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THE APPEARANCE AND DURABILITY OF MEN'S DURABLE PRESS TROUSERS AFTER LINE AND TUMBLE DRYING

A THESIS

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INTRODUCTION

Cotton as an apparel fiber has been held in high regard by the consumer for its comfort for many years. Since the beginning of the durable press era, however, it has been scrutinized closely with regard to its wear performance.

Although it is an established fact that the cellulosic molecule contributes toward the success of the durable press finish by providing sites for the crosslinking of the reactant with the fiber, numerous research studies have proved that the cotton fiber experiences a strength loss when the crosslinking and curing take place under conditions such as those used for the Koratron treatment.

This study, which paralleled those undertaken by Helen Ball and Grace Gingrich, sought to evaluate the effects of a variety of types of durable press finishes upon the laundering performance of 100 pairs of men's trousers composed of 100 per cent cotton and intimate blends of cotton and polyester fibers. As a means of drawing conclusions concerning the fabric-finish categories the following specific objectives were established.

SPECIFIC OBJECTIVES

1. To secure 20 pairs of men's durable press trousers, representative of the following respective fiber-finish categories:

    a. 100 per cent cotton finished with a melamine wet-fixation treatment
    b. 100 per cent cotton finished with a modified pad-dry-cure application of durable press finish
    c. 100 per cent cotton with a Koratron treatment
    d. 65/35 per cent cotton-polyester with a Coneprest III treatment
    e. 50/50 per cent cotton-polyester with a Lock-Prest durable press treatment

2. To subject the trousers to 30 periods of laundering without wear followed by line and tumble drying, respectively.

3. To evaluate the performance of the trousers after each laundering period with reference to:

    a. Fabric smoothness
    b. Seam smoothness
    c. Crease retention

4. To measure the durability of the trousers at various intervals during the laundering periods, with respect to:

a. Number of broken yarns and holes

b. Degree of abrasion experienced by trouser creases

c. Breaking strength

d. Tearing strength

5. To determine the stability of the trouser fabric after each five periods of laundering; and finally

6. To examine the fabrics for weight, initially and for wrinkle recovery angle and yarn count both initially and at the termination of the study.

REVIEW OF LITERATURE

The interaction between the hydrogen bonds of the cellulose molecule and formaldehyde, which, according to Roff (23) was discovered in 1904, gave rise to the durable press phenomenon which is so prevalent today.

As early as 1950 experiments concluded by Gagliardi and Gruntfest (7) revealed that degradation of the cellulose molecule which occurs during resin treatment has little to do with true cellulose degradation, either hydrolytic or oxidative. In determining these findings cotton sheeting was treated with various compounds by a padding process which involved the use of an aqueous solution in the presence of a catalyst. The impregnated fabrics were cured for 10 minutes at 150^{o}C. at their own original dimensions.

The results showed that the tensile and tearing strength and the abrasion resistance were reduced, which according to these authors happens during resin treatment as shown in the following statement:

> The reduction in various strength properties of cellulose fabrics appears to occur with any crease-proofing agent regardless of its chemical constitution or the method of application.

Since 1955 when Steele (24) concluded that hydrogen bonding between cellulose and formaldehyde was in reality a form of the reaction referred to today as crosslinking, research has been undertaken at a rapid pace in an effort to determine the chemicals and procedures most suitable for the crosslinking of the cellulose molecule in imparting durable press properties to cotton and cotton-polyester blends.

One of the first of these studies was conducted by Reid, Reinhardt, and Kullman (22), who proved the importance of a proper control of the curing of resin-treated fabrics.

An 80 x 80 boiled, bleached, and desized white cotton sheet print cloth was used for this experiment. The fabric was padded in a 9.0 per cent solution of CEU (Rhonite R-1) and 1.5 per cent of a 35 per cent solution of a modified zinc nitrate catalyst. The impregnated fabric was subjected to various curing times (15 seconds to 7.0 minutes at 120^{o}C.) and at various temperatures (60^{o} to 160^{o}C. for 30 minutes). The wrinkle recovery angle of each experimental fabric then was tested and the per cent of nitrogen was analyzed to determine the resin in the fibers. The investigators concluded that crosslinking depends upon the degree of curing and made the following general statement concerning the resin treatment of fabrics:

> Under proper conditions of resin application and cure, it is possible to produce a cotton garment which has excellent wash and wear

> characteristics. If the garment is made from resin-treated wrinkle resistant cotton, it is sometimes possible to introduce a reasonably durable crease into the garment. It is necessary that a catalyst and water be present when the crease is set in the garment by heat. This process is termed recuring.

In a study involving the chemistry of crosslinking agents Petersen (19) found that trimethoxymethyl urea cured fabrics exhibited a better resistance to acid hydrolysis, to wrinkles, and to chlorine than did fabrics treated with dimethylol-urea.

The effect of tension in the resin treatment of all-cotton fibers and yarns was studied by Orr, Burgis, and Grant (18). They found that the bonding forces between microscopic and submicroscopic elements of the fibers increased with the application of tension and that this lateral bonding determined the ability of the fibers to uniformly adjust and support the load. They stated that:

> For a given length of structural element, lateral bonding of optimum strength must exist for maximum fiber strength. If the lateral bonds are too weak the whole element will slip; if they are too strong, the element cannot slip enough locally to allow equalization of tensions between elements.

This study concluded that the strength and elongation changes due to resin treatment are a result of strength and elongation changes in the fibers. The loss of strength was accredited to the crosslinking of the internal fibers which affected the position for stress equalization and acid degradation which resulted from the treatment of the experimental fabrics.

Keating, Haydel, and Knoepfler (12) studied the characteristic of pad-dry treated cotton with formaldehyde as related to the catalyst, drying temperature, and drying time. Scoured and bleached print cloth (80 x 80) was treated with an aqueous solution of formaldehyde and sulfur dioxide followed by drying in a hot air oven.

This experiment was undertaken for two reasons. One was for the purpose of observing the influence of the sulfur dioxide on the breaking strength and wrinkle recovery characteristics of the experimental fabrics, and the other was for the purpose of determining the influence of temperature and drying time upon the same characteristics. The results showed that wrinkle recovery improved and breaking strength decreased as the amount of sulfur dioxide catalyst, the drying time, and the drying temperature, respectively, were increased.

That the structure of the fibers used in durable press fabrics affects the mechanical properties of the treated fiber was reported by Rebenfeld (21). In a study which confirmed these findings six different cotton yarns were treated for 30 minutes in a solution containing dimethylol-ethylene-urea; magnesium-chloride-hexahydrate;

and a cationic wetting agent. These impregnated yarns then were air dried for 30 minutes, and cured for the same length of time at 130°C. in a vent oven, before they were conditioned and tested. The results showed that all of the experimental cotton fibers lost strength, and indicated that all types of cotton fibers do not respond in the same manner to resin treatment.

Much of the research related to the durable press finish has taken place since the patenting in 1961 of the Koratron Process, which covers the use of dimethylol dihydroxy ethylene urea (DMDHEU) as a crosslinking agent. Although the application of the durable press finish under the conditions required by the Koratron Process imparts a memory of a resistance to wrinkling, good crease retention, little or no odor, and excellent shelf life for cotton and cotton-polyester blends, the loss of breaking and tearing strengths and abrasion resistance which accompanies the durable press treatment remains critical and demands the chief concern of those engaged in the field of textile research.

Knoepfler _et al_. (13) found that the abrasion resistance of durable press fabrics could be improved through intimate blending of treated and untreated cotton for in such blending the untreated cotton was found to resist the abrasion damage caused during laundering by the treated cotton. In a determination of these findings the experimental fabrics were treated with delayed-cure thermosetting and/or thermoplastic resins. Permafresh 183 was used as the thermosetting crosslinking agent; whereas, Rhoplex HA 8, Rhoplex HA 12, Rhoplex HA 20, and Polycryl 7 F 12 were used as the thermoplastic resins.

In 1967, Frick, Gautreaux, and Pierce (6) reported their work for improving the wash-and-wear performance and the wrinkle recovery angle of fabrics by the use of a swelling agent before the crosslinking application. Orthophosphoric acid (80 per cent) was used as the swelling agent, and DMEU was used for the crosslinking agent. Their study showed that fabrics thus treated rated 0.5 higher in fabric smoothness and 15 degrees higher in wrinkle recovery.

Frick and Gautreaux (5) reported their experiment in 1968 for the improvement of wrinkle recovery and breaking strength of durable press fabrics. This experiment was based on the use of a catalyst and a low temperature of 23^{o}C. for the crosslinking reaction, with DMEU serving as the crosslinking agent and zinc-nitrate hexahydrate as the catalyst. This treatment resulted in a 10-15 per cent higher wrinkle recovery angle and higher breaking strength values than were provided by a heat application treatment. Some chemicals such as DMEU and magnesium-chloride; DMU and zinc-nitrate; and bis-methoxoxy-methyl-ethylene urea and zinc-nitrate gave the same tendency according to these authors.

The wrinkle recovery angle, wash-and-wear performance, abrasion resistance and tear strength were improved by means of a copolymerization resin application to the fabric in an experiment conducted by Harris (9) et al. Commercial print cloth used in their laboratory experiment was dried to a maximum moisture content of 2.0 per cent and sealed in an atmosphere of nitrogen. This fabric then was irradiated to a dosage of one megarad with cobalt-60 gamma radiation, and later it was graft polymerized in a vinyl monomer solution. The crosslinking impregnation solution was made up of Permafresh 183, zinc-nitrate as the catalyst, and Triton X-100 as the wetting agent.

On the premise that mixed catalysts are more active than single ones Pierce, Baudreaux, and Reid (20) undertook a study. They proved that the enhanced activity of mixed catalysts will provide the same degree of crosslinking as a single catalyst with a lower concentration of catalyst in the bath, a shorter curing time, a lower curing temperature, or any combination of these three parameters.

Kravetz and Ferrante (14) improved the durability of 100 per cent cotton by a treatment with a crosslinking agent in the presence of a dual catalyst system. A 100 per cent cotton broadcloth fabric which was bleached and mercerized was padded in a Permafresh 183 solution at 100 per cent wet pick-up and cured in a Despatch oven at 200°F.

for four minutes and then at 250^{o}F. for two minutes. The padding process was done in the presence of two different catalysts. One involved the use of a dual catalyst system composed of 2.2 per cent magnesium-chloride hexahydrate and 0.22 per cent sodium-fluoborate. The other consisted of a 2.2 per cent magnesium-chloride hexahydrate only as a single catalyst.

The results showed that the dual catalyst treated cotton produced high wash-and-wear properties with a good durability to home and commercial launderings when compared to that treated with the single catalyst system.

Harper et al. (8) introduced their laboratory work concerning the changes of physical properties and fabric hand. This was achieved by the use of a hydrophilic polymer with reactive alcohol moieties attached to the cellulose molecules within cotton fabrics by crosslinking agents. DMDEU, DMEU, and long chain carbamates were used as the crosslinking agents, with polyethylene glycol and polypropylene glycol used for the reactive alcohol. As a result of the treatment an improvement in wrinkle recovery performance which ranged from 15 to 25 degrees was observed. The breaking strength increased, but the tearing strength showed a modest reduction.

According to Calamari et al (3) a crosslinking pretreatment of greige fabric can improve the smoothness drying properties of the finished durable press cotton. They found that the stiffness which might result from this process could be removed by pressure steaming, and that the satisfactory whiteness level upon bleaching could be attained by adding 0.3 per cent of an optical brightener to either the initial or to the final crosslinking formulation. This method also was found to prevent the formation of longitudinal wrinkles which often impair the appearance of the finished fabric even after resin treatment.

Morton, Hall, and Reid (17) found that a better performance of durable press resulted from the influence of chemical and mechanical treatments. Cotton broadcloth with a 136 x 72 yarn count and a weight of 3.5 ounces per square yard was used as the experimental fabric in their study along with three comparable twill fabrics with 110 x 54 yarns per inch and 8 ounces of weight. A pad-dry-cure treatment in which dimethylol-propylene-urea, magnesium-chloride hexahydrate, and a wetting agent were applied was followed by a film-forming treatment with polyurethane (Nyanthane WS-70). Stretching and compaction were applied as the mechanical treatment. The results showed that the polyurethane film improved the wrinkle recovery angle, the abrasion resistance, and the dimensional stability of the fabrics. The stretching process increased the tensile strength, and the compaction, and the polyurethane film improved the abrasion resistance and stability. Silicone and polyolefin were found to be useful in reducing the fabric stiffness which occurred in this process.

The merits of the vapor phase process for imparting improved durable press properties to cellulose fibers have been explored by a number of research teams. This process which was called the VP-3 Process was first announced by the Gagliardi Research Corporation (25) with the following important advantages accredited to it by the Corporation: (a) Complete freedom of operation outside of restrictive patents now covering other resin systems; (b) Low cost, permanent, and completely chlorine-proof crosslinking chemicals; (c) Higher tensile and tearing strength and abrasion resistance than afforded by resin-based high-temperature curing processes; and (d) No problem of storage.

Jutras, Cicione, and Kenney (11) from the Gagliardi Research Corporation, under a contract from the United States Department of Agriculture, compared the wash-and-wear properties of a fabric treated with formaldehyde in the vapor phase with that treated with the pad-dry-cure method.

One set of urea-impregnated fabrics was exposed to formaldehyde vapor and the other set, after being exposed, was subjected to a curing process. The results showed that both processes produced the same amount of resin in the fabric, which meant that the resin formation during the vapor phase reaction was completed.

The vapor phase-treated fabric produced a higher crease recovery angle both in the wet and dry states than did those treated with the pad-dry-cure process. The tensile strength and the abrasion resistance were also higher in the vapor-treated fabrics.

Extensive research was undertaken by Campbell and Staples (4) in relation to the vapor phase technique for imparting durable press properties to all-cotton fabrics. Experimental fabrics (80 x 80 inch cotton print cloth) were bleached and thereafter treated with an aqueous solution of 36-38 per cent formalin and about 12 per cent methanol. A three roll padder was used in the finishing process which provided a wet pick-up of approximately 80 per cent. After being padded the specimens were suspended in a closed glass tank and subjected to formaldehyde vapor supported by an open dish of formalin solution. The vapor-exposed samples were cured in an oven at 150° - 160°C. for five minutes and then washed, dried, and conditioned before they were tested.

The results showed the importance of a carefully selected catalyst for this type of durable press treatment. The urea-formaldehyde with an ammonium salt catalyst in the vapor phase application produced a better dry and wet crease recovery than was produced when zinc nitrate was used as a catalyst.

The wet-fixation durable press process, a new method of presensitizing cotton by means of a polymer deposition of N-methylol compound, has been studied and described as follows by Margeson and Getchell (15):

> These processes have demonstrated that melamine-formaldehyde can be deposited in cotton without affecting the strength or increasing the wash-wear properties of the untreated cotton.

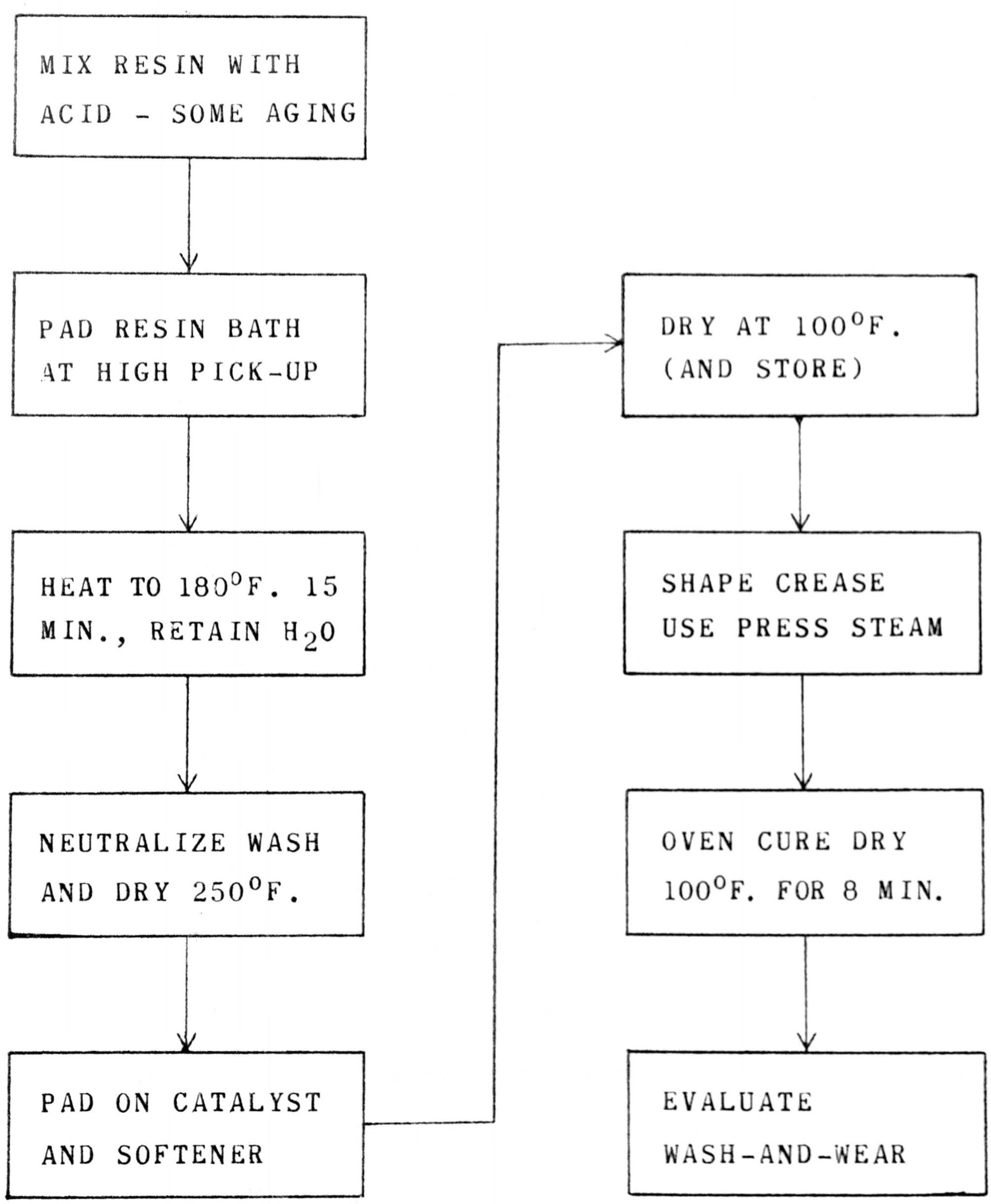
Besides the above-mentioned properties the investigators found that this process improved storage stability and gave higher crease sharpness despite the fact that the wash-wear properties did not reach those achieved by the conventional pad-dry-cure process.

In a determination of these findings cotton fabrics were treated with melamine-formaldehyde by means of the wet-fixation process, followed by a padding application of 0.5 per cent zinc-nitrate hexahydrate. The fabric then was dried at 40^{o}C. and cured at 160^{o}C. for 3.0 minutes. For comparative purposes the same fabric was padded with 3.0 per cent DMEU and 0.25 per cent zinc-nitrate hexahydrate, dried and cured by the same methods as were used for the wet-fixation process. The results showed that the balance between breaking and wash-and-wear properties was unusual as compared to those which resulted from the presensitized curing system. The same level of wash-and-wear properties of both treatments showed that the breaking and tearing strengths (average of warp and filling) were 11 and 12 per cent higher than those treated by the conventional pad-dry-cure treatment.

Additional work in relation to the breaking strength and wrinkle recovery of fabrics treated by means of the wet-fixation process was conducted by Hollies (10). Print cloth or twill were padded at 100 per cent wet pick-up with a water-soluble crosslinking resin mixed with hydrochloric acid at a low pH. This impregnated fabric then was dried at 100^{o}F., sealed in a flat condition in Mylar envelopes, and cured for a period of 15 minutes at 180^{o}F. The fabric was washed after being rinsed in a 2.0 per cent solution of sodium-carbonate and then padded in a catalyst solution of zinc-nitrate hexahydrate or magnesium-chloride hexahydrate. The pad-dry-cure process also was applied to the fabrics at a 100 per cent wet pick-up and with a bath containing 14.3 per cent Permafresh, 2.6 per cent Catalyst X-4, and 0.2 per cent Triton X-100. The curing was done at 320^{o}F.

The results showed that the wrinkle recovery was better for those fabrics treated with the pad-dry-cure process than for those treated at the same level of wash-and-wear with the wet-fixation method. The reverse was true with respect to breaking strength.

The procedure which was used in the application of the wet-fixation process by Hollies is shown as follows:



PLAN OF PROCEDURE

DESCRIPTION OF EXPERIMENTAL TROUSERS

One hundred pairs of men's durable press khaki trousers and matching yardage representative of five respective fiber-fabric-finish categories were used as experimental materials in this research study. The trousers and materials were categorized as follows: A (100); B (200); C (300); D; and E. Categories A, B, and C were representative of 100 per cent cotton; Category D of 65/35 cotton-polyester; and Category E of 50/50 cotton-polyester. Twenty pairs of trousers together with approximately two yards of matching material from each of the five categories made up the experimental lot.

The trousers were of a casual design with "executive" cut and with creased and cuffed legs. The all-cotton trousers (Categories A, B, and C) were manufactured by Delmar Pants Company, Delmar, Maryland, from identical fabrics which were treated with a melamine wet-fixation, a modified pad-dry-cure, and a Koratron finish, respectively.

The 65/35 cotton-polyester trousers in Category D were marketed by the Comander Garment Company under the brand name of "Hit Em Hard" and were treated with the Coneprest III treatment.

The 50/50 cotton-polyester trousers (Category E) were a product of Smith Brothers Manufacturing Company. Dacron 59 was used as the polyester in these trousers which were advertized as having a Lock-Prest durable press treatment. Further details concerning the experimental trousers can be found in Summary A.

SUMMARY A

Fabric Characteristics

Fabric Category	Fiber Content	Durable-Press Treatment	Yarn Count W	Yarn Count F	Weave	Weight in Oz/Sq.Yd.
A (100)	100% Cotton	Wet-Fixation (Melamine)	93.0	55.8	3/2 Twill	7.6
B (200)	100% Cotton	Modified Pad-Dry-Cure	96.0	56.6	3/2 Twill	7.6
C (300)	100% Cotton	Koratron	95.5	55.6	3/2 Twill	7.4
D	65/35 Cotton-Polyester	Coneprest III	116.4	50.6	3/1 Twill	8.2
E	50/50 Cotton-Polyester	Lock-Prest	113.2	49.0	3/1 Twill	7.3

IDENTIFICATION OF TROUSERS

As a means of identifying each pair of trousers in the study, permanent markings, which consisted of two letters and a numeral, were placed inside the waistband before the trousers were laundered. The first letter identified the fabric category (A, B, C, D, or E); whereas the second represented the method of drying (T-tumble; L-line), and the numeral represented the particular pair of trousers in a certain category (1-10). The fabric yardage was marked at one end in keeping with the above procedure.

LAUNDERING PROCEDURE

All trousers and fabrics were subjected to 30 laundering periods at 140°F. in an RCA Whirlpool Imperial Mark XII Washer. A 12-minute normal washing cycle followed by a warm rinse was used, with high agitation and high spin. The wash load was restricted to approximately six pounds, which usually consisted of five pairs of trousers and one or two pieces of the yardage. Before the experimental trousers and fabrics were placed in the washer, 135 grams of Dash detergent were added to the water and agitated until dissolved. The trousers were washed right side out with zippers closed and waistbands buttoned or hooked.

Immediately following the washing and rinsing cycles the trousers and fabrics were removed from the washer and prepared for the type of drying to which they were to be subjected. Those to be tumble dried were shaken, zippers were fastened, and pocket linings were pulled out before they were partially folded and placed in six-pound loads in a Whirlpool dryer. They were dried for 20 minutes at maximum temperature with no cool-down cycle. The trousers were removed from the dryer immediately after the 20-minute drying period. Again the pockets were straightened and the zippers and waistbands were fastened. The trousers were folded along the creases and placed on a table. The leg seams were stretched; the cuffs were straightened and the trousers as a whole were smoothed by hand. Following this procedure each pair of trousers was fastened to a wire hanger with two clothespins at the cuffs.

The trousers to be line dried were prepared for drying in much the same manner as the tumble dried trousers were treated after they were dried. Instead of fastening the trouser cuffs to wire hangers they were fastened to drying lines.

The fabric yardage was given no special treatment before or after tumble drying, but was smoothed by hand for line drying after it was attached to the line, with the warp direction perpendicular to the floor.

APPEARANCE EVALUATIONS

After each laundering and drying cycle the trousers were placed on hangers and allowed to relax before they were evaluated with reference to the smoothness of the fabric, the appearance of seams, and the sharpness of the creases. Each pair of trousers was attached to a viewing board of the overhead lighting device with the front crease of the right leg in full view of the three observers from the crotch of the trousers to the bottom of the cuff. Two clothespins were fastened to the bottom of the cuff on each side of the crease so that the trouser leg would hang straight. Standards were placed on the viewing board to the left of the viewer since the right side of the board was needed for the left leg of the trousers. The portion of the trousers opposite the standards was used for evaluation. Both the smoothness of the trousers and the sharpness of the creases were evaluated with the trousers in the above-described position in accordance with the AATCC Test Methods for smoothness (1c) and for creases (1b).

In order to evaluate the seams the investigator placed the trousers on the viewing board so that the side seam of the right leg was in full view of the observers. The standards were placed in the same position as described above and only the portion of the seam opposite the standards was evaluated following the AATCC (1a) procedure for seam evaluations.

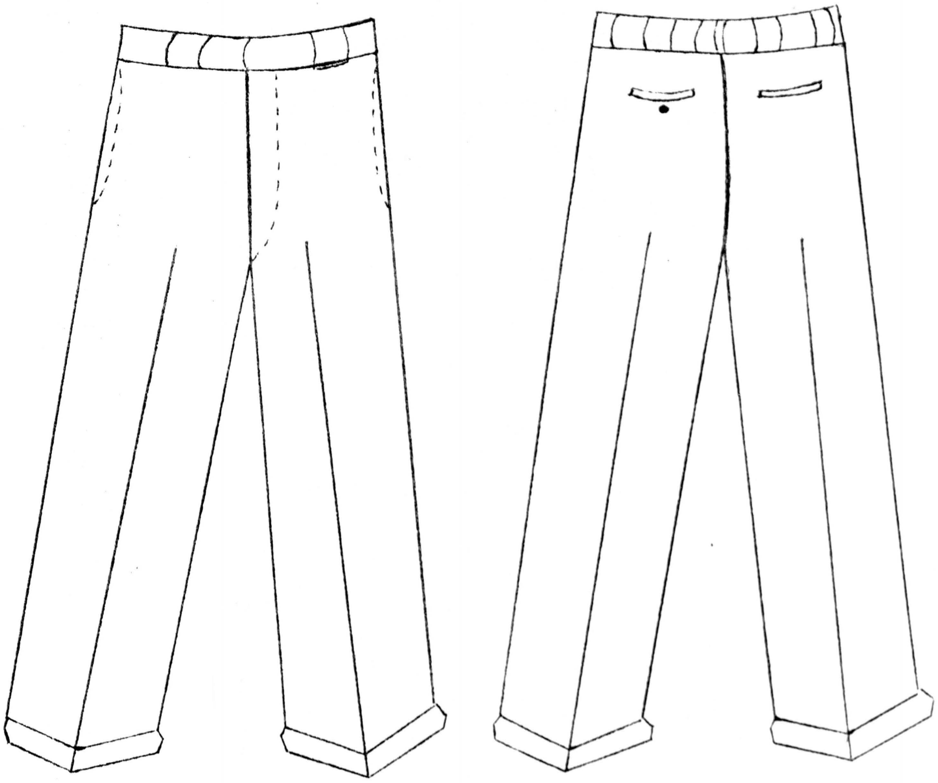
EVALUATION OF WEAR OR ABRASION

The experimental trousers were evaluated with reference to the amount of wear or abrasion they experienced by two different procedures. One of the procedures involved the number of warp and filling yarns and holes observed and the other the degree of abrasion evidenced along the creases at various intervals during the study.

Initially and after each of the 30 laundering cycles the trousers were examined carefully through a magnifying glass and the number of broken warp and filling yarns and holes were counted by a laboratory technician. Holes were defined as being one or more broken warp and filling yarns in one location. A front and back diagram of the trousers as shown in Figure 1 and the following key were used for recording the data:

Key to Wear Evaluation

T = Tear	PY = Pulled Yarn
H = Hole	AS = Abrasion Scratches
BW = Broken Warp	AT = Abrasion Thinness
BF = Broken Filling	FLM = Flow in Material
S = Stitches	FLC = Flow in Construction
P = Pilling	( ) = Number of launderings at each evaluation



Type of Wear	Number of Launderings						
	0	5	10	15	20	25	30
Warp							
Filling							
Holes							

FIGURE 1

DATA SHEET USED FOR RECORDING VISIBLE WEAR

Examples using the above key:

Hole with three broken warp and four broken filling yarns after 10 launderings = H 3 W + 4 F (10).

Tear with two warp and four filling yarns ruptured after 10 launderings = T 2 W + 4 F (10).

Initially and after each fifth laundering cycle the number of broken warp and filling yarns and holes were summarized and recorded under the following areas for each respective pair of trousers: band and loops; cuffs; pockets; fly; body of trousers; and along lines of construction.

The second procedure for the evaluation of wear involved an examination of the front and back creases of each pair of trousers after each laundering period by a panel of three textile majors. For these evaluations a fluorescent light was inserted in each leg and the amount of light transmitted through the front and back creases was compared with standards adapted as follows from the photographic replicas developed by Markezich (16):

Replica Developed by Markezich	Standards Used in This Study
2	1
4	2
6	3
8	4
10	5

BREAKING STRENGTH

The dry breaking strength values of the trouser fabrics were determined from the yardage previously described in this study. Ten specimens were tested from each yarn direction initially and after 30 laundering periods; whereas at other intervals of testing (after five, 10, 15, 20, and 25 laundering periods) five warp and eight filling specimens were tested. The specimens were prepared and tested in accordance with the Ravelled Strip Method described in ASTM (2c). All testing was done under standard conditions by means of a Scott Tensile Tester.

TEAR RESISTANCE

The trouser fabrics were tested with reference to their resistance to tearing initially and after each five laundering periods by means of the Thwing-Albert Elmendorf Tearing Tester equipped with the textile weight and following the ASTM procedure (2b).

WRINKLE RECOVERY

The wrinkle recovery of each fabric was determined initially and after 30 laundering periods in accordance with ASTM (2a). Twelve warp and filling specimens, respectively, were tested at each interval.

DIMENSIONAL STABILITY

The per cent dimensional change experienced by each trouser fabric was determined from a 10-inch square marked parallel to the warp and filling yarns of the fabric yardage which afforded three test measurements in each yarn direction. After each fifth laundering period the materials were pressed with a steam iron and with no pressure other than that caused by the actual weight of the iron. After being pressed they were room-conditioned for four hours and measured according to the procedure described by ASTM (2d).

YARN COUNT

The yarn count of each test fabric was determined initially and after 30 laundering periods following the procedure described in ASTM (2e).

FABRIC WEIGHT

The initial weight of each trouser fabric was determined in accordance with the "Method Applicable to a Small Sample," as directed by the American Society for Testing and Materials (2e).

ANALYSIS OF DATA

The data which resulted from the study were computed by means of an analysis of variance (AoV). Significant treatment effects were determined at the 95 per cent confidence level by means of Duncan's Multiple Range Test.

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

The data which resulted from an investigation of the effects of laundering, coupled with two respective types of drying (line and tumble) upon the appearance, stability, and durability of 100 pairs of men's durable press trousers representative of five fiber-fabric-finish categories are tabulated in Tables I through XIII in the Appendix of this manuscript. Tables I - III present data concerning the appearance of the fabric, of the creases, and of the seams; Tables IV - IX provide findings which resulted from the durability tests; and the remainder of the data as recorded in Tables X - XIII are typical of the wrinkle recovery, dimensional stability, and the yarn count of the experimental trouser fabrics.

Part A of each table gives the findings which resulted from the tumble drying process, whereas, Part B is indicative of the effects of the line drying procedure.

Variables such as the fabric category, drying procedure, and number of launderings were statistically analyzed by means of the Analysis of Variance (AoV) followed by Duncan's Multiple Range Test on the cumulative data from one through 10; 11 through 30; and one through 30 laundering periods, respectively. Significant differences are reported on the 95 per cent confidence level.

In the discussion which follows, a system of ranking was devised as a means of summarizing the findings for the respective tests to which the trousers were subjected. In all evaluations except those for visible wear, which included the actual number of broken yarns and holes, the rank order arrangements of the trouser types were based upon the number of times each demonstrated superior performance when statistical comparisons of the data were made. These statistical comparisons were made directly from the mean values of the five respective types of trousers with regard to the consistency reflected by the standard deviations.

FINDINGS CONCERNING FABRIC SMOOTHNESS

An analysis of the findings recorded in Table I revealed the fact that there were significant differences between the five categories of trousers with regard to their smoothness performance during laundering, irrespective of the number of launderings and the type of drying to which they were subjected.

As is noticeable from the graphical description of these data given in Figure 2, the initial smoothness of the five types of durable press trousers had deteriorated to their lowest value in the majority of cases by the end of the fifth laundering cycle, regardless of the type of drying employed. From that point on there was a tendency for the trousers from all five categories to become smoother as the number of launderings increased from five to 30.

TUMBLE DRYING

An intercomparison of the trouser types with reference to their response to tumble drying revealed the finding that, after 10 laundering periods, the all-cotton Koratron-treated trousers (Type C) with a mean rating of 4.9 displayed a smoother appearance than did the remainder of the trouser types, and the all-cotton trousers of Category B exhibited the most undesirable appearance as represented by a score of 3.5. The 65/35 cotton-polyester trousers (Type D) performed in a comparable manner to those of the 50/50 blend (Type E); and the smoothness of both blends was superior to that displayed by the all-cotton trousers representative of Types A and B.

From 11 through 30 periods of laundering followed by tumble drying, the 65/35 cotton-polyester and the all-cotton Koratron-treated trousers gave the most satisfactory performance in that the smoothness value of 4.9 accredited to them surpassed that assigned to each of the remaining types of trousers. Again Trousers B were found to be more prone to wrinkling than any of the other trouser types, as demonstrated by a low rating of 3.8.

A treatment of the cumulative smoothness data from one through 30 laundering periods followed by tumble drying revealed the following rank order arrangement of the trouser types based on the number of times each demonstrated superior smoothness values when statistical comparisons were made. These comparisons were made as described previously, based on the mean smoothness values of the five respective types of trousers, with regard to the consistency reflected by the standard deviation.

Rank	Type of Trousers
1	All-Cotton (C)
2	65/35 Cotton-Polyester (D)
2	50/50 Cotton-Polyester (E)
4	All-Cotton (A)
5	All-Cotton (B)

LINE DRYING

The relationship of the five types of experimental trousers was not altered to a great extent as the type of drying changed or as the number of launderings progressed.

Trousers in Category C continued to excel with reference to fabric smoothness after line drying as had been the case when they were tumble dried. The appearance of the all-cotton trousers of Category A, as measured by a value of 4.2, compared favorably with that of 4.4 assigned to Category C. The 65/35 and the 50/50 cotton-polyester blends (Trousers D and E), with their scores of 3.5 and 3.7, respectively, claimed a less spectacular position with reference to their performance.

The comparative ability of the trouser fabrics to retain their smoothness during 30 laundering periods followed by line drying is exemplified in the following rank order presentation:

Rank	Type of Trousers
1	All-Cotton (C)
2	All-Cotton (A)
3	50/50 Cotton-Polyester (E)
4	65/35 Cotton-Polyester (D)
5	All-Cotton (B)

TUMBLE DRYING VERSUS LINE DRYING

In all instances except two, tumble drying contributed toward a greater degree of fabric smoothness than did line drying. These exceptions were manifested when the data from the first 10 laundering periods were analyzed. This revealed the finding that the type of drying made no significant difference with respect to the smoothness of the all-cotton trousers of Categories A and B.

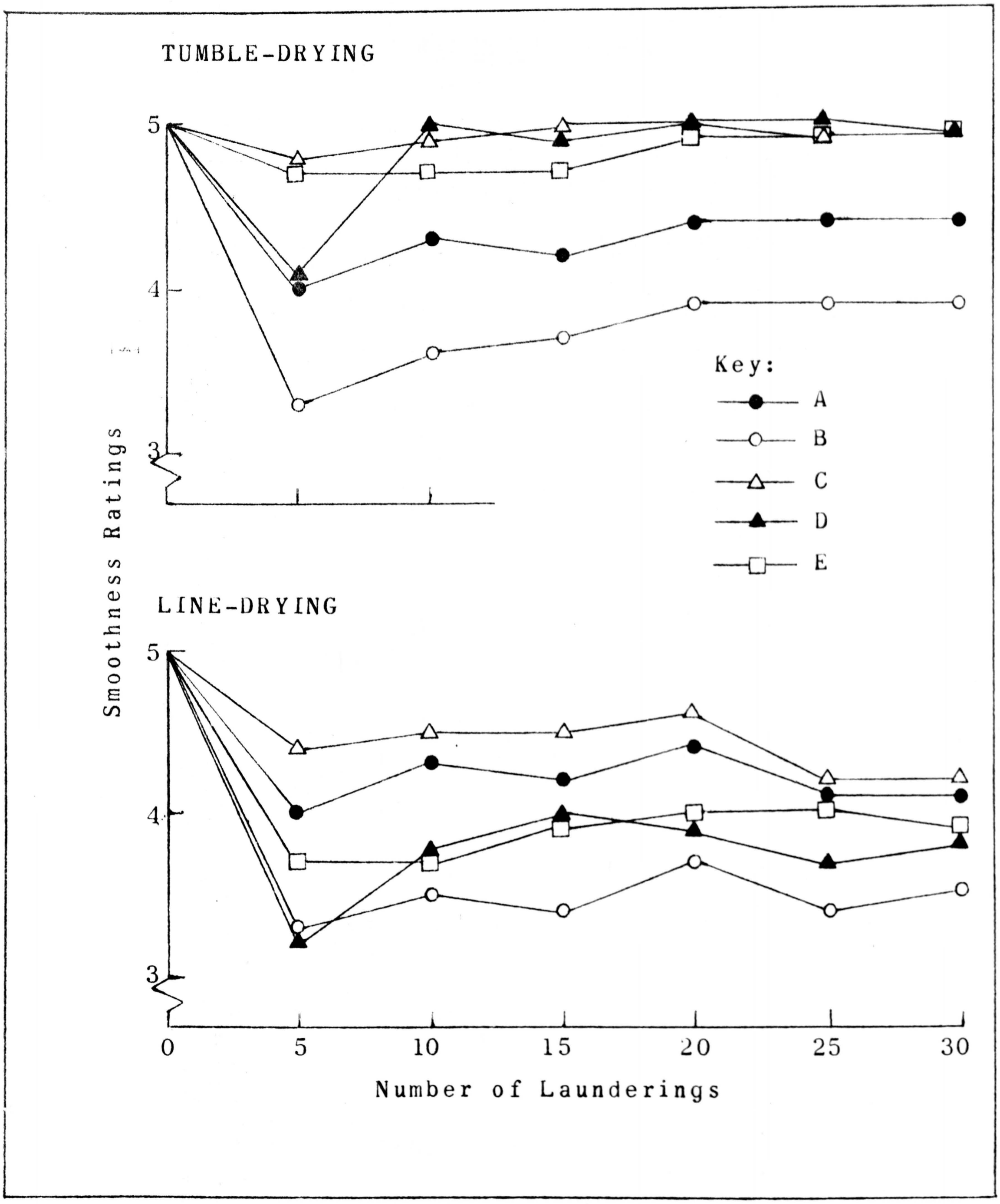


FIGURE 2

SMOOTHNESS OF TROUSERS AT INTERVALS OF LAUNDERING

APPEARANCE OF CREASES

The data tabulated in Table II are indicative of the appearance of the trouser creases as evaluated by a panel of three textile technologists initially and after each period of laundering. Each mean value given in the table is representative of 150 independent evaluations performed in accordance with the procedure recommended by AATCC (1b).

A consideration of these data from the standpoint of the relative performance of the five categories of trousers revealed a similar crease performance pattern for all types of trousers. As evidenced by the diagrammatical presentation of data shown in Figure 3 the creases were less defined after five laundering periods than they had been at the onset of the study. As a rule, they changed little from five through 20 periods of laundering. In many instances they became progressively poorer during the last 10 laundering periods, irrespective of the trouser types or the drying procedure which was used. Throughout the study, the all-cotton trousers of Category C obviously displayed the highest level of crease performance, while Trousers D, the 65/35 intimate blend of cotton-polyester, performed the poorest. An analysis of the data by means of the Duncan's Multiple Range Test consistently confirmed these findings both for the tumble-dried and for the line-dried trousers in Category C. In approximately 66 per cent of the cases which involved a comparison of Trousers B and D, however, the performance of the creases in the all-cotton trousers of Category B was not significantly better than that which was evidenced for the 65/35 blend.

TUMBLE DRYING

A treatment of the composite crease data which resulted from one through 10 launderings followed by tumble drying revealed, as mentioned above, that the creases of Trousers C represented by a value of 4.6 surpassed those in the remaining four types of trousers to a highly significant degree. At this point in the study Trousers A and Trousers E with crease values amounting to 3.6 and 3.7, respectively, shared second place by responding to tumble drying in a more acceptable manner than that displayed by trousers of Category B (3.3) and Category D (3.2).

From 11 through 30 periods of laundering and tumble drying, the Koratron-treated trousers (Type C) retained the favored position which they had gained during the first 10 laundering periods with respect to their creases, while the 65/35 cotton-polyester trousers continued to perform with the lowest level of crease retention as designated by a value of 2.9. The creases of the trousers of Type E (50/50 cotton-polyester) displayed a crease value of 3.3 at this point, which proved to be significantly better than the values accredited to Trousers A (3.1); B (3.0); and D (2.9).

The overall data from one through 30 periods of laundering and tumble drying attested to the findings which resulted from 11 - 30 laundering periods with reference to the creases of Trousers C and E. The performance of the all-cotton trousers of Type A, the crease value of which amounted to 3.3, proved to be significantly sharper than that given to the trousers in Category A (3.1). There was no significant difference between the performance of Trousers B and D. These observations are noticeable in the following rank-order arrangement of the five trouser types which were subjected to tumble drying:

Rank	Type of Trousers
1	All-Cotton (C)
2	50/50 Cotton-Polyester (E)
3	All-Cotton (A)
4	All-Cotton (B)
4	65/35 Cotton-Polyester (D)

LINE DRYING

With the line drying procedure the all-cotton trousers of Category C continued to display exceptionally sharp creases when the trouser types were intercompared in this regard after 10 and 30 laundering periods.

Additional findings after 10 launderings revealed the fact that the crease performance of Trousers A, B, and E was equivalent and Trousers D followed the usual trend of poor performance. From 11 - 30 periods of laundering followed by tumble drying the 50/50 cotton-polyester trouser creases performed more perfectly than did those of the all-cotton trousers in Categories A and B. This same pattern of performance prevailed when data for the entire study were compared with respect to the appearance of the creases. The following ranks are indicative of the performance of the five respective types of trousers:

Rank	Type of Trousers
1	All-Cotton (C)
2	50/50 Cotton-Polyester (E)
3	All-Cotton (A)
3	All-Cotton (B)
5	65/35 Cotton-Polyester (D)

TUMBLE DRYING VERSUS LINE DRYING

The fact that line drying contributed toward a better crease performance for the all-cotton trousers of Categories A and B than did tumble drying was evident at each interval of analysis (after 10 and 20 launderings and when the cumulative data for the entire study were considered). In all other instances, except after 20 laundering periods when Trousers E displayed a better appearance after being line dried, the drying method failed to affect the appearance of the creases.

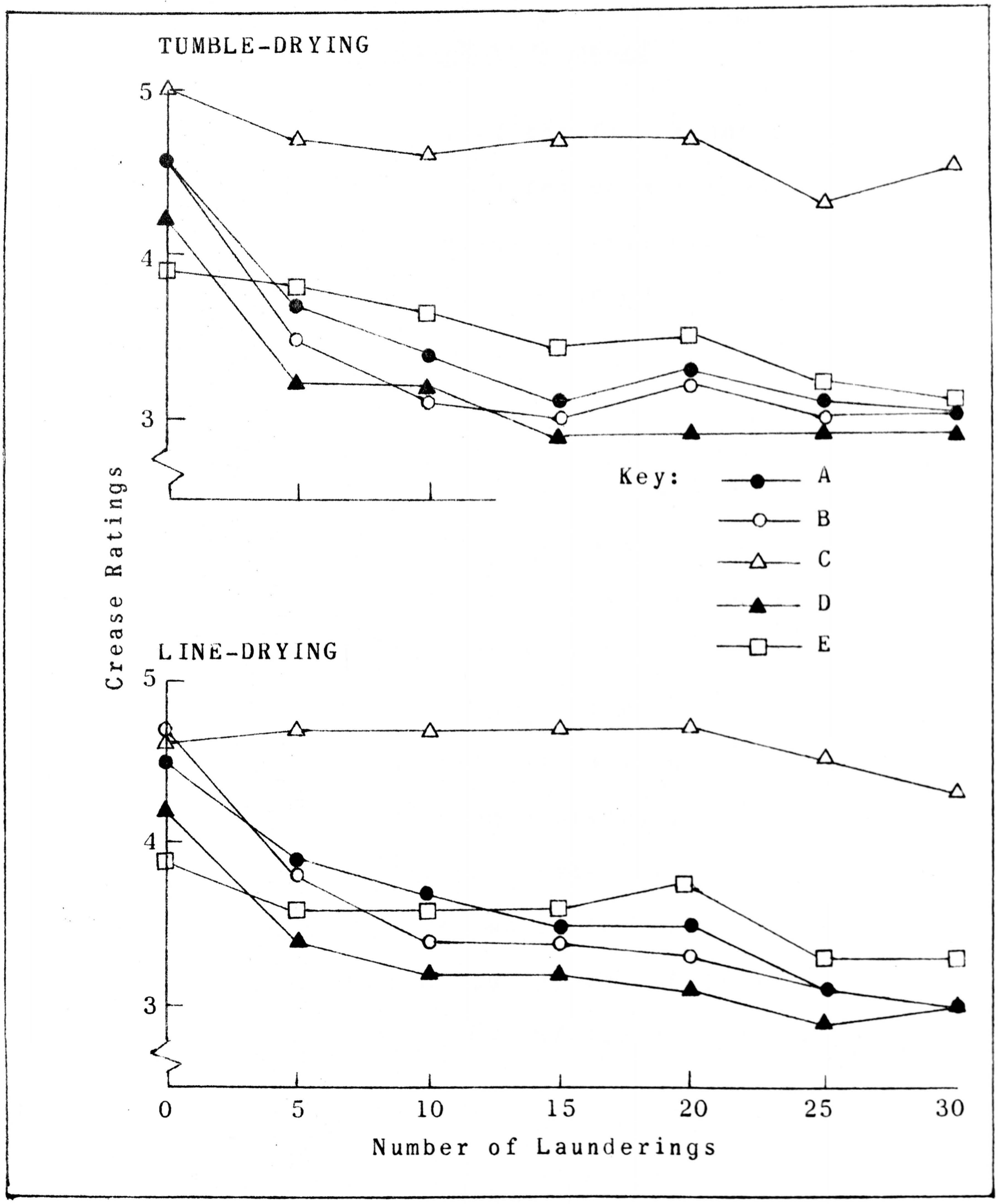


FIGURE 3

APPEARANCE OF CREASES IN TROUSERS AT INTERVALS OF LAUNDERING

APPEARANCE OF SEAMS

The seam smoothness of the five types of experimental trousers was examined after each period of laundering as described in another section of this manuscript. The data from such evaluations are recorded in Table III and are supported by the graphical description given in Figure 4.

From these data it is quite apparent that the seams of the five categories of trousers were not as smooth after five laundering periods as they had been initially. From that period throughout the remainder of the study several patterns of performance were demonstrated by the experimental trousers. The seams of the all-cotton trousers of Categories A and B became progressively more puckered with additional laundering periods. Trousers C and E changed little, and the seam smoothness of the 65/35 cotton-polyester trousers improved in appearance from 10 - 30 laundering periods irrespective of the drying procedure which was used.

TUMBLE DRYING

A statistical analysis of the recorded data which resulted from tumble drying revealed the findings that the trousers from Categories C and D, with a mean rating of 4.5

after 10 laundering periods, exhibited a better seam appearance than did the remaining categories of experimental trousers. The poorest seam performance during the early part of the study was demonstrated by Trousers A and B, with seam values of 4.0 and 4.1, respectively.

For the next 20 laundering periods (11 - 30), the 65/35 cotton-polyester trousers which were categorized as D Trousers were found to give the best seam performance, as indicated by a rating of 4.7, when compared to the other categories of trousers. Again the all-cotton A Trousers exhibited the lowest rating of 3.5. This undesirable performance of seam appearance also was found in the all-cotton B Trousers, with the rating of 3.7. A moderate degree of seam smoothness was demonstrated by the all-cotton Koratron-treated C Trousers and the 50/50 blend of cotton-polyester (Trousers E).

When the cumulative seam data for the entire study were compared with regard to the five types of trousers after tumble drying, the findings revealed the fact that the relationship between the trouser types with regard to seam smoothness was identical to that which was evident from 11 - 30 laundering periods, and was only slightly different from the trend which was established during the first 10 periods of laundering followed by tumble drying. The following order of performance prevailed for the various trouser types:

Rank	Type of Trousers
1	65/35 Cotton-Polyester (D)
2	All-Cotton (C)
2	50/50 Cotton-Polyester (E)
4	All-Cotton (B)
5	All-Cotton (A)

LINE DRYING

As early in the study as from one through 10 laundering periods followed by line drying, the satisfactory seam performance of the all-cotton Koratron-treated C Trousers; the 65/35 cotton-polyester D Trousers; and the 50/50 cotton-polyester E Trousers was shown. Values of 4.8, 4.7, and 4.7, respectively, were indicative of this type of performance.

From 11 - 30 laundering periods the 65/35 blend of cotton-polyester trousers (Type D) surpassed the 50/50 blend and the all-cotton Koratron-treated trousers with reference to seam smoothness. This position was retained by the respective trouser types when data for the entire study were analyzed.

A less spectacular performance was noticeable with respect to the all-cotton trousers of Categories A and B.

At every period of comparison, the seams of these trousers displayed the least desirable appearance. The following rank order exemplifies the overall performance of the trouser seams as a result of line drying:

Rank	Type of Trousers
1	65/35 Cotton-Polyester (D)
2	All-Cotton (C)
2	50/50 Cotton-Polyester (E)
4	All-Cotton (B)
4	All-Cotton (A)

TUMBLE DRYING VERSUS LINE DRYING

The results of this study failed to show that the type of drying to which the trousers were subjected was related in any way to the smoothness of the seams in the all-cotton trousers of Categories A and B.

From 11 - 30 launderings the same findings held true for Trousers C and D, although this was not the case with Trousers C, D, and E from one - 10 or from one - 30 laundering periods, or for Trousers E from 11 - 30 laundering periods. In all of these instances line drying contributed toward a greater degree of seam smoothness.

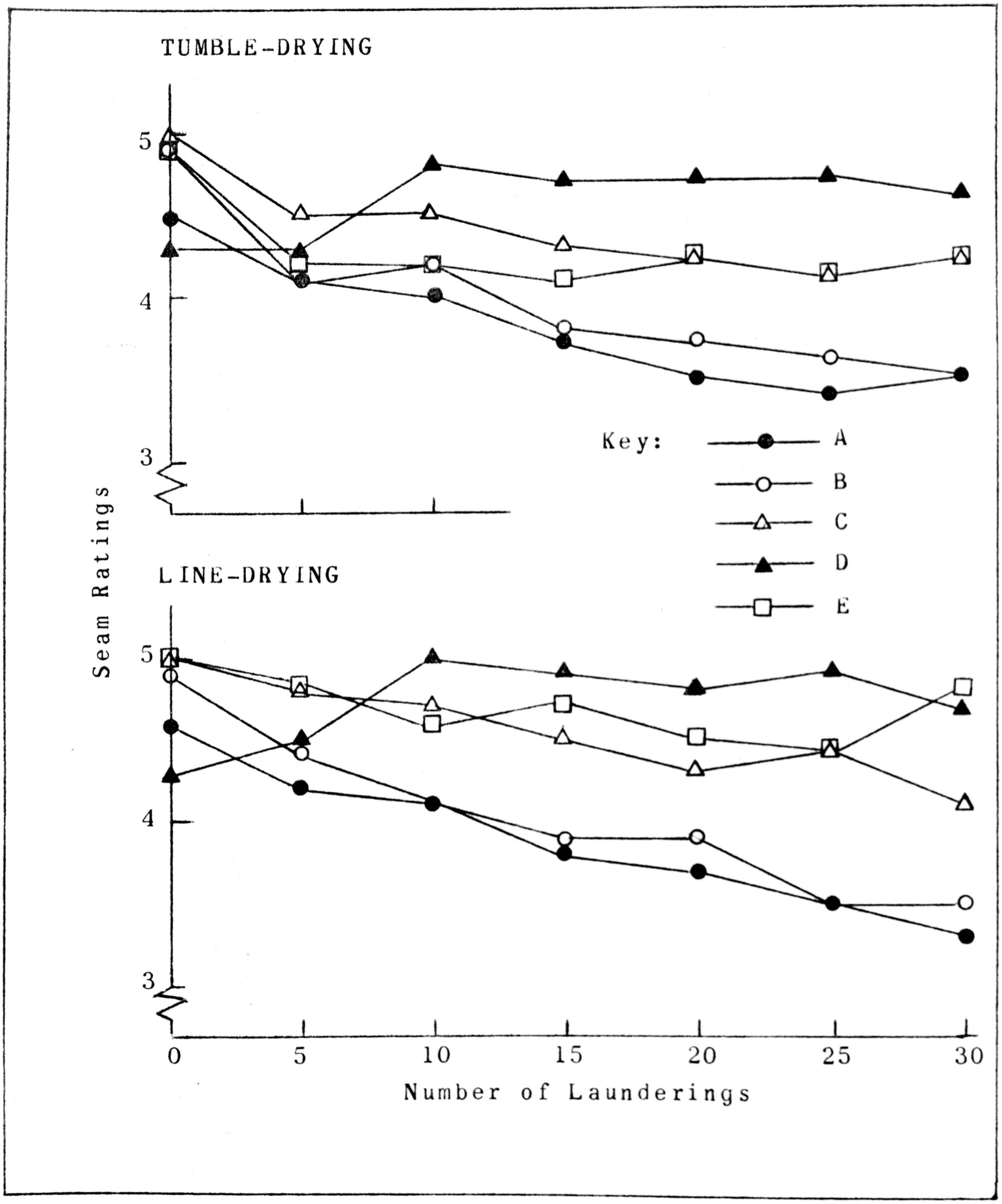


FIGURE 4

APPEARANCE OF SEAMS IN TROUSERS AT INTERVALS OF LAUNDERING

ABRASION RESISTANCE

The abrasion resistance of the five different fabric categories represented in this study was determined in accordance with the two procedures described elsewhere in this manuscript. One procedure involved the number of broken yarns (warp and filling) and the number of holes. The other evaluation of the abrasion performance was measured by means of the amount of light which was transmitted through the creases of the trouser legs when a fluorescent light assembly was inserted inside the legs. Cumulative data obtained from these procedures are recorded in Tables IV and V.

The Abrasion Performance as Indicated by Means of the Number of Broken Yarns and Holes

Table IV presents the cumulative number of broken warp and filling yarns, and the number of holes displayed by each trouser category, initially and after each fifth laundering period.

The following discussion is based on these data without the benefit of a statistical analysis since the nature of the data did not lend itself to statistical tests. In a determination of the relationship of the five types of trousers with reference to their resistance to abrasion during laundering the number of warp and filling yarns which were broken during the first 10 launderings; those which were broken during launderings 11 - 30; and those which occurred during the entire study were considered. Broken yarns which were evident in the garments before laundering or those which appeared along the lines of construction during laundering were not regarded in these analyses.

A study of these data reveals the fact that the majority of the wear evidenced by the non-worn trousers appeared in the form of broken warp yarns which were proportionate with the number of laundering cycles. This finding was to have been expected with reference to the twill fabrics (3/1 and 3/2) from which the trousers in this study were constructed. In such fabrics the warp yarns float over the surface of the fabric for a distance of the width of three filling yarns; therefore, the wear of warp yarns should be greater than that of the filling yarns. A confirmation of this expectation is shown in Table IV for both the tumble and line-dried trousers.

TUMBLE DRYING

After the first 10 laundering and tumble-drying periods, the 50/50 cotton-polyester Trouser E was found to be superior when the 10 broken yarns seen on these trousers were compared to those which were evident in the remaining four trouser categories. The all-cotton Koratron-treated C Trousers with 18 broken yarns ranked second with respect to abrasion resistance during 10 laundering and tumble drying periods. Little difference was noticeable between the performance of the all-cotton B Trousers which experienced 25 broken yarns and the 65/35 cotton-polyester blend (D Trousers) with 24 broken yarns to their credit. Trousers in Category A displayed the poorest resistance to abrasion as shown by a total of 57 broken yarns at this point of the study. As recorded in Table IV, only three holes appeared in the experimental trousers during the first 10 laundering periods two of which were accredited to Trousers A and the other to Trousers C.

As the number of laundering periods progressed from 11 - 30, differences between the abrasion resistance of the five respective types of trousers increased. The E Trousers continued their satisfactory resistance to abrasion by displaying only 41 broken yarns, and the 65/35 cotton-polyester D Trousers with 310 broken yarns surpassed the three types of all-cotton trousers (Categories A, B, and C). The least resistance to abrasion during the last 20 laundering and tumble-drying periods was displayed by the all-cotton C Trousers, as shown by the 862 broken yarns. Also, 36 holes occurred in these trousers during that time.

The overall results for the entire study (1 - 30 launderings followed by tumble drying) revealed the following pattern of abrasion resistance for the five respective types of trousers:

1 - 30 Launderings

Type of Trousers	Number of Broken Yarns (Warp and Filling)	Holes	Rank
50/50 Cotton-Polyester (E)	47	0	1
65/35 Cotton-Polyester (D)	332	5	2
All-Cotton (A)	408	15	3
All-Cotton (B)	524	29	4
All-Cotton (C)	779	37	5

LINE DRYING

When line drying was applied, the E Trousers again exhibited the most satisfactory performance relative to their abrasion resistance, as indicated by the six broken yarns accredited to these trousers after the first 10 launderings. The 65/35 cotton-polyester trousers (Trousers D) ranked in second place with their total wear equivalent to 14 broken yarns, whereas the all-cotton A Trousers exhibited the lowest resistance, which was represented by 89 broken yarns. Trousers C and B responded to laundering in much the same way as indicated by 23 broken yarns for the former and 27 for the latter.

From 11 - 30 laundering periods followed by line drying, the E and D Trousers continued their first and second place performance in comparison with that of the other categories (A, B, and C). The all-cotton A Trousers surpassed Trousers B and C with respect to abrasion resistance and the lowest resistance was displayed by Trousers C with 496 broken yarns.

In the overall observations (after 1 - 30 launderings followed by line drying) the following rank order which was established during the last 20 laundering periods prevailed with respect to the resistance of the five types of trousers:

1 - 30 Launderings

Type of Trousers	Number of Broken Yarns (Warp and Filling)	Holes	Rank
50/50 Cotton-Polyester (E)	29	0	1
65/35 Cotton-Polyester (D)	164	2	2
All-Cotton (A)	285	10	3
All-Cotton (B)	329	12	4
All-Cotton (C)	519	18	5

TUMBLE DRYING VERSUS LINE DRYING

The data showed that although the tumble drying process generally was more damaging to the experimental trouser types than was line drying the relative performance of the five types of trousers was comparable for both drying procedures. This finding is obvious from a study of Figure 5.

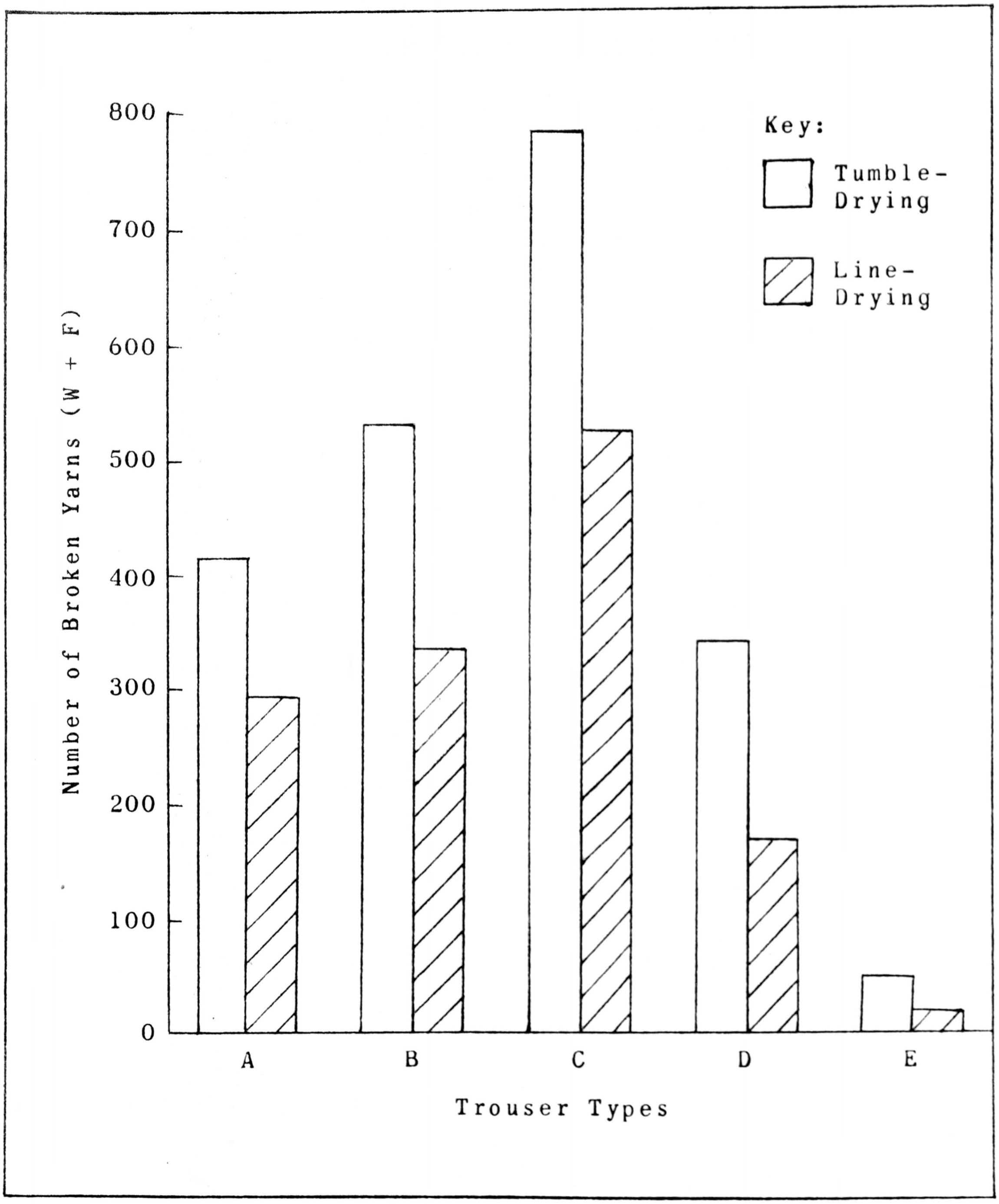


FIGURE 5

A COMPARISON OF THE EFFECTS OF TUMBLE AND LINE DRYING UPON THE TROUSERS WITH RESPECT TO THE NUMBER OF BROKEN YARNS

The Abrasion Performance as Indicated by Means of the Amount of Fluorescent Light Transmitted Through the Creases of the Trouser Legs

Table V shown in the Appendix includes the cumulative data representative of the crease abrasion of the five trouser fabrics. Each value represents a mean of the front and back crease values of the respective trouser categories, measured after each fifth laundering period in accordance with the procedure described earlier in this manuscript involving the insertion of a fluorescent light inside the trouser legs. The following discussion takes into consideration the relative crease abrasion of the five trouser categories as determined by means of AoV and Duncan's Multiple Range tests, after five - 10; 15 - 30; and five - 30 laundering periods followed by the two different drying applications (tumble and line), respectively.

TUMBLE DRYING

The first 10 laundering periods followed by tumble drying had no visible effect upon the creases in the legs of Trousers A, B, and C, in that the amount of light which was transmitted through the creases after 10 launderings was no greater than that which was transmitted initially. The highest value (5.0) afforded by the rating system was assigned these trouser types. The two types of trousers which were composed of a blend of cotton-polyester (Trousers D and E) exhibited lower values of 4.7 and 4.2, respectively, after 10 laundering periods.

The above-described tendencies continued throughout the remainder of the study as revealed by a crease abrasion rank order arrangement as follows:

Rank	Type of Trousers
1	All-Cotton (A)
1	All-Cotton (B)
1	All-Cotton (C)
4	65/35 Cotton-Polyester (D)
5	50/50 Cotton-Polyester (E)

LINE DRYING

The crease abrasion ratings of the five categories of trousers after each fifth laundering period followed by the line drying application were comparatively analyzed for launderings five - 10; 15 - 30; and five - 30, respectively. Data from an analysis of the crease abrasion during five - 10 launderings revealed the fact that four of the five trouser categories (Trousers A, B, C, and D) were virtually unharmed during this period. An exception to this finding was evident in Trousers E (50/50 cotton-polyester blend) as indicated by the rating of 4.4 which was assessed these trousers.

Throughout the remainder of the study the three types of all-cotton trousers (Categories A, B, and C) retained their original rating of 5.0. The 65/35 cotton-polyester D Trousers began to show crease wear as indicated by a rating of 4.3, and the rating assigned the 50/50 cotton-polyester E Trousers fell to a mean of 3.9.

The results of the overall comparison of the five types of garments with reference to their creases during the 30 laundering periods followed by line drying showed the following rank order for the respective trouser types:

Rank	Type of Trousers
1	All-Cotton (A)
1	All-Cotton (B)
1	All-Cotton (C)
4	65/35 Cotton-Polyester (D)
5	50/50 Cotton-Polyester (E)

TUMBLE DRYING VERSUS LINE DRYING

The two different types of drying which were applied to the five trouser categories (tumble and line) were analyzed comparatively with reference to launderings five - 10; 15 - 30; and five - 30, respectively. From these observations, the three all-cotton trousers (Categories A, B, and

C) performed in a comparable manner with both types of drying, with reference to their resistance to crease abrasion. The two different blends of cotton-polyester, which were categorized as Trousers D and Trousers E, exhibited a better resistance to abrasion when they were subjected to line drying than when they were tumble-dried.

BREAKING STRENGTH PERFORMANCE

The breaking strength performance of the five categories of trousers was determined initially and after each five laundering periods from experimental yardage representative of the trouser types and laundered under the same conditions as the trousers. Tables VI and VII contain the data which were derived from these determinations.

As shown graphically in Figures 6 and 7, each fabric category displayed its own characteristics in offering resistance to the stress placed upon it in the application of the strength tests. As a general rule the 30 laundering periods had little effect upon the strength of the fabrics. General conclusions which might be drawn from these diagrams concerning the warp direction of the fabrics point to the superior strength of the 50/50 cotton-polyester trousers (Trousers E), to the poor performance of the 65/35 cotton-polyester (Trousers D), and to the intermediate strength of the three types of all-cotton trousers (A, B, and C), irrespective of the drying procedure.

Fillingwise, Trousers A and B displayed the most outstanding performance, and no definite decision can be made concerning the status of the resistance of the remainder of the trouser types without statistical assistance. The following discussion takes into consideration the relationship of the five trouser fabrics with respect to breaking strength as determined by the AoV and Duncan's Multiple Range Test.

TUMBLE DRYING

A comparative analysis of the warp direction of the five types of trousers with reference to their resistance to breaking, initially and during the first 10 laundering and tumble drying periods, revealed the finding that the 50/50 cotton-polyester fabric (Trousers E), with a warp breaking strength of 112.2 pounds, was found to be superior to the remainder of the trouser fabrics. The all-cotton fabric from Trousers B performed better in this respect than did the other two all-cotton categories (A and C), whereas the least desirable warp breaking strength was exhibited by the 65/35 cotton-polyester D Trousers (71.6 pounds).

During the last 20 laundering periods, Fabric E (50/50 cotton-polyester) continued its satisfactory breaking strength characteristics; Trouser Fabric B surpassed the other all-cotton trouser fabrics (Categories A, C, and D). Again the 65/35 cotton-polyester D Trousers displayed the lowest breaking strength values in the warp direction.

From the above-described data there is evidence that the warp breaking strength of the experimental trousers was not altered to a significant degree during the last 20 periods of laundering followed by tumble drying except in one instance. The 71.6 pounds of warp breaking strength which was accredited to the 65/35 cotton-polyester Fabric D after a series of 10 periods of laundering was reduced to a mean value of 69.6 throughout the remainder of the study.

An overall analysis of the warp breaking strength data from the tumble dried fabrics revealed the following rank-order arrangement of the five types of trousers:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	All-Cotton (B)
3	All-Cotton (A)
3	All-Cotton (C)
5	65/35 Cotton-Polyester (D)

Generally, the fillingwise breaking strength values were found to be affected by the progressive launderings, followed by tumble drying, except for the all-cotton Trousers C, and the 50/50 cotton-polyester Trousers E, which were virtually unharmed by the 30 periods of laundering. The all-cotton fabrics of Trousers A and B and of the 65/35 cotton-polyester (Trousers D) became significantly weaker during launderings 11 - 30. The Trouser B fabric exhibited the highest filling breaking strength at all periods of analysis, when a comparison was made with these trousers and those of the remaining categories. There was conclusive evidence that, after the first 10 laundering periods followed by tumble drying, the 52.2 pounds of breaking strength accredited to the filling direction of the 65/35 cotton-polyester fabric of Trousers D placed this fabric in second place with reference to its strength performance. From 11 - 30 laundering periods Trousers D allowed this second place position to go to the 50/50 cotton-polyester blend (Trousers E). When data from the entire study were analyzed, however, the performance of these two trouser fabrics was comparable. Fabrics A and C displayed the poorest strength values throughout the study.

The five trouser fabrics which were subjected to tumble drying were found to be the following with respect to their strength performance in the filling direction when the data for the entire study were considered:

Rank	Type of Fabric
1	All-Cotton (B)
2	65/35 Cotton-Polyester (D)

2	50/50 Cotton-Polyester (E)
4	All-Cotton (A)
4	All-Cotton (C)

LINE DRYING

The breaking strength values for the five types of line dried trousers were compared with respect to the effects which a series of 30 laundering periods had upon them, in the same manner as was carried out with the tumble dried data. The results of these analyses showed that the warp breaking strength values for Fabrics A, B, C, and E were not altered to a significant degree by the last 20 laundering periods. A different reaction to laundering was noticeable for Fabric D. The mean warp strength representative of this fabric (73.3 pounds) after the first 10 laundering periods was reduced significantly to 69.3 pounds during laundering periods 11 - 30.

The 50/50 cotton-polyester E Fabric was found to be superior with respect to warp breaking strength values, with a mean of 109.7 pounds after the first 10 launderings to 111.9 pounds during the last 20 launderings, when compared to the remaining trousers categories. The all-cotton Fabric B ranked second in this respect, with mean values of 87.4 and 87.5 pounds at the respective evaluation periods. The D Fabric displayed the lowest warp breaking strength values among the line-dried fabrics as can be noted from the following system of ranking:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	All-Cotton (B)
3	All-Cotton (A)
3	All-Cotton (C)
5	65/35 Cotton-Polyester (D)

Less stability in the filling breaking strength resistance was noticeable throughout the 30 laundering periods than previously has been discussed for the warp direction. Trouser Fabrics A, B, and D displayed lower breaking strength values during the last 20 launderings than were found during the first 10 laundering periods.

At all intervals when data were analyzed statistically, the all-cotton B Fabric exhibited the highest breaking strength value. The performance pattern for the remainder of the trouser fabrics varied in relation to the specific evaluation period. During the first 10 laundering periods Fabrics A, D, and E ranked second and Fabric C displayed the poorest resistance to breaking, fillingwise. An analysis of the data from 11 - 30 laundering periods revealed the finding that Fabric E (50/50 cotton-polyester) ranked second in performances whereas, Fabrics A, C, and E were rated as offering the poorest resistance to breaking.

Overall, when data for the entire study were analyzed, the following findings were evident with reference to the comparative breaking strength performance of the fabrics in the filling direction:

Rank	Type of Fabric
1	All-Cotton (B)
2	65/35 Cotton-Polyester (D)
2	50/50 Cotton-Polyester (E)
4	All-Cotton (A)
5	All-Cotton (C)

TUMBLE DRYING VERSUS LINE DRYING

The two types of drying which were applied to the five different fiber-fabric categories failed to make any difference in breaking strength values at each period of analysis, except in the case of the 50/50 cotton-polyester E Fabric. This fabric showed a higher mean strength value with the application of tumble drying than with line drying.

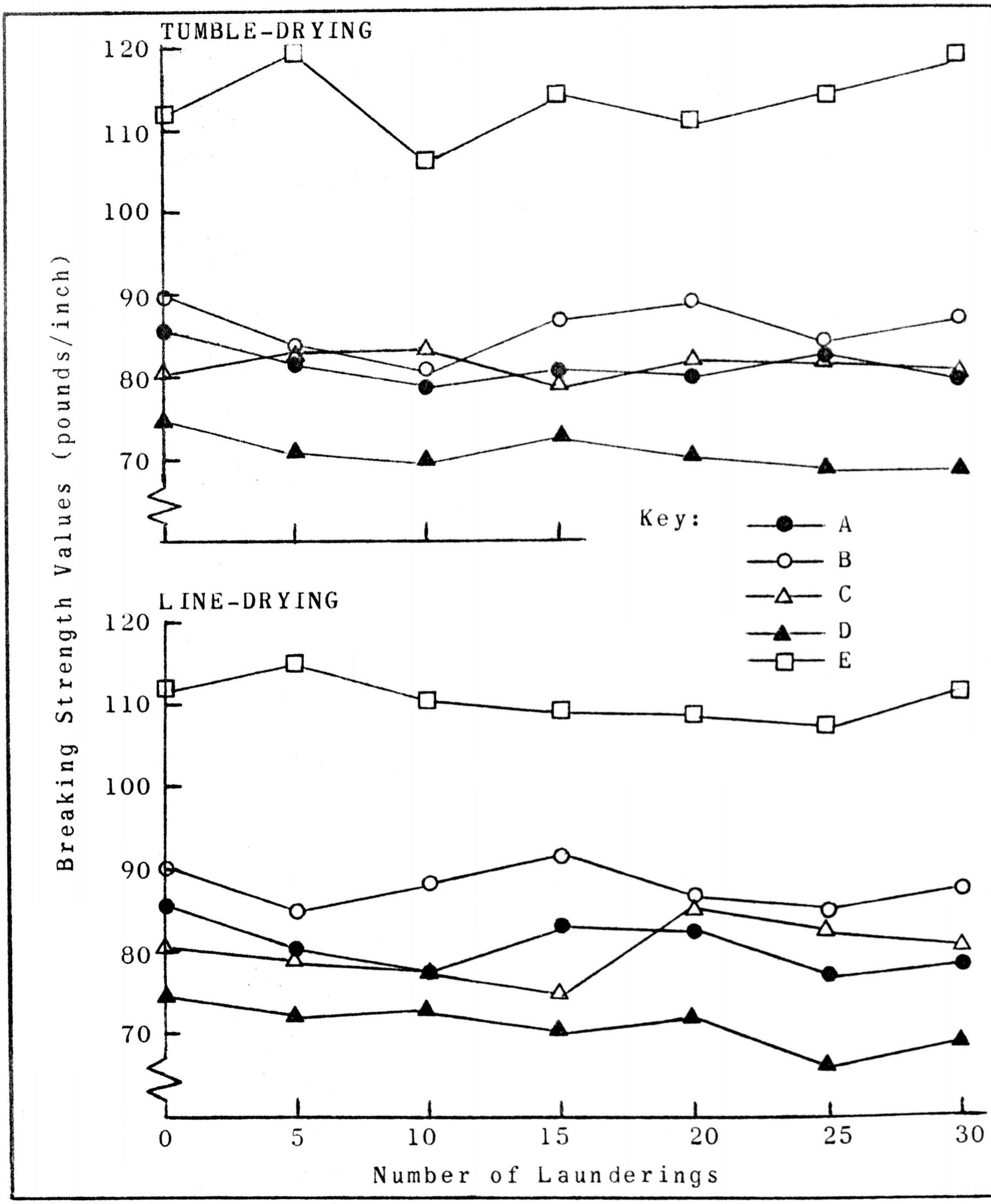


FIGURE 6

WARP BREAKING STRENGTH OF TROUSER FABRICS AT INTERVALS OF LAUNDERING

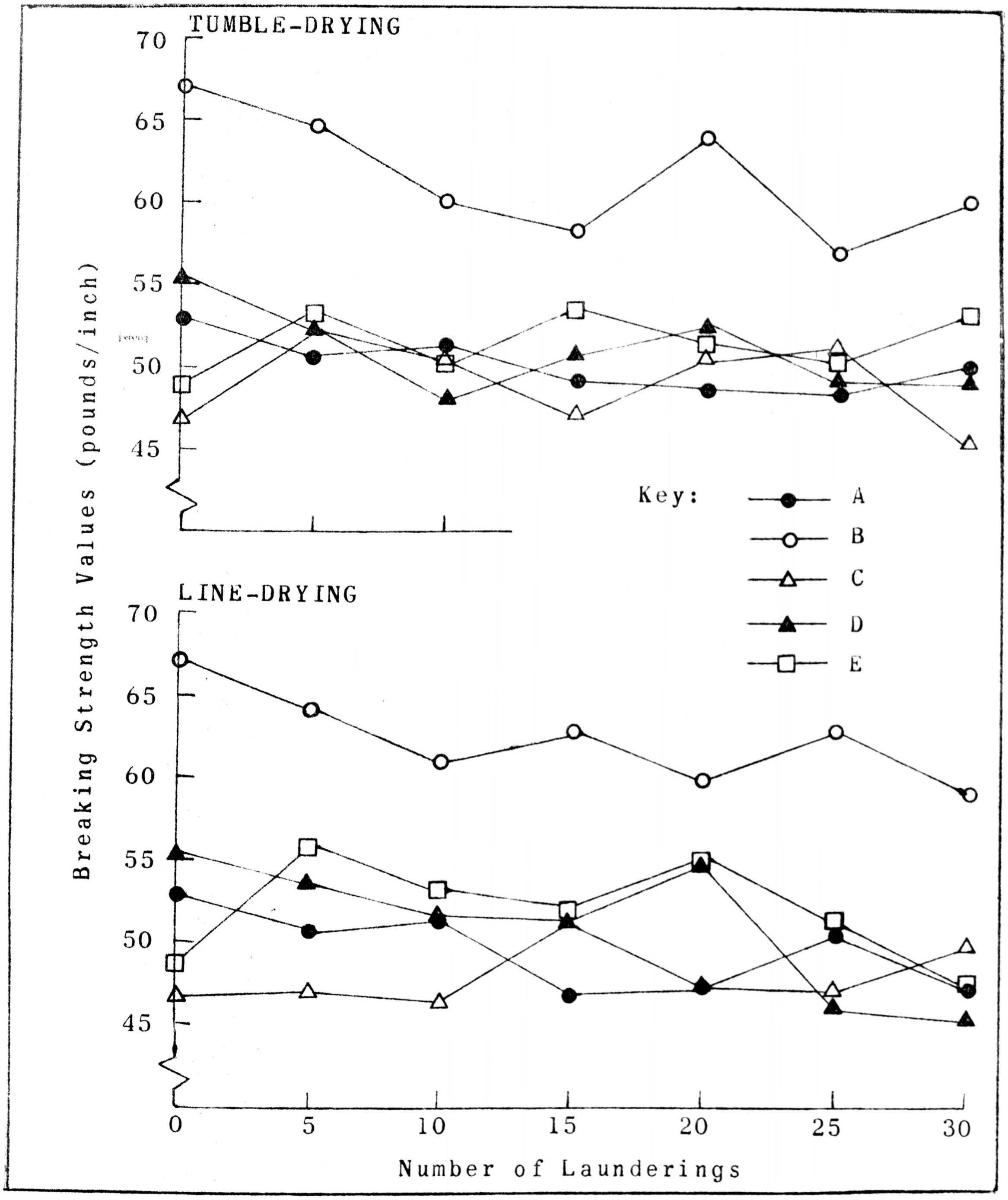


FIGURE 7

FILLING BREAKING STRENGTH OF TROUSER FABRICS AT INTERVALS OF LAUNDERING

TEARING STRENGTH PERFORMANCE

The tearing strength of the five categories of trouser fabrics was determined warpwise and fillingwise after each five laundering periods, from the experimental yardage representative of the trouser categories. The cumulative data from this experiment are recorded in Table IX.

Comparative analyses of these data were made initially and after one through 10, 11 through 30, and initially through 30 laundering periods, followed by the two respective drying procedures in order to determine the relative resistance to tearing of the five respective types of trousers. A treatment of these data is discussed in the following paragraphs.

TUMBLE DRYING

The comparative analysis of the mean warp tearing strength values accredited to the five fabric categories after the first 10 laundering periods, followed by the application of tumble drying, revealed the finding that the 4573 grams of resistance demonstrated by the 50/50 cotton-polyester (E Trousers) represented a resistance to tearing which was highly superior to that of the four remaining fabric categories. The performance of the all-cotton

Koratron-treated C Fabric with its warp tearing resistance of 2823 grams was found to be better in this respect than were the two other all-cotton fabric categories (Categories A and B). The least desirable mean warp tearing strength value of 2047 grams was exhibited by the 65/35 cotton-polyester D Fabric.

After launderings 11 - 30 followed by tumble drying, the trouser Fabric E continued to show its superior warp tearing strength characteristic by displaying a resistance of 4572 grams. The all-cotton Fabric A surpassed the two other all-cotton fabric categories (B and C); whereas Fabric D (65/35 cotton-polyester) again exhibited the lowest tearing strength resistance (2032 grams).

A comparison of warp tearing strength displayed by the five trouser fabrics after the first 10 launderings with that shown during launderings 11 - 30 followed by tumble drying revealed the fact that the resistance of the all-cotton A Fabric to tearing increased during the last 20 laundering periods. On the other hand, an overall reduction in resistance was noticeable for the all-cotton Koratron-treated C trouser fabrics. The remaining three categories (Fabrics B, D, and E) were not affected with reference to their resistance to tearing by the progression of launderings.

To exemplify the results which were revealed as an overall analysis of the warp tearing strength of the tumble-dried fabrics, the following rank order is provided:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	All-Cotton (A)
3	All-Cotton (B)
3	All-Cotton (C)
5	65/35 Cotton-Polyester (D)

In the filling direction of the tumble-dried trouser fabrics, a relatively unchanged pattern of tearing strength performance prevailed at the various intervals of analysis. It was conclusively shown that, both after the first 10 and the last 20 laundering periods followed by tumble drying, the 50/50 cotton-polyester fabric exhibited the greatest resistance to tearing (3240 and 3275 grams) when compared to the four remaining trouser fabric categories. The D 65/35 cotton-polyester fabric ranked next, followed by the all-cotton Fabrics A, and B. The filling direction of Fabric C offered the least resistance to tearing after 10 launderings (2117 grams), but it shared this lower position with Fabric A during the last 20 laundering periods followed by tumble drying. During this time, the fillingwise tearing strength values were reduced for the all-cotton A and B Trouser fabrics and the D Fabric (65/35 cotton-polyester).

Additional launderings followed by tumble drying failed to affect the all-cotton Koratron-treated C Fabric and the 50/50 cotton-polyester E Category to a significant degree.

An analysis of the cumulative data for the entire study in relation to tearing in the filling direction revealed the following strength performance rank order arrangement of the five trouser fabrics when tumble drying was applied:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	65/35 Cotton-Polyester (D)
3	All-Cotton (B)
4	All-Cotton (A)
5	All-Cotton (C)

LINE DRYING

The values representative of the resistance to tearing of the five trouser fabrics were analyzed after line drying as was discussed for the tumble-dried fabrics. The results showed that the number of launderings did not harm the warp tearing strength of the line-dried fabrics significantly, except in one instance, which was exhibited by the all-cotton Koratron-treated C trouser fabric. In this instance the overall resistance of this fabric was reduced considerably during the last 20 laundering periods.

A further analysis of the warp tearing strength data at the intervals mentioned above revealed the finding that the 50/50 cotton-polyester (Fabric E) was superior in its resistance to tearing when compared to the remaining four fabric categories. The all-cotton Fabric C performed better in this respect after the first 10 launderings than did the A and B Fabrics, whereas Fabric A proved to be superior during the last 20 laundering periods at all periods of comparison. The 65/35 cotton-polyester (Fabric D) displayed the least warp resistance to tearing.

A consideration of the warp tearing strength performance for the entire study revealed the following relative performance for the five line-dried experimental trouser fabrics:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	All-Cotton (A)
2	All-Cotton (C)
4	All-Cotton (B)
5	65/35 Cotton-Polyester (D)

In some instances different characteristics were shown by the trouser fabrics with reference to their filling-wise resistance to tearing than were found in the warp direction. Trouser Fabrics A, B, and D were affected by the progression of launderings, as indicated by a reduction in tearing strength of about 10 per cent.

During the first 10 laundering periods followed by line drying, the 50/50 cotton-polyester blend, fillingwise, reacted in much the same way as was evident for the warp direction. The resistance of this fabric to tearing was highly superior to that offered by the remainder of the fabrics. Fabric C, on the other hand, displayed the poorest performance, while Fabrics D, A, and B obtained intermediate positions with reference to their resistance to tearing. The same tendency was demonstrated during the next 20 launderings and for the entire series of laundering periods followed by line drying, as exemplified by the following presentation:

Rank	Type of Fabric
1	50/50 Cotton-Polyester (E)
2	65/35 Cotton-Polyester (D)
3	All-Cotton (A)
3	All-Cotton (B)
5	All-Cotton (C)

TUMBLE DRYING VERSUS LINE DRYING

A statistical analysis of the comparative effects of the two drying applications (tumble and line) upon the tearing resistance of the trouser fabrics revealed the finding that the experimental trousers were affected differently by the two drying applications with respect to the tearing strength in the warp and filling directions after the first 10 laundering periods.

From 11 - 30 laundering periods this trend continued for the warp direction of the fabrics except for the all-cotton Fabric A, the warp strength of which was 2880 grams after tumble drying and a lower value of 2725 grams after line drying. In the filling direction during these last 20 laundering periods, further evidence was forthcoming to the effect that Fabrics B, C, and D showed that line drying contributed to the loss of resistance to tearing.

A study of the overall results revealed the finding that generally the five categories of fabrics performed equally as well with the two types of drying with reference to their tearing resistance, both in the warp and filling directions of the fabrics.

One exception to this finding was noticeable in the warp direction of the all-cotton Fabric A when the resistance provided by tumble drying (2824 grams) exceeded that which resulted from line drying (2736 grams).

WRINKLE RECOVERY PERFORMANCE

The data for the degree of dry wrinkle recovery displayed by the five different experimental trouser fabrics are found in Table X. These data result from the determination of the face-to-face and back-to-back wrinkle recovery angles which were measured initially and after 30 laundering periods, followed by tumble and line drying, respectively.

The following discussion is based upon the findings which were revealed from a statistical analysis of the data in comparing the relative wrinkle recovery performance of the five experimental trouser fabrics.

A treatment of the warpwise wrinkle recovery data of the respective fabrics before they were laundered revealed values which ranged from a low of 129.6 degrees as found in Fabric B to a high of 154.5 degrees displayed by the 50/50 blend (Fabric E). Intermediate values of 136.3, 148.7, and 150.3 degrees were found for Fabrics A, C, and D, respectively.

In the filling direction of the fabrics, differences between the wrinkle recovery performance of the five trouser fabrics were not as marked as were those shown in the warp direction. Fabrics A and B shared the lowest recovery angle of 141 degrees. The 65/35 blend of cotton-polyester

(Fabric D) ranked highest as demonstrated by an angle of 160.4 degrees, whereas Fabrics E and C displayed intermediate values of 157.8 and 150.6, respectively.

When the initial wrinkle recovery data were analyzed statistically the following ranking system was devised:

Rank		Type of Fabric
Warp	Filling	
1	2	All-Cotton (C)
1	1	65/35 Cotton-Polyester (D)
1	2	50/50 Cotton-Polyester (E)
4	4	All-Cotton (A)
4	4	All-Cotton (B)

TUMBLE DRYING

The tumble drying procedure showed an opposite effect upon the warp direction of the all-cotton Fabrics A and B. The performance of Fabric A improved from 136.3 to 153.7 degrees with 30 launderings followed by tumble drying, whereas Fabric B experienced a performance which was lowered from the initial value of 129.6 degrees to 126.1 degrees.

The three remaining trouser fabrics (Fabrics C, D, and E) with respective wrinkle recovery values of 147.1, 146.1 and 156.4 failed to show any significant differences in their warp wrinkle recovery.

The findings which were representative of the fillingwise direction of the tumble-dried fabrics revealed the fact that the general trend of wrinkle recovery performance was much like that described for the warp direction, except in the case of Fabric C. The wrinkle recovery of this fabric was lowered to a greater extent (from 150.6 to 141.5 degrees in the filling direction than the amount cited warpwise.

The relative performance of the trouser fabrics after 30 launderings followed by tumble drying was statistically analyzed as follows:

Rank		Type of Fabric
Warp	Filling	
1	1	All-Cotton (A)
1	4	All-Cotton (C)
1	1	65/35 Cotton-Polyester (D)
1	1	50/50 Cotton-Polyester (E)
5	4	All-Cotton (B)

LINE DRYING

A further analysis of the warp wrinkle recovery data showed that the all-cotton A fabric and the two blends of cotton-polyester (Fabrics D and E) were not affected by 30 launderings followed by line drying. This was not the case with the all-cotton Fabrics B and C, since they exhibited a considerable reduction in wrinkle recovery (10.3 and 11.4 degrees) when 30 launderings followed by line drying were applied.

Fillingwise, Fabric A showed more improvement in wrinkle recovery performance from line drying than did the remainder of the fabrics, as exemplified by a change in values from 141.8 degrees initially to 151.1 degrees after 30 launderings followed by line drying. The 50/50 cotton-polyester blend displayed a slightly improved performance amounting to 1.6 degrees, whereas line drying proved to be harmful to the remainder of the fabrics (Categories B, C, and D).

After 30 laundering periods followed by line drying the observations shown below were evident concerning the relationships of the trouser fabrics with reference to wrinkle recovery:

Rank		Type of Fabric
Warp	Filling	
1	1	50/50 Cotton-Polyester (E)
1	1	65/35 Cotton-Polyester (D)
3	1	All-Cotton (A)
3	4	All-Cotton (C)
5	4	All-Cotton (B)

TUMBLE DRYING VERSUS LINE DRYING

When the warp dry wrinkle recovery angles of the tumble and line dried fabrics were compared, the analysis revealed the finding that the all-cotton categories (Fabrics A, B, and C) exhibited a greater degree of wrinkle recovery after being subjected to tumble drying than after being line-dried. The 65/35 and 50/50 cotton-polyester Fabrics D and E performed as well with one type of drying as with the other.

Fillingwise, Fabric A was the only fabric which responded differently with the two drying procedures. With this fabric, tumble drying produced the more favorable results. The four remaining categories (Fabrics B, C, D, and E) did not show any differences in their filling wrinkle recovery when the two different drying procedures were applied upon them.

DIMENSIONAL STABILITY

Tables XI and XII contain data which are indicative of the per cent dimensional change of the five types of experimental trouser fabrics. From these data it is noticeable that, with both drying applications, the 65/35 cotton-polyester Fabric D displayed the best warp stability, which ranged from no change to 1.0 per cent change. The four remaining trouser categories demonstrated changes in dimensions ranging from 1.0 to 3.3 per cent for the warp direction of the tumble-dried fabrics, and from 0.0 to 2.0 per cent for the line-dried fabrics.

In the filling direction, all of the fabrics proved to be more dimensionally stable than was found to be the case with the warp direction. Line drying resulted in changes of less than 1.0 per cent, whereas tumble drying produced changes in dimensions ranging from 0.2 to 1.6 per cent.

TUMBLE DRYING

During the first 10 laundering periods followed by tumble drying, the 65/35 cotton-polyester D Fabric showed the least amount of change in its warp dimensions, with a rating of 0.7 per cent. The all-cotton C Fabric came out next with 1.6 per cent of shrinkage. Fabrics A and E shrank 2.1 per cent, respectively. The performance of the all-cotton Fabric B proved to be the least desirable with reference to dimensional stability by displaying the greatest amount of shrinkage (2.75 per cent) during launderings one through 10. With an increase in the number of launderings from 11 through 30, the 65/35 cotton-polyester trouser fabric (D) continued to demonstrate its superiority over the remainder of the trouser fabrics with its warp shrinkage amounting to an overall mean of less than one per cent (0.8 per cent). Fabrics A, B, and E demonstrated the least amount of warp stability at this point as exemplified by shrinkage values which exceeded the 2.0 per cent mark.

A comparison of the data from one through 10 launderings with that from 11 - 30 launderings revealed the finding that most of the warp shrinkage was incurred in the experimental fabrics during the first 10 laundering periods when tumble drying was used as the method of drying.

When data from the entire study were pooled and analyzed, the following order of performance was noted relative to the warp dimensional stability of the five trouser fabrics after tumble drying:

Rank	Type of Fabric
1	65/35 Cotton-Polyester (D)
2	All-Cotton (C)
3	All-Cotton (A)
3	50/50 Cotton-Polyester (E)
5	All-Cotton (B)

In the filling direction the stability displayed by the various trouser fabrics was quite different from that described above for the warp direction. Fabrics B and C in some instances shrank as much as one per cent with the application of tumble drying, whereas the stability of the remainder of the fabrics was greater.

A comparison of the data accumulated during the first 10 laundering periods with that of the last 20 revealed the fact that most of the shrinkage took place during the early periods of laundering. Fabrics A and B showed tendencies of relaxation during the last 20 laundering periods, although the changes which took place in the remainder of the trouser fabrics were of no significance.

An overall analysis of the data showed Fabric A (all-cotton) and Fabric E (50/50 cotton-polyester) to be the most stable, fillingwise, after tumble drying, with Fabric B the poorest in this respect. This can be noted from the following ranks:

Rank	Type of Fabric
1	All-Cotton (A)
1	50/50 Cotton-Polyester (E)
3	65/35 Cotton-Polyester (D)
4	All-Cotton (C)
5	All-Cotton (B)

LINE DRYING

Again, as was found to be the case with tumble drying, the 65/35 cotton-polyester D Fabric demonstrated good stability in its warp dimension with a 0.5 per cent change both after 10 and after 30 launderings. The all-cotton Fabrics A and B continued to be the least stable dimensionally with mean warp shrinkage values amounting to 1.4 and 2.0 per cent, respectively. The performance of the remainder of the trouser fabrics fell between the two extremes mentioned above.

The following performance patterns evolved from comparisons of the warpwise dimensional stability of the five experimental trouser fabrics after a series of 30 periods of laundering followed by line drying.

Rank	Type of Fabric
1	65/35 Cotton-Polyester (D)
2	All-Cotton (C)
3	50/50 Cotton-Polyester (E)
4	All-Cotton (A)
5	All-Cotton (B)

Although dimensional changes experienced by the filling direction of the five line-dried trouser fabrics were almost too small to mention (less than 0.5 per cent) one significant difference was noticeable between the performance of two of the fabrics during the first 10 laundering periods. In this respect Fabric A performed in a superior manner when compared with Fabric E.

When 11 - 30 laundering periods were followed by line drying, differences between the fabrics became greater and a comparison of the trouser fabrics on the basis of these data for the entire study showed the following ranks for the filling direction of the five fabrics:

Rank	Type of Fabric
1	All-Cotton (A)
2	All-Cotton (B)
3	All-Cotton (C)
4	65/35 Cotton-Polyester (D)
5	50/50 Cotton-Polyester (E)

TUMBLE DRYING VERSUS LINE DRYING

A statistical comparison of the data which resulted from tumble drying with that which resulted from line drying showed that, in all comparisons except one, tumble drying was more detrimental to the stability of the five types of trouser fabrics than was line drying, irrespective of yarn direction. This one exception was found in the filling direction of Trousers E (50/50 cotton-polyester) when both types of drying performed in a comparable manner.

SUMMARY

One hundred pairs of men's durable press khaki trousers and matching yardage, representative of five respective fiber-fabric-finish categories, were included by the author in the study reported in this thesis, for the purpose of finding the effects of laundering on the trousers, irrespective of wear. Especial emphasis was placed on the drying method followed in the laundering procedure, with tumble and line drying methods alternated with each trouser type.

The trousers were categorized with respect to their fabrics and finishes as follows: Trousers A (100); Trousers B (200); Trousers C (300); Trousers D; and Trousers E. Categories A, B, and C were made of all-cotton, with Fabric A having a melamine wet-fixation finish, Fabric B a modified pad-dry-cure treatment, and Fabric C a Koratron durable press application. Category D was composed of 65/35 cotton-Dacron 59 and was treated with a Coneprest III finish, whereas Category E consisted of a 50/50 cotton-polyester blend and was finished with a Lock-Prest durable press treatment.

The experimental trousers and fabrics were subjected to 30 periods of laundering under controlled conditions; and thereafter they were dried by means of tumble and line drying procedures, respectively, for comparative purposes.

Evaluations were performed at specified periods during the investigation, pertaining to the appearance of the trousers (fabric smoothness, crease retention, seam smoothness, and wrinkle recovery), together with durability tests (visible abrasion, breaking strength, tearing strength, and dimensional stability). Data from these evaluations were computed by means of an analysis of variance (AoV). Significant treatment effects were determined at the 95 per cent confidence level by means of Duncan's Multiple Range Test, and trouser types were ranked according to the number of times each demonstrated superior performance when statistical comparisons were made. These ranks were made directly from the mean values with regard to the consistency reflected by the standard deviations. The findings thus determined are summarized under two general headings Appearance and Durability with respect to type of trousers, and drying procedure as shown in Summaries B and C which follow.

APPEARANCE OF TROUSERS

A summary has been compiled of the rankings which resulted from the appearance evaluations made on the laundered trousers. The factors upon which appearance was based, as noted, included fabric smoothness, crease retention, seam smoothness, and wrinkle recovery of the five respective categories of trousers after they had been subjected to 30 periods of laundering and drying. Summary B, which follows, denotes the trousers categories, the type of evaluations, the method of drying, and the ranks of the trousers following laundering.

From the ranks tabulated in Summary B, an overall picture of the performance of the experimental trousers with regard to their appearance following laundering is evident.

Rank of Drying Methods. Taking all of the factors into consideration, the sum of the ranks for the two drying methods were not far apart as follows:

	Total Ranks
Tumble Drying.	62
Line Drying.	66

Rank of Appearance Factors. The five factors which were taken into consideration when the two drying methods were undergoing comparison had the following ranks with

SUMMARY B

Rank-Order Arrangement of Laundered Trousers with Respect to Their Appearance According to the Two Methods of Drying

Type of Evaluation	Rank-Order									
	Trousers A		Trousers B		Trousers C		Trousers D		Trousers E	
	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying
Fabric Smoothness	4	2	5	5	1	1	2	4	2	3
Crease Retention	3	3	4	3	1	1	4	5	2	2
Seam Appearance	5	4	4	4	2	2	1	1	2	2
Wrinkle Recovery: Warp	1	3	5	5	1	3	1	1	1	1
Filling	1	1	4	4	4	4	1	1	1	1
Total Ranks	14	13	22	21	9	11	9	12	8	9

respect to tumble drying and line drying:

	Tumble Drying Rank
Wrinkle Recovery, Warp	1
Wrinkle Recovery, Filling. . .	2
Seam Appearance.	3
Fabric Smoothness.	3
Crease Retention	5

	Line Drying Rank
Wrinkle Recovery, Filling. . .	1
Wrinkle Recovery, Warp	2
Seam Appearance.	2
Crease Retention	4
Fabric Smoothness.	5

Rank of Trouser Types. The trousers ranked as follows with respect to appearance after being dried according to the two methods used in this study:

	Tumble Drying Rank
Trousers E	1
Trousers D	2
Trousers C	2
Trousers A	4
Trousers B	5

	Line Drying Rank
Trousers E	1
Trousers C	2
Trousers D	3
Trousers A	4
Trousers B	5

From the data summarized above, it can be seen that the overall ranks differed only slightly with respect to the two methods of drying. Of the five fabric types used in the trousers, Trousers E (50/50 cotton-polyester fabric) ranked first with respect to appearance factors with both drying methods. This was followed closely by Trousers D (65/35 cotton-Dacron treated with a Coneprest III finish) after tumble drying and by Trousers C (all-cotton with a Koratron treatment) after line drying.

The lowest ratings emanating from both types of drying were received by the all-cotton Trousers A and B.

The appearance factors which were easiest to improve during laundering with both drying methods consisted of wrinkle recovery, both warp and filling. Seam appearance fared better with line drying, fabric smoothness with tumble drying, and crease retention with line drying. Differences between the two drying methods, however, were not extreme for all appearance factors.

These findings revealed the fact that the 50/50 cotton-polyester Trousers E and the all-cotton Koratron-treated C Trousers exhibited a desirable durable press performance for men's trousers which are durable to many launderings with no required drying conditions.

Evidence also points to the fact that trousers composed of a high level blend of cotton and polyester (65/35 per cent) and treated with Coneprest III finish also can perform in an acceptable manner when subjected to tumble drying.

The wet-fixation melamine and the modified pad-dry-cure treatment met with the least amount of success in producing a desirable durable press performance for the all-cotton trousers irrespective of drying procedure.

DURABILITY OF TROUSERS

The overall durability of the five respective durable press trouser fabrics as determined by rank orders developed from the actual number of broken holes; thinness of the creases; breaking and tearing strength; and dimensional stability of the fabrics shown in Summary C, which follows.

SUMMARY C

Rank-Order of Laundered Trousers with Respect to Their Durability According to the Two Methods of Drying

Type of Evaluation	Rank-Order									
	Trousers A		Trousers B		Trousers C		Trousers D		Trousers E	
	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying	Tumble Drying	Line Drying
Number of Broken Yarns	3	3	4	4	5	5	2	2	1	1
Crease Abrasion	1	1	1	1	1	1	4	4	5	5
Breaking Strength										
Warp	3	3	2	2	3	3	5	5	1	1
Filling	4	4	1	1	4	5	2	2	2	2
Tearing Strength										
Warp	2	2	3	4	3	2	5	5	1	1
Filling	4	3	3	3	5	5	2	2	1	1
Dimensional Stability										
Warp	3	4	5	5	2	2	1	1	3	3
Filling	1	1	5	2	4	3	3	4	1	5
Total Ranks	21	21	24	22	27	26	24	25	15	19

There was little difference in durability performance with respect to the two types of drying in the laundering treatments. The overall total ranks were 111 for tumble drying and 113 for line drying.

With respect to factors related to durability, the following total ranks give an overall summary of the comparative response of the fabrics to the two methods of drying during the laundering procedure:

	Drying Method Tumble	Drying Method Line
Total Ranks Based on the Number of Broken Yarns	15	15
Total Ranks Based on Crease Abrasion	12	12
Total Ranks Based on Breaking Strength, Warp.	14	14
Total Ranks Based on Breaking Strength, Filling	16	15
Total Ranks Based on Tearing Strength, Warp.	14	14
Total Ranks Based on Tearing Strength, Filling	15	14
Total Ranks Based on Dimensional Stability, Warp. . .	14	15
Total Ranks Based on Dimensional Stability, Filling .	14	15

Summary C reveals the overall durability of the 50/50 cotton-polyester Trousers E and the following order of durability performance for the remainder of the fabrics (ranked in the order given): Trousers A, B and D, C. Both drying procedures produced comparable results except in the case of Trousers D when this fabric performed in a more acceptable manner with tumble drying.

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A P P E N D I X

TABLE I

SMOOTHNESS OF NON-WORN DURABLE PRESS TROUSERS AS EVALUATED BY AATCC STANDARDS AFTER DESIGNATED PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	1-5	6-10	11-15	16-20	21-25	26-30
A (100) 100% Cotton	4.0	4.3	4.2	4.4	4.4	4.4
B (200) 100% Cotton	3.3	3.6	3.7	3.9	3.9	3.9
C (300) 100% Cotton	4.8	4.9	5.0	5.0	4.9	4.9
D 65/35 Cotton-Polyester	4.1	5.0	4.9	5.0	5.0	4.9
E 50/50 Cotton-Polyester	4.7	4.7	4.7	4.9	4.9	4.9

PART B. LINE DRIED

A (100) 100% Cotton	4.0	4.3	4.2	4.4	4.1	4.1
B (200) 100% Cotton	3.3	3.5	3.4	3.7	3.4	3.5
C (300) 100% Cotton	4.4	4.5	4.5	4.6	4.2	4.2
D 65/35 Cotton-Polyester	3.2	3.8	4.0	3.9	3.7	3.8
E 50/50 Cotton-Polyester	3.7	3.7	3.9	4.0	4.0	3.9

TABLE II

APPEARANCE OF CREASES OF NON-WORN DURABLE PRESS TROUSERS AS EVALUATED BY AATCC STANDARDS AFTER DESIGNATED PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	0-5	6-10	11-15	16-20	21-25	26-30
A (100) 100% Cotton	3.7	3.4	3.1	3.3	3.1	3.0
B (200) 100% Cotton	3.5	3.1	3.0	3.2	3.0	3.0
C (300) 100% Cotton	4.7	4.6	4.7	4.7	4.3	4.5
D 65/35 Cotton-Polyester	3.2	3.2	2.9	2.9	2.9	2.9
E 50/50 Cotton-Polyester	3.8	3.6	3.4	3.5	3.2	3.1

PART B. LINE DRIED

A (100) 100% Cotton	3.9	3.7	3.5	3.5	3.1	3.0
B (200) 100% Cotton	3.8	3.4	3.4	3.3	3.1	3.0
C (300) 100% Cotton	4.7	4.7	4.7	4.7	4.5	4.3
D 65/35 Cotton-Polyester	3.4	3.2	3.2	3.1	2.9	3.0
E 50/50 Cotton-Polyester	3.6	3.6	3.6	3.7	3.3	3.3

TABLE III

APPEARANCE OF SEAMS OF NON-WORN DURABLE PRESS TROUSERS AS EVALUATED BY AATCC STANDARDS AFTER DESIGNATED PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	0-5	6-10	11-15	16-20	21-25	26-30
A (100) 100% Cotton	4.1	4.0	3.7	3.5	3.4	3.5
B (200) 100% Cotton	4.1	4.2	3.8	3.7	3.6	3.5
C (300) 100% Cotton	4.5	4.5	4.3	4.2	4.1	4.2
D 65/35 Cotton-Polyester	4.3	4.8	4.7	4.7	4.7	4.6
E 50/50 Cotton-Polyester	4.2	4.2	4.1	4.2	4.1	4.2

PART B. LINE DRIED

A (100) 100% Cotton	4.2	4.1	3.8	3.7	3.5	3.3
B (200) 100% Cotton	4.4	4.1	3.9	3.9	3.5	3.5
C (300) 100% Cotton	4.8	4.7	4.5	4.3	4.4	4.1
D 65/35 Cotton-Polyester	4.5	5.0	4.9	4.8	4.9	4.7
E 50/50 Cotton-Polyester	4.8	4.6	4.7	4.5	4.4	4.8

TABLE IV

ABRASION OF NON-WORN DURABLE PRESS TROUSERS AS INDICATED BY BROKEN YARNS AND HOLES AFTER DESIGNATED PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings																				
	0			5			10			15			20			25			30		
	W*	F**	H***	W	F	H	W	F	H	W	F	H	W	F	H	W	F	H	W	F	H
A (100) 100% Cotton	1	0	0	27	5	1	52	6	2	103	6	2	143	7	2	198	7	2	369	40	15
B (200) 100% Cotton	5	0	0	15	1	0	28	2	0	75	3	0	111	6	1	222	19	6	464	65	29
C (300) 100% Cotton	1	0	0	6	2	1	17	2	1	79	3	1	183	10	2	269	52	16	777	103	37
D 65/35 Cotton-Polyester	2	0	0	19	0	0	26	0	0	38	0	0	51	0	0	155	3	3	328	6	5
E 50/50 Cotton-Polyester	4	0	0	11	0	0	14	0	0	22	0	0	32	0	0	40	0	0	51	0	0

PART B. LINE DRIED

A (100) 100% Cotton	7	0	0	23	1	0	90	6	1	110	8	1	124	9	2	178	12	4	252	40	10
B (200) 100% Cotton	0	0	0	12	1	1	25	2	1	52	3	1	67	6	1	112	19	4	264	65	12
C (300) 100% Cotton	0	0	0	5	2	0	21	2	0	43	3	0	78	8	0	187	50	6	416	103	18
D 65/35 Cotton-Polyester	0	0	0	3	0	0	14	0	0	25	0	0	35	0	0	57	3	0	158	6	2
E 50/50 Cotton-Polyester	0	0	0	2	0	0	6	0	0	9	0	0	11	0	0	13	0	0	29	0	0

*Warp **Filling ***Holes

TABLE V

CREASE ABRASION OF NON-WORN DURABLE PRESS TROUSERS EVALUATED BY MEANS OF A FLUORESCENT LIGHT ASSEMBLY INSIDE TROUSER LEG

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	5	10	15	20	25	30
A (100) 100% Cotton	5.0	5.0	5.0	5.0	5.0	5.0
B (200) 100% Cotton	5.0	5.0	5.0	5.0	5.0	5.0
C (300) 100% Cotton	5.0	5.0	5.0	5.0	5.0	5.0
D 65/35 Cotton-Polyester	5.0	4.4	4.0	3.8	3.4	3.5
E 50/50 Cotton-Polyester	4.4	4.0	3.7	3.5	3.2	3.4

PART B. LINE DRIED

A (100) 100% Cotton	5.0	5.0	5.0	5.0	4.9	5.0
B (200) 100% Cotton	5.0	5.0	5.0	5.0	5.0	5.0
C (300) 100% Cotton	5.0	5.0	5.0	5.0	5.0	5.0
D 65/35 Cotton-Polyester	5.0	5.0	4.4	4.6	4.0	4.0
E 50/50 Cotton-Polyester	4.6	4.2	4.1	4.0	3.7	3.8

TABLE VI

DRY WARP BREAKING STRENGTH OF NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING (POUNDS)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings						
	0	5	10	15	20	25	30
A (100) 100% Cotton	85.4	81.2	78.3	81.2	79.9	81.8	79.3
B (200) 100% Cotton	89.8	83.5	80.3	86.6	88.3	82.8	86.1
C (300) 100% Cotton	80.1	83.8	83.1	78.6	82.0	81.5	80.2
D 65/35 Cotton-Polyester	75.0	70.9	68.9	72.7	69.8	68.0	68.1
E 50/50 Cotton-Polyester	111.6	119.2	106.0	113.7	110.4	114.8	117.7

PART B. LINE DRIED

A (100) 100% Cotton	85.4	79.1	77.4	82.8	82.7	76.8	78.7
B (200) 100% Cotton	89.8	84.6	87.6	91.1	86.7	84.7	87.4
C (300) 100% Cotton	80.1	78.7	77.5	74.8	85.1	82.6	81.0
D 65/35 Cotton-Polyester	75.0	72.0	72.8	70.8	71.4	66.1	69.0
E 50/50 Cotton-Polyester	111.6	114.2	110.1	108.8	108.5	107.1	111.4

TABLE VII

DRY FILLING BREAKING STRENGTH OF NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING (POUNDS)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings						
	0	5	10	15	20	25	30
A (100) 100% Cotton	52.9	50.4	51.3	49.0	47.6	48.4	49.9
B (200) 100% Cotton	66.8	64.5	60.1	58.4	63.8	56.8	60.0
C (300) 100% Cotton	46.6	51.9	50.5	47.1	50.6	51.4	45.6
D 65/35 Cotton-Polyester	55.7	52.4	48.4	50.7	52.5	49.4	49.3
E 50/50 Cotton-Polyester	48.6	53.0	50.1	53.2	51.4	50.3	53.2

PART B. LINE DRIED

A (100) 100% Cotton	52.9	50.7	51.1	46.7	47.3	50.1	46.9
B (200) 100% Cotton	66.8	64.4	61.1	62.7	59.9	62.6	59.0
C (300) 100% Cotton	46.6	47.1	46.4	51.1	47.3	47.0	49.7
D 65/35 Cotton-Polyester	55.7	53.8	52.0	51.2	54.7	45.8	45.5
E 50/50 Cotton-Polyester	48.6	55.6	53.1	50.9	55.1	49.0	47.3

TABLE VIII

DRY WARP TEARING STRENGTH OF NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING

(GRAMS)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings						
	0	5	10	15	20	25	30
A (100) 100% Cotton	2590	2680	2980	2900	2720	3020	2880
B (200) 100% Cotton	2530	2540	2840	2660	2620	2780	2520
C (300) 100% Cotton	2670	2800	3000	2900	2600	2500	2510
D 65/35 Cotton-Polyester	1880	2040	2220	2200	1940	2020	1970
E 50/50 Cotton-Polyester	4760	4620	4340	4280	4160	4880	4970

PART B. LINE DRIED

A (100) 100% Cotton	2590	2740	2920	2920	2540	2740	2700
B (200) 100% Cotton	2530	2620	2720	2880	2340	2340	2530
C (300) 100% Cotton	2670	2860	2900	2760	2640	2540	2630
D 65/35 Cotton-Polyester	1880	2220	2280	2140	1940	1920	2070
E 50/50 Cotton-Polyester	4760	4600	4440	4480	4160	4900	4860

TABLE IX

DRY FILLING TEARING STRENGTH OF NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING (GRAMS)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings						
	0	5	10	15	20	25	30
A (100) 100% Cotton	2310	2220	2240	2200	1860	2120	2140
B (200) 100% Cotton	2480	2280	2220	2420	2100	2160	2150
C (300) 100% Cotton	1970	2220	2160	2320	1900	1980	2060
D 65/35 Cotton-Polyester	2700	2880	2720	2580	2440	2600	2630
E 50/50 Cotton-Polyester	3220	3280	3220	3360	3100	3380	3260

PART B. LINE DRIED

A (100) 100% Cotton	2310	2240	2220	2080	1960	2000	2140
B (200) 100% Cotton	2480	2140	2400	2320	2040	2060	2060
C (300) 100% Cotton	1970	2120	2160	2140	1780	1960	1980
D 65/35 Cotton-Polyester	2700	2940	2620	2700	2500	2500	2340
E 50/50 Cotton-Polyester	3220	3460	3320	3260	3300	3340	3290

TABLE X

DRY WRINKLE RECOVERY ANGLES OF NON-WORN DURABLE PRESS TROUSER FABRICS INITIALLY AND AFTER 30 PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Fabric Types	0 Launderings				30 Launderings			
	Warp		Filling		Warp		Filling	
	Face-to-Face	Back-to-Back	Face-to-Face	Back-to-Back	Face-to-Face	Back-to-Back	Face-to-Face	Back-to-Back
A (100) 100% Cotton	133.3	139.3	142.8	141.7	142.2	165.2	163.7	156.5
B (200) 100% Cotton	137.0	122.3	141.8	142.0	123.5	128.7	150.3	118.3
C (300) 100% Cotton	144.7	152.8	158.5	150.8	143.5	150.8	146.7	136.3
D 65/35 Cotton-Polyester	135.3	165.3	164.5	156.2	125.0	167.3	167.3	146.2
E 50/50 Cotton-Polyester	149.8	159.7	163.2	152.5	156.0	156.7	169.0	152.3

PART B. LINE DRIED

A (100) 100% Cotton	133.3	139.3	142.8	141.7	131.3	139.3	157.0	145.2
B (200) 100% Cotton	137.0	122.3	141.8	142.0	113.8	124.8	137.8	129.2
C (300) 100% Cotton	144.7	152.8	158.5	150.8	130.5	144.2	140.3	141.2
D 65/35 Cotton-Polyester	135.3	165.3	164.5	156.2	134.3	168.3	170.3	141.3
E 50/50 Cotton-Polyester	149.8	159.7	163.2	152.5	150.5	166.7	175.7	143.2

TABLE XI

PER CENT DIMENSIONAL CHANGE EXPERIENCED BY NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING (WARP DIRECTION)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	5	10	15	20	25	30
A (100) 100% Cotton	-1.5	-2.7	-2.2	-1.8	-2.2	-2.7
B (200) 100% Cotton	-2.5	-3.0	-1.9	-2.2	-3.3	-2.8
C (300) 100% Cotton	-1.2	-2.1	-2.5	-1.1	-2.3	-1.4
D 65/35 Cotton-Polyester	-0.7	-0.6	-0.7	-0.6	-1.0	-0.9
E 50/50 Cotton-Polyester	-1.9	-2.3	-2.0	-2.0	-2.7	-2.1

PART B. LINE DRIED

A (100) 100% Cotton	-1.4	-1.6	-1.1	-1.7	-1.3	-1.7
B (200) 100% Cotton	-1.9	-1.4	-1.0	-1.7	-1.7	-1.5
C (300) 100% Cotton	-1.0	-0.8	-1.2	-1.1	-0.8	-0.6
D 65/35 Cotton-Polyester	-0.5	-0.5	-0.4	-0.7	-0.3	-0.5
E 50/50 Cotton-Polyester	-0.9	-1.1	-1.2	-1.6	-1.1	-1.8

TABLE XII

PER CENT DIMENSIONAL CHANGE EXPERIENCED BY NON-WORN DURABLE PRESS TROUSER FABRICS AFTER DESIGNATED PERIODS OF LAUNDERING (FILLING DIRECTION)

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings					
	5	10	15	20	25	30
A (100) 100% Cotton	-0.3	-0.4	-0.2	0.0	0.0	-0.3
B (200) 100% Cotton	-1.4	-1.5	-0.9	-0.8	-1.6	-1.2
C (300) 100% Cotton	-0.5	-1.0	-1.4	-0.4	-1.0	-0.5
D 65/35 Cotton-Polyester	-0.3	-0.3	-0.3	-0.4	-0.6	-0.4
E 50/50 Cotton-Polyester	-0.2	-0.4	-0.2	-0.4	-0.6	-0.5

PART B. LINE DRIED

A (100) 100% Cotton	-0.2	-0.2	+0.2	0.0	+0.2	0.0
B (200) 100% Cotton	-0.4	-0.3	-0.1	-0.3	-0.2	-0.1
C (300) 100% Cotton	-0.5	-0.3	-0.6	-0.5	-0.3	+0.1
D 65/35 Cotton-Polyester	-0.3	-0.4	-0.5	-0.7	-1.0	-0.9
E 50/50 Cotton-Polyester	-0.4	-0.5	-0.3	-0.6	-0.5	-0.7

TABLE XIII

YARN COUNT OF NON-WORN DURABLE PRESS TROUSER FABRICS INITIALLY AND AFTER 30 PERIODS OF LAUNDERING

PART A. TUMBLE DRIED

Trouser Types	Number of Launderings			
	Warp		Filling	
	0	30	0	30
A (100) 100% Cotton	98.0	98.2	55.8	57.4
B (200) 100% Cotton	96.0	97.6	56.6	59.2
C (300) 100% Cotton	95.5	96.0	55.6	57.6
D 65/35 Cotton-Polyester	116.4	116.8	50.6	50.6
E 50/50 Cotton-Polyester	113.2	115.8	49.0	50.8

PART B. LINE DRIED

A (100) 100% Cotton	98.0	96.4	55.8	56.8
B (200) 100% Cotton	96.0	97.0	56.6	58.2
C (300) 100% Cotton	95.5	97.2	55.6	56.8
D 65/35 Cotton-Polyester	116.4	117.8	50.6	51.0
E 50/50 Cotton-Polyester	113.2	113.8	49.0	50.6