Two Fabrics

Standard error of a treatment mean: 0.4396

Means ranked in order:

Original		Laundry One	
F_2	F_1	F_1	F_2
22.89861	23.46667	20.72917	21.00139

Laundry Three		Laundry Nine	
F_1	F_2	F_1	F_2
19.50694	21.35000	18.65139	20.18056

Note: Any two means underlined by the same line are not significantly different at .05 level.

F_1 Permanent-Press Fabric

F_2 Wash-Wear Fabric

laundering of the two fabrics, but this study was terminated at nine launderings.

The analysis of variance revealed a highly significant difference between creased and non-creased samples of the two fabrics as would be expected. As a result of creasing, the crease line was the weakest area of all samples because of fiber bending and cross-linking breakage.

The Duncan's Test was used to study the interaction of the laundering cycles and the fabric conditions (Table 10). For the creased samples of both fabrics, the original breaking strength specimens were significantly stronger than the specimens that were laundered. The laundered specimens, however, were not significantly different from each other. This indicates the abrasive action of the launderings, regardless of the number of cycles, had a significant effect on the most vulnerable area, the crease. Frosting or the teasing out of fibers, especially the cotton, also occurred in this area, thus decreasing the initial strength. The results indicate that the samples did not become weaker with successive launderings. Most of the degradation action occurred during the initial laundering cycle.

For the non-creased samples, the original breaking strength specimens were significantly stronger than those which were laundered. The ninth laundry specimens were significantly weaker than the third laundry breaking strengths. The first and third launderings, however, were not significantly different from each other. This suggests a definite loss of finish and fabric hand after the first laundering, but no appreciable amount of variation in changes were caused by the

Table 10. Duncan's New Multiple Range Test of the Interaction of Laundry Cycles and Fabric Conditions

Standard error of a treatment mean: 0.4396

Means ranked in order:

Condition: Non-Creased

L_4	L_3	L_2	L_1
21.05000	22.85139	23.86944	26.46250

Condition: Creased

L_4	L_3	L_2	L_1
17.78194	17.86111	18.00556	19.90278

Note: Any two means underlined by the same line are not significantly different at .05 level.

L_1 Originals

L_2 Laundry 1

L_3 Laundry 3

L_4 Laundry 9

addition of two cycles. The loss of finish in the fabrics may have been gradual up through the third laundering which would indicate a fairly stable fabric finish. The loss may have been gradual through the ninth laundering also but the collective amount was large enough to give the significant difference with the Duncan's Test. It is possible that the laundering effect could have accelerated the rate of finish removal.

Duncan's Multiple Range Test for the interaction between the abrasion time periods and the fabrics' conditions, creased or non-creased, shows for both fabric conditions, a significant difference between the samples with no abrasion and samples abraded for the three time periods (Table 11). The breaking strengths of the original creased and non-creased specimens were much greater than those which were abraded. The breaking strengths for the 1-minute abrasion period for both fabric conditions was significantly greater than the other abraded samples, but in each case, the 1-1/2-minute and 2-minute time period samples were significantly lower than all other time periods but not from each other. This indicates that abrasion beyond the first minute up to two minutes had no further noticeable effect on the samples whether creased or non-creased. This was also evident from the graphs made from the raw data. The initial abrasion, that is, abrasion up to 1 minute in duration, caused greater effects on the original samples in relation to breaking strength than did successive abrasion periods. In the first minute of abrasion more changes

Table 11. Duncan's New Multiple Range Test of the Interaction of Abrasion Time Periods and Fabric Conditions

Standard error of a treatment mean: 0.4396

Means ranked in order:

Condition: Non-Creased

T_4	T_3	T_2	T_1
20.24861	21.11528	22.92222	29.94722

Condition: Creased

T_4	T_3	T_2	T_1
13.81528	14.51111	16.21111	29.01389

Note: Any two means underlined by the same line are not significantly different at .05 level.

T_1 Without Abrasion

T_2 One Minute Abrasion

T_3 One, One-Half Minute Abrasion

T_4 Two Minute Abrasion

occurred. The fabric was softened and the cotton fibers in the creased samples were abraded out, exposing the stronger polyester fibers.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study evaluated the effects of permanent creasing on two broadcloth fabrics of 65% polyester and 35% cotton by weight. The wash-wear fabric (pink) had been finished by a conventional pre-cure process while the permanent-press fabric (white) required a final oven-cure after fabrication.

Samples were cut from both fabrics, half of which were creased and the other half remained uncreased. All samples from both fabrics were subjected to the same heat-setting treatment. The time-temperature combination used in the heat-setting treatment was recommended by the manufacturer for the permanent-press fabric but it was applied to the wash-wear fabric as well in order to eliminate a potential variable.

The permanent-press samples were oven-cured using the time-temperature recommendation of the manufacturer. The samples from each fabric were divided into four groups with an equal number of creased and non-creased samples in each group. The first group of samples from each fabric were the originals and were used as controls. The other three groups were samples evaluated after the first, third, and ninth launderings.

The measurements used to evaluate the creases of the two fabrics included crease appearance ratings, abrasion resistance, and breaking strength. The crease appearance ratings were given by a panel of judges. The breaking strength values were obtained through the use of a constant-rate-of-extension Scott-Tester after the samples had been divided into four abrasion groups of 0, 1, 1-1/2, and 2 minutes at 3,000 revolutions per minute of abrasion in the Accelerator.

A fabric analysis revealed more turns per inch of twist in the warp and filling yarns of the wash-wear than in the corresponding warp and filling yarns of the permanent-press fabric. Both fabrics were distorted. The permanent-press was skewed off-grain 2.3% and the wash-wear fabric was skewed off-grain 0.6% and bowed off-grain 1.7%. Other physical properties for the two fabrics, except for finish and color, were similar.

The following conclusions appear to be true as a result of this study:

Hypothesis 1: A statistical analysis of the crease appearance ratings was of no value because of the bias of the judges to the color difference between the two fabrics and because the ratings of one judge were consistently lower than those of the other two judges. The raw data, however, indicated that the crease appearances of the two fabrics whether new or after nine launderings were very similar.

Hypothesis 2: The abrasion time periods for the two fabrics were highly significant. The one-minute abrasion period breaking strengths for both fabrics whether creased or non-creased were significantly higher than all other abrasion time period breaking strengths. But abrasion beyond the first minute up to two minutes had no significantly differing effects on the samples whether creased or non-creased. In the first minute of abrading the fabrics were softened and the cotton fibers in the creased samples were abraded out, leaving the stronger polyester fibers.

Hypothesis 3: The breaking strengths of the two fabrics were significantly different at the .05 level. This tends to indicate that permanent-press fabrics may be weaker than conventional wash-wear fabrics of a similar weight. The higher amount of twist in the wash-wear fabric may have contributed to its higher strength but it is doubtful whether this difference of about ten turns per inch will cause this much difference in strength.

With increased launderings, it appears that the effect on the breaking strength of the permanent-press fabric is greater perhaps because of the severity of the curing conditions required by the permanent-press finish.

Recommendations For Further Study

The results of this study emphasize the need for more study and development in the following areas:

1. The effects of the permanent-press finish and the wash-wear finish on fabrics of equal blends.

2. The statistical analysis of crease appearance ratings using fabrics with no color differences.

3. A more sensitive photographic standard for judging crease appearance ratings of permanent-press and wash-wear fabrics.

4. The testing of fabrics with all physical properties being identical.

5. A study where the exact recommendations of the manufacturer are observed as related to heat-setting and oven-curing.

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THE EFFECTS OF PERMANENT CREASING ON TWO TYPES OF 65/35 POLYESTER-COTTON BLENDS AS MEASURED BY APPEARANCE, ABRASION RESISTANCE, AND BREAKING STRENGTH

by
Kathleen Elaine Ager

ABSTRACT

This study compared the creasing qualities of two types of 65/35% polyester/cotton broadcloth fabrics. The wash-wear fabric (pink) had been finished by a conventional pre-cure method and the permanent-press fabric (white) by a post-cure or delayed-cure method which requires a final oven-cure after fabrication.

Equal numbers of creased and non-creased specimens from both fabrics were evaluated for crease retention, Accelerator abrasion resistance, and breaking strength. These specimens were evaluated in the original form and after one, three, and nine launderings.

The crease appearances were rated by a panel of three judges and it was found that all creases of both fabrics whether new or laundered were very similar.

The samples for both fabrics were abraded for 0, 1, 1-1/2, and 2 minutes. The wash-wear fabric had significantly better abrasion resistance than did the permanent-press. The initial abrasion, abrasion up to 1 minute in duration, caused greater effects on the original wash-wear and permanent-press samples in relation to breaking strength than did successive abrasion periods. More changes occurred in the first minute of abrasion when the fabric was softened and the cotton fibers were beginning to be abraded or teased.

The breaking strengths of the two fabrics were significantly different only at the .05 level which tends to indicate the permanent-press fabric may be weaker than the conventional wash-wear fabric of a similar weight.

The laundering cycles tended to cause a decrease in breaking strength of the test specimens. The permanent-press fabric's strength was more affected than was that of the wash-wear fabric.