THE DURABILITY AND APPEARANCE OF ALL-COTTON AND COTTON-POLYESTER WORK TROUSERS AFTER WEAR AND LAUNDERING

A DISSERTATION
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN TEXTILES AND CLOTHING IN THE GRADUATE SCHOOL OF THE TEXAS WOMAN'S UNIVERSITY

COLLEGE OF
HOUSEHOLD ARTS AND SCIENCES

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Texas Woman's University

Denton, Texas

September, 1973

We hereby recommend that the dissertation prepared under our supervision by LaVera Dallman Roemhildt entitled "The Durability and Appearance of All-Cotton and Cotton-Polyester Work Trousers After Wear and Laundering"

be accepted as fulfilling this part of the requirements for the Degree of Doctor of Philosophy.

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CHAPTER I

INTRODUCTION

The study described in this report was conducted for the purpose of investigating the effects of wear and laundering upon men's durable press trousers of all-cotton and of cotton blended with various percentages of regular and high modulus polyester, respectively. A total of 108 pairs of trousers was included in the study. They were worn by blue-collar workers for 30 eight-hour periods and evaluated at specified laundering periods with respect to their appearance and durability.

Since the introduction of durable press in 1964, consumers have expressed concern relative to the strength loss of garments made from such fabrics. Cadwallader (10) found the strength loss of durable press to be a primary consumer complaint in the clothing market. The early problems experienced by manufacturers of cotton fabrics in durable press, particularly in men's and boys' wear, are well known; but improvements are being made in the overall performance characteristics of durable press. According to an editorial in the American Dyestuff Reporter (15), major chain retailers of durable press garments report a decrease in consumer complaints, which indicates that the in-use performance of these garments approximates the expectations of customers.

Several areas have been researched in an effort to improve durable press, including fabric construction variables, new finishes, fiber modifications, softeners, and soil release agents. As a means of achieving optimum performance and durability characteristics in men's trousers, considerable attention is now being placed on varying the blend level and type of polyester used in the fabrics.

Polyester-cotton blends are widely used in durable press garments to counter the adverse effects which this finishing treatment has on the strength and abrasion resistance of cellulosic fibers, according to Looney (32). Problems, however, have arisen in blending polyester and cotton. Canter, Jones, and Weaver (11) cited failures due to fiber moduli differences. According to their findings, the modulus of the stronger fiber should match that of the cellulosic fiber treated for durable press. High modulus polyester is the result of work which has been completed to improve the polyester itself. The engineering of a high wet modulus polyester with lower elongation has been found to contribute strength to the entire breaking range of cotton.

Evaluations and comparisons drawn from the research described in this report will be utilized in determining the optimum blend level of cotton and polyester and the type of polyester which will provide the wearing qualities desired in men's work trousers. The following specific objectives have been chosen as the basis for providing information needed for these determinations:

Specific Objectives

1. To obtain men's durable press trousers composed of all-cotton and of cotton blended with regular and high modulus polyester in 87/13, 75/25, 63/37, and 50/50 cotton-polyester percentage combinations;
2. To organize a wear panel composed of 27 blue collar workers;
3. To subject each pair of trousers to a total of 30 eight-hour periods of wear and laundering;
4. To evaluate the effects of wear and laundering upon the trousers at various intervals with respect to the following:
    a. Smoothness
    b. Crease sharpness
    c. Crease wear
    d. Broken yarns
    e. Soiling
5. To analyze and evaluate the performance of trousers after 30 wear and laundering cycles by use of the

following tests:

a. Dry wrinkle recovery

b. Breaking strength

c. Tearing Strength

d. Flat abrasion

e. Colorfastness

6. To compare the results of this study relative to fabric performance with a comparion study of matched fabrics; and

7. To analyze the data by statistical methods with respect to blend level and type of polyester in relation to fabric performance.

CHAPTER II

REVIEW OF LITERATURE

Durable press garments of polyester-cotton blends including men's work trousers have become popular as an item in the ready-to-wear market. Durable press has been defined by Lee (29) as the ability of a garment to keep its shape-retention properties including sharp creases, flat seams and wrinkle-free appearance for its wear life. Forrester and Davison (16) emphasized that the production of polyester-cotton blend durable press fabrics which will meet end-use specifications and give consumer satisfaction relative to men's work trousers requires a well-engineered fabric and selection of the proper chemicals by the finisher to treat a given polyester-cotton blend. The engineering of a fabric involves many factors, including fiber blend, yarn size and twist, and fabric construction to achieve the desired properties.

Fabrics made of 100 per cent cotton, which introduced the durable press era, have been replaced to a large extent by polyester-cotton blended fabrics in men's work trousers. The chemical treatment used to produce cellulosic durable press garments reduced the tear strength and abrasion resistance up to 50 per cent or more, according to Lee (30). In addition, Moussalli and Browne (34) found that about 33 per cent of breaking elongation and 50 per cent of breaking strength is lost when all-cellulosic fabrics are resin finished to produce durable press fabrics.

Since the chemical treatment of cellulosics through the use of resins to produce durable press resulted in the loss of breaking strength and elongation, the average toughness which is one-half the product of breaking strength and breaking elongation also was reduced. Toughness has been defined by Dyer (14) as the quality of enduring stress and deformation without rupture.

It was necessary, therefore, to resolve these losses, and the solution to the problem was assumed to be the blending of synthetics with cellulose. Lee (30) pointed out that synthetic fibers, including acetate blended with cellulosics, are not affected by the use of chemicals in finishing. The addition of strong, chemically resistant fibers such as nylon and polyester were introduced to reinforce cotton. Moussalli and Browne (34) stated that polyester has become the preferred fiber because of its ease-of-care and superior hand, in addition to the availability of a suitable dyeing method.

Fortess and Stultz (18) found that polyester-cotton blends have produced a satisfactory fabric with respect to breaking strength, resistance to abrasion, and retention of shape at 9.0, 8.5, and 6.0 ounces per square yard for men's and boys' casual slacks. The first durable press garments were made of eleven-ounce fabric and, therefore, were rather heavy. Jackle (25) gave several reasons relative to the increasing demand for polyester including durability without excessive weight; high breaking strength and abrasion resistance; retention of appearance including wrinkle resistance and retention of creases; ease of care qualities; and dimensional stability.

Nylon also has displayed many outstanding properties in durable press fabrics, including high strength, breaking elongation, abrasion resistance and recovery from deformation. According to Stille (44), however, its resiliency is lower than that of polyester since it has an aliphatic structure which provides greater flexibility. Polyester, on the other hand, has an aromatic structure which contributes stiffness resulting in outstanding resilience and wrinkle recovery.

Richardson (39) compared the fiber performance of polyester and nylon in terms of work recovery. He stated that work recovery determines the performance of a fiber relative to wrinkle recovery, ability to accept and retain sharp creases and pleats, and fabric resilience. According to Richardson, polyester provided good work recovery from the 1.0 to 3.0 per cent level of recovery from low stretch, whereas nylon did not. Good work recovery from the 1.0 to the 3.0 per cent level results in a resilient fiber. Nylon is superior in recovery from high stretch above 3.0 per cent and is, therefore, highly suitable for use in women's hosiery and other items requiring high stretch.

Polyester-cotton and nylon-cotton blends in boys' durable press trousers were studied by Roch (41) at Texas Woman's University. The study researched 121 pairs of boys' trousers treated with a Koratron finish which represented blends of 65/35 and 50/50 per cent polyester-cotton, in addition to blends of 85/15 and 92/8 per cent cotton-nylon.

The 64 pairs of worn trousers were evaluated after each of 35 wear-laundering periods relative to wash-and-wear appearance, crease retention, general wear, staining, and color change. The remainder of the trousers was reserved for physical testing at designated laundering periods and comprised the non-worn group.

The polyester-cotton trousers exhibited the highest performance throughout all wear-laundering intervals in relation to appearance, crease sharpness, seam smoothness and visible wear as contrasted to the ratings of the cotton-nylon trouser types. No significant differences between trouser styles were noted in stain retention and frosting. The polyester-cotton trousers, however, again performed in a superior manner for the physical tests with good correlation between laboratory and wear tests. Improved wear qualities were associated with trousers containing the higher percentages of synthetic fibers.

The production of regular polyester-cotton fabrics to compensate for strength and abrasion loss was not completely successful, however. Manufacturers were quite concerned when "fortified" fabrics failed in certain applications. Canter, Jones, and Weaver (11) discussed one of the early problems of polyester-cotton blends relative to boys' trousers bursting at the knee, although the fabric was a 50/50 polyester-cotton blend, and laboratory tests indicated excellent breaking strength, tearing strength and abrasion resistance. Investigations of these authors led them to the following conclusion:

> These unexpected failures are shown to be due to differences in the moduli of the fibers, up to the rupture point of the resin treated cotton and can be duplicated in the laboratory by stretching a blended fabric beyond the breaking elongation of the cotton, relaxing the stretched fabric, manipulating the fabric in order to remove the cotton fragments and finally "breaking" the loosely coherent polyester yarns which remain.

> . . . If wear life of garments is related to the toughness of the fabric employed, then it is obvious that the maximum wear life of a durable press blend should be achieved with fibers whose moduli are compatible up to the rupture point of the weakest fiber. If this weakest fiber is cotton or rayon, then the modulus of the stronger fiber should match that of the cellulosic fiber treated for durable press, not that of the untreated fiber.

Many researchers have studied the design of a polyester fiber for blending with cotton which takes into account stress-strain curve relationships of the two fibers. Alpert (2) found that the modulus of regular polyester is not matched with that of cotton. When strain is applied, the lower elongation of cotton causes it to break first, and then the polyester breaks. Since each component in this system acts independently, the full potential of the fabric is not realized.

A second generation of polyester, high modulus polyester, has been specifically engineered for blending with cotton. According to Norris (35), stress-strain characteristics of the high modulus polyester closely matched those of cotton throughout the cotton stress-strain curve. This means that both fibers in the blend bear the load throughout the total breaking range of cotton.

Dyer (14) found that the selection of a polyester fiber with desirable properties for blending with a given grade of cotton can be determined by a comparison of the stress-strain curves of the polyester fibers being considered with the stress-strain curve of any given cotton fiber at strains or elongations up to the breaking elongation of the cotton. The author stated that theoretical calculations of mechanical properties related to tensile stress of materials can be applied to the engineering of a fiber. Mechanical properties included were strength or ability to resist stress; stiffness or ability to resist deformation when supporting a load; elasticity or ability of the stretched yarn to return to its original shape after the load is removed; resilience or ability to resist permanent deformation; and toughness or ability to endure stress and deformation without rupture.

Cone (12), however, explained that detailed problems are not always a known quantity to those who specify fibers and attempt to predict yarn and fabric behavior. For example, a great difference exists between the natural twist of cotton and twist given a synthetic fiber intended for blending with cotton. Compatibility of any given staple length also may cause problems. In addition, natural fibers tend to vary more within themselves than man-made fibers.

Many polyester fibers exemplifying a variety of performance characteristics are on the market, but only two are considered at this point since they closely match the stress-strain curve of cotton. Vycron Tough Stuff, a high modulus fiber, is Beaunit's (7) answer to polyester fibers which elongate to a greater extent than the cotton fiber they are reinforcing. This fiber has been engineered for lower elongation to produce added toughness and characteristics more compatible with cotton.

Kodel IV high modulus polyester developed by Tennessee Eastman is another example of the engineered approach. The stress-strain curve of Kodel IV high modulus fiber closely matches the stress-strain curve of cotton at all levels of stress up to the breaking point of cotton and has a higher breaking strength, according to Dyer (14). He reported that the increased benefits of these high modulus polyesters made possible the use of a lower resin concentration on the cotton fiber resulting in improved abrasion and breaking strength characteristics.

Fiber blending for durability and appearance has been of primary importance in the textile field, but the type and amount of fibers in blends have been a debatable question. Many opinions have been expressed concerning the type and amount of fibers necessary to provide optimal performance in durable press blended fabrics.

In an editorial which appeared in the American Dyestuff Reporter (15), blend levels were discussed indicating that higher percentages of polyester were being used due to lower price differential from raw material to end-product. However, it was pointed out that reverse blends with a higher percentage of cotton than polyester were becoming popular in garments which at one time were all-cotton. Joseph (27) made this statement:

> For most blends on the textile market, optimum percentages have been established for at least one of the fibers involved. For example, it has been fairly well agreed among textile manufacturers that in blends of polyester and cotton, the percentage of polyester should range between 50 and 65 per cent.

Many researchers have studied the problem of predicting optimal blend levels. With respect to prediction of blended yarn strength, research by Denyes (13) yielded the following information:

> . . . By determining yarn strengths of any two fibers in 100 per cent form and plotting the stress-strain curve of each of the two fibers, an accurate curve can be drawn to plot the yarn strengths that will be achieved from blends of the two fibers. For the mill man critically assessing the performance of the spun yarn through spinning, weaving, or knitting, not only yarn strength, but also yarn elongation must be considered. Using the same method by which strength is determined, it is also possible to predict elongations that will be achieved at any blend level.

The stress-strain curve obtained indicated a transitional point, that is the point at which the high strength fiber dominated the blend. The addition of small amounts of a stronger fiber to a weaker fiber sometimes actually depressed the yarn strength. Increasing the amounts of the stronger fiber, however, reversed the trend to establish a transitional point. Smith (43) reported this phenomenon relative to Kodel IV when used in a blend with cotton.

> As the amount of Kodel fiber in a blend with cotton increases, strength of the spun yarn decreases until approximately 50% Kodel IV has been added to the blend. At this point, spun yarn strength begins to increase.

To obtain optimal fabric properties, blend levels of Kodel IV were set forth by Eastman Chemical Products, Incorporated and were based on laboratory results and wear-test experience. A minimum of 50 per cent Kodel IV for yarns of 36/1 cotton count or coarser and a minimum of 65 per cent Kodel IV for 37/1 cotton count or finer were recommended.

Smith (43) discussed two major factors which are used to determine polyester content in a blend with cotton to achieve optimal strength and ease-of-care. Lighter weight fabrics, such as batiste, are composed of fine yarns and require a higher percentage of polyester than a twill or poplin which contain coarser yarns. Also, yarn strength, grab and tear strength were found to be adequate in 50/50 polyester-cotton fabrics when yarn counts are coarse and the fabric is medium-weight.

Forrester and Davison (16) pointed out that blend level must be selected relative to overall fabric properties, including strength and elongation for the desired end-use performance. In addition, these authors stressed the importance of economic considerations.

> It has been shown that the higher the polyester content in cellulosic blends, the higher the fabric strength and elongation. For some fabrics such as batistes, broadcloths, etc., higher strength and elongation is important. However, heavier weight fabrics of large volume such as those used in the work clothing field can be materially up-graded by the use of smaller percentages of polyester fiber than those normally employed. In this area pure economics play an important role.

In research at Texas Woman's University, Ball (5) considered the type of wear and the effect of wear relative to fiber content and fabric finish. Two hundred pairs of men's durable press trousers representing five categories, including the all-cotton of 3/2 construction finished by three different treatments; the 3/1 twill of 65/35 cotton-polyester with a Coneprest III finish; and the 3/1 twill of 50/50 polyester-cotton with a Lock-Prest treatment were evaluated relative to appearance.

From overall comparisons after 30 wear-laundering cycles irrespective of trouser style, the investigator found that the type of wear relative to blue collar versus white collar wearers had no influence on smoothness. Crease sharpness, however, was superior in the trousers worn by the white collar group, whereas smoother seams were demonstrated by the trousers worn by blue collar workers.

Overall comparisons after 30 test intervals irrespective of trouser style proved that non-worn trousers demonstrated superior smoothness, sharper creases and smoother seams than the worn trousers. In summary, the all-cotton Koratron finished trousers achieved the highest overall rank followed by the 65/35 cotton-polyester with the Cone-prest finish relative to appearance.

Smith (43) stated that polyester fibers play an important role in blends with cotton due to a reduction in the price of the raw fiber. Other factors cited were the high resiliency of polyester; the development of high modulus fibers compatible with the stress-strain curve of cotton; and the engineering of polyester fibers with high white retention made possible by the use of optical brighteners.

In companion studies at Texas Woman's University, research was conducted relative to Type 180 sheets constructed from 100 per cent cotton and cotton blended with regular and high modulus polyester in 87/13, 75/25, 63/37, and 50/50 cotton-polyester percentage combinations. A carbamate durable press finish was used on 108 sheets and the remainder were untreated. After 50 periods of use and laundering, Bostrum (8) found that regular polyester out-performed high modulus polyester relative to smoothness, whiteness, and resistance to pilling. On the other hand, research by Burkett (9) proved that high modulus polyester was superior to regular polyester in breaking, tearing, and bursting strength. Exceptions, when found, occurred in the 87/13 cotton-polyester blends where no difference in performance of the polyester types was sometimes noted.

Texas Woman's University has conducted many studies to determine desirable blend levels relative to various end-uses, including trousers. Two of these studies were considered at this point, since they involved comparisons between regular and high modulus polyester in blends with cotton.

"Comparative Evaluations of Men's Work Trouser Fabrics Composed of All-Cotton and of Cotton Blended with Regular and High Modulus Polyester" was the title of a study by Larson (28). Fabrics were identical to those used in the construction of the trousers evaluated in the study reported in this manuscript and were subjected to 30 home laundering and tumble-drying cycles. The fabrics were composed of all-cotton and cotton blended with regular and high modulus polyester in 87/13, 75/35, 63/37, and 50/50 cotton-polyester percentage combinations. Fabrics were evaluated at specified intervals to determine appearance and durability performance.

No definite pattern relative to significant differences between the performance of the cotton-high modulus polyester blends and the cotton-regular polyester blends was found relative to durable press appearance, wrinkle recovery, colorfastness, resistance to flat abrasion or dimensional stability. High modulus polyester blends, however, did significantly outperform regular polyester blends in tearing and breaking strength relative to both yarn directions.

Overall performance ranks showed that cotton-high modulus polyester fabrics were superior to fabrics containing the regular polyester at all blend levels. In general, the higher the percentage of polyester the higher the overall rank with the exception of the 75/25 cotton-high modulus polyester which received a higher overall rank than did the 63/37 cotton-regular polyester. The 100 per cent cotton trousers received the lowest overall rank position.

Turner (47) also studied the end-use performance of men's durable press work trousers made of all-cotton and of cotton-polyester blends. Five trouser types made of twill fabrics composed of the same weave and weight were used as test specimens with fiber content and finish as variables. The five experimental combinations were 65/35 cotton-polyester, Coneprest III; 50/50 cotton-polyester, Koratron; all-cotton, Fixapret PCL; all-cotton, Fixapret CP-40; and all-cotton, Koratron. The trousers were subjected to 15 wear-laundering cycles. Appearance, crease sharpness, and general wear were evaluated following each laundering interval. Soiling was evaluated before and after each laundering. Physical tests were performed initially and after 15 wear-laundering cycles relative to reflectance, dry and wet wrinkle recovery, dry and wet breaking strength, dry tearing strength, and resistance to flat and edge abrasion.

The all-cotton trousers with both types of Fixapret finish outperformed the remaining styles relative to crease wear. The Fixapret PCL finish demonstrated superior color retention while the Fixapret CP-40 finish received second rank with regard to general wear for the all-cotton trousers. The Koratron finish received favorable appearance, crease retention and wrinkle recovery performance values in the 100 per cent cotton trousers.

The 65/35 cotton-polyester, Vycron Xtra-Tuf trousers with a Coneprest III finish achieved superior appearance and durability ratings and ranked in first position relative to overall performance. Koratron finished 50/50 cotton-polyester trousers ranked second relative to durable press ratings and first in wrinkle recovery and crease retention. General wear and crease wear ratings, however, were low.

Therefore, this trouser type received the second rank in overall performance and was followed by the all-cotton types.

In addition, Dyer (14) of Tennessee Eastman Company conducted a study of durable press heavyweight twill fabrics in which a blend of 50/50 high modulus polyester-cotton was compared with that of 50/50 regular polyester-cotton. The high modulus blend was significantly superior in tensile strength when tested by both the grab and ravelled strip methods. Further observations showed no difference relative to appearance, wrinkle recovery, pilling or shrinkage.

Joseph (27) stressed the importance of fiber, yarn and fabric geometry as a means of predicting potential behavior of a given fabric. The potential change in fabric characteristics due to finishes now employed, however, was emphasized.

A study to determine optimal fabric construction was conducted by Looney (32) to interpret the relationships of such variables as polyester content, yarn size, yarn twist, fabric tightness and weave relative to the wear qualities of polyester-cotton durable press trousers. Fabric weight was considered to be an independent variable based on yarn count and fabric tightness relationships. Each of the variables was evaluated individually at several levels while fixing remaining variables at the design mid-point designated by a 2/1 twill similar to a common commercial fabric.

Prior to testing, the individual fabric pieces were pressed, cured and subjected to five launderings in order to remove the excess resin present. Physical tests included grab strength after surface abrasion; measurement of weight loss, edge abrasion and bursting strength due to Accelerotor abrasion; and a modified Wyzenbeek test, which involved concentrated abrasion of fabric under tension by rubbing it against an abrasive surface which was irregular.

The outcome of this study showed that the flat and Accelerotor abrasion resistance of polyester-cotton warp faced durable press fabrics can be improved by increasing the percentage of polyester; reducing weave tightness by increasing the number of warp threads per unit width of fabric; by reducing yarn twist; and by using loose weave constructions such as a 2/2 twill. Edge abrasion resistance, however, was increased by using fewer total yarns as opposed to flat abrasion results.

Laundry durability tests of men's trousers made from the experimental fabrics showed good correlation with laboratory tests. Interpretation of laboratory results apparently indicated that at a constant polyester content durability is determined to a great extent by fiber mobility, since in nearly every case, an increase in durability was noted as fabric stiffness decreased. In addition, since warp yarns were on the surface, they absorbed initial damage due to abrasion. Therefore, increasing the number of warp yarns per unit width of fabric can be expected to increase durability.

It was found, however, that a combination of high polyester percentage, low yarn twist, use of coarse yarns and mobile fabric structure resulted in pilling. Further research relative to the 2/2 twill revealed that pilling can be controlled by an increase in yarn twist and in yarns per inch without sacrificing resistance to flat abrasion.

Forrester and Davison (16) , in their study of polyester/cellulosic blend fabrics, found that the engineering of polyester-cellulosic blend fabrics requires determination of the optimal number of warp and filling yarns in relation to the number of interlacings found in the fabric. This relationship is expressed as warp and filling cover factor or the ratio of threads per inch to the square root of the yarn count. Therefore, there is a maximum warp and filling cover factor which can be woven for any given yarn count and yarns per inch. The ratio of warp plus filling cover factors for the fabric to be constructed to the sum of the maximum cover factors which can be woven for that weave and yarn size equals the per cent maximum construction. Most well-designed fabrics range between 80 and 95 per cent maximum construction. Per cent maximum construction influences fabric tightness, hand, strength, and tendency to pill.

Denyes (13) related fabric structure to tensile properties of woven fabrics in his study entitled "Durable Press, the Role of Polyester." Data from this study of Kodel IV regular polyester and untreated cotton blends indicated very high correlation between spun yarn strength and fabric ravelled strip strength when blend curves were compared. He pointed out, however, that grab and tear tests are more complex. In the grab test breaking strength is influenced by the yarns directly between the jaws in addition to those outside the jaws. Denyes (13) explained the relationship which exists as follows:

> The amount of reinforcement is dependent upon the mobility of the yarns within the structure of the fabric and is determined by such factors as weave, tightness of construction, finish applied to the fabric, and particularly by the elongation of the yarns within the fabric. The greater the mobility of yarns within a fabric or the elongation of yarns, the more reinforcement that will be achieved from these ends outside of the width of the jaws.
>
> Tear strength results are also dependent upon mobility of yarns within the fabric and the elongation of the yarns. With little mobility or elongation, as experienced in a sheet of paper, for example, tear strength is extremely low. Greater mobility or

> elongation such as might be found in an elastic fabric can significantly increase the resultant tear strength.

When both yarn strength and elongation were plotted, based on the strength of the 100 per cent yarns for each fiber in the proposed blend, grab and tear strength did not follow the established yarn curve. However, both grab and tear strength increased at the transitional point relative to elongation with 30 to 40 per cent Kodel IV. At lower percentages of Kodel the elongation is low since both fibers are working together. At higher Kodel percentages when the high elongation of the fiber influences the total blended yarn, elongation increases; and a rapid rise in grab and tear strength can be predicted. With respect to this observation, Denyes (13) offered these comments:

> Spun yarn strength for the blend of Kodel IV and cotton is at its lowest level at approximately a 50/50 blend of these two fibers. However, grab and tear strengths are equal to or higher than the original cotton blend at this same level. This becomes extremely important since extensive testing has shown grab and tear test to be the best laboratory measures of the tensile properties of fabrics to determine how a fabric will perform in use.

The previous discussion has been based on non-resin treated blended fabrics. To understand relationships existing after durable press finishing, blend curves must again be constructed based on resin treated cotton properties. Tests confirmed that cotton lost approximately 66 per cent of its original breaking strength and 50 per cent of its elongation after the resin treatment. Research on resin treated polyester-cotton blends at Tennessee Eastman by Denyes (13) revealed the following:

> . . . that the transitional point of strength or the point at which the Kodel fiber becomes the dominant factor of the blend occurs at about 20%, whereas prior to durable press this point occurred at about the 50% blend level. Yarn elongation has also been affected. The elongation begins to rise at a lower blend level than previously experienced. A comparison of the two curves at the 50% level shows strength to be the same before and after resin treatment; however, after resin treatment, yarn elongation is higher. It must be remembered that in practice neither the cotton fiber nor the spun yarn would be resin treated. This curve has been documented by raveling yarn from fabric and by testing cotton fibers removed from fabrics which have been fully resinated for durable press finishes. This has allowed a much better understanding of fabric properties. As can be seen, an entirely new picture is created. At all blend levels containing more than about 20% polyester, the polyester dominates the blend. Therefore, resultant fabric properties are quite dependent upon the polyester fiber.
>
> . . . Earlier it was pointed out that yarn strength of a 50% blend level for Kodel IV and cotton yarn was the same before and after resin treatment but that yarn elongation was somewhat higher after treatment. An influence of this change is evidenced by repeated findings that many fabrics containing a 50/50 blend exhibit slightly higher grab and tear strengths after resin treatment. The effects of resination have caused the cotton to be less able to restrict the Kodel fiber so that its full strength and elongation are utilized.

Another major factor of importance is fabric abrasion resistance. In heavyweight fabrics, Denyes (13) found that the presence of small amounts of man-made fiber may provide adequate grab, tear, and abrasion resistance to meet minimum requirements relative to laboratory abrasion tests. He emphasized, however, that the resin-treated cellulose in the blend abrades quickly, leaving only the man-made component, and recommended that adequate amounts of the synthetic fiber be used to pass laboratory tests and provide garment serviceability during actual wear.

The study by Denyes (13) concerned regular polyester-cotton blends. In summarizing the research conducted, he made the following statement relative to modified polyester:

> A modified polyester fiber with high strength and low elongation can provide better blend compatibility with cotton. However, the resins currently used to produce durable press so severely change the strength characteristics of cotton that this improvement is not realized after resin treatment. Final fabric strength is almost totally dependent upon the polyester in the fabric; therefore the normal polyester fibers, such as Kodel IV, perform as well as those with modified tensile characteristics. With further advancement in resin technology, the potential offered by modified fibers may be realized.

Stultz (45) designated blends of polyester and cotton as the major fabric on the present market for men's work clothing and men's and boys' casual wear. Since this blend predominates, so do the procedures under which it is finished. Success of durable press depends upon fiber type, yarn size, yarn twist, fabric construction, blend level, and the finishing process employed. Reid (37) stated that the post-cure durable press resin generally used on men's work trousers of polyester-cotton blends at the present time is the cyclic reactant dimethyloldihydroxyethyleneurea (DMDHEU). DMDHEU meets the requirements for colored fabrics, but it is not suitable for white goods because of its poor resistance to chlorination, according to Alexander (1). Frick et al. (19) found that repeated laundering lowered chlorine resistance; however, a high degree of wrinkle resistance was retained. With respect to the use of DMDHEU Jones (26) made the following comments:

> It is a sobering fact that, while research has been able to offer more and more varied procedures for improving durable press cotton-containing materials, actual mill practice has been becoming less and less varied. Use of the cheapest available resin (DMDHEU) applied by the most convenient procedure (pad-dry-cure) to polyester-cotton blends is currently so acceptable that there is often little incentive to introduce new processes whose specific merits are to improve the strength and abrasion resistance of the cotton component.

The use of carbamate finishing agents in the deferred-cure durable press process has been suppressed because of the high release of formaldehyde from sensitized fabric during storage and manufacture. Reid, Küllman and Reinhardt (38) explained methods used in an attempt to solve the problem:

> Methods have been sought for reducing or eliminating free formaldehyde normally present in solutions of methylolated carbamate finishing agents. Techniques pursued for producing carbamate solutions with decreased free formaldehyde contents were a) improving the efficiency of methylolation, b) removing free formaldehyde by physical means, and c) treating the

solution with a chemical agent to consume the free formaldehyde.

These methods were studied at the Southern Regional Research Laboratory by Reid et al. (38). Decreases in free formaldehyde were attained by improving the efficiency of methylolation and consumption of the free formaldehyde by treating the solution with a chemical agent. Physical methods were not successful for the removal of free formaldehyde.

It was found that fabrics treated in the above manner demonstrated less resistance to chlorine damage when bleached. Modified carbamate products, however, may be useful for colored fabrics which do not require bleaching.

Beaumont (6) summarized the requirements of resins suitable for durable press dyed fabrics as follows:

1. The ability of the resin system to remain in a dormant state within the fabric for an extended length of time without curing.

2. The ability of the resin system to give performance when activated with heat at a later date equal to or near equal to the performance given when cured immediately after application.

3. The resin must give a high level of performance.

4. The resin must not leave odors in the fabric.

5. The resin must be durable to repeated washings.

6. The resin must not cause dyestuffs to lose an excessive degree of light-fastness or cause an excessive shade change.

Reid (37) held the opinion that resins used for producing durable press goods are limited in number and ruled out the following types of resins and reactants for deferred cure:

1. Urea formaldehyde monomers, because of fish odor and speed of cure.

2. Most of the ethyl, methyl and hydroxyethyl carbamates, because of the excess free formaldehyde that they contain and yield as readily during the pressing of the garments.

3. Most of the triazones, because of their development of fish odor. However, some modified triazones are still under investigation.

4. Melamines tend to harshen because of the formation of three dimensional polymer--they often cure readily and give bad odor. When modified with urons they have greater stability.

5. Urons are still under investigation but so far they are not used in any great quantity.

6. Sulfonyl diethanol and similar sulfones that cure on the alkaline side tend to yellow the fabrics and are toxic unless afterwashed.

7. Acrolein derivatives cannot be considered because of lachrymose effect on the eyes.

8. Acetals give off excessive formaldehyde.

9. Epoxy reactants lack good wrinkle recovery.

Fortess (17) stated that the post-cure or delayed-cure approach involves chemical treatment of the dyed fabric; drying at low temperatures so that minimum cross-linking takes place in the flat fabric; fabrication to the garment stage; pressing; and finally curing the fabric or garment to form the cross-links.

The deferred-cure process, according to Beaumont (6), was launched by the Koratron Company in 1964 and is regulated by a licensing and royalty program subject to a quality control system. Koratron's process moved a chemical operation from one industry to another, turning the garment manufacturer into a textile finisher.

Harper and Bruno (23) studied various aspects of finishing all-cotton and polyester-cotton fabric blends using dimethyloldihydroxyethyleneurea (DMDHEU) as the cross-linking agent. Three fabrics including all-cotton, 50/50 polyester-cotton, and 65/35 polyester-cotton were treated with various levels (2.3, 4.5, 6.8, 9.0 and 11.3 per cent) of the cross-linking agent DMDHEU using the conventional pad-dry-cure process.

Results indicated that relative to nitrogen content, the percentage of nitrogen bound to any given fabric type increased as the amount of the crosslinking agent in the pad bath increased. Also, the percentage of nitrogen bound to the blended fabric types was about 90 per cent that of the all-cotton fabric.

A special fabric blend treated with 9.0 per cent DMDHEU which had an all-cotton warp and a 100 per cent polyester filling was used to determine what occurred in the blended fabric. The conclusion drawn was that the use of a crosslinking finish formulation designed for all-cotton fabric on a blended fabric caused the cotton component in the blend to be excessively crosslinked. It was further observed that excessive crosslinking lowered the strength and abrasion resistance characteristics of the cotton.

Harpo and Bruno (23) inspected bulletins of several fiber producers and found that the recommended finish formulations were 9.0 to 11.3 per cent DMDHEU for cellulose containing fabrics whether all-cotton, 50/50 polyester-cotton, or 65/35 polyester-cotton, without provision for adjusting formulas to compensate for percentage of cotton in a given fabric. These authors stated that the above practice results in excessive add-on relative to the cotton component in the blend and suggested a 4.5 per cent DMDHEU as adequate in polyester cotton blends to achieve a durable press rating equivalent to the 9.0 per cent DMDHEU in the all-cotton fabric.

In further research, Roberts (40) concluded that the amount of resin add-on and cross-linking is much greater for the cotton component of a blended fabric than occurs in an all-cotton fabric treated with the same resin formulation. In addition, he found that this trend is accentuated as the percentage of cotton in the blend is lowered.

To further illustrate these concepts, Harper and Bruno (23) researched two fabrics finished with varying levels of the crosslinking agent DMDHEU. Both fabrics had the same all-cotton warp; however, one fabric had an all-cotton filling and the other a 100 per cent polyester filling. The investigators found that the cotton warp in the blend was cross-linked to a greater extent than the all-cotton when both fabrics were given the same treatment with a specified percentage of the crosslinking agent.

An evaluation of wrinkle recovery, breaking strength and tearing strength led to the conclusion that the same performance level can be obtained in the blend by using approximately half the amount of the crosslinking agent that was applied to the all-cotton fabric due to excessive crosslinking of the cotton component in a blend. For example, the cotton warp yarns of the blended fabric treated with 4.5 per cent DMDHEU had wrinkle recovery, breaking strength, and tearing strength values about equal to that of the all-cotton fabric treated with 9.0 per cent DMDHEU.

Abrasion resistance, also, was evaluated, but Harper and Bruno (23) pointed out that the evaluation of abrasion resistance is difficult to demonstrate, since both yarn directions and polyester toughness are involved in abrasion tests. Findings indicated that abrasion resistance was reduced by excessive crosslinking. Although the untreated blended fabric had an initial flex resistance about three times that of the untreated cotton fabric, excessive crosslinking in the DMDHEU blended fabric reduced the flex resistance to a lower value than that of the crosslinked all-cotton fabric.

Finally, Harpo and Bruno (23) investigated a series of four broadcloths consisting of 100 per cent cotton; 50/50 polyester-cotton blend yarns in warp and filling; 100 per cent cotton warp and 50/50 polyester-cotton blend filling; and 50/50 polyester-cotton blend warp, 100 per cent cotton filling. The results indicated a tendency for the crosslinking resin to shift to the all-cotton component. These authors concluded:

> The necessity for control of treatment levels in the crosslinking of blended polyester-cotton fabrics has been examined from the view point of whether cotton fibers in such blends are overcrosslinked. It was concluded that overcrosslinking can be easily done if a treatment suitable for an all-cotton fabric is applied to blends with no allowance for the percent polyester in the blend. This danger of overcrosslinking becomes greater as the amount of cotton in the blend is decreased.

The wide use of polyester-cotton blends poses a challenge for cotton researchers, and the problem is being approached in three ways, according to Jones (26). Adding new or desirable features at the crosslinking stage, such as fire retardancy, is a classic example. A second approach involves conversion of the cotton fiber structure into a form which accepts the crosslinking resin without losses in physical properties, such as in the vapor phase process.

Jones (26) described the advantages of the vapor phase formaldehyde/sulfur dioxide process for garments as follows:

> Probably the most promotable feature of this process is the new, high level of durable press possible. Elimination of problems associated with storing, cutting, sewing and pressing resinated fabric; stabilization of cellulose-containing sewings and trimmings, the high line-dry performance; the known durability of formaldehyde crosslinks;--all contribute to better overall total shape retention. The more complex or highly styled the garment, and the more severe the intended laundering conditions (including acid-souring and bleaching), the more promotable this feature will be. In addition, the absorbency of the cotton appears to be completely retained, to the advantage of comfort and ease of cleaning.
>
> Since these promotable features are dependent on the cotton component, the overall incentive to use cotton is increased. Since the process also gives better abrasion resistance than a conventional process (but not tensile strength), the overall incentive to use synthetics is diminished. Given the right promotional backing, these two factors should combine to achieve adjustments in what are considered the "proper" blend levels in the various DP market areas.

The possible advantages of applying a crosslinker, and/or catalysts, for example, in vapor phase rather than aqueous impregnation or applying part of the crosslinker by aqueous padding followed by vapor phase to complete the molecule and effect the crosslinking have caused widespread interest in the vapor phase system. Goldstein (20) reviewed the flexibility of the process as well as its disadvantages:

> If the vapor phase process is applied in the textile mill while the cloth is in the piece (in a flat state), we obtain a pre-cure effect. On the other hand, it's possible to make a garment from untreated (or partially treated) cloth, and then expose the garment to the vapor and effect crosslinking in the garment configuration, and thus obtain the equivalent of post-curing.
>
> At present, although there is some indication that the use of vapor phase application will provide a better relationship between strength retention and performance on 100% cotton fabrics, there are some extremely difficult technological problems which have held back commercial scale utilization of this approach.
>
> For example, some of the more promising crosslinker-catalyst systems are so corrosive, that only very selected materials of construction may be used for the vapor phase chamber, making the cost prohibitively high.
>
> Secondly, and especially when treating garments where several thicknesses of cloth must be treated, the rate of vapor diffusion into the cloth (to effect crosslinking) and then out of the cloth (to eliminate odor and other undesirable side effects) is so slow that extremely long processing times are required.

Investigations at the Stanford Research Institute, where the vapor phase process was first developed under the sponsorship of the Cotton Producers Institute, were reviewed by Swidler, Gamaria and Jones (46). The reaction in the vapor phase process depends on the simultaneous presence of moisture, sulfur dioxide and formaldehyde on the fabric, with moisture content being the most critical component. Intermediate initial moisture content produced the most desirable end-product. A comparison of twill fabrics finished by the conventional pad-dry-cure DMDHEU process and the vapor-phase process yielded the following results.

Durable press tumble dry ratings were found to be equal. The fabrics with the vapor-phase finish, however, demonstrated higher line dry performance. Abrasion resistance and moisture regain values, also, were found to be higher in the vapor phase fabrics, but tensile strength retention varied from equivalence to slightly below the values obtained with the conventional durable press process.

Commercialization of the vapor phase process for garments was announced by the American Laundry Machinery Industries in 1970. Their conclusions relative to the benefits of the vapor phase process were consistent with the findings of the Stanford Research Institute as indicated by Swidler, Gamaria and Jones (46).

> For example, in terms of durable press performance, a very high level of fabric smoothness is obtained after laundering and tumble or line drying. The effect is durable through repeated high temperature launderings, acid sourings, and bleachings involved in the industrial laundering of uniforms. Because the fabric which is sewn into garments is non-resinated, all the problems of sewing resinated fabric are eliminated resulting in better seam appearance. The effect is accentuated by the stabilization of cellulosic-containing sewings and trimmings.
>
> In terms of wear life, the abrasion resistance as assessed by Accelerotor weight loss is much better than in currently available DP garments. Wear trials are still in progress to determine just how much

> longer the useful wear life is. Also contributing to the improved wear life is better color retention, because of the better abrasion resistance and/or greater dye fixation by the formaldehyde itself.
>
> In terms of esthetics, the process does not give the "resinated" hand associated with conventional DP processing. A stiffer hand can be built in by choice of suitable additives, and, if the preferred ones are used, the formaldehyde contributes to the fixation of the additive. Therefore, the hand can be manipulated over a wider range than usual. Moisture regain and absorbency values are higher, and, therefore, presumably comfort. Stain removal, especially of greasy stains, is easier; this also is probably associated with better retention of the hydrophilicity of cotton.
>
> There are bonus features associated with ease of processing. Mill processing is simplified. Fabric shelf life is, of course, indefinite, so that storage and pressing, problems associated with conventional DP fabric are eliminated, as are odor problems during cutting, sewing and pressing.

A third approach being used by cotton researchers to meet the challenge of polyester-cotton blends is to develop mechanisms other than crosslinking to achieve the resilience demanded for durable press. Research studies to determine the influence of pre-weaving treatment of yarns with polymers show that fabric characteristics, expecially durable press performance, are affected. Lofton _et al_. (31) in a progress report of research at the Southern Regional Laboratory stated that exploratory work showed the following:

> . . . fabrics woven from polymer-sized yarns and treated with resins by postcure techniques had a desirable hand without the boardiness frequently associated with polymer-treated fabrics. Cuffs

> fabricated from these experimental fabrics sustained 50 home-type launderings without damage and retained a warp plus filling wrinkle recovery angle of 300.

In addition, the investigations of Lofton et al. (31) led to the conclusion that fabrics woven from polymer-treated yarns required a lower amount of the cross-linking agent and usually demonstrated better physical properties, with some improvement in abrasion, after crosslinking than did polymer-treated fabrics. Research relative to the use of polymer sizes is continuing in an effort to improve durable press cotton fabrics.

Further research, conducted by the Gulf Coast Section of the American Association of Textile Chemists and Colorists, 1971 Intersectional Technical Paper Competition Committee (21), explored the relationships between wrinkle recovery and durable press ratings on chemically finished cotton fabrics. Three fabric types used included a white cotton print cloth, 80x80; a khaki 3/1 twill; and a white 50/50 cotton-polyester sheeting. These fabrics were cross-linked to produce different levels of wrinkle recovery and a wide ratio range between dry and wet wrinkle recovery angles. The following summary was made by the authors relative to wrinkle recovery and durable press rating relationships:

> Relationships have been established on cotton fabric among dry and wet wrinkle recovery angles and durable

press ratings after tumble and line drying. There is a good correlation between tumble dry durable press ratings and dry wrinkle recovery angles. Also a good correlation exists between the sum of dry and wet wrinkle recovery angles and tumble dry ratings. However, these correlations seem due to a prevalent ratio between dry and wet recovery angles in fabrics with most treatments.

A relationship between wrinkle recovery angles and durable press ratings after tumble drying that is independent of treatment is more complicated. For a given tumble dry rating a minimum dry recovery angle is required. After the minimum both dry and wet recovery angles influence the rating with the wet wrinkle recovery angle more important.

With line dry durable press ratings, wet wrinkle recovery angles are the only factor. Dry wrinkle recovery angles have no influence.

On cotton/polyester blend, no relationship could be established.

Hjalmarsson and Asnes (24) studied laundering conditions for improved wash-and-wear appearance. They found that the degree and time of deformation, in addition to recovery during the laundering process, were influenced by changes in temperature, moisture, and swelling conditions, and mechanical agitation. The study utilized 15x32 mm. samples cut in the warp direction and then creased in a device developed at the Swedish Institute for Textile Research and especially designed for use in water. Fabrics of polyester and cotton were studied relative to crease formation and crease recovery during conditions similar to those which occur in the washing process. Degree of swelling at the time of wet creasing, temperature and time during wet creasing, and wet crease recovery were studied relative to their influence on crease recovery. The authors summarized their findings as follows:

> The crease recovery angles of cotton and cotton/polyester fabrics were affected by the degree of swelling at the time of wet creasing. Creases set during a swelling process will recover less than creases set after the swelling is complete. The crease recovery of polyester-containing fabrics is very sensitive to a temperature drop during creasing. Two factors, the temperature drop interval and the initial temperature level, determine the magnitude of the crease recovery.
>
> Wet creasing and wet crease recovery were performed at the same temperature. Temperatures in the range of 30-90° C. were investigated. The higher the temperature, the lower the recovery angles. However, for the polyester there was a minimum at about 70° C., and above 80° C. the recovery decreased again.
>
> . . . The influence of wet-creasing time 30 sec. 60 min. on the magnitude and rate of wet crease recovery was studied for cotton and polyester fabrics. The cotton fabric was insensitive to changes in wet-creasing time, while the polyester one was markedly affected. For the polyester, the magnitude as well as the rate of recovery decreases by increasing the time of creasing. The effects are largest within the wet-creasing time interval of 0-5 min. and during the first seconds of wet crease recovery.

In general, research in the United States tends to develop products suitable for laundering methods employed in this country. Since we do export products to other markets, it is of interest to note the laundering procedures in Europe, for example, and how these methods influence durable press.

While in Europe, Reid (37) found that European laundering problems are different from ours. Acid sours generally are unknown and since they are not used extensively, many resin finishes can be utilized. In England, Germany, and the Scandinavian countries the resin finish must resist peroxide bleach and a wash which is highly alkaline at 200^{0} F. or above. Therefore, garments with high percentages of polyester do not perform satisfactorily.

The twin-tub washing machine with a high spin rate to remove most of the water in preparation for line drying also is used. Few tumble dryers are available to the consumer. Most of the European machines have metal baffles and a high-speed centrifuge system to remove the water. This method of laundering develops large wrinkles unless the fabric has high wet crease recovery. Reid (37) made this explanation:

> High wet crease recovery is obtained by several methods of wet curing, notably by treatment at room temperature with strong acid and the cross-linking agent, by the Belofast procedure, and by use of Tootal-Broadhurst-Lee's Teb-X-Cel or sulfonium process.

Silalahi (42) researched the appearance and durability of men's durable press trousers after line and tumble drying. One hundred pairs of men's durable press khaki trousers and matched fabrics represented the following fiber-fabric-finish combinations: all-cotton, melamine wet-fixation finish; all-cotton, modified pad-dry-cure treatment; all-cotton, Koratron durable press application; 65/35 cotton-Dacron 59, Coneprest finish; and 50/50 cotton-polyester, Lockprest treatment.

From summarized data it was found that the overall appearance rank within any given trouser type differed only slightly relative to the two drying methods. Although differences were not extreme, seam appearance and crease retention received higher ranks when the line drying method was used. Fabric smoothness, however, received a higher rank when tumble-drying was used.

A comparison of trouser types placed the 50/50 cotton-polyester in first rank position with respect to both drying methods followed in second rank position by the 65/35 cotton-Dacron after tumble drying and the all-cotton Koratron finished trousers relative to both drying methods. Appearance ratings were based on fabric smoothness, crease retention, seam smoothness, and wrinkle recovery after 30 intervals of laundering and drying.

Little difference was found between the two drying methods within a given trouser type relative to durability. The author found by comparison of the trouser types that the 50/50 cotton-polyester exhibited superior durability performance. Factors related to durability were determined by rank orders developed from number of broken yarns, thinning of creases, tearing and breaking strength, and dimensional stability.

In addition to a consideration of the procedure used by the consumer in washing and drying the durable press garment industry in the United States is becoming more aware of consumer satisfaction with the end product. The consumer in the United States is becoming more sophisticated relative to likes and dislikes. Powderly (36) stated that Celanese has been working in the direction of defining performance standards which more realistically reflect what the consumer expects. Celanese has utilized questionnaires and interviews to form a body of knowledge which will reflect consumer attitudes relative to specific garments both in small and large scale wear trials.

In the future, consumer expectation, therefore, may become a more important consideration, in addition to such factors as fiber blend, yarn size and twist, fabric construction and finish in engineering a fabric for end-use requirements.

CHAPTER III

PLAN OF PROCEDURE

Description of Experimental Trousers

This study was concerned with a comparative evaluation of 108 pairs of men's khaki trousers of 3/1 twill construction. Fabrics from which the trousers were constructed were composed of 100 per cent cotton and of cotton blended with regular and high modulus polyester, respectively, in the following percentage combinations: 87/13, 75/25, 63/37, and 50/50.

The experimental trousers were treated with a conventional pad-dry-cure durable press finish and were similarly styled with straight side pockets, hip pockets, a looped waistband, a zippered fly, and cuffed and creased legs. The trousers were classified according to blend level by nine respective style numbers as shown in Summary I. Under each style number there were 12 pairs of trousers.

SUMMARY I

IDENTIFICATION OF TROUSER STYLES

Trouser Style	Fiber Content and Blend Level
1	100 per cent cotton
2	87/13 cotton-regular polyester
3	87/13 cotton-high modulus polyester
4	75/25 cotton-regular polyester
5	75/25 cotton-high modulus polyester
6	63/37 cotton-regular polyester
7	63/37 cotton-high modulus polyester
8	50/50 cotton-regular polyester
9	50/50 cotton-high modulus polyester

Selection of Wearers

The experimental trousers were subjected to 30 periods of wear by a volunteer panel of 27 blue-collar workers. The majority of these workers were employed at Texas Woman's University in maintenance positions, such as yard work, carpentry, and electrical and mechanical services. Neither age nor size was considered in the selection of the panel members.

An incomplete block design was used in the assignment of trousers to the wearers as a means of finishing the study as soon as possible. This involved the assignment of a set of four pairs of trousers to each wear-panel member. Although the trousers were constructed according to the measurements of wearers, some alterations such as adjustment of waist size and inseams were necessary.

The experimental trousers were coded for identification purposes. The style and the number of the wearer were permanently marked inside the waistband of each pair of experimental trousers. Each panel member was instructed to wear each pair of trousers a minimum of eight hours before returning them to the textile research laboratories for laundering and evaluation.

Laundering Procedure

In preparation for laundering, the trousers were folded along the leg creases and weighed to obtain approximately the eight pounds of dry trousers required for a washer load. After weighing the trousers, the pocket linings were turned right side out and emptied of any contents. The zipper was closed, and the waistband was buttoned. Oily stains and ground-in soil were spotted before the trousers were laundered.

For general spotting, a paste of one part of AATCC Standard Detergent 124 and one part of water was placed on the stained area. After cleaning the area with a fold of trouser fabric saturated with the spotting solution, hot running water was applied to remove detergent and soil.

Oily stains, grease and other similar stains which were difficult to remove were treated with Picrin, a dry spotting agent, manufactured by R. R. Street Company, Chicago, Illinois, for the drycleaning and laundering trade. Picrin was applied to the stained area with a plastic applicator bottle. The stains then were scrubbed with a small brush and wet with the paste mixture. The soiled area was rubbed again with a fold of fabric. Finally, the spotting agent and paste were flushed with hot water. Heavy stains required a second application of Picrin.

After soiled spots were pretreated, each pair of trousers was folded into a pan of warm water to soak until a wash load of trousers was prepared for laundering. Trousers which did not require spotting were wet with warm water and placed in the warm soaking bath.

All laundering was done in an automatic home type Whirlpool washer. A running suds was maintained with 180 grams of AATCC Standard Detergent 124. Water temperature was 140 ± 2^{o} F. for the wash cycle of 12 minutes, and a temperature of about 110^{o} F. was used for the rinse cycle. A high water level with high agitation and high spin speed was used during laundering, and each washer load was allowed to proceed through the normal wash-wear cycle.

The trousers were removed from the washer immediately after completion of the wash cycle and dried in a Whirlpool dryer with a cool down cycle. At the end of the drying cycle the trousers were removed from the dryer. The pockets were turned in, and each pair of trousers was folded on the leg creases and stretched along seam lines by hand to minimize puckering.

After each laundering cycle, reference marks were placed in the waistband beside the trouser code to indicate the number of laundering cycles to which the trousers had been subjected. The trousers were hung by the cuffs with two clothes pins on an indoor line and permitted to hang for a minimum of 30 minutes, after which they were placed on a wire clothes hanger in such a manner as to avoid disturbing the leg crease.

Visual Evaluations

Visual evaluations including smoothness, crease sharpness, crease wear, and colorfastness were performed by a panel of three observers trained in textile technology. The members of the panel worked together to facilitate evaluations; however, each panelist rated each pair of trousers independently and recorded her scores on data sheets assigned to her. General wear and soiling evaluations were performed by one technician. Scores which resulted from the above-described evaluations were used to calculate the mean score for each pair of experimental trousers after specified wear and laundering cycles.

Durable Press

Test Method AATCC 124-1969 (3c) was used to evaluate the trousers with reference to their smoothness after 1, 5, 10, 15, 20, 25, and 30 wear and laundering cycles. A darkened room was used for these evaluations and overhead lighting was provided by a fluorescent light as prescribed by the test method. In preparation for the evaluation procedure the trousers were placed over a rod attached to the viewing board of the overhead lighting device with the crease of the left trouser leg from the crotch to the cuff in full view of the observer. Three-dimensional plastic replicas were placed on each side of the trouser leg to facilitate comparative rating. To eliminate reflective interference, the walls on either side and back of the viewing board were covered with blackout curtains.

Panel members assigned the number of the replica which most nearly matched the appearance of the trouser leg while they stood directly in front of the specimen and four feet away from the board. The greatest amount of wrinkling was represented by a rating of 1, while a rating of 5 indicated a very smooth trouser fabric.

Crease Sharpness

Crease sharpness evaluations were made before the trousers were worn and after 1, 5, 10, 15, 20, 25, and 30 wear and laundering cycles. For these evaluations the trousers remained in the same position as described for the durable press evaluations. A wire clamp clothespin was fastened to the left cuff in such a manner as to provide the weight necessary to cause the trouser leg to hang straight.

Evaluations were made according to the procedure given in AATCC Test Method 88C-1970 (3b). The appearance of each crease was compared with the AATCC standard under specified lighting conditions. Evaluations were confined to the crease itself, and the appearance of the fabric was disregarded. The number of the standard which most nearly matched the crease was recorded by each panel member as the rating for the particular pair of trousers being evaluated.

Crease Wear

The front crease of the left trouser leg of each pair of trousers was inspected for wear by the evaluation panel to determine the abrasion damage sustained as a result of wear and laundering. The degree of abrasion wear was determined by the amount of light transmitted through the worn areas along the crease of the trousers after 1, 5, 10, 15, 20, 25, and 30 wear and laundering cycles.

A set of edge abrasion standards developed by Markezich (33) at the U.S.D.A. Southern Regional Research Laboratory was used as a means of evaluating crease wear. The standards show successively greater damage from a rating of 10, no damage, to a rating of one, maximum damage. In this study five of the 10 standards were used. They were Numbers 2, 4, 6, 8, and 10, respectively.

For this evaluation, the trousers were placed on a flat surface and a fluorescent tube lighting device supported by a wire frame was raised into each trouser leg. The standards were placed over a light box with a fluorescent light source. The panel members looked directly down at the trouser crease as comparisons were made with the crease wear standards on the light box which was aligned directly with the trouser crease. The trousers were assigned the number of the replica which most nearly matched the crease wear of the specimen.

Broken Yarns

Before initial wear and after 1, 5, 10, 15, 20, 25 and 30 wear and laundering periods, trousers were examined by a trained technician for evidences of damage due to actual wear and to laundering. A hand magnifying glass was used, as needed, to aid in examining and counting broken yarns. The number of broken yarns was recorded for the front and back trouser areas separately at each evaluation period on diagrams such as that shown in Figure 1. A different color of ink was used for each respective interval of evaluation. Each time the size or amount of the fabric failure increased, additions were made beside the previous notations. When a hole, tear, or broken yarn occurred on the worn trousers, the garments were repaired as needed before they were

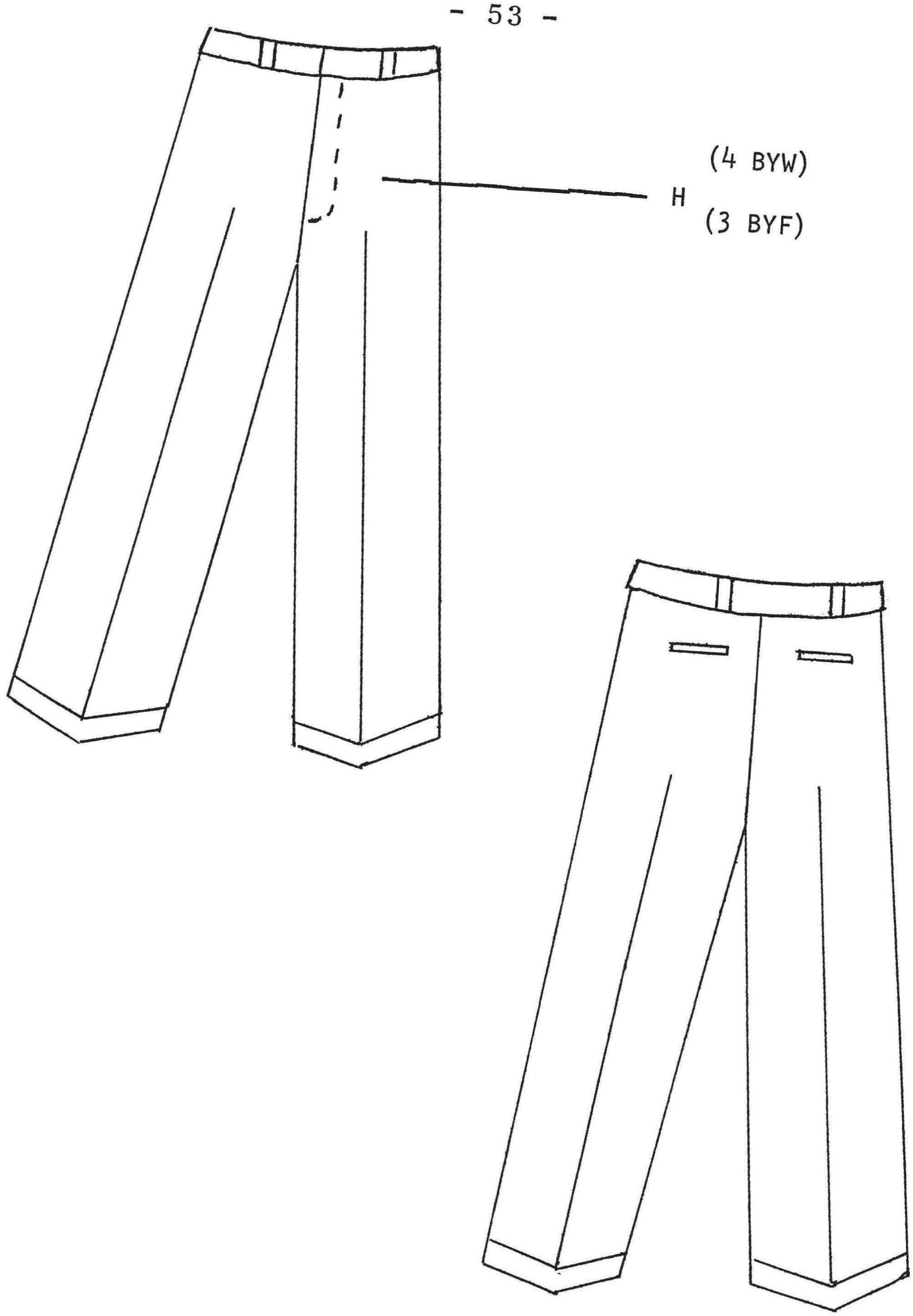


Figure 1

Pictorial Diagram of Trouser Front and Trouser Back returned to the participant for further wear. Trousers with extensive tears were withdrawn from the study. Although incidences of flaws in the material, tears, and abrasion thinness were recorded, only broken yarns were considered in the analysis of data for this report. Both the diagram shown in Figure 1 and the following key which was adapted from those prepared by Haas (22) were used in recording wear:

T = Tear	BY = Broken Yarn
H = Hole	PY = Pulled Yarn
W = Warp	AT = Abrasion Thinness
F = Filling	FLM = Flaw in Material

A hole with four broken warp and three broken filling yarns was recorded as follows:

H (4 BYW)
(3 BYF)

Colorfastness

The AATCC Gray Scale for Evaluating Change in Color Procedure 1 (3a) was used in evaluating the colorfastness of the trousers after 30 periods of wear and laundering. These evaluations were accomplished by placing an original trouser fabric beside its worn and laundered counterpart in the same plane and oriented in the same direction as the chips in the Gray Scale. The area was illuminated with natural light from the north sky. The visual differences between the original and the specimen which was subjected to 30 wear and laundering periods were evaluated independently by each of the three panel members. The number of the fastness rating which most nearly matched the Gray Scale contrast was assigned to indicate the change in color. Ratings based on loss of color as indicated by the Gray Scale ranged from a value of 5 (no color loss) to a value of 0 (severe color loss).

Soiling

After each wear cycle when the trousers were returned to the research laboratory for laundering and evaluation, the amount of soil on them was determined by visual inspection. Such evaluations were made before and after 1, 5, 10, 15, 20, 25, and 30 launderings to determine soil pick-up and release. Each pair of trousers was rated under a fluorescent light placed 18 inches above the trousers, according to the following scale adapted from those used by Roch (41), Turner (47), and Ball (5).

Rating	Description of Soiling and Staining
5	Clean overall; no visible spots or stains
4	Light soil; small oil stains; pencil and ink marks or other discolorations
3	Medium soil; medium-sized or many oil, food or earth stains; small permanent stains

2	Dirty overall; localized ground-in soil; large oil stains; splattered paint; persistant discolorations
1	Heavy soil; dirty oil stains; large or many paint stains; other permanent, unsightly discolorations

Physical Tests

The specimens for the physical tests which included breaking strength, tearing strength, flat abrasion resistance, and wrinkle recovery were taken from trousers which were subjected to 30 wear and laundering cycles. The diagram in Figure 2 was followed in the preparation of specimens from the areas of greater wear. Mended areas, however, were avoided. Duplicate specimens were prepared for each yarn direction from each pair of trousers for the tests indicated above. Each specimen was permanently marked with the code letters for the wearer, the fiber content and the yarn direction. Specimens to be tested were placed under standard conditions of $70^{o} + 2^{o}$ F. and 65 $\pm$ 2 per cent relative humidity for a minimum of four hours before being tested as recommended in ASTM Designation: D-1776-67 (4e).

Breaking Strength

The dry breaking strength of the trousers was determined by the raveled strip method as described in

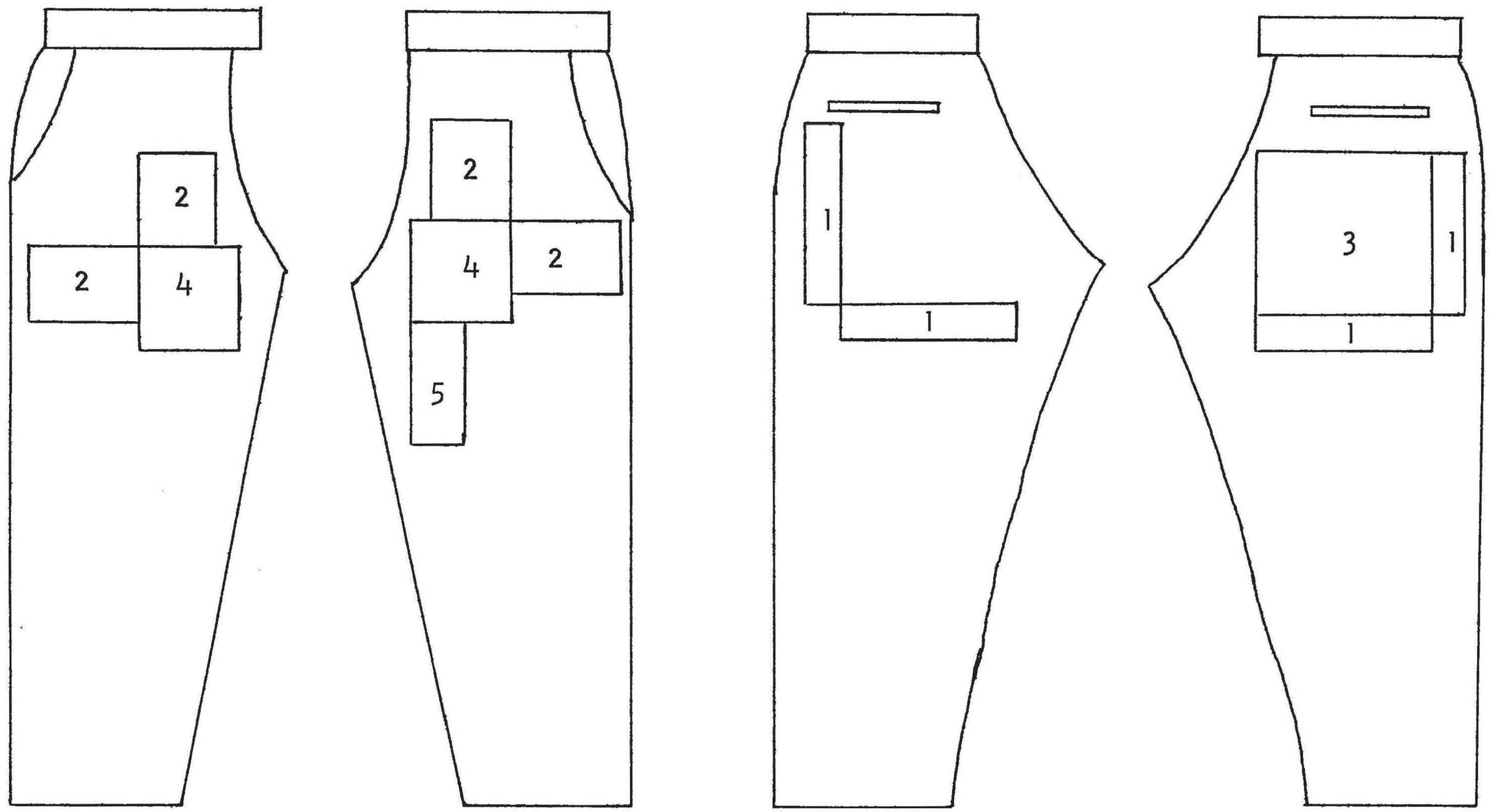


Figure 2

Sampling Diagrams

1. Breaking Strength
2. Tearing Strength
3. Flat Abrasion
4. Wrinkle Recovery
5. Color Loss

ASTM Designation: D 1682-70 (4d) with the exception that two specimens were tested in each yarn direction from each pair of trousers. The specimens were cut on grain 1.25 inches wide and 6.0 inches long after which they were raveled to a width of 1.0 inch. The Alfred Suter Pick Counter was used to insure accuracy in the final preparation of specimens and the breaking strength tests accomplished on the Scott Tester.

Tearing Strength

The tearing strength was determined in accordance with the procedure given in ASTM Designation: D 1424-70 (4c) and by means of the Elmendorf Tear Tester equipped with a Textile Augmenting Weight. Two specimens from each pair of trousers were cut on grain 2.75 inches by 4.0 inches in each yarn direction. Each specimen was raveled along one edge to 2.5 inches in width and checked for accuracy with the Alfred Suter Pick Counter. Glue was placed on the raveled edge with the exception of an area approximately one-inch in the center of each specimen to insure tearing of all yarns in the specimen.

Resistance to Flat Abrasion

The abrasion resistance of the trouser fabrics was tested on a Taber Abraser by means of the Rotary Platform, Double Head Method, as given in ASTM Designation: D 1175-71 (4a). For this test one specimen was cut from each pair of trousers with dimensions of seven inches both in the warp and in the filling directions.

Abrasion resistance was measured by subjecting each specimen to 300 cycles of rotary rubbing, using six sets of CS-10 Calibrase rubber base wheels and a 500 gram head-weight. The specimens were grouped into six sets with one set for each of the six respective sets of wheels. The members of each set of specimens were selected at random with two specimens from each trouser type selected for each wheel. The wheels were brushed after each 300 cycles of abrasion and resurfaced after every 600 cycles.

After abrasion, raveled strip strength specimens, one-half inch in width as described by Zook (48), were prepared from the abraded fabric. The specimens were tested on the Scott Tester in accordance with the raveled strip method described in ASTM Designation: D 1682-70 (4d) except that the distance between the jaws of the tester was one inch rather than three inches. The path of abrasion on each specimen was placed midway between the jaws during the breaking procedure.

The average breaking strength after abrasion was calculated per inch for each group of specimens and was used in determining the per cent loss in breaking strength due to abrasion.

Wrinkle Recovery

The experimental trousers were tested to determine their ability to recover from creasing by means of the Wrinkle Recovery Tester manufactured by Edwards. Two specimens, 1.5 by 4.0 centimeters, were cut in the warp and two in the filling direction from each pair of trousers and tested in accordance with ASTM Designation: D 1295-67 (4b). One warp and one filling specimen from each pair of trousers were tested face-to-face. The other set of warp and filling specimens was tested back-to-back.

To reduce the influence of variability factors, two testers labeled A and B, respectively, were used. Tester A was used for the face-to-face tests and Tester B for the back-to-back tests. Alignment problems of fabric deformation were handled according to Paragraph 8.7, Note 3, of the test procedure.

Fabric Count

Two warp and two filling fabric counts were made for each of the 108 trousers after 30 wear-laundering cycles. The Alfred Suter Pick Counter was used with the aid of a light box to make an accurate count in a one-inch width, according to the procedure given in ASTM Designation D 1910-70 (4f).

CHAPTER IV

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

Data concerning the performance of nine types of trousers composed of cotton and of cotton-polyester blends are summarized in Tables I through XXIV of the Appendix. These data are representative of the durable press appearance, crease sharpness, crease wear, broken yarns, and soiling of the trousers after specified laundering intervals and of their dry wrinkle recovery, breaking strength, tearing strength, flat abrasion resistance, and colorfastness initially and after 30 periods of wear and laundering.

The relative performance of the experimental trousers was measured by means of an analysis of variance (AoV) followed by Duncan's Multiple Comparison Test. Differences which serve as the basis for the following discussion were determined at the alpha .05 level of probability after specified wear-laundering periods, as the nature of the data permitted.

Interspersed throughout the discussion is a further comparison of the trouser types, such as provided in Figures 3 through 18. These comparisons are based upon the performance of the trouser types with respect both to mean values and to the number of times each type demonstrated a superior performance to that of another type in the statistical analysis of the data.

Durable Press Appearance

The experimental trousers were evaluated for their durable press appearance after 1, 5, 10, 15, 20, 25, and 30 wear and laundering cycles. Results are recorded in Table I of the Appendix in the form of mean values for each fabric type. These data accompanied by the representative Figures 3 and 4 are incorporated in the discussion which follows.

Comparison of Durable Press Values After Specified Wear-Laundering Cycles

The results of the analysis of variance as shown in Table II of the Appendix indicated the significance of the durable press data after the specified wear-laundering intervals and cumulatively after 30 wear-laundering intervals. An examination of Figure 3 which was based upon the results of Duncan's Multiple Comparison Test showed that, with one exception, after the first wear-laundering period, all trouser types displayed the same level of smoothness performance both with respect to mean values and ranks

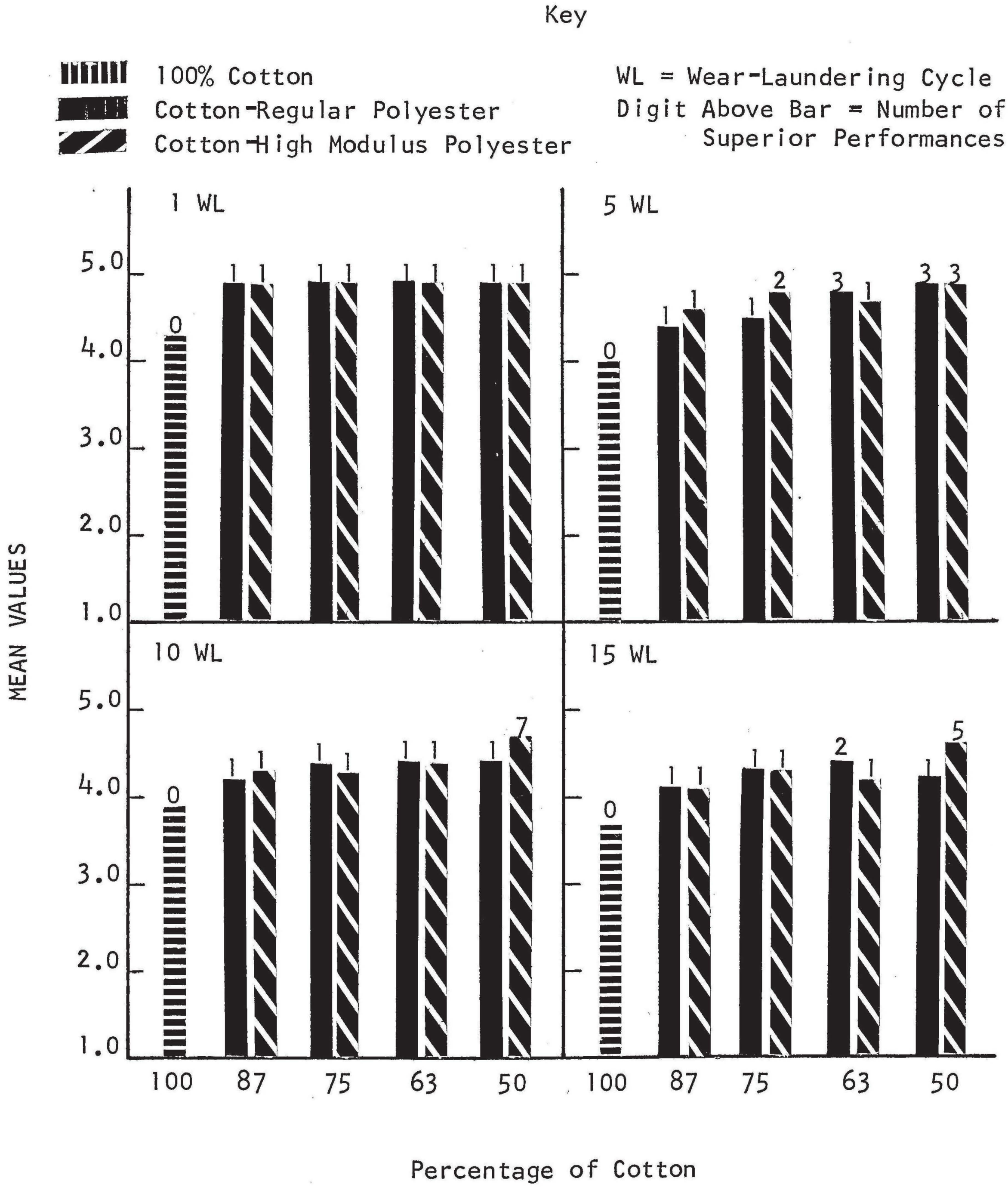


Figure 3

A Comparison of Durable Press Values of Trousers

at Specified Wear-Laundering Cycles

which were based upon the number of times a superior performance was noted. This exception was the 100 per cent cotton which displayed the poorest overall performance.

After the fifth wear-laundering cycle, some differentiation was apparent relative to the durable press performance. Blend levels of 50/50 cotton with both types of polyester and the 63/37 cotton-regular polyester received the highest rank, since each trouser type was superior to three other types and displayed means of 4.9 and 4.8, respectively. The remaining blend levels, with the exception of the 75/25 cotton-high modulus polyester, were superior only to one other trouser type, the 100 per cent cotton. The 75/25 cotton-high modulus polyester blend with a mean durable press value of 4.8 was superior to two fabrics including the 100 per cent cotton and the 87/13 cotton-regular polyester.

Upon examination of the results after 10 wear-laundering cycles, it was readily detected that the appearance of the 50/50 cotton-high modulus polyester trousers excelled that of the remainder of the types with the exception of the 63/37 cotton-regular polyester. Other intercomparisons pointed to the poor performance of the all-cotton trousers. A further study of these data showed that in the majority of cases the durable press appearance had depreciated from that observed after one wear-laundering period.

A comparison of trouser types after 15 wear-laundering cycles reflected little change. The 50/50 cotton-high modulus polyester trousers, however, continued to maintain the first rank position with a mean durable press value of 4.6. The 63/37 cotton-regular polyester trousers having a mean smoothness value of 4.4 improved slightly and received second rank, since they were superior to the 100 per cent cotton and the 87/12 cotton-regular polyester trousers.

After the completion of 20 wear-laundering cycles, the trousers composed of 50/50 cotton-high modulus polyester maintained a durable press value of 4.6 and were superior to seven other trouser types as shown in Figure 4. The 50/50 cotton-regular polyester blend with a mean value of 4.4 was superior to two other trouser types, those composed of the 100 per cent cotton and of 87/13 cotton-high modulus polyester. Both of the 75/25 blend levels and the 63/37 cotton-regular polyester with mean durable press values of 4.3 were superior to 100 per cent cotton which had a mean value of 3.8. No other differences were noted between the trouser types at this period of evaluation.

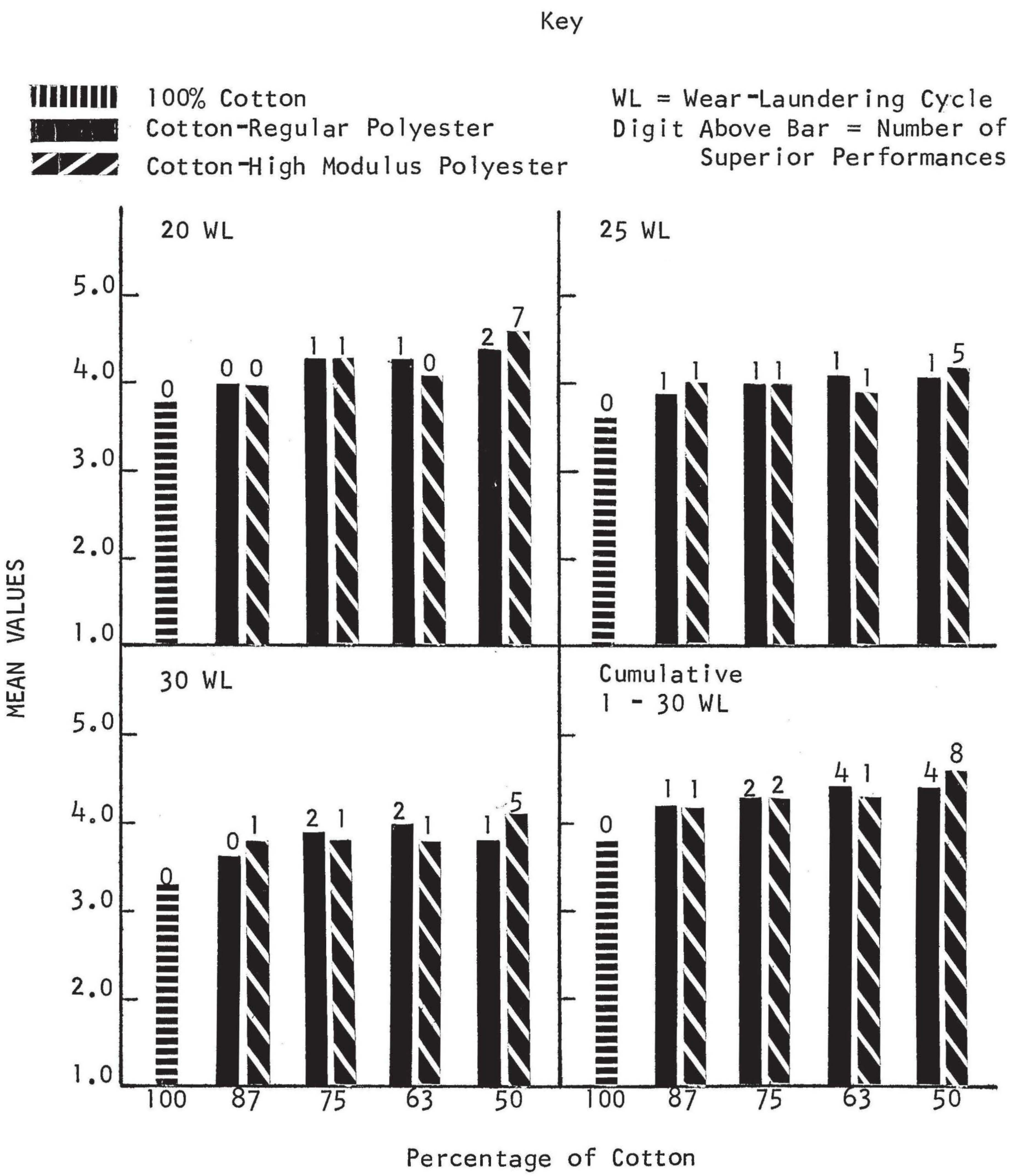


Figure 4

A Comparison of Durable Press Values of Trousers

After Specified Wear-Laundering Cycles

Intercomparisons at the end of 25 wear and laundering cycles were similar to those observed after 10 cycles, although mean durable press values of the trousers were slightly lower. Ratings ranged from 3.9 to 4.7 after 10 wear-laundering periods and from 3.6 to 4.2 after 25 cycles. Only one type of trousers, those of 50/50 cotton-high modulus polyester, was outstanding at this evaluation period, but its appearance proved to be no better than that demonstrated by the 63/37 cotton-regular polyester and the 50/50 cotton-regular polyester.

After the final wear-laundering cycle, the 50/50 cotton-high modulus polyester trousers continued to retain their position of first rank with a durable press rating of 4.1. Second rank positions were claimed by the trousers composed of 63/37 and 75/25 cotton-regular polyester while the all-cotton and the 87/13 cotton-regular polyester demonstrated the poorest performance of the lot with values ranging from 3.3 to 4.1.

The type of polyester used did not influence the smoothness ratings of the trousers either in the 75/25 or in the 87/13 blend levels. As the percentage of polyester increased, however, the type of polyester significantly affected the smoothness of the trousers. In the 63/37 blend level a superior smoothness was provided by the regular polyester, whereas in the 50/50 blends the high modulus gave the superior results.

Comparison of Cumulative Durable Press Values

As can be noted from the tabulated data in Table II, significant differences again were found to exist between the durable press values of the trouser types when 1, 5, 10, 15, 20, 25 and 30 wear-laundering periods were combined for each respective type of trousers. A comparison of the trouser types indicated that, in general, smoothness was related to the level of polyester in the trouser fabrics. This finding readily can be observed in Figure 4.

The 50/50 cotton-high modulus polyester trousers with a cumulative mean durable press value of 4.6 were superior to the remainder of the trouser types and, therefore, received the highest rank. Second rank on the basis of the number of times one type of trousers was superior to another was attained by the 63/37 cotton-regular polyester and the 50/50 cotton-regular polyester trousers, both of which had cumulative mean values of 4.4 and were superior to four other trouser types. Fourth rank was earned by the 75/25 blends with both types of polyester which were superior to the 100 per cent cotton and the 87/13 cotton-regular polyester. Sixth rank was attained by 63/37 and the 87/13 cotton-high modulus polyester and the 87/13 cotton-regular polyester, both of which displayed a greater degree of smoothness than that displayed by the 100 per cent cotton trousers.

The entire sequence of wear-laundering cycles depicted a general downward trend of the durable press values for all trouser types with successive wear-laundering periods. The 50/50 cotton-high modulus polyester trousers outperformed those of other blend levels relative to their mean durable press values as well as the number of times the performance of these trousers was superior to other types throughout the wear-laundering cycles. The data indicated, however, that after each wear-laundering cycle, with the exception of after 20 wear-laundering periods, the 63/37 regular polyester was equal in performance to the 50/50 high modulus polyester.

In general, the percentage of polyester contained in the trouser fabrics influenced the smoothness ratings, but polyester type did not consistently appear to have any effect upon these values. In three of the seven comparisons involving the smoothness of the 50/50 cotton-polyester trouser types, the high modulus fibers provided the most desirable results. The significant differences were noted after 10, 15, and 30 periods of wear and laundering.

Crease Sharpness

After 0, 1, 5, 10, 15, 20, 25, and 30 wear-laundering cycles, the crease sharpness of the test trousers was evaluated. Table III reports the resultant data in the form of mean values for each trouser type. Figures 5, 6, and 7 which appear in the following discussion show intercomparisons of these data.

Comparison of Crease Sharpness Values After Specified Wear-Laundering Cycles

When an analysis of variance was applied to the crease sharpness data, the results as shown in Table IV of the Appendix indicated that significant differences existed between trouser types as a result of wear and laundering. A further analysis of these data by means of Duncan's Multiple Comparison Test pointed to the information diagrammatically sketched in Figures 5, 6, and 7 as discussed in the following paragraphs.

Although the initial sharpness values ranged from 3.8 to 4.2, significant differences were not evident between the nine types of trousers at this period of evaluation. After the first wear-laundering cycle, the 50/50 cotton-high modulus polyester trousers were significantly superior with regard to crease sharpness to five other trouser styles. The remainder of the blends displayed a

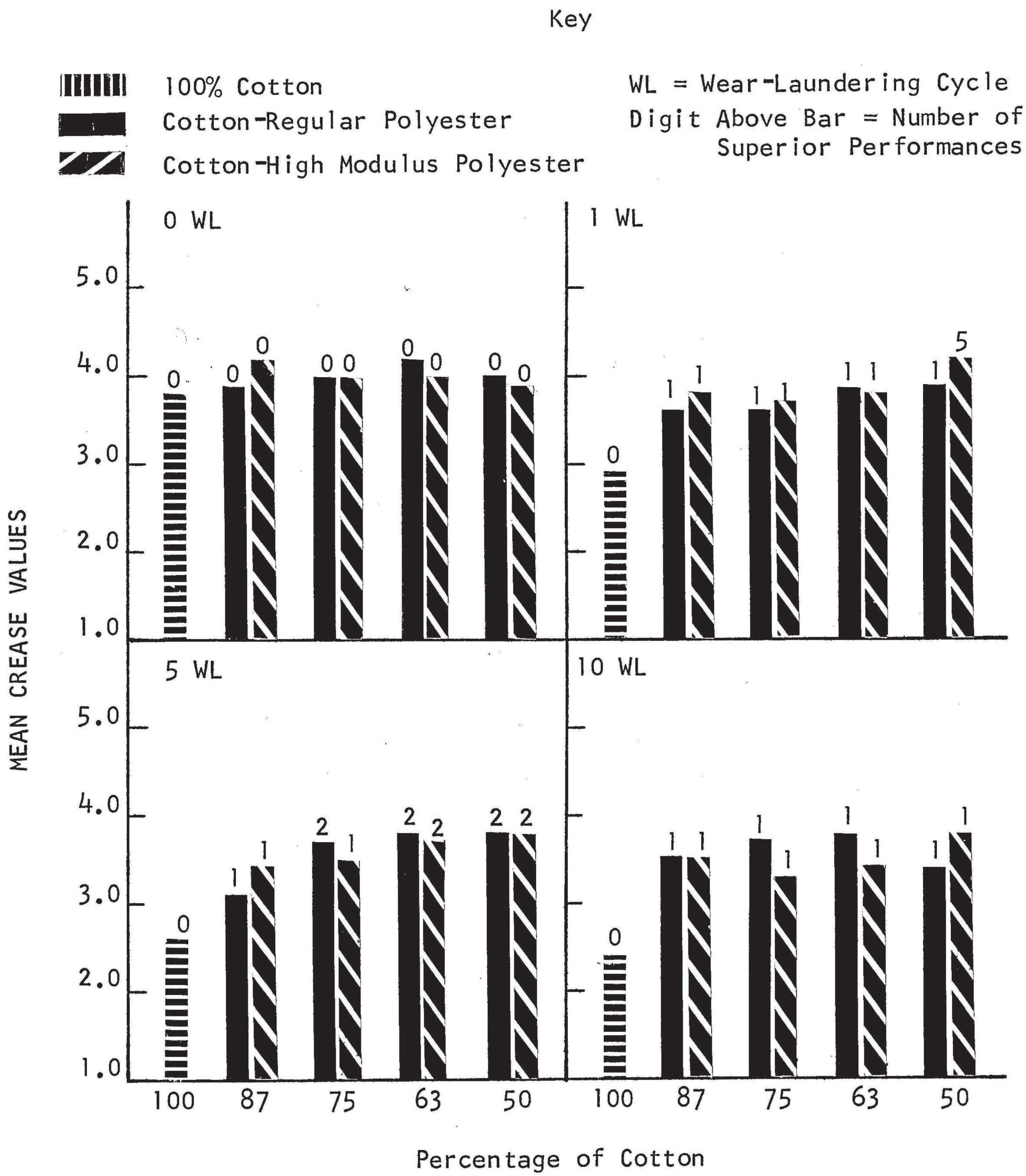


Figure 5

A Comparison of Crease Sharpness of Men's Trousers

After Specified Wear-Laundering Cycles

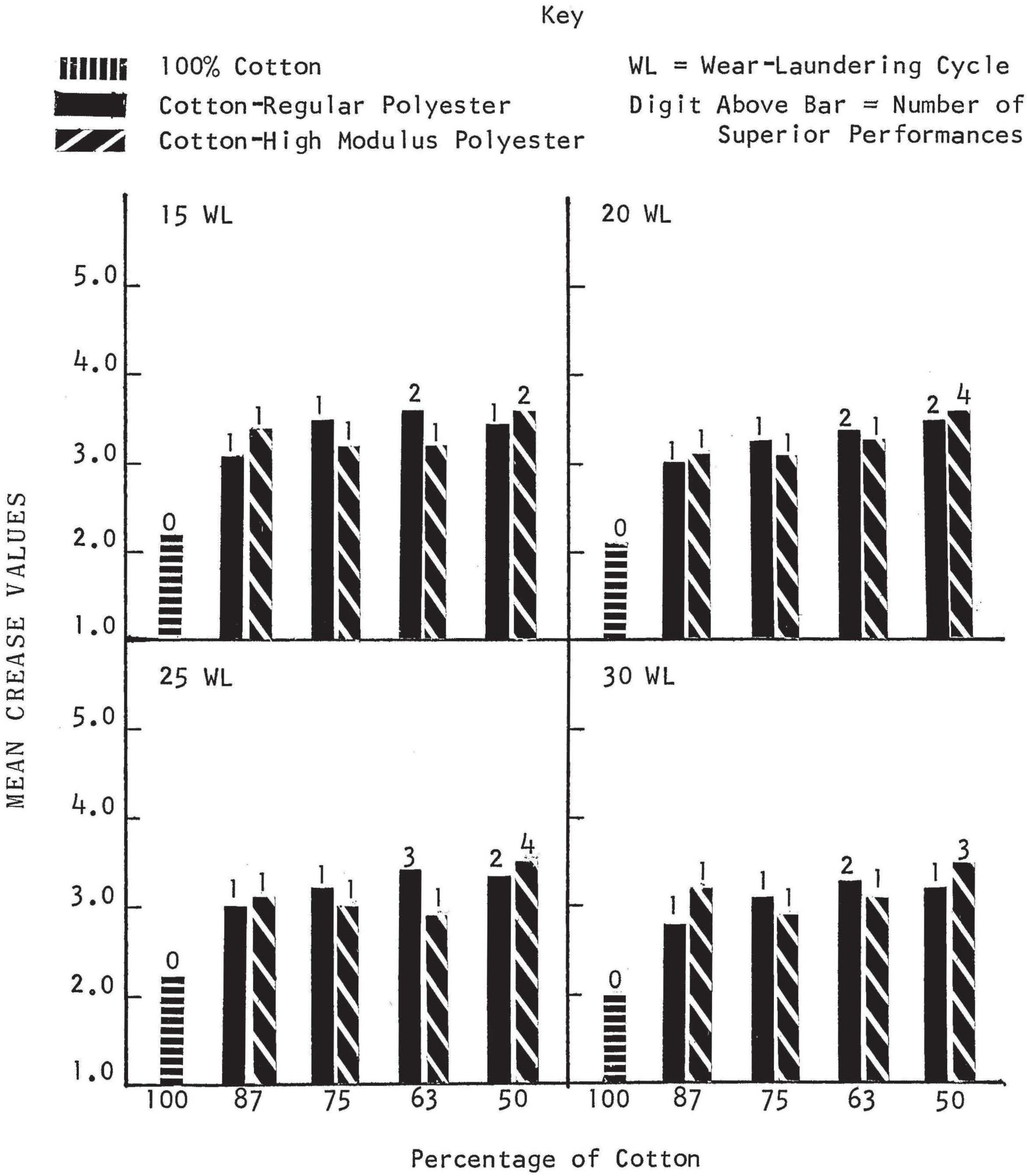


Figure 6

A Comparison of Crease Sharpness of Men's Trousers

After Specified Wear-Laundering Cycles

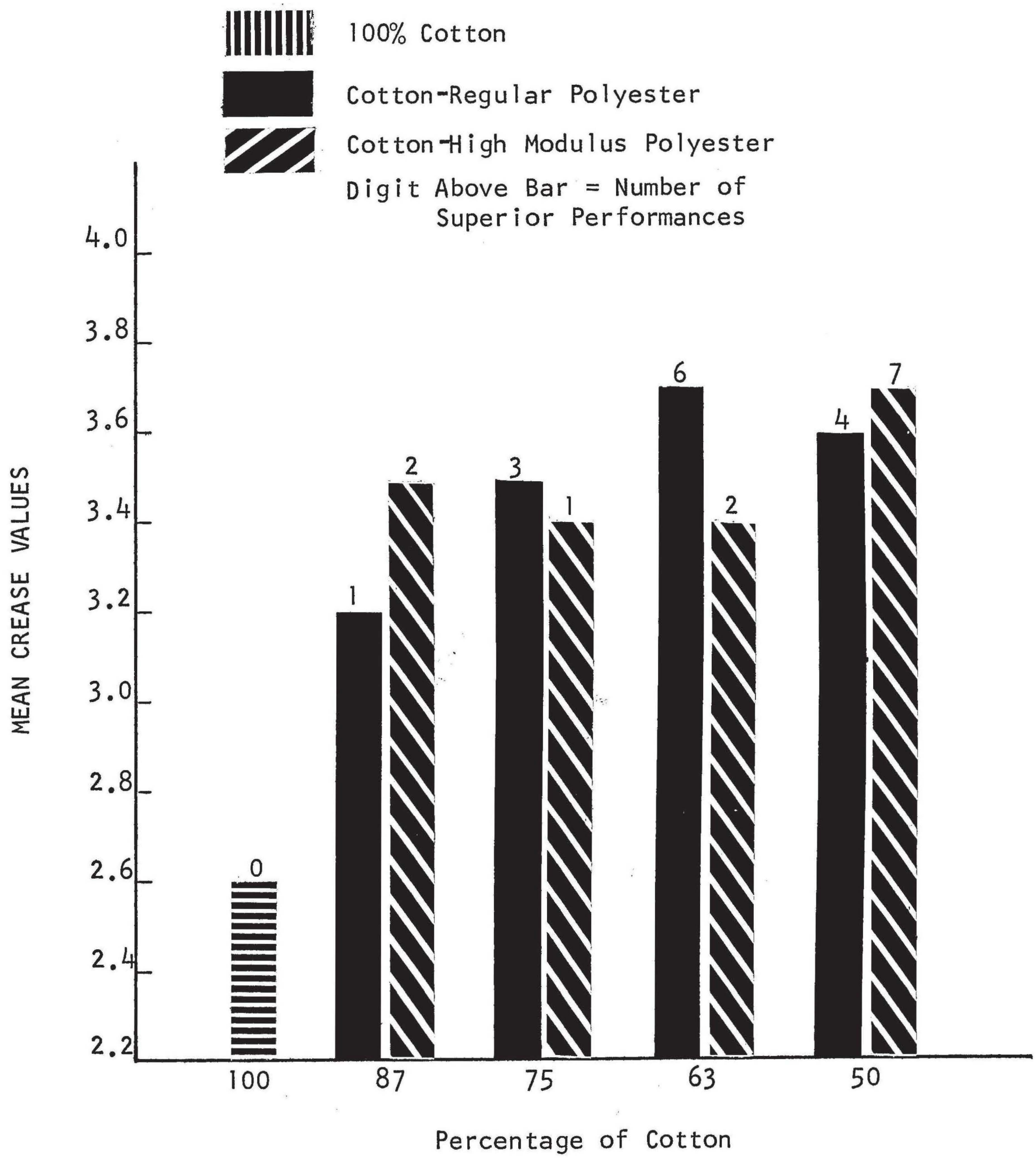


Figure 7

A Comparison of Men's Trousers on the Basis of Cumulative Crease-Sharpness Values Through 30 Wear-Laundering Cycles performance superior only to that of 100 per cent cotton. Further observations showed that the 63/37 blends and the 50/50 cotton-regular polyester trousers performed on an equal basis with those composed of 50/50 cotton-high modulus polyester when intercomparisons were made between these particular trouser types.

After five wear-laundering cycles when mean crease values ranged from 2.6 to 3.8, the above-mentioned blends continued with the same level of crease performance but shared their rank position with the 75/25 cotton-regular polyester. Three trouser types, those of 75/25 cotton-high modulus polyester and the 87/13 combinations with both types of polyester, were superior only to the 100 per cent cotton trousers. This pattern of performance changed after 10 wear-laundering cycles when all trouser types with the exception of the 100 per cent cotton performed in a similar manner.

After 15 wear-laundering periods the crease performance of the all-cotton trousers continued to be inferior to that of the remainder of the trouser types. A further study of the data indicated that the creases of the 50/50 cotton-high modulus polyester and of the 63/37 cotton-regular polyester trousers not only were sharper than those recorded for the 100 per cent cotton but also were sharper than those demonstrated by the 87/13 cotton-regular polyester trousers. No other differences were noted at this period of evaluation.

When 20 wear-laundering cycles were completed, the creases of the 50/50 cotton-high modulus polyester trousers were significantly superior to those of the 100 per cent cotton, the 87/13 blends, and the 75/25 cotton-high modulus polyester trousers, but proved to be little different from the remainder. Further observations pointed to the continued poor performance of the all-cotton trousers and to differences favorable to the 50/50 and the 63/37 cotton-regular polyester when the crease sharpness of these trousers was compared to that of the 87/13 cotton-regular polyester trousers.

A comparison of the crease sharpness of the various trouser types after 25 wear-laundering cycles showed that the 50/50 cotton-high modulus trouser creases continued to rank first in that they were superior to those observed for the 100 per cent cotton, the 63/37 and the 75/25 cotton-high modulus polyester, as well as for the 87/13 cotton-regular polyester. Falling next in line were the 63/37, followed by the 50/50 cotton-regular polyester blends. There was no difference noticed in behalf of the remainder of the trousers at this point in the study except that the creases demonstrated by the blends in every instance were superior to those of the all-cotton trousers.

When 30 wear-laundering cycles were completed, the 100 per cent cotton trousers occupied the lowest rank position with all eight trouser types ranking superior to them. Although the 50/50 cotton-high modulus polyester trouser creases received first rank, they were superior only to those of 100 per cent cotton, of 87/13 cotton-regular polyester and of 75/25 cotton-high modulus polyester. Further analyses showed that the 63/37 cotton-regular polyester performed on an equal basis with the 50/50 cotton-high modulus polyester, although it earned the second rank position.

In general, the type of polyester did not influence crease sharpness values at any specific period of evaluation except after the completion of 25 wear-laundering cycles when the 63/37 cotton-regular polyester trouser creases were superior to those of the 63/37 cotton-high modulus polyester blend. Although the 50/50 cotton-high modulus polyester trousers received a greater number of superior crease sharpness ratings throughout the wear-laundering series than did the 63/37 cotton-regular polyester, at no time did they outperform the latter.

Comparison of Cumulative Crease Sharpness Values

As can be noted from the F-ratio in Table IV of the Appendix, significant differences again were found to exist between the trouser types when the crease sharpness values from 0, 1, 5, 10, 15, 20, 25, and 30 wear-laundering periods were combined and analyzed. A comparison of the trouser styles on the basis of these data as shown in Figure 7 indicated that in some instances crease sharpness was related to the percentage of polyester in the blend, but in other instances there seemed to be little relationship between the two factors. Blend levels with the highest percentage of regular polyester tended to exhibit a superior performance except in one instance when the 63/37 cotton-regular polyester trousers displayed more desirable overall crease values than were displayed by the 50/50 cotton-regular polyester.

The 50/50 cotton-high modulus polyester trouser creases were superior to those of all trouser styles except the 63/37 cotton-regular polyester which outperformed the following six trouser types: the 100 per cent cotton, the 87/13 and 75/25 blends with both types of polyester, and the 63/37 cotton-high modulus polyester. The 50/50 cotton-regular polyester trousers fell next in line with respect to their crease sharpness followed by the 75/25 cotton-regular polyester and the remainder of the blends. Cotton exhibited the poorest allover performance as can be noted from Figure 7.

The type of polyester used in the blend influenced the crease sharpness performance of the experimental trousers when cumulative data were considered, but no distinct pattern of performance was evident. The high modulus polyester gave the sharpest creases in the 50/50 and the 87/13 combinations; however, the regular polyester proved to be the preferred type in the 63/37 and the 75/25 blends.

Crease Wear

Evaluations of the experimental trousers with respect to crease wear were performed after 1, 5, 10, 15, 20, 25, and 30 wear-laundering cycles. Results for each trouser type are recorded in Table V of this report in the form of mean values. Incorporated in the discussion which follows are comparisons of these data accompanied by representative figures.

Comparison of Crease Wear Values After Specified Wear-Laundering Cycles

An analysis of variance indicated that significant differences among the trouser types were evident as indicated in Table VI of the Appendix. Duncan's Multiple Comparison Test was employed in a further analysis of the data to determine the nature of these differences.

As can be noted from Figure 8, few differences were evident between the trouser types with respect to the degree of wear sustained by the creases after one period of wear and laundering. At this interval the 87/13 cotton-regular polyester trouser creases received first rank with a mean value of 10. They proved to be superior to the 75/25 cotton-high modulus polyester and the 50/50 cotton-regular polyester trousers which displayed values of 9.4 and 9.5, respectively.

Further comparisons showed that the 75/25 cotton-regular polyester and the 87/13 cotton-high modulus polyester trousers displayed a performance superior to that observed for the 75/25 cotton-high modulus polyester and thereby received second rank. No other differences were evident with respect to crease wear at this early period of evaluation. A comparison of polyester types revealed that the high modulus polyester performed as well as did the regular polyester with the exception of the 75/25 blend where regular polyester was significantly superior to the high modulus polyester.

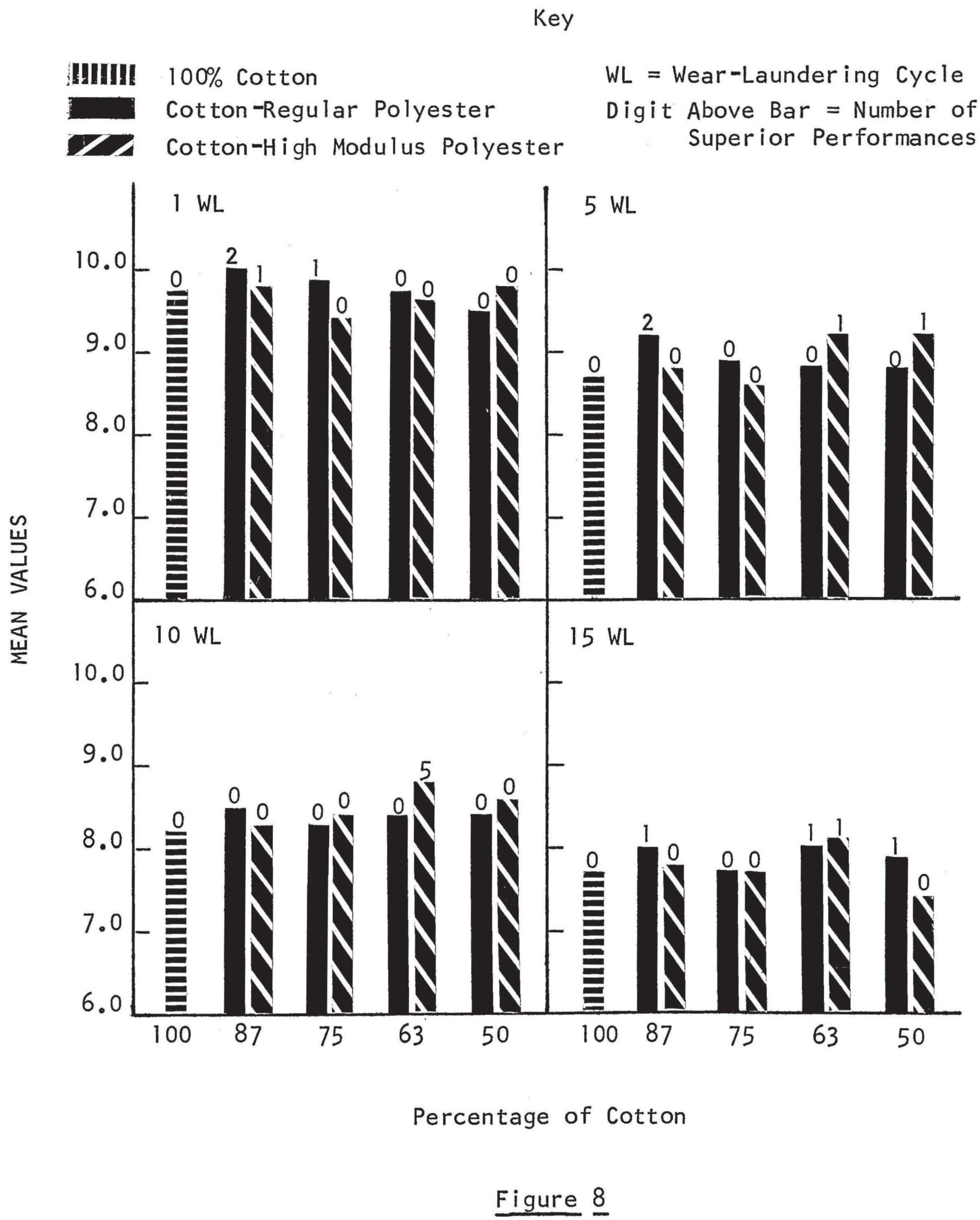


Figure 8

A Comparison of Crease Wear Values of Men's Trousers

After Specified Wear-Laundering Cycles

A comparison of trouser types after five wear-laundering cycles revealed that the creases of the 87/13 cotton-regular polyester trousers again sustained the least amount of wear and retained first rank with a mean value of 9.2. They were superior to the 75/25 cotton-high modulus polyester and the 100 per cent cotton trousers. Although the 63/37 and the 50/50 cotton-high modulus polyester trousers received the second rank position, they performed on an equal basis with the 87/13 cotton-regular polyester and were superior only to the 75/25 cotton-high modulus polyester with respect to crease wear. Other comparisons of these data failed to reveal additional differences between the trouser types.

The above-mentioned pattern of crease wear changed after 10 wear-laundering cycles when the 63/37 cotton-high modulus polyester received a mean value of 8.8 and ranked significantly superior to the following five trouser types: the 100 per cent cotton, the 87/13 cotton-high modulus polyester, the 75/25 blends with both types of polyester and the 63/37 cotton-regular polyester. Further observations indicated that the 87/13 cotton-regular polyester and the 50/50 blend levels performed as well as did the 63/37 cotton-high modulus polyester. Polyester type was not a significant factor with the exception of the 63/37 cotton-polyester blend where high modulus polyester significantly outperformed regular polyester.

Upon examination of the results after 15 wear-laundering cycles, it was noted that crease wear differences were confined to the 63/37 blends, the 87/13 cotton-regular polyester, and the 50/50 cotton-regular polyester trouser creases which sustained significantly less wear than did the creases of the 50/50 cotton-high modulus polyester trousers. Polyester type was a determining factor in the 50/50 blend where the regular polyester was superior to the high modulus polyester.

An examination of Figure 9 shows that, generally, by the end of 20 wear-laundering cycles crease wear values had deteriorated somewhat and differences between the trouser types had become more widespread. The 63/37 blends with both types of polyester as well as the 87/13 cotton-regular polyester trouser creases proved to be the best performers in that the values accredited to them (7.6, 7.7, and 7.8) were superior to those of the trousers composed of 50/50 cotton-high modulus polyester (6.8) and the 75/25 blends with both types of polyester (7.1 and 7.0). The 50/50 cotton-regular polyester trouser creases ranked second at this period of evaluation followed by the 100 per cent cotton and the 87/13 cotton-high modulus polyester.

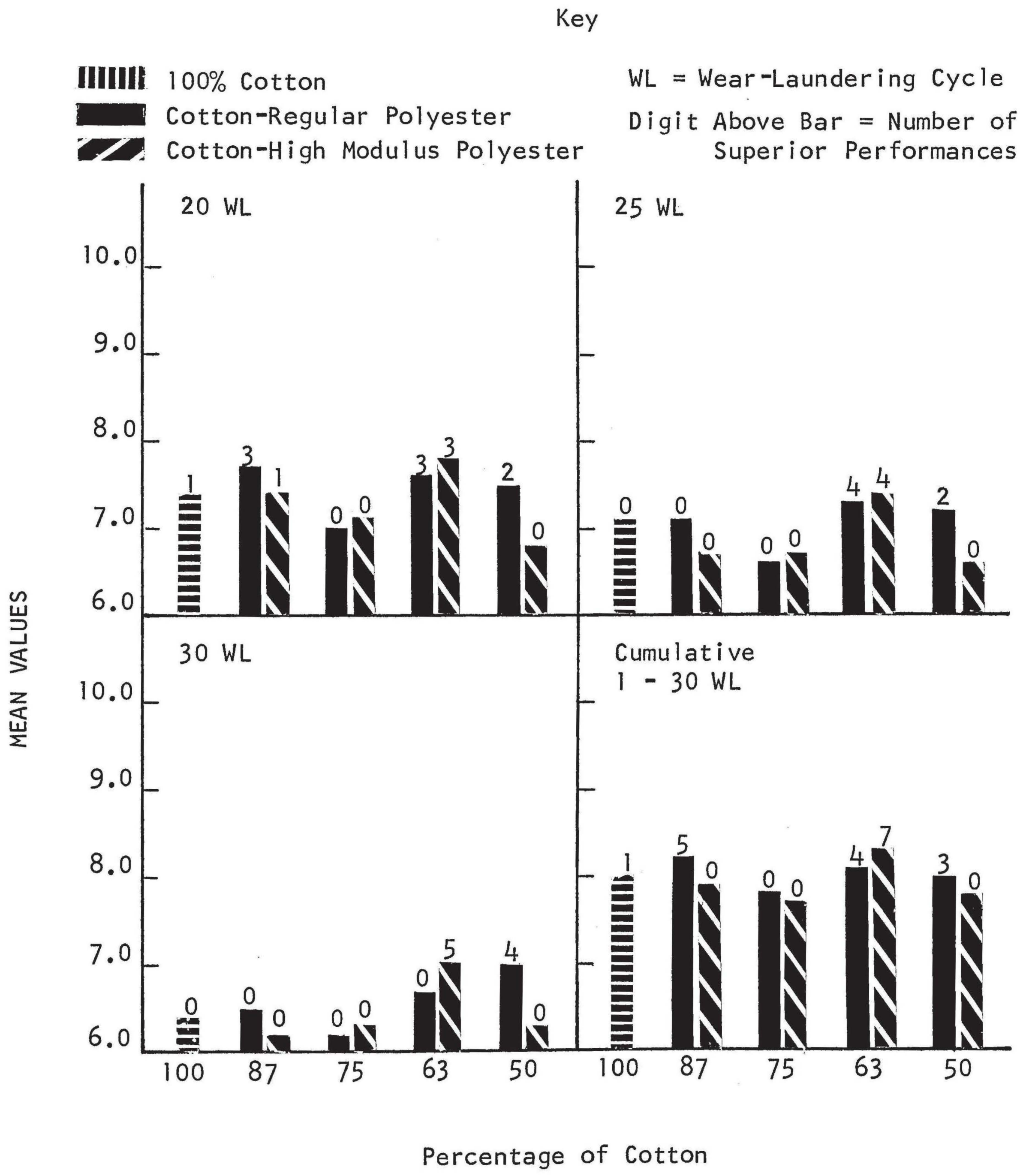


Figure 9

A Comparison of Crease Wear Values of Men's Trousers

After Specified Wear-Laundering Cycles

Polyester type was a determining factor in the 50/50 blend only, because the regular polyester was significantly superior to the high modulus polyester.

Results at the end of 25 wear-laundering cycles indicated that the 63/37 blends with both types of polyester received first rank with four superior performances accredited to them. The creases of these trousers wore to a lesser degree than did those of the 50/50 cotton-high modulus polyester, the 75/25 blends with the two types of polyester and the 87/13 cotton-high modulus polyester trousers. Additional findings pointed to the superior performance of the trouser creases of the 50/50 cotton-regular polyester when comparisons were made between the crease wear of these trousers and that of the trousers composed of 50/50 cotton-high modulus polyester and the 75/25 cotton-regular polyester.

After 30 periods of wear and laundering, comparisons pointed to the continued first-rank performance of the creases of the 63/37 cotton-high modulus polyester trousers. The relative performance of these trouser creases remained the same as those described after 20 wear-laundering periods with one addition. They were more acceptable than the creases observed for the all-cotton trousers. Other significant differences were favorable to the 50/50 cotton-regular polyester trouser creases at this period of evaluation. See Figure 9 for additional information.

Although a general deterioration of creases was evident for all of the trouser types as the wear-laundering cycles to which they were subjected progressed from one through 30, a well-defined pattern was evident with respect to the performance of the 63/37 cotton-high modulus polyester trousers. At no period of evaluation was another trouser style superior to these trousers with respect to crease wear.

The type of polyester used in the blends only affected crease wear in six out of the 28 comparisons which were made between the two types. In five of these instances regular polyester outperformed the high modulus, but in the other cases the latter type proved to be the superior. The amount of crease wear was less for the 50/50 cotton-regular polyester after 15, 20, 25, and 30 wear-laundering cycles when compared to the 50/50 cotton-high modulus polyester. Other significant differences were not consistent, but it was noted that at the first wear-laundering cycle the 75/25 cotton-regular polyester outperformed the 75/25 cotton-high modulus polyester. Also, after 10 wear-laundering cycles, the 63/37 cotton-high modulus polyester outranked the 63/37 cotton-regular polyester.

<u>Comparison of Cumulative Crease Wear Values</u>

When the crease wear values throughout the study were pooled for each of the respective trouser types, the overall values ranged from a mean of 7.7 to 8.3 on a scale in which 10.0 was the highest possible value. A comparison of the crease wear of the trousers on this basis indicated the superiority of the 63/37 cotton-high modulus polyester blend over all of the trouser types except those constructed from the 87/13 blend of cotton-regular polyester which ranked second with respect to the thinning of their creases. These trousers displayed a performance superior to that of the 75/25 blends with both types of polyester, the 50/50 and the 87/13 cotton-high modulus polyester, and the 100 per cent cotton trousers. The relative overall crease wear performance, as can be noted in Figure 9, was as follows: the 63/37 cotton-regular polyester was superior to four other trouser types; the 50/50 cotton-regular polyester was superior to three types; and the 100 per cent cotton only outperformed the 75/25 cotton-high modulus trousers. Each of the remaining blend levels performed on an equal basis, being superior to no other trouser types. Although the all-cotton trousers failed to rank high with respect to their superiority over other trouser types, the creases of these trousers were surpassed only by those of the 63/37 cotton-high modulus polyester and the 87/13 cotton-regular polyester with respect to the damage they sustained through 30 periods of wear and laundering.

An evaluation of the performance of the two types of polyester on the basis of the cumulative data showed varied results with respect to crease wear. The regular polyester provided a superior resistance to wear in the 87/13 and the 50/50 blends, whereas the high modulus polyester was superior to the regular polyester in the 63/37 blends. Differences were not evident between the two types of polyester in the 75/25 blends.

Broken Yarns

The experimental trousers were evaluated with respect to the number of broken yarns initially and after 1, 5, 10, 15, 20, 25, and 30 wear-laundering cycles as one means of determining the durability of the various types of trousers. The data which resulted are recorded in Table VII of the Appendix. Illustrations of the relative cumulative performance of the trousers on the basis of these data are shown in Figure 10 of this section of the report.

Comparison of Cumulative Number of Broken Yarns After Specified Wear-Laundering Cycles

Significant differences were obtained between trouser types as a result of wear and laundering when an analysis of variance was applied to the data at each evaluation period. See Table VIII. A further analysis of these data by means of Duncan's Multiple Comparison Tests provided the information used in the following discussion.

Although the broken yarn values ranged from 1.5 to 7.0 initially, little difference was noted between the trouser types except in the case of the 100 per cent cotton. Intercomparisons of the data showed that these trousers displayed significantly more broken yarns than were noted in the remainder of the trouser types with the exception of those constructed from 87/13 cotton-regular polyester blend.

Some differentiation was apparent after the first wear-laundering cycle. An examination of these data showed that the 50/50 blends and the 63/37 cotton-regular polyester had significantly fewer broken yarns than were demonstrated by the 100 per cent cotton and the 63/37 cotton-high modulus polyester trousers. The 75/25 cotton-regular polyester fell next in line by being superior to the 100 per cent cotton while other trouser types performed on an equal basis with respect to broken yarns.

After five wear-laundering periods, the trouser types generally received the same ranks they had earned initially. The only exception was found in the 87/13 cotton-regular polyester trousers which moved up to first rank with the other fabrics, thus outranking the 100 per cent cotton which had significantly more broken yarns than did the remainder of the trouser types.

When 10 wear-laundering cycles had been completed, three changes were evident. The 63/37 cotton-regular polyester and the 50/50 cotton-high modulus polyester in first rank position were significantly superior with respect to broken yarns to three trouser types: the 100 per cent cotton, the 87/13 cotton-high modulus polyester, and the 75/25 cotton-high modulus polyester. The other change noted was related to the 50/50 cotton-regular polyester trouser type which attained third rank position by significantly outperforming the 100 per cent cotton and the 87/13 cotton-high modulus polyester trousers. Other comparisons after 10 wear-laundering cycles continued to point to the unsatisfactory performance of the all-cotton trousers.

After 15 wear-laundering cycles, first rank position was attained by the 50/50 cotton-high modulus polyester trousers which outperformed all of the trouser styles except their regular polyester counterpart and those composed of

63/37 cotton-regular polyester. The 50/50 cotton-regular polyester ranked second and was followed by the 63/37 cotton-regular polyester trousers when comparisons were made on the basis of the number of broken yarns at this period of evaluation.

Differences evident after 20 wear-laundering cycles with respect to broken yarns were favorable to the 50/50 blends, both of which received a first rank position. These trouser types displayed fewer broken yarns than did the all-cotton, the 87/13 blends, as well as the 75/25 cotton-regular polyester and the 63/37 cotton-high modulus polyester trousers. Neither of these blends outperformed the 63/37 cotton-regular polyester or the 75/25 cotton-high modulus polyester trouser types. The 63/37 cotton-regular polyester remained in the third rank position, and the 100 per cent cotton trousers continued to display the least desirable level of performance.

After the completion of 25 wear-laundering cycles, the 50/50 cotton high modulus polyester trousers had not changed with respect to broken yarns from their above-described position after 20 periods of wear and laundering. Although the 50/50 cotton-regular polyester blends retained their second rank status, their performance proved to be superior only to that of the all-cotton and the 87/13 blends.

Other comparisons favored both the 63/37 cotton-regular polyester and the 75/25 cotton-high modulus polyester trousers as contenders for third place, and as usual the performance of the all-cotton trousers was the poorest.

Following the general pattern described for other periods of evaluation, the 50/50 blends with both types of polyester and the 63/37 cotton-regular polyester trousers demonstrated significantly fewer broken yarns than were noted for the remainder of the trouser types after 30 periods of wear and laundering. Each of these trouser types was superior to the 100 per cent cotton, the 87/13 blends and the 75/25 cotton-regular polyester trousers. Fourth rank positions were accredited to the 63/37 and the 75/25 cotton-high modulus trousers which were found to be superior to the 87/13 cotton-high modulus polyester and the 100 per cent cotton trousers with respect to broken yarns as shown in Figure 10. Other comparisons continued to magnify the shortcomings of the all-cotton trousers.

The type of polyester was not a significant factor relative to the number of broken yarns displayed by the various trouser types at each of the periods of evaluation. A significant difference was noted only after the first wear-laundering cycle when the 63/37 cotton-regular polyester outperformed the cotton-high modulus polyester combination of the same percentage content.

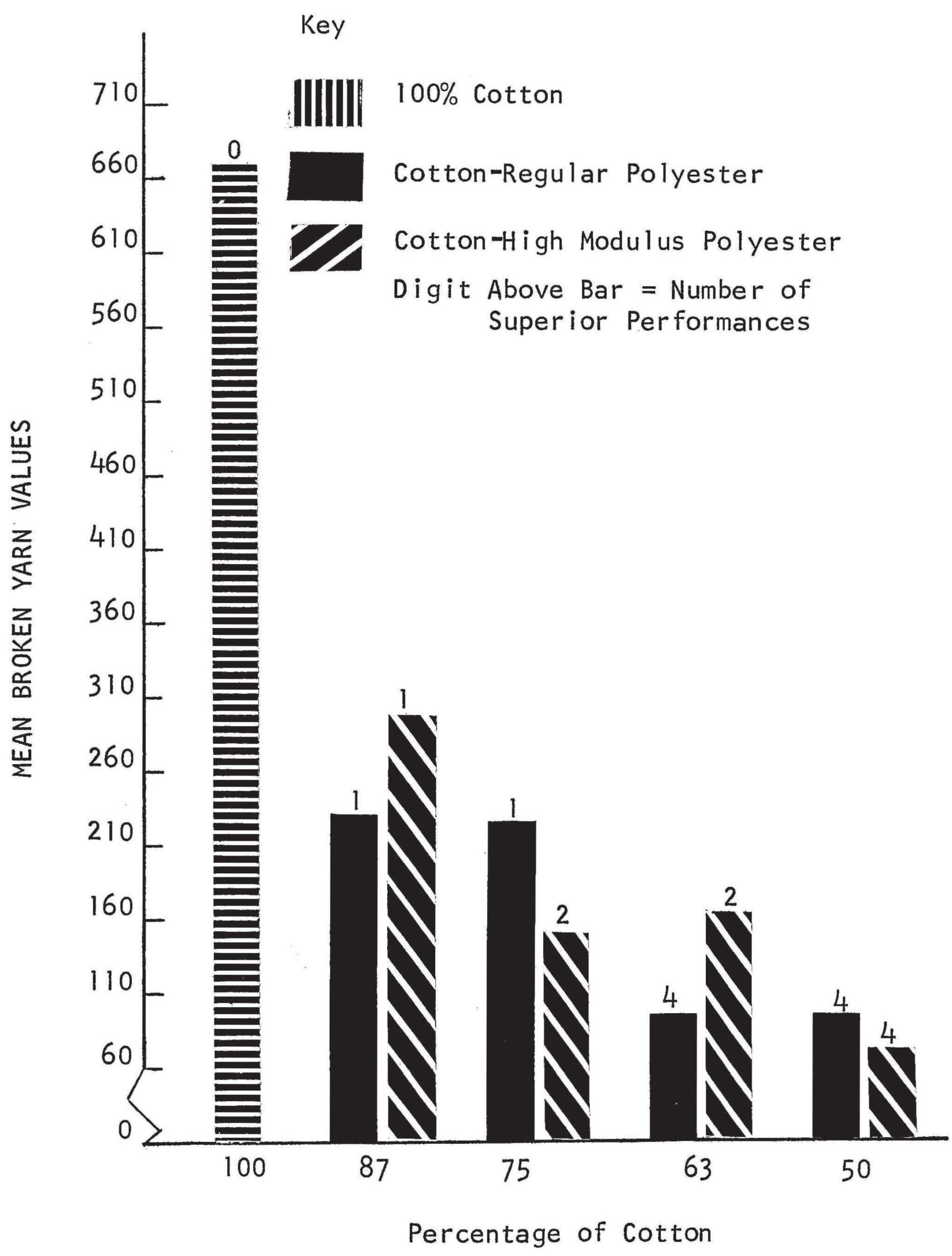


Figure 10

A Comparison of Cumulative Number of Broken Yarns (Exclusive of Tears) In Men's Trousers After 30 Wear-Laundering Cycles (Warp and Filling)

A cumulative analysis of all trouser types after 30 wear-laundering cycles showed that initially and after one wear-laundering cycle there were no significant differences in the overall number of broken yarns in the nine types of trousers. Consequently, the initial test interval and the first wear-laundering cycle ranked in first position with the fewest number of broken yarns. The fifth and tenth laundering interval placed in third rank position with significantly more broken yarns. From that period throughout the remainder of the study, as the number of wear-laundering intervals increased, so did the number of broken yarns.

Colorfastness

The colorfastness of the experimental trousers was determined after 30 wear-laundering cycles by a comparison of those specimens with the initial specimens in accordance with the procedure described previously in this manuscript. Mean color values obtained from these tests are tabulated in Table IX of the Appendix. A graphical presentation of intercomparisons of the data is shown in Figure 11.

Colorfastness of Trousers After 30 Wear-Laundering Cycles

Significant differences were noted among trouser styles relative to their colorfastness after 30 wear-laundering cycles as indicated by the F-Ratio of 353.5588 with mean square values of 10.0166 and 0.0283, respectively. As can be noted in Figure 11, a colorfastness rating of 4.7 earned by the 50/50 cotton-regular polyester trousers placed this blend level in the first rank position, since it outperformed all other blend levels including the 100 per cent cotton which received the lowest color retention value of 1.8. Three trouser styles, the 50/50 cotton-high modulus polyester and the 63/37 blends with both types of polyester, earned the second rank position. Each of these three trouser types was significantly superior to the 100 per cent cotton and to the 87/13 and 75/25 blends with both types of polyester.

Fifth rank position was achieved by the 75/25 blends which outperformed the all-cotton and the 87/13 blends. This placed the 87/13 blends with both types of polyester in the seventh rank position, because their colorfastness was superior only to that of the 100 per cent cotton trousers.

Regular polyester outperformed the high modulus polyester only in the 50/50 blends. In other blend levels, high modulus polyester performed on an equal basis with the regular polyester.

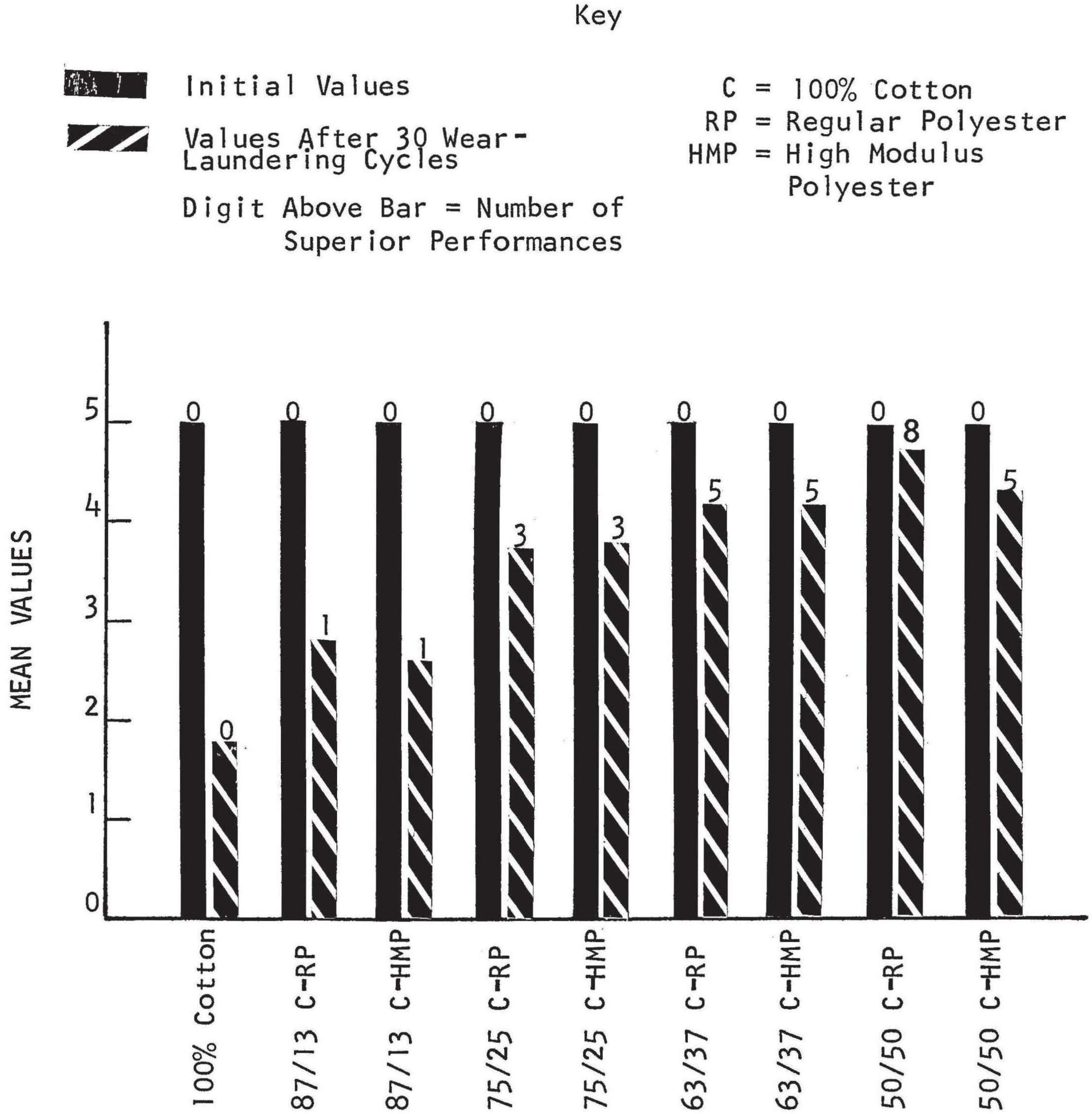


Figure 11

Colorfastness Comparisons Initially and After

30 Wear-Laundering Cycles

The fabrics which were not laundered were arbitrarily assigned the color value of 5.0 on the AATCC Gray Scale; therefore, the initial values charted in Figure 11 are identical but were included to show color retention qualities of various trouser types after 30 wear-laundering cycles. As can be noted, color retention was directly influenced by polyester content with the trouser types containing greater amounts of polyester receiving higher color retention values.

Soiling

The amount of soil which was observed on each pair of trousers during wear was evaluated before and after 1, 5, 10, 15, 20, 25, and 30 wear-laundering cycles as described in a previous section of this report. These data which are recorded in Tables X and XI were used as the basis for determining the amount of soil which was released by the respective trouser types during laundering.

Data in Table X provided the basis for analyzing the amount of soil which adhered to the various trouser styles during wear at test intervals specified in the previous section of this manuscript. As can be noted from these data, the greatest amount of soiling was apparent in the two 50/50 cotton-polyester trouser types after five periods of wear as exemplified by values of 2.7. The greatest resistance to soiling (3.8) was displayed by the 63/37 cotton-regular polyester after one period of wear.

When an analysis of variance was applied to these data, the results of which are shown in Table XIII, Part A, significant differences were not identified between the trouser types at any test interval. Further analysis of the data relative to significant differences between test intervals indicated that during the first wear period the experimental trousers picked up significantly less soil than was found to adhere to them during any of the remaining wear periods.

As a result of 10 periods of wear, less soil was observed on the trousers than was noted after 5, 15, or 25 periods of wear. Significant differences were not noted among the remaining wear periods relative to the degree of soiling.

Mean soil values observed in the men's trousers before and after specified test intervals as indicated in Tables X and XI were utilized to determine mean soil release values after specified periods of wear and laundering as shown in Table XII. Soil release values as determined from these tables ranged from a low of 0.6 for the 63/37 cotton-regular polyester trousers after one laundering period to a high of 1.8 for the 87/13 cotton-high modulus polyester trousers after five wear-laundering periods. When an analysis of variance was applied to these data, the results as shown by the F-ratio in Table XII, Part B, only identified differences between the trousers after one and 30 wear-laundering periods, respectively. After one wear-laundering period, two trouser types, the 100 per cent cotton and the 87/13 cotton-high modulus polyester trousers, released more soil than did the trousers which were constructed from the 75/25 and the 63/37 cotton-regular polyester. The 50/50 cotton-regular polyester trousers gave up more soil than did their counterparts after 30 periods of wear and laundering. Further analysis of the data showed no significant differences relative to soil release of trouser types either at any wear-laundering cycle or when data were treated cumulatively.

Breaking Strength

The experimental trousers were evaluated for breaking strength after 30 wear-laundering cycles both in the warp and filling directions. Results from these evaluations were compared with the initial performance values obtained by Larson (28). Data have been recorded in Table XIV of the Appendix in the form of mean values for each trouser type initially and after 30 wear-laundering periods. Intercomparisons of these data revealed the information recorded in Parts A and B of Table XV as well as the comparisons shown in Figure 12. They serve as the basis for the following discussion.

Comparison of Breaking Strength Initially and After 30 Wear-Laundering Cycles

When an analysis of variance was applied to the data, the results as shown in Table XV of the Appendix indicated that significant differences were present between trouser types as a result of wear and laundering. Upon further analysis of these data by means of the Duncan's Multiple Comparison Test, the following breaking strength performance patterns were determined for the nine respective types of trousers.

Warp Direction. As is evident from Table XIV, the mean breaking strength values for the worn and laundered trousers ranged from a high of 103.1 pounds per inch for the 50/50 cotton-high modulus polyester to the lowest values of 61.5 and 65.1 pounds per inch for the 75/25 and the 87/13 cotton-regular polyester trousers, respectively. The performance of the 50/50 cotton-regular polyester trousers placed them in second rank position with a breaking strength value of 92.2 pounds per inch.

Falling next in line were the 63/37 cotton-high modulus polyester trousers which significantly outperformed all but the 50/50 blends with both types of polyester and the 100 per cent cotton. The all-cotton trousers gained an intermediate position (Rank 4) with respect to warp-wise breaking strength. Their performance proved to be superior to that of the remaining blend levels except those with a 75/25 cotton-high modulus polyester content which earned a fifth rank position.

Intercomparisons of initial warp data and that obtained after 30 wear-laundering cycles revealed that the initial values were higher than those observed after 30 wear-laundering cycles with the exception of the 50/50 cotton-regular polyester which performed at the same level. A further examination of the data pointed to the superior performance of high modulus polyester after 30 wear-laundering intervals as compared to regular polyester in all blend levels except the 87/13 when both types of polyester performed at the same level. Initial results also showed that high modulus polyester was superior to the regular polyester except in the 63/37 blends.

Filling Direction. When filling direction determinations were made in relation to breaking strength after 30 wear-laundering cycles, the 50/50 and the 75/25 cotton-high modulus polyester trouser types received first and second rank positions, respectively. All of the regular polyester trouser types, as well as the 87/13 cotton-high modulus polyester and the 100 per cent cotton, were surpassed by the 63/37 cotton-high modulus polyester trousers which ranked in third position. The poorest performance was evident for the 87/13 cotton-regular polyester trousers, since the remaining trouser types were superior to this blend in filling breaking strength performance.

Intercomparisons of the initial data and data obtained after 30 wear-laundering cycles are shown in Figure 12. It is evident from this diagram that the initial filling breaking strength was slightly higher than that displayed by the trousers after 30 wear-laundering cycles. Initial mean values in the filling direction ranged from a low of 30.9 pounds per inch for the 75/25 cotton-regular polyester to a high of 47.7 pounds per inch for the 50/50 cotton-high modulus polyester trousers. Upon completion of 30 wear-laundering cycles, the lowest mean value of 28.5 pounds was accredited to the 87/13 cotton-regular polyester, whereas the highest mean value of 37.6 pounds per inch was tabulated for the 50/50 cotton-high modulus polyester, fillingwise, as indicated in Table XIV of the Appendix.

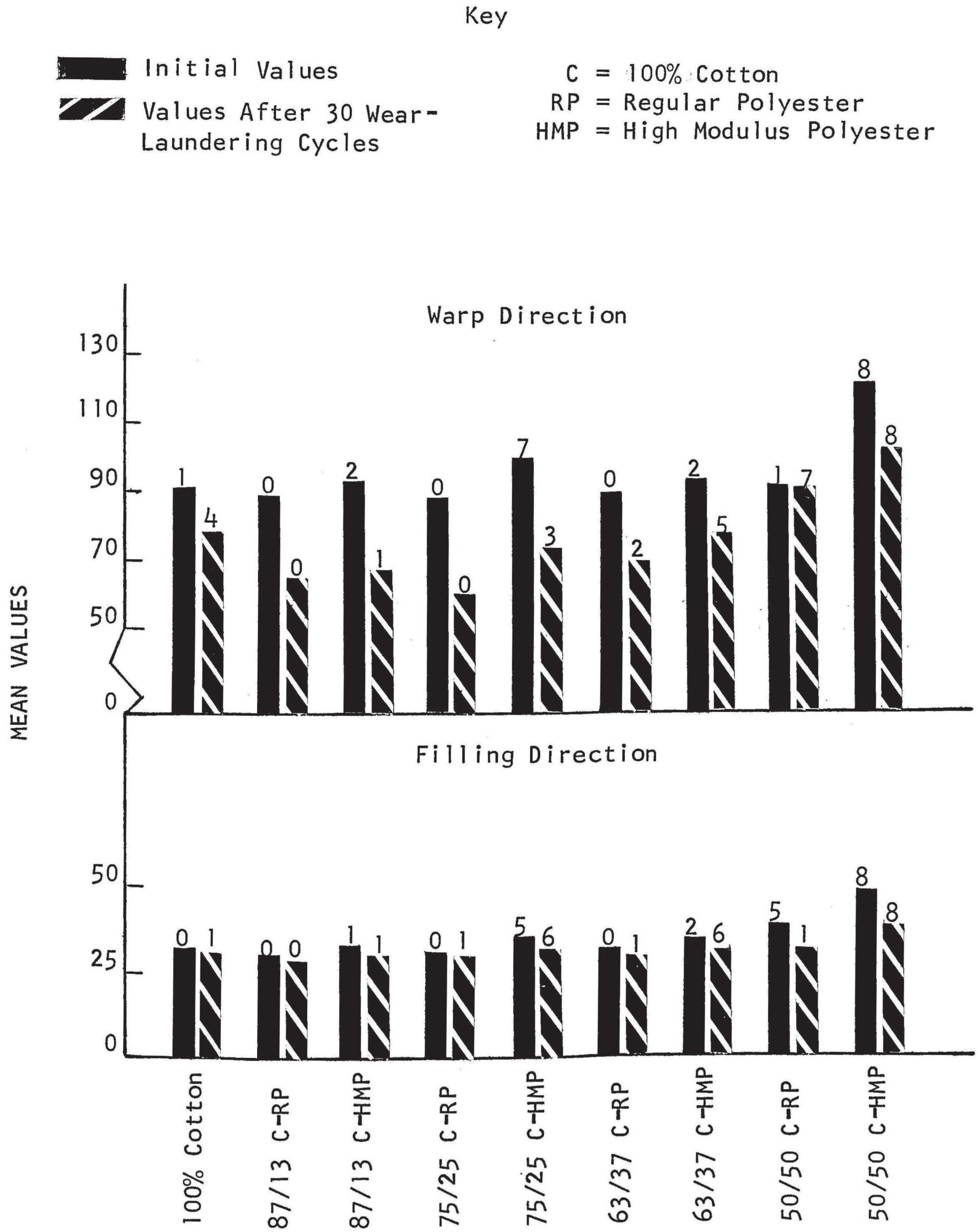


Figure 12

A Comparison of Breaking Strength Values of Men's Trousers Initially and After 30 Wear-Laundering Cycles

With respect to the relative performance of the two types of polyester, the initial data revealed that high modulus polyester surpassed the regular polyester in the 50/50 and 75/25 blends only, whereas after 30 wear-laundering cycles the high modulus polyester trouser types were superior to the regular polyester at each blend level.

Tearing Strength

Tearing strength determinations for the experimental trousers were performed after 30 wear-laundering periods. These data, along with those obtained from the initial fabrics by Larson (28), may be found in Table XVI. Additional information concerning intercomparisons of these data are provided in Table XVII and in Figures 13 and 14.

Tearing Strength After 30 Wear-Laundering Cycles

Tearing strength results as shown in Parts A and B of Table XVII of the Appendix indicate that significant differences between trouser styles were found in the warp as well as in the filling direction after 30 wear-laundering cycles. Duncan's Multiple Comparison Test, therefore, was applied to further analyze the data, a discussion of which is presented in the following paragraphs.

Warp Direction. A study of the data in Table XVI and the graphical presentation of these data as shown in Figure 13 reveals that, in general, after 30 wear-laundering cycles, tear strength values and number of superior performances were most desirable in trouser styles with higher percentages of polyester. Mean tear strength values after 30 wear-laundering cycles ranged from 3642 grams for the 50/50 cotton-high modulus polyester to the lowest value of 1633 grams displayed by the 100 per cent cotton. Intercomparisons of data relative to warp tearing strength placed the 50/50 cotton-high modulus and the 50/50 cotton-regular polyester in the first and second rank positions, respectively.

Third and fourth ranks were attained by the 63/37 blends with the high modulus polyester trousers earning the higher rank. This pattern was repeated for the 75/25 blends which ranked in fifth and sixth positions with the high modulus polyester trousers again achieving the higher rank. A change was noted in blends with the lowest amount of polyester (87/13) in that both types of polyester performed at the same level.

A comparative study of warp tear strength initially and after 30 wear-laundering cycles demonstrated that the trouser types containing greater amounts of cotton lost

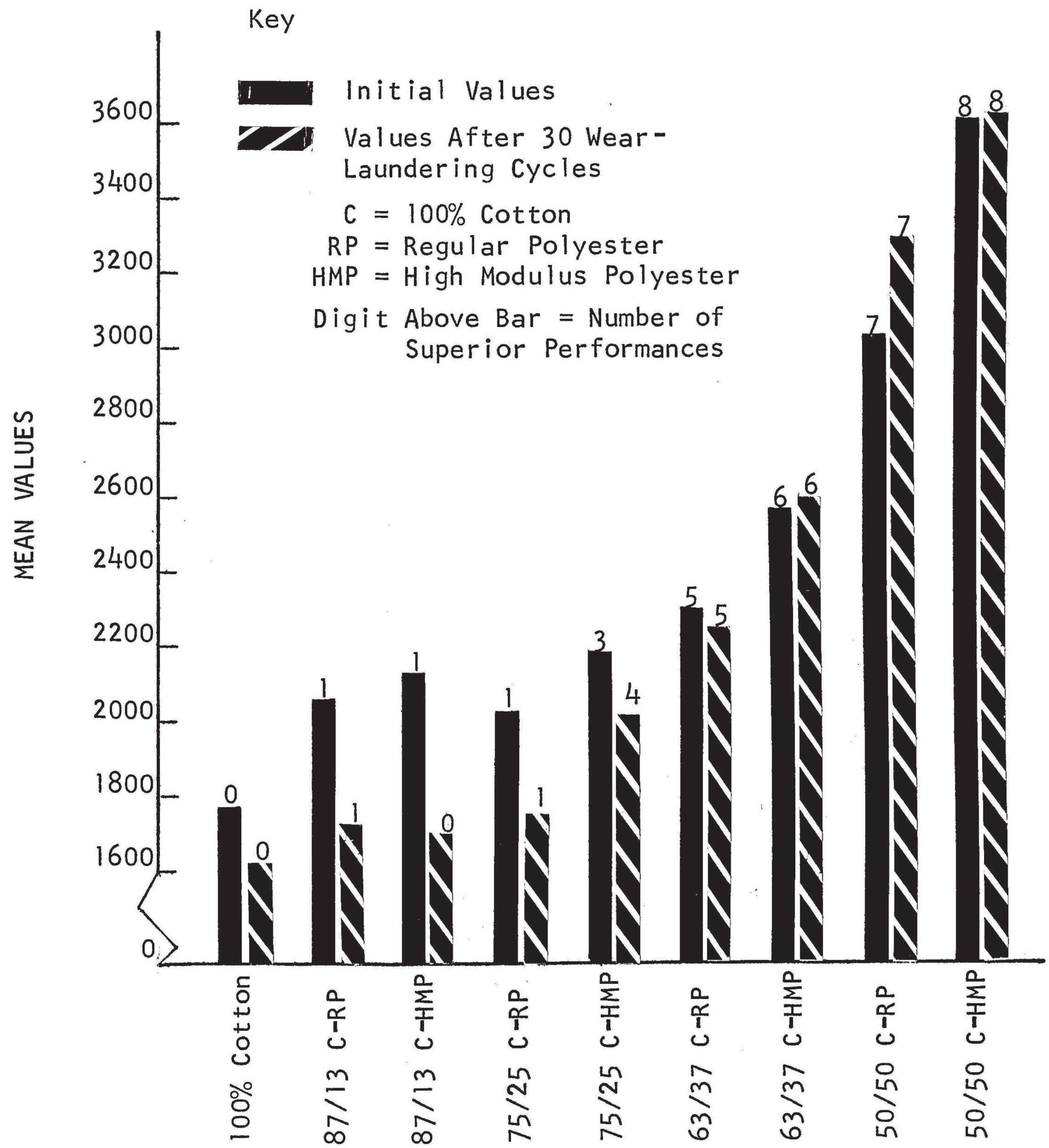


Figure 13

A Comparison of Warp Tearing Strength Values of Men's Trousers Initially and After 30 Wear-Laundering Cycles strength, whereas higher polyester content contributed to a slight gain. See Figure 13. Further observations of the data showed that the high modulus polyester trousers provided significantly greater resistance to tearing in the warp direction than did their regular polyester counterparts except in the 87/13 blends which performed on an equal basis.

All but two trouser types maintained their initial rating relative to the number of times they demonstrated a superior performance with respect to warp tearing strength. The 75/25 cotton-high modulus polyester ranked superior to four as compared to three trouser types, initially. In addition, the 87/13 cotton-high modulus polyester trousers were superior to one trouser style initially and to none after 30 cycles of wear and laundering.

Comparisons of warp tear strength results in Figure 13 indicate that the 100 per cent cotton trousers rated lower initially and after 30 wear-laundering cycles, and only one additional trouser type, the 87/13 cotton-high modulus polyester, received a comparative low rating with no superior performances. Both of the 50/50 blend levels performed at high levels initially and after 30 test intervals with the high modulus yielding the most favorable results.

Filling Direction. Tearing strength determinations in the filling direction which ranged from 1364 grams to 2421 grams after 30 wear-laundering cycles are shown in Table XVI. Statistical intercomparisons of these data and the graphical presentation of the mean values as shown in Figure 14 point to the superior performance of the 50/50 cotton-high modulus and the second rank of the 50/50 cotton-regular polyester as attained in the warp direction. Third and fourth rank positions were again earned by the 63/37 blends with the high modulus trousers achieving the higher rank. Fourth rank, however, was shared with the 75/25 cotton-high modulus polyester trousers. Further observations pointed to the performance of the trouser types containing higher percentages of cotton with the exception of the 87/13 cotton-high modulus polyester which proved to be superior to the following three trouser types: the 75/25 and 87/13 cotton-regular polyester and the 100 per cent cotton.

When data obtained after 30 wear-laundering cycles were compared further, it was noted that trouser styles containing high modulus polyester outperformed regular polyester in every comparison except in the 87/13 blends initially where a significant difference was not apparent. A comparison of initial tear strength results with those

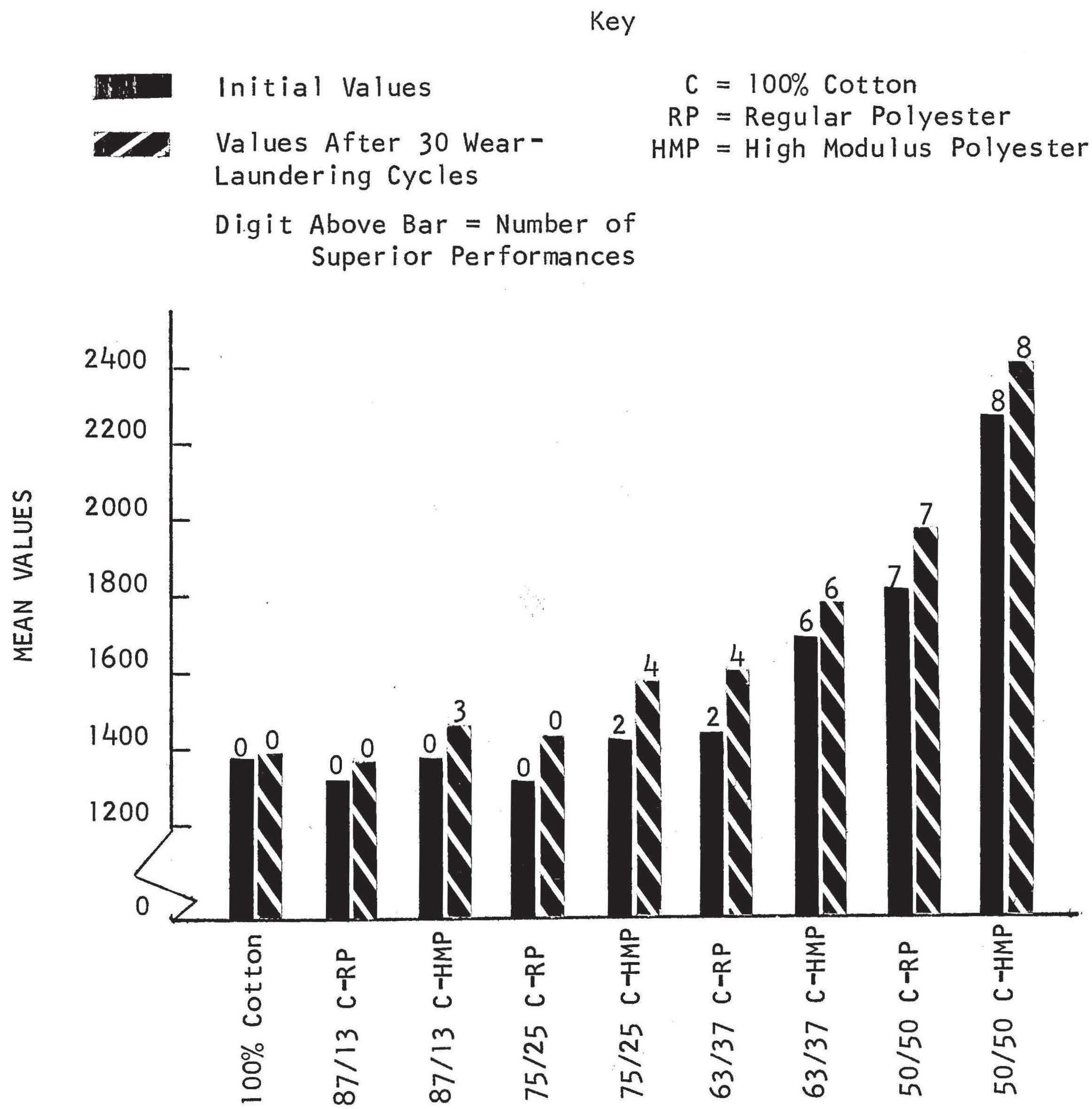


Figure 14

A Comparison of Filling Tearing Strength Values of Men's Trousers Initially and After 30 Wear-Laundering Cycles obtained after 30 wear-laundering periods indicated that each trouser style gained some resistance to tearing in the filling direction after 30 wear-laundering cycles.

All but three fabrics maintained their original position relative to superiority. The 63/37 cotton-regular polyester and the 75/25 cotton-high modulus polyester after 30 wear-laundering cycles were superior to four other fabrics instead of two fabrics as found in the initial comparisons. The 87/13 cotton-high modulus polyester was superior to three other fabrics as compared to being superior to no other fabrics initially.

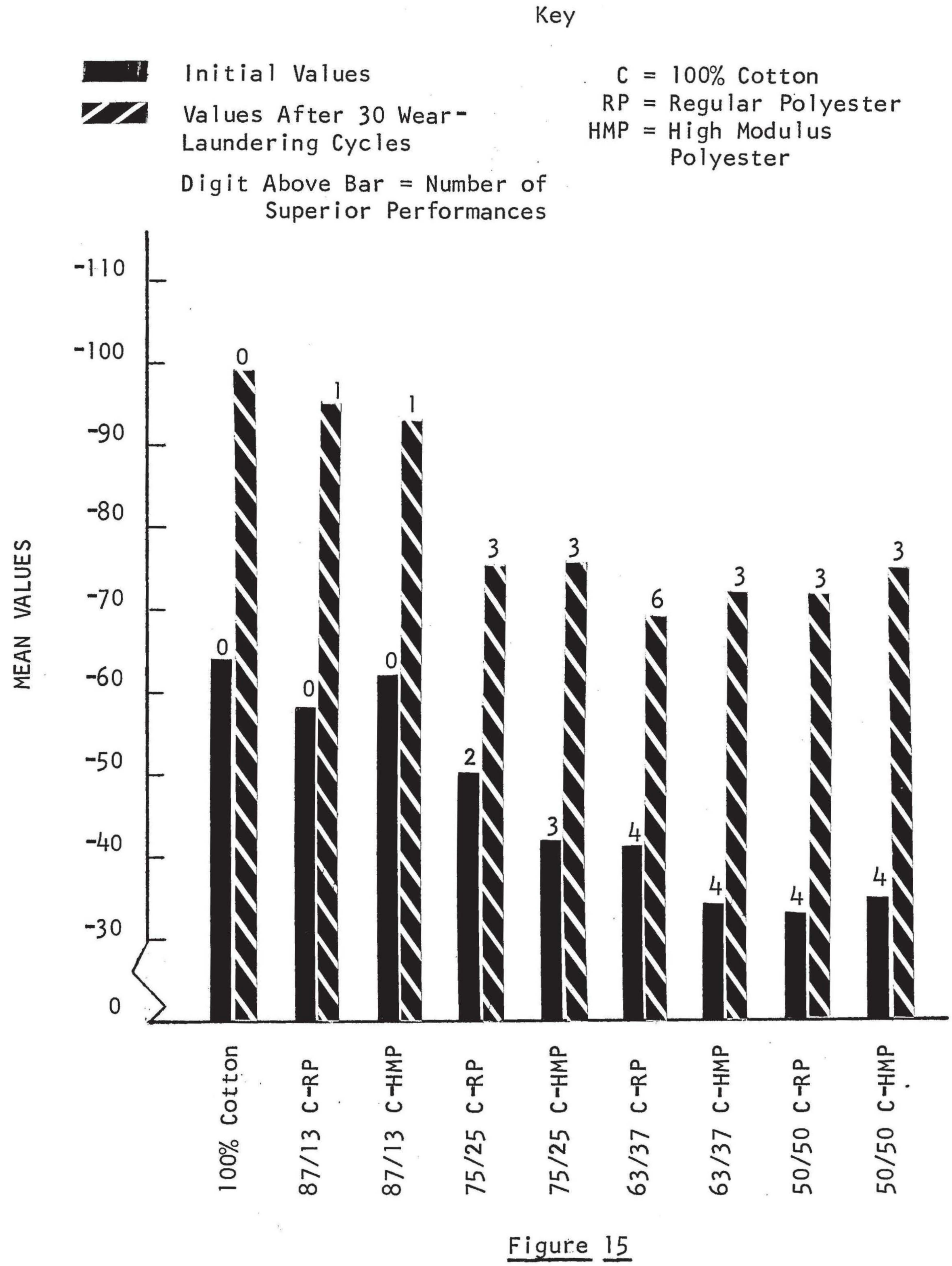
Breaking Strength After Flat Abrasion

Significant differences were present between trouser types after 30 wear-laundering cycles when mean breaking strength after flat abrasion data recorded in Table XVIII were analyzed statistically as shown in Parts A and B in Table XX of the Appendix. Further analysis of data utilizing Duncan's Multiple Comparison Test provided a basis for the following discussion. Figures 15 and 16 demonstrate comparisons between initial data obtained by Larson (28) and data obtained after 30 wear-laundering cycles of the trouser styles.

Breaking Strength After
Flat Abrasion After 30
Wear-Laundering Cycles

Warp Direction. A study of the performance of the experimental trousers after 30 wear-laundering cycles on the basis of the per cent change in warp breaking strength after flat abrasion points to the superiority of the 63/37 cotton-regular polyester trousers which outperformed six trouser types to rank in first place. See Table XIX. The 50/50 and 75/25 blends with both types of polyester as well as the 63/37 cotton-high modulus polyester received the second rank position. Low performers in the group with respect to abrasion resistance were the 87/13 blends with both types of polyester and the 100 per cent cotton trousers.

Polyester type was not an influencing factor as far as resistance to abrasion was concerned after 30 wear-laundering periods. In every instance the regular polyester performed as well as did the high modulus polyester trousers. Comparisons of initial data with data obtained after 30 wear-laundering cycles points to the increased loss of abrasion resistance after 30 test intervals for each trouser type. The poor performance of the all-cotton trousers and trousers containing the higher percentage of cotton is evident in Figure 15, both at the initial test interval and after 30 wear-laundering intervals. Trouser



<u>Figure 15</u>

A Comparison of Per Cent Change In Warp Breaking Strength Values of Men's Trousers Due To Flat Abrasion Initially and After 30 Wear-Laundering Cycles types with higher levels of the polyester fiber performed at a more desirable level initially and after 30 wear-laundering cycles.

Filling Direction. From the data tabulated in Table XVIII and graphed in Figure 16, when trouser types were ranked on the basis of their performance, there was evidence that the filling breaking strength of two trouser types, the 50/50 cotton-polyester blends, increased with abrasion while the strength of the remainder deteriorated. Only three trouser types were significantly superior to another. The 50/50 cotton-high modulus, the 50/50 and the 87/13 cotton-regular polyester ranked in first, second, and third positions, respectively.

Upon comparison of initial data and also those obtained after 30 wear-laundering cycles, a similar trend was apparent for both in that only two trouser types were significantly superior to another--the 50/50 cotton-high modulus polyester and the 75/25 cotton-regular polyester. Upon further study it was noted that the 50/50 blends with both types of polyester gained strength after 30 wear-laundering cycles when subjected to flat abrasion. All other trouser styles lost breaking strength after flat abrasion both initially and after 30 test intervals. Initially, polyester content was not an influencing factor;

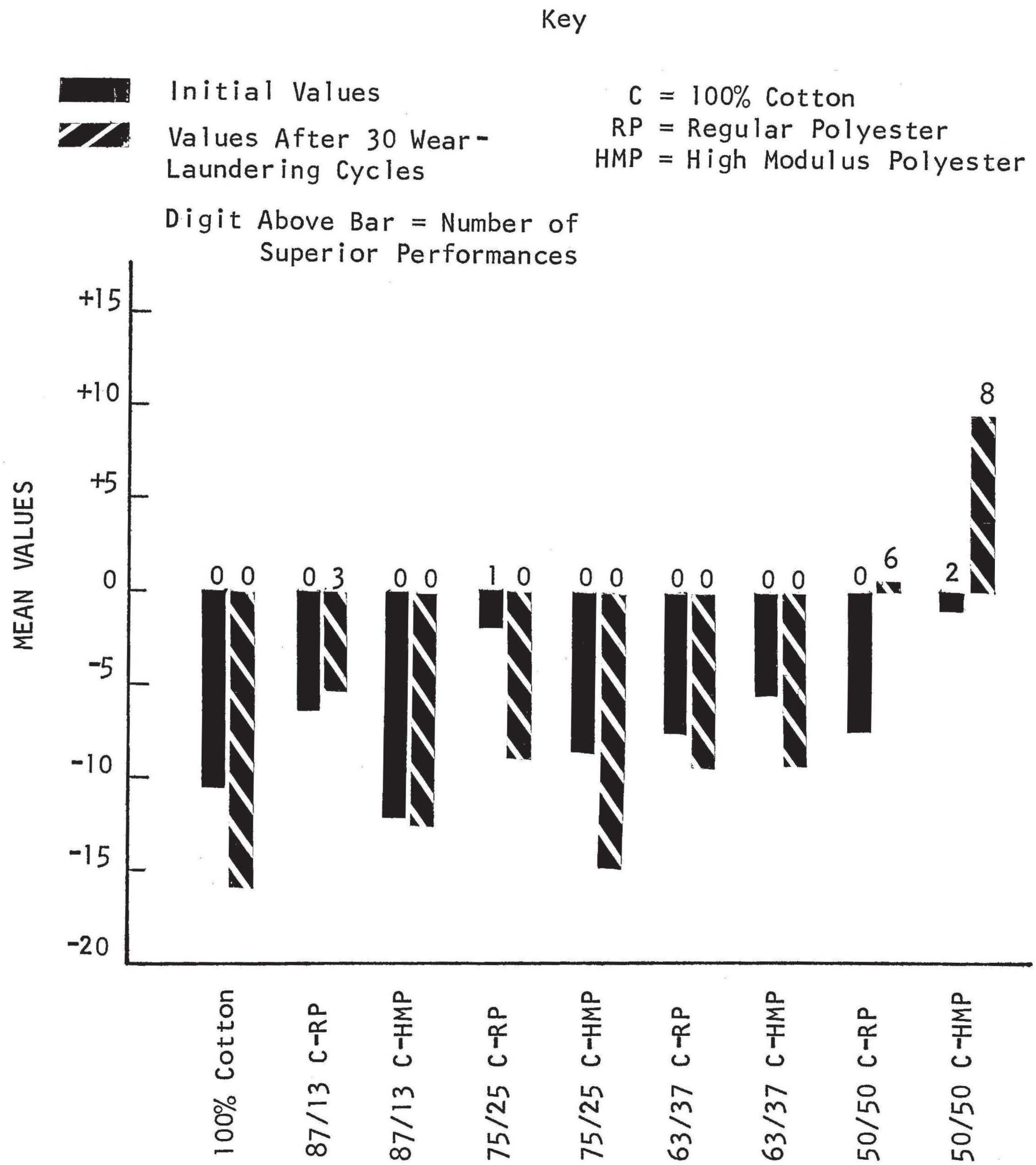


Figure 16

Comparison of Per Cent Change In Breaking Strength Due To Flat Abrasion Initially and After 30 Wear-Laundering Cycles In the Filling Direction however, after 30 wear-laundering cycles, the regular polyester trousers were superior to the high modulus polyester trousers both in the 87/13 and in the 50/50 blends.

Wrinkle Recovery Performance

A statistical analysis of the wrinkle recovery data as recorded in Tables XXI and XXII of the Appendix indicated that significant differences were present among trouser styles after 30 wear-laundering cycles as shown in Parts A and B of Table XXIII in the Appendix. The application of Duncan's Multiple Comparison Test provided a further analysis of these data. The statistical analysis and the following discussion are based on the combined warp and filling values for each trouser type relative to face-to-face and back-to-back wrinkle recovery angles, respectively. Intercomparisons of the initial wrinkle recovery data obtained by Larson (28) with the performance values of the trousers after 30 wear-laundering cycles are shown in Figures 17 and 18.

Comparison of Face-to-Face Wrinkle Recovery Values Initially and After 30 Wear-Laundering Periods

Three trouser types were given first rank positions relative to their face-to-face wrinkle recovery performance. They were the 75/25 blends with both types of polyester and the 50/50 cotton-high modulus polyester. These three trouser types were significantly superior to the other blend levels which performed on an equal basis with one another but in a manner superior to the 100 per cent cotton trousers.

When initial values and those obtained after 30 wear-laundering cycles were compared, it was noted that all trouser types attained lower face-to-face wrinkle recovery angles after 30 test intervals were completed as shown in Figure 17. Regular polyester performed at the same level as high modulus polyester in the various trouser types both initially and after 30 wear-laundering cycles with the exception of the 50/50 blends where the high modulus outperformed the regular polyester types after 30 test intervals. As may be noted in Table XXI of the Appendix, initial wrinkle recovery angles ranged from a low of 282.4 for the 100 per cent cotton to a high of 305.6 for the 50/50 cotton-high modulus polyester. After 30 wear-laundering cycles, these values dropped to 237.4 for the all-cotton trousers which repeated their low initial performances and 280.3 for the 50/50 cotton-high modulus polyester which retained the initial first rank position. It should be noted, however, that the 75/25 cotton-high modulus polyester attained a wrinkle recovery angle of 282.1 after 30 wear-laundering cycles, and its regular polyester counterpart reached 278.7.

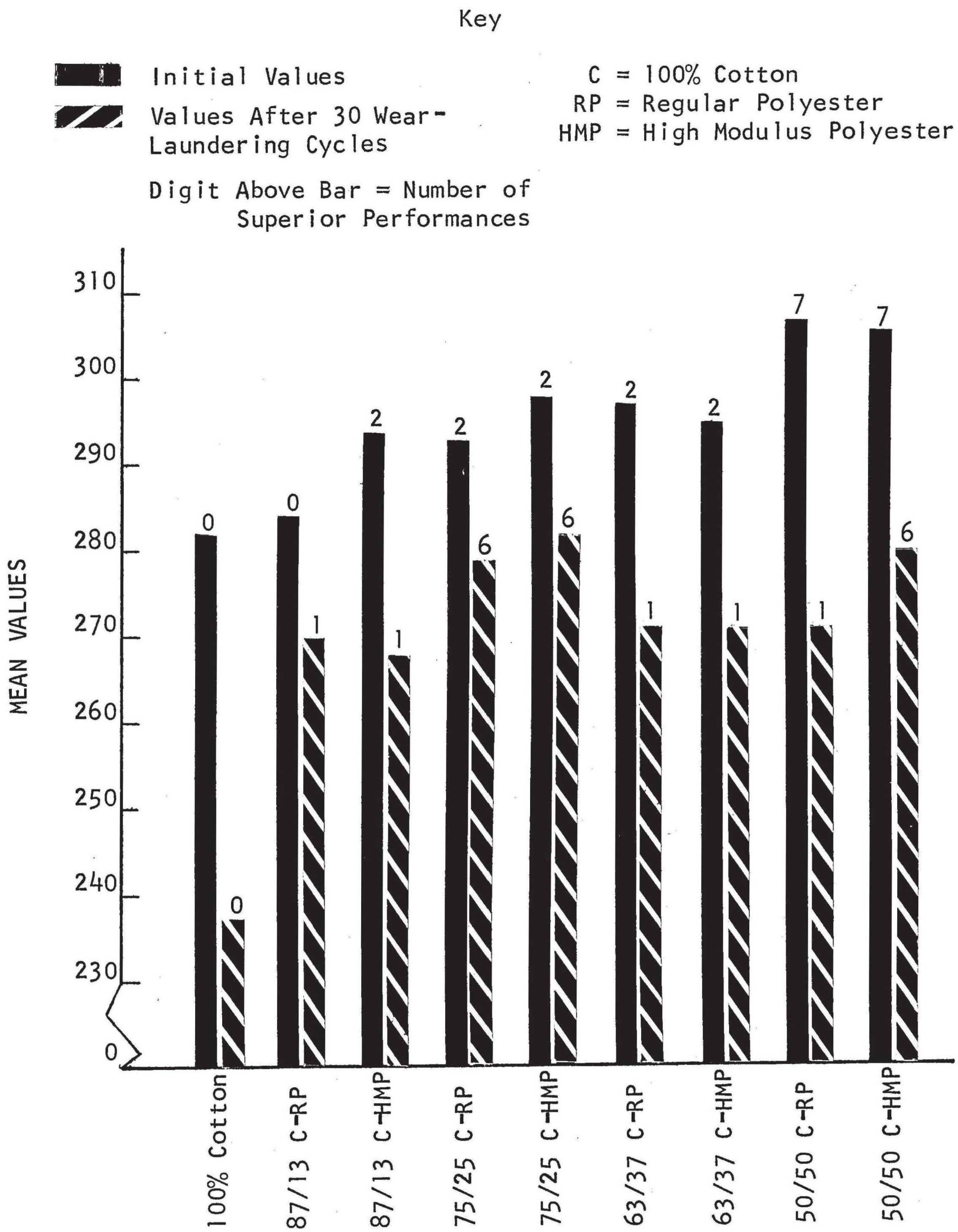


Figure 17

A Comparison of Face-to-Face Wrinkle Recovery Values of Men's Trousers Initially and After 30 Wear-Laundering Cycles (Warp and Filling)

Comparison of Back-to-Back Wrinkle Recovery Values Initially and After 30 Wear-Laundering Periods

Superior back-to-back wrinkle recovery angles were demonstrated by the 87/13 and the 75/25 cotton-regular polyester trousers after 30 periods of wear and laundering. These trousers, therefore, ranked in first position with mean values of 282.6 and 281.2, respectively, and were superior to the levels of performance demonstrated by the remainder of the trouser types. Other trouser types which performed well included the 50/50 cotton-regular polyester in third rank as well as the 75/25 and 87/13 cotton-high modulus polyester in the fourth rank position. Lower performance values were displayed by the 63/37 cotton-regular polyester trousers which performed significantly better than did their companion trouser style and those composed of 100 per cent cotton.

As can be noted from Table XXII and Figure 18, the back-to-back wrinkle recovery performance of the experimental trousers deteriorated with 30 periods of wear and laundering. Three trouser styles retained the positions they had earned initially. They were the 87/13 cotton-regular polyester trousers (Rank 1) and the 50/50 blends with both types of polyester (Ranks 4 and 2). As can be observed in Figure 18, blends of cotton with regular

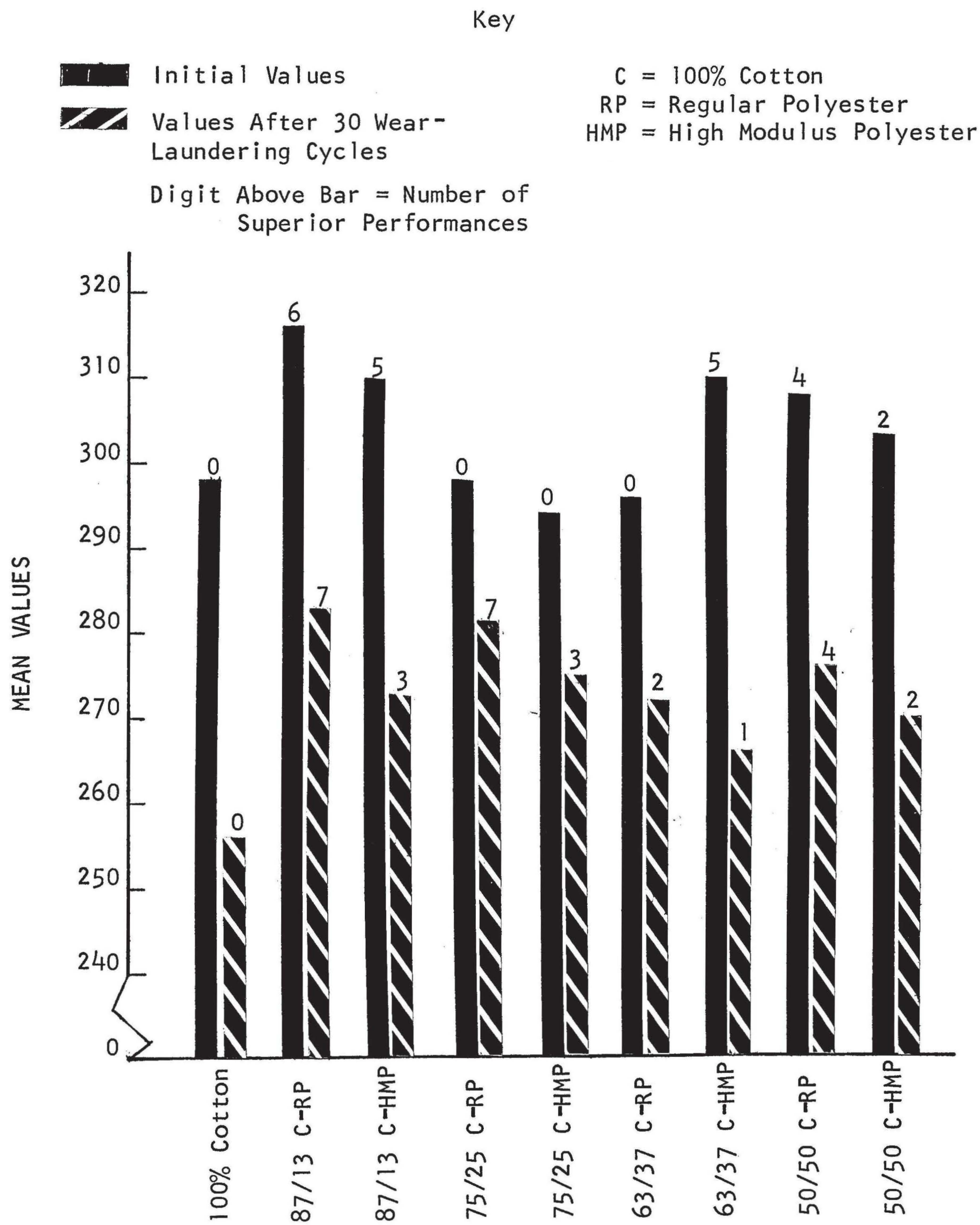


Figure 18

A Comparison of Back-to-Back Wrinkle Recovery Values of Men's Trousers Initially and After 30 Wear-Laundering Cycles (Warp and Filling) polyester gained in number of superior performances or retained their initial status after 30 test intervals. No definite trend was observed relative to trouser styles which contained the high modulus polyester fiber. After 30 test intervals regular polyester performed in a manner superior to the high modulus polyester trousers in every instance, whereas initially the polyester types performed in a comparable manner except in the 63/37 blends when the back-to-back wrinkle recovery of the high modulus fiber out-performed that of the regular polyester.

Fabric Count

The fabric count of the nine experimental trouser styles was performed on the basis of yarns per inch for each yarn direction after 30 wear-laundering periods. Mean values obtained are reported in Table XXIV of the Appendix.

Mean fabric count values in the warp direction ranged from a low of 124.1 yarns per inch for the 87/13 cotton-regular polyester to a high of 127.8 for the 50/50 cotton-high modulus polyester. In the filling direction the lowest mean value obtained was 49.2 yarns per inch for the all-cotton trousers. The highest count of 50.5 was displayed by the 50/50 cotton-regular polyester.

CHAPTER V

SUMMARY

This study was concerned with a comparative evaluation of 108 pairs of men's khaki trousers of 3/1 twill construction treated with a pad-dry-cure durable press finish. Fabrics from which the trousers were constructed were composed of 100 per cent cotton and of cotton blended with regular and high modulus polyester, respectively, in the following percentage combinations: 87/13, 75/25, 63/37, and 50/50.

Each pair of trousers was subjected to a total of 30 eight-hour periods of wear. After each wear period the trousers were laundered at 140^{o} F. and tumble dried. Visual evaluations including durable press appearance, crease sharpness, crease wear, and colorfastness were made at specified wear-laundering intervals by a panel of three observers trained in textile technology. The specimens for the physical tests which included breaking strength, tearing strength, flat abrasion resistance, wrinkle recovery, and fabric count were taken from the areas of greatest wear after the trousers were subjected to 30 wear-laundering cycles. Physical test specimens were conditioned and tested in a standard atmosphere of $70^{o} \pm 2^{o}$ F. and 65 $\pm$ 2 per cent relative humidity.

Results obtained from this study were compared relative to fabric performance with those from a companion study of matched fabrics by Larson (28). An analysis of variance and Duncan's Multiple Comparison Test were used to determine significant differences between the trouser types at the .05 per cent level of probability. A summary relative to the findings of the study follows.

Durable Press Appearance

When durable press values obtained at each wear-laundering test interval were combined for each respective trouser type, significant differences were found to exist between the types. In general, smoothness was directly related to the level of polyester in the trouser types.

The 50/50 cotton-high modulus polyester trousers with a cumulative mean durable press value of 4.6 were superior to the remainder of the trouser types and, therefore, received the highest rank. Second rank on the basis of the number of times one type of trousers was superior to another was attained by the 63/37 and the 50/50 cotton-regular polyester trousers, both of which had cumulative mean values of 4.4 and were superior to four other trouser types. Fourth rank was earned by the 75/25 blends with both types of polyester which were superior to the 100 per cent cotton and to the 87/13 cotton-regular polyester. The 100 per cent cotton trousers again displayed the lowest degree of smoothness. They were outperformed by the remainder of the trouser types.

Successive wear-laundering periods evidenced a general downward trend of the durable press values for all trouser types. Throughout the wear-laundering cycles, the 50/50 cotton-high modulus polyester trousers outperformed other blend levels relative to mean durable press values and superior performances. With the exception of after 20 wear-laundering periods, the 63/37 cotton-regular polyester was equal in performance to the 50/50 cotton-high modulus polyester.

Polyester type did not consistently have any effect upon durable press values. It was noted, however, that in three out of seven comparisons involving the 50/50 blends, the high modulus fibers provided the desirable results. These significant differences were observed after 10, 15, and 30 periods of wear and laundering.

Crease Sharpness

A comparison of the trouser styles on the basis of cumulative data obtained from the test intervals indicated that in some instances crease sharpness was directly related to the percentage of polyester in the blend while in other instances little relationship appeared to exist between the two factors. Blend levels with the highest percentage of polyester tended to exhibit a superior performance except in one instance when the 63/37 cotton-regular polyester trousers displayed more desirable overall crease values than were displayed by the 50/50 cotton-regular polyester.

The 50/50 cotton-high modulus polyester trouser creases were superior to those of all trouser styles except the 63/37 cotton-regular polyester which outperformed six trouser types including the 100 per cent cotton, the 87/13 and 75/25 blends with both types of polyester, and the 63/37 cotton-high modulus polyester. Falling next in line with respect to crease sharpness were the 50/50 cotton-regular polyester trousers, followed by the 75/25 cotton-regular polyester and the remainder of the blends. The all-cotton trouser type was consistently outperformed by the remainder of the styles with respect to the sharpness of their creases.

When cumulative data were considered, the type of polyester used in the blend influenced the crease sharpness performance of the experimental trousers, but no definite pattern was evident. The high modulus polyester produced the sharpest creases in the 50/50 and the 87/13 cotton-polyester combinations, whereas the regular polyester proved to be superior in performance in the 63/37 and the 75/25 blends.

Crease Wear

Overall pooled crease wear values for the nine trouser types ranged from a mean of 7.7 to 8.3 on a scale in which 10.0 was the highest possible value. The superiority of the 63/37 cotton-high modulus polyester blend was evident, since it outperformed all of the trouser types except those constructed from the 87/13 cotton-regular polyester which ranked in second position with respect to the thinning of their creases. These trousers were superior in performance to the 75/25 blends with both polyester types, to the 50/50 and the 87/13 cotton-high modulus polyester, and to the all-cotton trousers.

Falling next in line were the 63/37 cotton-regular polyester trousers, the creases of which were superior to those of four other trouser types, and the 50/50 cotton-regular polyester trousers which were superior to three other styles. The all-cotton trousers outperformed only one trouser style, the 75/25 cotton-high modulus trousers. It was noted, however, that although the 100 per cent cotton trousers did not rank high relative to their superiority over other trouser types, the creases of these trousers were surpassed only by those of the 63/37 cotton-high modulus polyester and the 87/13 cotton-regular polyester with respect to the damage they sustained through 30 periods of wear and laundering.

No definite trend was evident with respect to crease wear in relation to polyester type, since performance evaluations on the basis of the cumulative data showed varied results. The regular polyester provided a superior resistance to wear in the 87/13 and the 50/50 blends while the high modulus polyester was superior to the regular polyester in the 63/37 blends. No significant differences were noted between the two types of polyester in the 75/25 blends.

Broken Yarns

An analysis of the cumulative number of broken yarns for all trouser types after 30 wear-laundering periods showed that the 50/50 blends with both polyester types and the 63/37 cotton-regular polyester trousers demonstrated significantly fewer broken yarns than were noted for the remainder of the trouser types. The above-mentioned trouser types were superior to the all-cotton trousers, the 87/13 blends and the 75/25 cotton-regular polyester trousers. Two trouser types, the 63/37 and the 75/25 cotton-high modulus blends, earned a fourth rank position with significantly fewer broken yarns than were found in the 87/13 cotton-high modulus polyester and in the 100 per cent cotton trousers. Other comparisons continued to magnify the shortcomings of the all-cotton trousers.

The polyester type was not a significant factor relative to the number of broken yarns displayed by the various trouser styles. Only after the first wear-laundering cycle when the 63/37 cotton-regular polyester outperformed its companion fabric was a significant difference noted. Generally, broken yarns were related to wear-laundering cycles. As the number of wear-laundering cycles increased, so did the number of broken yarns.

Colorfastness

A colorfastness rating of 4.7 earned the first rank position for the 50/50 cotton-regular polyester trousers, since they outperformed all other blend levels including the all-cotton trousers which received the lowest color rating of 1.8. The second rank position was earned by three trouser styles including the 50/50 cotton-high modulus polyester and the 63/37 blends containing both polyester types. Each of these three trouser styles was significantly superior with respect to colorfastness to the 100 per cent cotton and to the 87/13 and the 75/25 blends with both types of polyester.

The 75/25 blends which outperformed the all-cotton and the 87/13 blends achieved a fifth rank position. This placed the 87/13 blends with both types of polyester in the seventh rank position, because their colorfastness was superior only to that of the all-cotton trousers.

The high modulus polyester was outperformed by the regular polyester only in the 50/50 blends. In other blend levels high modulus polyester performed on an equal basis with the regular polyester.

Soiling

Significant differences were not evident between the trouser types at any interval of testing when the amount of soil which adhered to the trousers during wear was analyzed. Further analyses showed that during the first wear period the experimental trousers picked up significantly less soil than was found to adhere to them during any of the remaining wear periods.

With respect to the amount of soil which was released by the various trouser types during laundering, significant differences were identified between the trousers only after one and 30 wear-laundering cycles. Two trouser types, the 100 per cent cotton and the 87/13 cotton-high modulus polyester trousers, released more soil after one wear-laundering period than did the trousers which were constructed from the 75/25 and the 63/37 cotton-regular polyester. After 30 periods of wear and laundering, the 50/50 cotton-regular polyester trousers gave up more soil than did their counterparts. Further data analysis relative to soil release failed to show significant differences between any of the remainder of the trouser types at the final period of evaluation.

Breaking Strength

The 50/50 cotton-high modulus polyester trousers exhibited a superior performance both in the warp and filling directions relative to breaking strength after 30 periods of wear and laundering. The 50/50 cotton-regular polyester ranked in second position in the warp direction with seven superior performances. Only one superior performance, however, was observed for these trousers in the filling direction which resulted in a fourth rank position.

Third rank position was earned by the 63/37 cotton-high modulus polyester trousers in both yarn directions. The 100 per cent cotton ranked in fourth place both in the warp and filling directions by being superior to three other trouser styles in the warp direction and sharing this position with four other trouser styles in the filling direction.

Intercomparisons of initial warp data and those obtained after 30 wear-laundering cycles revealed that initial values were higher with the exception of the 50/50 cotton-regular polyester which performed at the same level in both instances. A further examination of the data pointed to the superior performance of the high modulus polyester initially and after 30 wear-laundering cycles. One exception was noted initially when the high modulus polyester was superior to its counterpart in the 63/37 blends. Another exception was noted after 30 wear-laundering periods when both types of polyester performed at the same level in the 87/13 blends.

With respect to the relative performance of the two types of polyester in the filling yarns, initial data revealed that high modulus polyester surpassed the regular polyester in breaking strength in the 50/50 and the 75/25 blends only, whereas after 30 wear-laundering cycles the high modulus polyester trouser types were superior to the regular polyester in each blend level.

Tearing Strength

A well defined pattern was observed in tearing strength data relative to blend level and polyester type. Trouser styles containing the highest percentages of polyester consistently performed in a manner superior to the trousers with higher percentages of cotton. The only exception to this observation was found in the filling specimens when the 75/25 cotton-regular polyester ranked below the 87/13 cotton-high modulus polyester. In every comparison the high modulus trouser types performed in a manner superior to their regular polyester counterparts both in the warp and filling directions.

A comparison of warp tearing strength initially and after 30 wear-laundering cycles demonstrated that the trouser types containing greater amounts of cotton lost tear strength; higher polyester content contributed to a slight gain. In the filling direction, a comparison of initial tear strength results and those obtained after 30 wear-laundering cycles indicated that each trouser style gained some resistance to tearing in the filling direction after 30 wear-laundering cycles.

Breaking Strength After Flat Abrasion

A comparison of the trouser types on the basis of the per cent loss in breaking strength due to flat abrasion showed that greater strength loss occurred in the warp than in the filling direction. A study of the warp breaking strength values after 30 wear-laundering periods pointed to the superiority of the 63/37 cotton-regular polyester trousers which outperformed six trouser types to rank in first position. Five trouser types ranked in second position, including the 50/50 and 75/25 blends with both types of polyester as well as the 63/37 cotton-high modulus polyester. Low performers were the 87/13 blends with both types of polyester and the all-cotton trousers.

Polyester type was not an influencing factor in relation to warpwise abrasion resistance. Comparisons of initial warp data with data after 30 wear-laundering cycles pointed to the increased loss of abrasion resistance after 30 intervals for each trouser type. The poor performance of the all-cotton trousers and the trousers containing the higher percentage of cotton was evident both initially and after 30 wear-laundering test intervals.

The filling breaking strength of the two trouser types, the 50/50 cotton-polyester blends, increased with abrasion while the strength of the remainder deteriorated. Only three trouser types were significantly superior to another. They were the 50/50 cotton-high modulus polyester and the 50/50 and the 87/13 cotton-regular polyester in first, second, and third rank positions, respectively. Initially, polyester content was not an influencing factor; however, after 30 wear-laundering test intervals, the regular polyester trousers were superior to their counterparts in filling breaking strength after abrasion both in the 87/13 and in the 50/50 blends.

Wrinkle Recovery

A study of data obtained from the nine trouser types revealed a difference between specimens which were tested face-to-face and those which were tested back-to-back with the exception of the 75/25 cotton-regular polyester which ranked in first position in each test direction. Three trouser types were given first rank position relative to face-to-face wrinkle recovery performance. They were the trousers composed of the 75/25 blends with both types of polyester and the 50/50 cotton-high modulus polyester. These three trouser types were significantly superior to the other blend levels which performed on an equal basis with one another, but in a manner superior to the all-cotton trousers.

All trouser types attained lower face-to-face wrinkle recovery angles after 30 wear-laundering intervals than were accredited to them initially. In addition, regular polyester performed at the same level as high modulus polyester both initially and after 30 test intervals except in the 50/50 blends where the high modulus outperformed the regular polyester after 30 wear-laundering cycles.

Superior back-to-back wrinkle recovery angles were demonstrated by the 87/13 and the 75/25 cotton-regular polyester trousers after 30 periods of wear and laundering periods. These trouser types ranked in first position, because they outperformed the remainder of the types.

The back-to-back wrinkle recovery performance of the trousers deteriorated with 30 periods of wear and laundering when compared to initial performance. After 30 test intervals regular polyester performed in a manner superior to the high modulus polyester trousers in every instance; however, initially only the 63/37 blends demonstrated the superior performance of the high modulus fiber, with other blend levels performing on an equal basis.

Other trouser types which performed well included the 50/50 cotton-regular polyester in third rank as well as the 75/25 and the 87/13 cotton-high modulus polyester in fourth rank position. Lower performance values were accredited to the 63/37 cotton-regular polyester trousers which performed significantly better than did their companion trouser style and those composed of 100 per cent cotton.

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APPENDIX

TABLE I

MEAN DURABLE PRESS APPEARANCE OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings							
	0	1	5	10	15	20	25	30
1--100% Cotton	5	4.3	4.0	3.9	3.7	3.8	3.6	3.3
2--87% Cotton 13% Polyester (Reg)	5	4.9	4.4	4.2	4.1	4.0	3.9	3.6
3--87% Cotton 13% Polyester (HM)	5	4.9	4.6	4.3	4.1	4.0	4.0	3.8
4--75% Cotton 25% Polyester (Reg)	5	4.9	4.5	4.4	4.3	4.3	4.0	3.9
5--75% Cotton 25% Polyester (HM)	5	4.9	4.8	4.3	4.3	4.3	4.0	3.8
6--63% Cotton 37% Polyester (Reg)	5	4.9	4.8	4.4	4.4	4.3	4.1	4.0
7--63% Cotton 37% Polyester (HM)	5	4.9	4.7	4.4	4.2	4.1	3.9	3.8
8--50% Cotton 50% Polyester (Reg)	5	4.9	4.9	4.4	4.2	4.4	4.1	3.8
9--50% Cotton 50% Polyester (HM)	5	4.9	4.9	4.7	4.6	4.6	4.2	4.1

Reg - Regular
HM - High Modulus

TABLE II

ANALYSIS OF VARIANCE RESULTS RELATIVE TO DURABLE PRESS APPEARANCE OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
1	Between	3.6683	8	0.4585	7.0554***
	Within	6.4342	99	0.0650	
	Total	10.1025	107		
5	Between	7.4463	8	0.9308	8.0997***
	Within	11.3767	99	0.1149	
	Total	18.8230	107		
10	Between	4.6291	8	0.5786	4.4623***
	Within	12.5782	97	0.1297	
	Total	17.2073	105		
15	Between	5.2355	8	0.6544	4.9092***
	Within	12.9310	97	0.1333	
	Total	18.1665	105		
20	Between	5.3822	8	0.6728	4.8558***
	Within	13.4393	97	0.1385	
	Total	18.8215	105		
25	Between	2.6034	8	0.3254	3.6621***
	Within	8.4419	95	0.0889	
	Total	11.0453	103		
30	Between	3.9007	8	0.4876	5.7119***
	Within	8.1096	95	0.0854	
	Total	12.0104	103		
Cumulative 1-30	Row[1]	25.8752	8	3.2344	29.9570***
	Column[2]	76.8175	6	12.8029	118.5808***
	Interaction	6.9904	48	0.1456	1.3489
	Within	73.3102	679	0.1080	
	Total	182.9933	741		

*** = .001 level of significance
1 = Trouser Type
2 = Laundering Interval

TABLE III

MEAN CREASE SHARPNESS OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings							
	0	1	5	10	15	20	25	30
1--100% Cotton	3.8	2.9	2.6	2.4	2.2	2.1	2.2	2.0
2--87% Cotton 13% Polyester (Reg)	3.9	3.6	3.1	3.5	3.1	3.0	3.0	2.8
3--87% Cotton 13% Polyester (HM)	4.2	3.8	3.4	3.5	3.4	3.1	3.1	3.2
4--75% Cotton 25% Polyester (Reg)	4.0	3.6	3.7	3.7	3.5	3.3	3.2	3.1
5--75% Cotton 25% Polyester (HM)	4.0	3.7	3.5	3.3	3.2	3.1	3.0	2.9
6--63% Cotton 37% Polyester (Reg)	4.2	3.9	3.8	3.8	3.6	3.4	3.4	3.7
7--63% Cotton 37% Polyester (HM)	4.0	3.8	3.7	3.4	3.2	3.3	2.9	3.1
8--50% Cotton 50% Polyester (Reg)	4.0	3.9	3.8	3.4	3.5	3.5	3.3	3.2
9--50% Cotton 50% Polyester (HM)	3.9	4.2	3.8	3.8	3.6	3.6	3.5	3.5

Reg - Regular
HM - High Modulues

TABLE IV

ANALYSIS OF VARIANCE RESULTS RELATIVE TO CREASE SHARPNESS OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
0	Between	1.6012	8	0.2001	0.8811
	Within	22.2618	98	0.2272	
	Total	23.8630	106		
1	Between	12.3650	8	1.5456	7.9772***
	Within	19.1817	99	0.1938	
	Total	31.5467	107		
5	Between	15.0380	8	1.8797	9.5003***
	Within	19.5883	99	0.1979	
	Total	34.6263	107		
10	Between	14.2605	8	1.7826	7.1395***
	Within	24.2185	97	0.2497	
	Total	38.4790	105		
15	Between	15.4454	8	1.9307	9.2907***
	Within	20.1573	97	0.2078	
	Total	35.6027	105		
20	Between	16.7612	8	2.0952	9.2990***
	Within	21.8550	97	0.2253	
	Total	38.6162	105		
25	Between	11.9390	8	1.4924	6.3121***
	Within	22.4610	95	0.2364	
	Total	34.4000	103		
30	Between	14.9911	8	1.8739	7.8919***
	Within	22.5573	95	0.2374	
	Total	37.5484	103		
Cumulative 1-30	Row[1]	82.2305	8	10.2788	46.3584***
	Column[2]	79.7146	7	11.3878	51.3600***
	Interaction	20.1708	56	0.3602	1.6245**
	Within	172.2804	777	0.2217	
	Total	354.3964	848		

** = .01 level of significance
*** = .001 level of significance
1 = Trouser Type
2 = Laundering Interval

TABLE V

MEAN CREASE WEAR VALUES OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings							
	0	1	5	10	15	20	25	30
1--100% Cotton	10	9.7	8.7	8.2	7.7	7.4	7.1	6.4
2--87% Cotton 13% Polyester (Reg)	10	10.0	9.2	8.5	8.0	7.7	7.1	6.5
3--87% Cotton 13% Polyester (HM)	10	9.8	8.8	8.3	7.8	7.4	6.7	6.2
4--75% Cotton 25% Polyester (Reg)	10	9.9	8.9	8.3	7.7	7.0	6.6	6.2
5--75% Cotton 25% Polyester (HM)	10	9.4	8.6	8.4	7.7	7.0	6.7	6.3
6--63% Cotton 37% Polyester (Reg)	10	9.7	8.8	8.4	8.0	7.6	7.3	6.7
7--63% Cotton 37% Polyester (HM)	10	9.6	9.2	8.8	8.0	7.8	7.4	7.0
8--50% Cotton 50% Polyester (Reg)	10	9.5	8.8	8.4	7.9	7.5	7.2	7.0
9--50% Cotton 50% Polyester (HM)	10	9.8	9.2	8.6	7.4	6.8	6.6	6.3

Reg - Regular
HM - High Modulus

TABLE VI

ANALYSIS OF VARIANCE RESULTS RELATIVE TO CREASE WEAR OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
1	Between	3.9302	8	0.4913	2.1216*
	Within	22.9242	99	0.2316	
	Total	26.8544	107		
5	Between	5.4030	8	0.6754	2.0017
	Within	33.4025	99	0.3374	
	Total	38.8054	107		
10	Between	2.9771	8	0.3721	1.7424
	Within	20.7173	97	0.2136	
	Total	23.6944	105		
15	Between	3.6430	8	0.4554	1.9432
	Within	22.7310	97	0.2343	
	Total	26.3740	105		
20	Between	11.6243	8	1.4530	4.5858***
	Within	30.7350	97	0.3169	
	Total	42.3593	105		
25	Between	10.3877	8	1.2985	3.4092**
	Within	36.1826	95	0.3809	
	Total	46.5704	103		
30	Between	9.2267	8	1.1533	2.7770**
	Within	39.4555	95	0.4153	
	Total	48.6822	103		
Cumulative 1-30	Row[1]	22.7859	8	2.8482	9.3816***
	Column[2]	811.9812	6	135.3302	445.7521***
	Interaction	24.4061	48	0.5085	1.6748**
	Within	206.1442	679	0.3036	
	Total	1065.3174	741		

* = .05 level of significance
** = .01 level of significance
*** = .001 level of significance
1 = Trouser Type
2 = Laundering Interval

TABLE VII

MEAN CUMULATIVE NUMBER OF BROKEN YARNS, EXCLUSIVE OF TEARS, IN MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING
(Warp and Filling)

Trouser Type and Fiber Content	Number of Launderings							
	0	1	5	10	15	20	25	30
1--100% Cotton	6.96	17.46	80.46	81.40	136.55	269.10	464.17	669.94
2--87% Cotton 13% Polyester (Reg)	4.41	7.71	20.62	32.67	50.83	81.46	134.14	228.18
3--87% Cotton 13% Polyester (HM)	3.67	9.67	24.04	41.79	63.71	95.54	174.00	300.96
4--75% Cotton 25% Polyester (Reg)	2.87	6.62	21.04	36.46	57.71	79.42	118.96	227.08
5--75% Cotton 25% Polyester (HM)	3.12	9.33	28.71	39.42	54.00	71.00	99.79	149.62

TABLE VII--Continued

Trouser Type and Fiber Content	Number of Launderings							
	0	1	5	10	15	20	25	30
6--63% Cotton 37% Polyester (Reg)	2.62	4.29	11.12	15.92	29.08	46.38	68.54	96.62
7--63% Cotton 37% Polyester (HM)	2.54	16.75	23.62	36.25	50.58	82.21	123.92	167.29
8--50% Cotton 50% Polyester (Reg)	1.92	4.08	10.46	19.25	24.58	35.38	58.25	94.29
99--50% Cotton 50% Polyester (HM)	1.46	1.75	6.75	15.46	21.67	29.04	46.25	72.42

Reg - Regular
HM - High Modulus

TABLE VIII

ANALYSIS OF VARIANCE RESULTS RELATIVE TO CUMULATIVE NUMBER OF BROKEN YARNS, EXCLUSIVE OF TEARS, IN MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
0	Between	508.4988	8	63.5623	3.2235**
	Within	4042.2348	205	19.7182	
	Total	4550.7336	213		
1	Between	5691.3704	8	711.4213	2.5550**
	Within	57637.0000	207	278.4396	
	Total	63328.3704	215		
5	Between	92727.8704	8	11590.9838	5.1605***
	Within	464945.1667	207	2246.1119	
	Total	557673.0370	215		
10	Between	68666.0939	8	8583.2617	7.7121***
	Within	225930.6750	203	1112.9590	
	Total	294596.7689	211		
15	Between	199830.7167	8	24978.8396	12.6468***
	Within	400947.0333	203	1975.1085	
	Total	600777.7500	211		
20	Between	856420.9626	8	107052.6203	21.2927***
	Within	1020617.7167	203	5027.6735	
	Total	1877038.6792	211		
25	Between	2461885.3883	8	307735.6735	25.4285***
	Within	2408298.7992	199	12102.0040	
	Total	4870184.1875	207		
30	Between	5236093.9719	8	654511.7465	23.8966***
	Within	5450468.0088	199	27389.2865	
	Total	10686561.9808	207		

** = .01 level of significance.
*** = .001 level of significance.

TABLE IX

MEAN COLORFASTNESS VALUES OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings	
	0	30
1--100% Cotton	5	1.8
2--87% Cotton 13% Polyester (Reg)	5	2.8
3--87% Cotton 13% Polyester (HM)	5	2.6
4--75% Cotton 25% Polyester (Reg)	5	3.7
5--75% Cotton 25% Polyester (HM)	5	3.8
6--63% Cotton 37% Polyester (Reg)	5	4.2
7--63% Cotton 37% Polyester (HM)	5	4.2
8--50% Cotton 50% Polyester (Reg)	5	4.7
9--50% Cotton 50% Polyester (HM)	5	4.3

Reg - Regular
HM - High Modulus

TABLE X

MEAN SOIL VALUES OBSERVED IN MEN'S TROUSERS BEFORE SPECIFIED PERIODS OF LAUNDERING

Trouser Type and Fiber Content	Number of Launderings						
	1	5	10	15	20	25	30
1--100% Cotton	3.2	3.0	3.3	3.1	3.3	3.0	3.2
2--87% Cotton 13% Polyester (Reg)	3.5	2.9	3.4	3.0	3.1	3.2	3.2
3--87% Cotton 13% Polyester (HM)	3.2	3.0	3.2	2.9	3.0	3.0	3.2
4--75% Cotton 25% Polyester (Reg)	3.7	3.0	3.0	3.0	3.1	2.9	3.1
5--75% Cotton 25% Polyester (HM)	3.6	2.8	2.9	2.8	2.9	3.0	2.9
6--63% Cotton 37% Polyester (Reg)	3.8	3.1	3.4	3.0	3.0	2.9	3.0
7--63% Cotton 37% Polyester (HM)	3.2	2.9	3.2	3.2	3.1	3.0	2.9
8--50% Cotton 50% Polyester (Reg)	3.6	2.7	3.2	3.1	3.2	3.2	2.9
9--50% Cotton 50% Polyester (HM)	3.1	2.7	3.1	2.8	2.9	3.0	3.4

Reg - Regular
HM - High Modulus

TABLE XI

MEAN SOIL VALUES OBSERVED IN MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings						
	1	5	10	15	20	25	30
1--100% Cotton	4.5	4.5	4.6	4.4	4.6	4.1	4.4
2--87% Cotton 13% Polyester (Reg)	4.3	4.6	4.8	4.4	4.2	4.5	4.1
3--87% Cotton 13% Polyester (HM)	4.5	4.8	4.8	4.5	4.3	4.2	4.3
4--75% Cotton 25% Polyester (Reg)	4.3	4.6	4.5	4.6	4.4	4.3	4.3
5--75% Cotton 25% Polyester (HM)	4.4	4.4	4.3	4.4	4.2	4.1	4.1
6--63% Cotton 37% Polyester (Reg)	4.5	4.6	4.6	4.3	4.5	4.3	4.3
7--63% Cotton 37% Polyester (HM)	4.3	4.3	4.4	4.5	4.2	4.2	4.2
8--50% Cotton 50% Polyester (Reg)	4.4	4.2	4.6	4.5	4.5	4.3	4.3
9--50% Cotton 50% Polyester (HM)	4.0	4.2	4.2	4.2	4.2	4.3	4.3

Reg - Regular
HM - High Modulus

TABLE XII

MEAN SOIL RELEASE VALUES IN MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings						
	1	5	10	15	20	25	30
1--100% Cotton	1.3	1.5	1.3	1.3	1.3	1.1	1.1
2--87% Cotton 13% Polyester (Reg)	0.8	1.7	1.3	1.4	1.2	1.4	1.3
3--87% Cotton 13% Polyester (HM)	1.3	1.8	1.6	1.6	1.3	1.2	1.2
4--75% Cotton 25% Polyester (Reg)	0.7	1.6	1.5	1.6	1.3	1.4	1.2
5--75% Cotton 25% Polyester (HM)	0.8	1.6	1.4	1.6	1.2	1.4	1.2
6--63% Cotton 37% Polyester (Reg)	0.6	1.5	1.2	1.3	1.5	1.4	1.3
7--63% Cotton 37% Polyester (HM)	1.1	1.4	1.2	1.2	1.2	1.2	1.2
8--50% Cotton 50% Polyester (Reg)	0.8	1.6	1.3	1.4	1.3	1.2	1.4
9--50% Cotton 50% Polyester (HM)	0.9	1.6	1.2	1.4	1.3	1.3	0.9

Reg - Regular
HM - High Modulus

TABLE XIII

ANALYSIS OF VARIANCE RESULTS RELATIVE TO THE SOILING OF MEN'S TROUSERS AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

PART A. APPARENT SOIL VALUES BEFORE LAUNDERING

	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
	Row[1]	4.0365	8	0.5046	1.1150
	Column[2]	19.1754	6	3.1959	7.0824***
	Interaction	15.4821	48	0.3225	0.7128
	Within	307.2616	679	0.4525	

PART B. APPARENT SOIL RELEASED DURING LAUNDERING

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
1	Between	6.1667	8	0.7708	1.6066
	Within	47.5000	99	0.4798	
	Total	53.6667	107		
5	Between	0.9074	8	0.1134	0.2581
	Within	43.5000	99	0.4394	
	Total	44.4074	107		
10	Between	1.9236	8	0.2404	0.9779
	Within	23.8500	98	0.2459	
	Total	25.7736	105		
15	Between	1.5211	8	0.1901	0.6044
	Within	30.5167	97	0.3146	
	Total	32.0377	105		
20	Between	0.9896	8	0.1237	0.4733
	Within	25.3500	97	0.2613	
	Total	26.3396	105		
25	Between	1.1362	8	0.1420	0.5862
	Within	23.0177	95	0.2423	
	Total	24.1538	103		
30	Between	1.9421	8	0.2428	1.1885
	Within	19.4040	95	0.2043	
	Total	21.3462	103		
Cumulative 1-30	Between	2.2291	8	0.2786	0.8165
	Within	250.1482	733	0.3413	
	Total	252.3774	741		

*** = .001 level of significance
1 = Trouser Type
2 = Laundering Interval

TABLE XIV

MEAN BREAKING STRENGTH VALUES OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING
(Pounds Per Inch)

Trouser Type and Fiber Content	Number of Launderings			
	Warp		Filling	
	0*	30	0*	30
1--100% Cotton	92.6	77.3	32.7	31.1
2--87% Cotton 13% Polyester (Reg)	87.4	65.1	31.2	28.5
3--87% Cotton 13% Polyester (HM)	93.2	67.3	33.1	30.0
4--75% Cotton 25% Polyester (Reg)	86.6	61.5	30.9	30.3
5--75% Cotton 25% Polyester (HM)	100.4	73.6	35.8	32.9
6--63% Cotton 37% Polyester (Reg)	90.5	70.0	32.8	29.9
7--63% Cotton 37% Polyester (HM)	94.4	78.2	34.7	32.7
8--50% Cotton 50% Polyester (Reg)	92.2	92.2	36.6	31.0
9--50% Cotton 50% Polyester (HM)	121.2	103.1	47.7	37.6

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XV

ANALYSIS OF VARIANCE RESULTS RELATIVE TO BREAKING STRENGTH OF MEN'S TROUSERS AFTER 30 PERIODS OF WEAR AND LAUNDERING

PART A. WARP DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	34520.4133	8	4315.0517	95.6768***
	Within	8974.9605	199	45.1003	
	Total	43495.3738	207		

PART B. FILLING DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	1337.1126	8	167.1391	42.8913***
	Within	775.4643	199	3.8968	
	Total	2112.5769	207		

*** = .001 level of significance.

TABLE XVI

MEAN TEARING STRENGTH VALUES OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING (Grams)

Trouser Type and Fiber Content	Number of Launderings			
	Warp		Filling	
	0*	30	0*	30
1--100% Cotton	1770	1633	1380	1389
2--87% Cotton 13% Polyester (Reg)	2060	1723	1340	1364
3--87% Cotton 13% Polyester (HM)	2140	1708	1370	1458
4--75% Cotton 25% Polyester (Reg)	2030	1746	1330	1392
5--75% Cotton 25% Polyester (HM)	2190	2017	1420	1579
6--63% Cotton 37% Polyester (Reg)	2310	2262	1430	1592
7--63% Cotton 37% Polyester (HM)	2590	2612	1690	1783
8--50% Cotton 50% Polyester (Reg)	3040	3308	1840	1971
9--50% Cotton 50% Polyester (HM)	3620	3642	2270	2421

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XVII

ANALYSIS OF VARIANCE RESULTS RELATIVE TO THE TEARING STRENGTH OF MEN'S TROUSERS AFTER 30 PERIODS OF WEAR AND LAUNDERING

PART A. WARP DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	102934023.8928	8	12866752.9866	823.5575 ***
	Within	3109053.0303	199	15623.3821	
	Total	106043076.9231	207		

PART B. FILLING DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	22760606.6096	8	2845075.8262	369.2771 ***
	Within	1525480.3469	198	7704.4462	
	Total	24286086.9565	206		

*** = .001 level of significance.

TABLE XVIII

MEAN BREAKING STRENGTH VALUES DUE TO FLAT ABRASION OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING (Pounds Per Inch)

Trouser Type and Fiber Content	Number of Launderings			
	Warp		Filling	
	0*	30	0*	30
1--100% Cotton	32.9	0.5	28.7	25.9
2--87% Cotton 13% Polyester (Reg)	36.2	3.4	29.2	26.8
3--87% Cotton 13% Polyester (HM)	35.3	4.6	28.9	26.2
4--75% Cotton 25% Polyester (Reg)	43.0	15.4	30.1	27.4
5--75% Cotton 25% Polyester (HM)	58.3	17.8	32.7	28.0
6--63% Cotton 37% Polyester (Reg)	53.8	21.7	30.3	27.0
7--63% Cotton 37% Polyester (HM)	61.8	21.7	32.7	29.5
8--50% Cotton 50% Polyester (Reg)	61.9	25.6	33.7	31.0
9--50% Cotton 50% Polyester (HM)	78.9	25.8	48.1	41.0

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XIX

MEAN PER CENT CHANGE IN BREAKING STRENGTH OF MEN'S TROUSERS DUE TO FLAT ABRASION AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

Trouser Type and Fiber Content	Number of Launderings			
	Warp		Filling	
	0*	30	0*	30
1--100% Cotton	-64.1	-99.4	-11.2	-16.1
2--87% Cotton 13% Polyester (Reg)	-58.4	-94.8	- 6.4	- 5.6
3--87% Cotton 13% Polyester (HM)	-61.9	-93.4	-12.3	-12.6
4--75% Cotton 25% Polyester (Reg)	-50.1	-75.0	- 2.2	- 9.2
5--75% Cotton 25% Polyester (HM)	-41.9	-75.7	- 8.5	-14.9
6--63% Cotton 37% Polyester (Reg)	-40.6	-69.0	- 7.4	- 9.5
7--63% Cotton 37% Polyester (HM)	-33.8	-72.3	- 5.7	- 9.7
8--50% Cotton 50% Polyester (Reg)	-32.8	-72.3	- 7.9	+ 0.2
9--50% Cotton 50% Polyester (HM)	-34.9	-74.9	- 1.1	+ 9.5

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XX

ANALYSIS OF VARIANCE RESULTS RELATIVE TO PER CENT CHANGE IN BREAKING STRENGTH OF MEN'S TROUSERS DUE TO FLAT ABRASION AFTER SPECIFIED PERIODS OF WEAR AND LAUNDERING

PART A. WARP DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	23310.6765	8	2913.8346	86.4827***
	Within	6704.8465	199	33.6927	
	Total	30015.5230	207		

PART B. FILLING DIRECTION

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	11953.5110	8	1494.1889	13.2497***
	Within	22441.5766	199	112.7717	
	Total	34395.0876	207		

*** = .001 level of significance.

TABLE XXI

MEAN FACE-TO-FACE WRINKLE RECOVERY ANGLES OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING
(Warp and Filling)

Trouser Type and Fiber Content	Number of Launderings	
	0*	30
1--100% Cotton	282.4	237.4
2--87% Cotton 13% Polyester (Reg)	283.6	269.8
3--87% Cotton 13% Polyester (HM)	294.4	268.5
4--75% Cotton 25% Polyester (Reg)	293.2	278.7
5--75% Cotton 25% Polyester (HM)	298.0	282.1
6--63% Cotton 37% Polyester (Reg)	297.2	271.3
7--63% Cotton 37% Polyester (HM)	295.2	271.4
8--50% Cotton 50% Polyester (Reg)	307.2	271.2
9--50% Cotton 50% Polyester (HM)	305.6	280.3

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XXII

MEAN BACK-TO-BACK WRINKLE RECOVERY ANGLES OF MEN'S TROUSERS INITIALLY AND AFTER 30 PERIODS OF WEAR AND LAUNDERING
(Warp and Filling)

Trouser Type and Fiber Content	Number of Launderings	
	0*	30
1--100% Cotton	298.4	256.4
2--87% Cotton 13% Polyester (Reg)	316.0	282.6
3--87% Cotton 13% Polyester (HM)	310.0	273.3
4--75% Cotton 25% Polyester (Reg)	297.6	281.2
5--75% Cotton 25% Polyester (HM)	294.4	274.7
6--63% Cotton 37% Polyester (Reg)	296.0	271.9
7--63% Cotton 37% Polyester (HM)	310.4	266.4
8--50% Cotton 50% Polyester (Reg)	308.0	275.8
9--50% Cotton 50% Polyester (HM)	302.8	269.6

Reg - Regular
HM - High Modulus
* - Data compiled by Larson (28).

TABLE XXIII

ANALYSIS OF VARIANCE RESULTS RELATIVE TO WRINKLE RECOVERY OF MEN'S TROUSERS AFTER 30 PERIODS OF WEAR AND LAUNDERING
(Warp and Filling)

PART A. FACE-TO-FACE

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	134529042.3465	8	16816130.2933	99.7870 ***
	Within	16009419.1919	95	168520.2020	
	Total	150538461.5385	103		

PART B. BACK-TO-BACK

Wear and Laundering Interval	Source	Sum Squares	Degrees of Freedom	Mean Squares	F Ratio
30	Between	50839919.3862	8	6354989.9233	48.0378 ***
	Within	12567676.7677	95	132291.3344	
	Total	63407596.1539	103		

*** = .001 level of significance.

TABLE XXIV

FABRIC COUNT OF MEN'S TROUSERS AFTER 30 PERIODS OF WEAR AND LAUNDERING
(Yarns Per Inch)

Trouser Type and Fiber Content	Yarn Direction	
	Warp	Filling
1--100% Cotton	124.3	49.2
2--87% Cotton 13% Polyester (Reg)	124.1	49.3
3--87% Cotton 13% Polyester (HM)	124.3	49.5
4--75% Cotton 25% Polyester (Reg)	124.6	49.4
5--75% Cotton 25% Polyester (HM)	125.1	50.2
6--63% Cotton 37% Polyester (Reg)	125.0	50.0
7--63% Cotton 37% Polyester (HM)	124.8	50.0
8--50% Cotton 50% Polyester (Reg)	126.3	50.5
9--50% Cotton 50% Polyester (HM)	127.8	50.0

Reg - Regular
HM - High Modulus