GENERAL APPEARANCE, DIMENSIONAL STABILITY, AND DURABILITY OF MEN'S KNIT SHIRTS AFTER WEAR AND LAUNDERING

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BY
SUTASINI SUANSAMROENG, B.S., M.S.

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We hereby recommend that the dissertation prepared under our supervision by Sutasini Suansamroeng entitled "General Appearance, Dimensional Stability, and Durability of Men's Knit Shirts After Wear and Laundering"

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

Committee:

Esther R. Broome
Chairman
Clarice Garrett
Bethel M. Caster
George H. Stewart
Harold N. Simpson

Accepted:
Mary Evelyn Huey
Dean of Graduate Studies

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CHAPTER I

INTRODUCTION

This study was undertaken for the purpose of making a comparative analysis of the general appearance, dimensional stability, and durability of various types of men's long-sleeve knit shirts which were available to the consumer during 1972. A total of 182 shirts representative of warp, circular, and interlock knitting constructions were included in the study. They were composed of 100 per cent cotton, 100 per cent Arnel triacetate, 65/35 Arnel triacetate-Dacron polyester, and of 50/50 cotton-Dacron polyester.

Dimensional control of knitted fabrics always has been difficult both for textile and garment industries; and, despite the fact that a number of studies have been conducted in this area, the process involved still remains incompletely understood and correspondingly empirical and inexact.

Munden (25) pointed out that the dimensions of relaxed knitted fabrics are determined by the length of the yarn in the knitted loop. Hurt (16) investigated the geometry of cotton interlock in which the dimensions of the relaxed fabric were found to depend both upon loop length and yarn diameter.

Several studies concerning other physical properties of various knitted fabrics have been conducted. Brown and Metha (6) studied the effects of tumble-drying on some sensory and physical properties of acrylic-fiber fabrics and discussed the possibility of devising a suitable process to pre-relax such fabrics. Nutting (29) observed that the wet-relaxation process is irreversible, but that the dimensions of the fabric depend upon the water temperature used for relaxation and the regain of the fabrics when they are measured. Knight and Brown (20) studied the moisture characteristics of some knitted fabrics made from blended yarn. The investigation included the measurement of air-permeability, moisture regain, moisture imbibition, shrinkage, and multi-directional bursting strength.

Wear studies designed to investigate the overall end use properties of knit fabrics, especially those of shirting weight and of blended yarns, have been limited despite the fact that it is possible for such studies to provide more accurate results than can be obtained in the laboratory under simulated conditions. This study, therefore, has been undertaken with the following objectives, as a means of providing information along this line:

1. To secure men's knit shirts representative of the various constructions and fiber combinations available to the consumer.

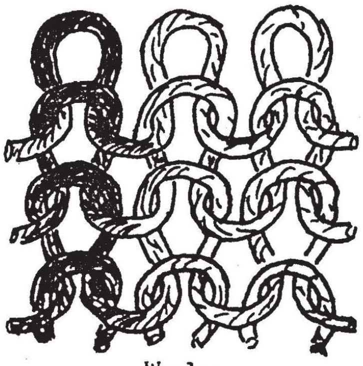
2. To classify the experimental shirts into two groups--one group to be subjected to 25 periods of laundering without previous wear and the other group to be worn and laundered.
3. To evaluate the worn and non-worn shirts at specified intervals of laundering with respect to the following:
    a. Smoothness
    b. Seam appearance
    c. Color retention
    d. Pilling of Collars
    e. Wale and course count
    f. Dimensional stability
    g. Abrasion of collars and cuffs
    h. Bursting strength
4. To analyze the data statistically with respect to the relative performance of the various types of shirts.

CHAPTER II

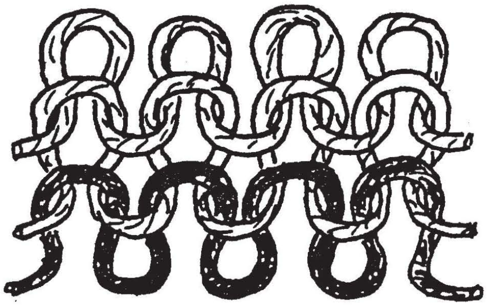
REVIEW OF LITERATURE

Men's tailored knitwear was introduced in the United States during the last decade, and at the early stages of introduction its acceptance was unsure. For the past five years, however, the industry has agreed that knitwear plays a major role in men's wear, but that problems of the industry lie in the production of a desirable fabric which can be made into garments with consumer appeal. In order to be acceptable the fabric must be dimensionally stable, pill resistant, non-sagging, elastic and resilient. Garments constructed from these fabrics must retain shape and size through repeated machine washings and dryings.

Knitted fabrics are composed of rows of loops with each row caught into the rows previously formed. In the construction and analysis of knits two terms are used--wale and course. See illustration below.



Wale



Course

The American Society for Testing and Materials (2a) defines these two terms as follows:

> Wale--a column of loops in successive courses. The column is parallel with the loop axes.
>
> Course--the series of successive loops lying crosswise of a knitted fabric; that is, lying at right angles to a line passing through the open throat to the closed end of the loops.

There are two basic types of knit construction--warp knit, which also is known as flat knit, and weft knit construction, which is better known as circular knit. Each type, however, has several modifications. The essential difference between warp and weft knitting is that the former uses many parallel yarns which are carried by as many needles in the vertical direction; the latter usually uses one yarn in a crosswise direction. Circular knit items are formed in a continuous tube which is split open and cut into the pieces from which the article is to be made. Warp knitted fabrics as described by Labarthe (22) are firmer than the weft-knit type (circular knit) and will not stretch appreciably in length. This characteristic makes them snag resistant. According to Kornreich (21), the basis of a knitted pattern is the stitch which varies according to whether weft or warp knitting is employed. The same author further mentioned that there are three basic weft knit stitches from which others can be developed--the plain, the rib, and the purl stitch. A particular form of rib stitch is the interlock knit in which two threads are used alternately and knitted by the opposite needles so that an interlocked structure is obtained. The feature of warp knitted fabric as described by Kornreich is the transversal interlooping of the threads. If only one step sideways is carried out, the 1x1 warp knit results. It is possible to traverse more than one wale (2x1, etc.), whereby the tricot knit results. Wilson (39) stated that the quality of a knitted fabric is based upon a combination of two factors--wales and courses per inch and the structure or amount of yarn in each individual stitch. The combination of these two factors gives a weight per unit area.

The complexity of the knit structure as related to dimensional and other performance properties is often misunderstood. Several studies have been devoted to the assessment of different geometrical aspects of various knit fabrics in an effort to explain the complication of this relationship.

Shinn (35) mentioned that the calendering process, which still is used today, is an incidental event and leaves much to be done for shrinkage control. He further stated that shrinkage in knit cloth begins immediately after the fabric leaves the needles of the knitting machine, because a portion of the force required to put the yarn into loop form remains in the loops after knitting. Because of frictional restraints within the fabric and the tension of the draw-off mechanism, however, a total relaxation of the fabric cannot occur at this point. The same author advancingly noted that if the fabric is to be scoured, bleached and/or dyed, it must be exposed to water; and, if this is done under slack or tensionless conditions, it will result in fabric relaxation. In subsequent drying and calendering operations, however, the fabric will again be stretched and distorted; consequently, a great deal of shrinkage potential will be introduced into the material. A complete relaxation exists when the fabric has reached the ultimate consumer in the form of a garment.

According to Honour (15), the quality of a finished product is determined not only by the quality of the yarns used or the efficiency and versatility of the knitting machinery but also by the equipment employed in the finishing processes. He mentioned that the most important step in the entire dyeing and finishing process is a successful relaxation, or conditioning of the fabric. The way this process is performed will determine the final appearance, the dimensional stability and the shape of the finished products. The same author further explained that the high tension under which the yarn is knitted disturbs the normally crimped characteristics of the yarn; and, before any further processing can be done, it is essential that the material be permitted to relax free of tension and return to its original stage of resilience. Usual methods involve cold scouring of the finishing product in a soap or detergent bath and then rinsing.

According to Munden (26), the shrinkage of knit fabrics is divided into three categories--relaxation shrinkage, consolidation shrinkage, and felting shrinkage. He explained the present-day concepts of these shrinkages as follows:

> Relaxation shrinkage is obtained when fabrics are immersed statically in the water. The strains imparted to the fabric by boarding, pressing, calendering, and other distortions imparted to the fabric in the dry state are normally released and measured by this treatment.
>
> Consolidation shrinkage is observed during washing treatments after wet-relaxation. Consolidation shrinkage is caused by the gradual return of the fabrics to their stable wet-relaxed shape from a loop shape temporarily set into the fabrics by the wet-finishing treatments.
>
> Felting shrinkage is unique to wool fabrics. It results from matting of the fiber, which causes the knitted loops to be bent out of the fabric plane. It is normally measured by dimensional changes in the fabric during a standard washing treatment, but the figure obtained in this way is the sum of felting and consolidation shrinkages.

Munden further reported in his study on the dimensional stability of plain-knit fabrics that the wet-finished fabrics often exhibit a width increase and a high length shrinkage during washing. He indicated that the gain in width during washing is more pronounced in dyed cotton interlock fabrics than in other types of knits.

Another investigation of knitted fabrics as related to dimensional properties was carried out by Smerfitt (37). The results obtained were fitted to a simple model of 1x1 rib stitch based on Leaf's model of plain-knitted loop (23). The geometry of cotton interlock fabric was investigated by Hurt (16), the author stated that the dimension of such a fabric related to the stitch length and the shape of the loop.

Nutting and Leaf (30) studied the geometry of weft-knitted fabrics. Their experiment showed that the geometry of these fabrics was controlled by loop length and fiber properties as well as by the method used for relaxation. The authors clarified the concept of a relaxed state as implying that the longitudinal strain introduced to yarns during knitting was removed and that the fabrics were said to be in a state of stable equilibrium, or of minimum energy.

According to Nutting (29), two formal relaxed states are recognized--dry-relaxed and wet-relaxed. The author described these dry and wet relaxed states as follows:

> <u>Dry-relaxed state</u>: It is implicit that a dry-relaxed fabric is one which has been knitted and has had no wet treatment. Thus a fabric which has been

> steam-pressed or wetted out in water cannot be considered as dry-relaxed. A fabric is said to be in a dry-relaxed state when all stresses and strains introduced into the yarn during knitting have been dissipated, with the exception of strains introduced by yarn-to-yarn contacts required to maintain the shape of the knitted loop. The usual procedure to achieve a dry-relaxed state is to place fabric in the standard atmosphere for testing and leave for the necessary time. Sometimes, however, the inter-yarn friction opposing recovery is more than the energy stored in the distorted fabric can overcome. In such instances, the fabric does not reach a fully dry-relaxed state unless some external assistance, such as agitation, is given.
>
> Wet-relaxed state: A fabric is said to be wet-relaxed when the fabric has been allowed to relax in water until equilibrium is reached. The fabric is then carefully removed and allowed to dry under standard atmospheric conditions. This static soak is usually sufficient to relax fully dry-relaxed fabrics or fabrics which have had only a slight steam press.

The same author disclosed that the effect of the setting treatment was assessed by measuring the changes in dimensions which take place and the stability of the dimensions to relaxation under conditions described in each state. The author further revealed that changes in the area of a plain-knitted wool fabric were a result of changes in moisture regain as well as fabric stiffness and previous treatment of the fabric.

Leaf and Glaskin (23) discussed a geometrical model of a plain knitted loop as a basis for a mathematical description of the dimensional properties of a plain-knit fabric. Munden, Knapton and Frith (27) described other possible variables that affect the characteristics of the knitted fabrics. He included wale and course count, yarn twist, moisture content, quality and package hardness as yarn variables; furthermore, temperature of machine, machine gauge, machine cam setting, needle timing and knock-over, take down tension, yarn tension, and sinker timing and knock-over--all were described as the knitting variables.

Fletch and Roberts (12) studied the geometry of plain and rib knit cotton fabrics and their relation to shrinkage in laundering. The investigation was carried out on six plain and six rib knit cotton fabrics treated with three different finishes. The laundering tests revealed that the shrinkage of the yarn was negligible (less than 1.0 per cent) in the finished fabrics. The gray material shrank in length and stretched excessively in width. The study also showed that the fabrics with the greatest knitting stiffness shrank the most in area.

Many attempts have been made in the past to obtain a consistent and satisfactory geometrical description of the plain knit structure. Peirce (32) explained the geometrical structure of the knitted fabrics:

> . . . the structure of the knitted fabric is reduced to a simple form in which the yarn axis follows a path composed of circular arcs and straight lines, on a cylindrical surface following the direction of a course. A formula is deduced for the length of stitch

> in terms of the number of wales and courses per inch, and the yarn size. This allows calculation of cloth weight and provides a method of measuring closeness of knitting and analyzing the changes of structure that occur in stretching and shrinking.

Peirce indicated that the knitting density may be used to express the tightness of the knitting in a way analogous to the use of weave density.

Burnip and Elmasri (7) studied the geometrical parameters of eyelet fabrics relative to dimensional properties and disclosed that the eyelet stitch was a combination of plain and transferred loops, normally two wales in width and four courses in length. The author further explained that the courses of the eyelet structure were composed of two distinct types--a plain type containing the courses of a plain loop and a gather type with a transferred loop in the course. The fabric dimensions were found to be related to the length of the plain loop in the structure. While the courses of the eyelet structure behaved in the same manner as those in a plain-knit fabric, the eyelet wale behaved differently. It also was noted that the weight per square yard of the fabric was related to the geometrical parameters.

Knapton, Richards and Fong (19) concluded in their study on dimensional properties of knitted wool fabrics that machine washing of plain-knit wool fabrics is feasible, but the fabrics must be fully relaxed and adequately treated against felting. The resin treatment was claimed to be successful for this purpose.

Baird and Foulds (4) have made a significant contribution toward the basic problem of differentiating relaxation shrinkage from felting shrinkage. Their analysis of laundering shrinkage showed that it was not appropriate to estimate the effect of any one variable on area shrinkage without taking into account other variables. They found out that for oxidative shrink-resist treatments at any level the strict control of cover factor was necessary to hold shrinkage rates below any prescribed level. A given relaxation treatment could produce different relaxation levels as measured in terms of k_s (k--value of fabric, or fabric geometry constant) if fabrics of different tightness were to be used.

Brown and Metha (6) devised test methods for the detection of the onset of felting during the washing of knitted fabrics. One method involved the change in area under the load-extension curve (energy to stretch) and the other measured the change in load required to remove the yarn from the fabric (yarn-withdrawal force).

Shinn (35) mentioned in his article entitled "Shrinkage Control of Knitting Fabrics" that shrinkage in knit fabrics is due mainly to relaxation after a series of distortions during manufacture. He further noted that one of the basic laws explaining the behavior of knitted fabrics had to do with the fact that when the courses per inch increase in a fabric, the wales per inch decrease. Since there are a given number of wales in the knitted tube, the fabric becomes wider because fewer wales occupy an inch of space. Several methods for controlling the construction of finished materials as adopted by the industry also were discussed by the author.

Rayner and Turner (33) reviewed some current studies which concern the relationship between the geometry of weft knitted fabrics and their dimensional properties. The authors summarized some basic laws governing the behavior of the knitted structure as follows:

> 1. Loop length is the fundamental unit of a weft knitted fabric.
> 2. Loop shape determines the dimensions of the fabric, and this shape depends upon the type of yarn used and the treatment which the fabric has received.
> 3. The relationship between loop shape and loop length may be expressed in the form of simple equations.

The same authors further disclosed that the behavior of the plain-knit fabric during relaxation was affected by other factors such as cover and tightness.

Doyle (8) investigated the fundamental aspects of the design of knitted fabrics and revealed that the load extension characteristics of plain and ribbed structures were considered together with the bending and twisting force when fabrics were under stress. The length of the yarn per stitch was regarded as a factor of fundamental importance since it was independent of the fiber from which the yarn was spun. The author also stated that the dimensions of a length of the fabric or garment depend on two factors--the spacing apart of the unit cell in the structure (number of courses and stitches per inch) and the total number of courses and stitches actually knitted. The author also pointed out that pilling was affected by such factors as the knitted structure as well as by the yarn and the twist.

Eggleston and Cox (11) investigated a three dimensional geometry of bulk nylon yarns in plain-knit and weft-knit fabrics by a comparison of fabric stitch density and thickness for bulk and unbulked yarns. The authors explained that a measure of yarn bulk in fabrics was related to yarn relaxation. Edwards and Davis (10) studied the effects of twist on the stability of knitted fabric and the tendency for unbalanced twist to cause spirality. Results revealed that the degree of spirality could be related to the twist liveliness in the yarn rather than the absolute twist and to the tightness of fabric structure.

Turner (38) reported that the work done at the Centre de Recherches de la Bonneterie disclosed a linear relation between air-permeability and cover factor, measured in terms of d/L (d=yarn diameter, L=length of yarn in the loop). Munden (27) revealed that the cover factor of a knitted fabric, K, is proportional to $1/L\sqrt{N}$, where L (stitch length) is the dimensional factor, and N is the yarn count. A few studies disclosed that fabric properties are shown to be related to knitted fabric cover factors. Typical examples were the collapse of the fabric knitted from stretch yarns, which was investigated by Munden (27); the pilling of knitted fabric, which was examined by Richards (34); and the change in fabric area by drying, which was observed by Nutting (29).

Richards (34) studied the effect of fabric construction, yarn count, and twist on the pilling of plain and rib knit fabrics knitted from two-fold worsted yarn. The following results were concluded: pilling decreased as the stitch length was reduced, wet relaxed fabrics pilled more than dry-relaxed fabrics, and pilling decreased with the comparatively large increase in single or two-fold twist. As the worsted count of yarn increased, pilling increased where all other yarn and fabric factors were kept constant.

Brown and Metha (6) observed the effects of tumble drying on the dimensions, aesthetic softness and limpness of plain-knit acrylic fabrics. Tumble drying techniques similar to those that might be encountered in home laundering also were observed. The authors concluded that hot tumbling of the acrylic plain-knit fabrics produced dimensional changes similar to those which would occur in garment drying. The fabric decreased in length and increased in width until the ratio of courses to wales reached approximately 1.6, which was considered to be higher than the dry-relaxed value. The authors further noted that any garments produced from dyed yarn and finished in the normal way likely would suffer severe dimensional changes in home laundering.

Shinn (36) explained in his study, entitled "An Engineering Approach to Jersey Fabric Construction," that a jersey fabric is made on a single bank of needles, that all of the stitches are drawn in the same direction--back to face--and that the character of this fabric is determined almost entirely by the yarn itself. He also pointed out that wales per inch are determined by the yarn diameter, and each wale is equal to four yarn thicknesses. Fabric width also was reported to be a function of the yarn diameter and the total number of the needles used in its formation. The author attempted to accredit the failure of a jersey knit garment to hold its shape to fabric distortion. Fabric weight was included as one of the factors which predicts the properties of fabric and which changes as the stitch length changes. The weight per square yard was found to increase as the stitch length was reduced and the gain in the weight was the result of an increase in the number of courses per inch. Fabric thickness also was mentioned as an important dimension. He introduced Tompkin's formula for the fabric thickness calculation as $T = 2d$, where T is the thickness of the material, and d is the diameter of yarn.

The moisture and barrier properties--water-vapor transmission, moisture imbibition, moisture regain, and air permeability of plain and 1x1 rib fabrics constructed from synthetic-cotton fiber blended yarns--were investigated by Knight, Hersh, and Brown (20). Measurements of fabric bursting strength and shrinkage also were reported. The experimental fabrics were fabricated from single yarns of 24s cotton count (25 Tex), of cotton-nylon, of cotton-polyester, and of cotton-acrylic-fiber blends in various proportions. Findings revealed that water vapor was transmitted through a single thickness of plain jersey fabric faster than through equivalent rib fabrics, and significant increases in water-vapor transmission occurred as the synthetic-fiber component of the blend was increased. Greater relative increases in air-permeability were observed with the increasing synthetic-fiber content. It was concluded that the moisture-vapor flow through knitted fabrics occurred almost entirely through the fabric interstices, and the hygroscopic nature of the fibers in the blend played only a minor role. Moisture regain, imbibition, and shrinkage were found to decrease as the synthetic-fiber content of the fabrics increased.

The measurement of air-permeability of the weft-knitted fabrics was discussed by Oxtoby (31). He indicated that the air-permeability of a single layer of fabric may be determined from multi-layer readings when the open structure precludes a direct reading. The Shirley Air-permeability Tester was utilized in this investigation.

Bergen and Clutz (5) mentioned in their mill study on the dimensional stability of woolen and worsted fabrics that the change in the amount of moisture in a fabric with normal change in the weather conditions produced very significant effects in the garments. These effects were reflected themselves in the size of the tailored garments as well as in their general appearance.

Wilson (39) pointed out in his study of a simple instrument for the measurement of courses or picks per inch in a moving fabric that instrumentation for the control of the dimensions of the finished fabric is very important, expecially in the field of knitted goods where many different fabrics may be produced from one gray structure by stretching the fabric either in the direction of the wales or the courses, or in both directions. For fabrics knitted from yarns of non-thermoplastic fibers, many of the structures are unstable, and shrinkage during washing results. It is necessary, therefore, to be able to measure and accurately control the dimensions of these fabrics during finishing. Wilson introduced an instrument which was used for measuring the number of courses per inch in a knitted fabric running through a tenter. This device consisted of a taper line grating supported above the fabric, but as close to it as possible. The author also designated that the wales and courses per inch and the structure or amount of yarn in each individual loop or stitch indicate the quality of the products. The combination of these two factors yields a weight per unit area. Wales and courses per inch, however, may vary while the weight per unit area remains unchanged.

Several papers on the abrasion behavior of fabrics have been published. Turner (38) reported that a Russian paper described tests on various double-knit fabrics and also demonstrated that an increase in stability to washing may be obtained by the use of coarser yarn, high stitch densities, low-stretch structure, and spun rather than continuous filament yarns. Turner also reported that abrasive tests on various fabrics in plain, rib, and purl structures demonstrated the effect of abrasion time and the number of washing cycles on the surface density of pilling.

Grover and Hamby (14) explained that the strength of a knit fabric may be determined from three approaches, such as the resistance to tensile load, the resistance to tearing load, and the resistance to a bursting force. They also elaborated on the bursting strength of knit and lightweight woven fabric by stating that bursting tests measure a composite strength and indicate the extent to which a fabric can withstand a bursting type of force when the pressure is applied to the surface of the fabric.

Irvine (17) found that the application of cellulose crosslinking agents to a knit fabric imparted a high degree of wrinkle recovery and wash-and-wear performance, as well as increased shrinkage resistance. The same author noted that when a 5.0 to 8.0 per cent level of various crease proofing agents was used, the fabric lost from 32 to 66 per cent in bursting strength and the use of dimethylolethyleneurea

(DMEU) exhibited strength losses from 52 to 55 per cent with the same levels. He concluded that the strength loss might be considered the price paid for the advantages gained in dimensional control and wash-and-wear appearance of knits.

Andrews (3) reported on the chemical finishing of circular-knit cotton fabrics. He found that a durable press rating of 3.4 to 4.2 was obtained when 5.0 to 6.0 per cent solutions of crosslinking agents were applied. He also noted that with the application of DMEU at the same level of treatment, the bursting losses were 53 to 62 per cent. The knitted fabric, however, had surprisingly high resistance to laundering abrasion, and withstood at least 30 laundering cycles.

Murphy, Margavio, and Welch (28) of the Southern Regional Research Laboratory in New Orleans studied durable press cotton knits made from mercerized plied yarns. The study utilized two circular jersey knit fabrics made from 36/2 greige yarn mercerized commercially by prewetting the yarn with hot water, tension-mercerizing it with 25 per cent sodium hydroxide, rinsing and stretching it to approximately 1.5 per cent beyond normal length, followed by souring, washing, and drying. Prior to use, the fabrics were scoured on a pin frame at constant dimensions with 2.0 per cent sodium hydroxide at 200^{o}F. for one hour and bleached with

1.05 per cent of hydrogen peroxide and 1.5 per cent sodium silicate at 200^{o}F. for one hour. The crosslinking used was DMEU, and the high viscosity polyvinyl alcohol (PVA) and Wyandotte Type E-503 polyurethane were used as shrinkage control additives. The results revealed that yarn-mercerized fabrics showed unexpected high bursting strength. The same experiment also showed that the durability to abrasion damage during repeated launderings was observed to be higher for yarn-mercerized cuffs treated with 9.0 per cent dimethylolethyleneurea (DMEU) than for treated unmercerized cuffs. It also was noted that the treated yarn-mercerized cuffs withstood 50-60 launderings with high durable press and crease sharpness ratings and with considerable dimensional stability.

Kirkpatrick (18) studied the effects of grade and color upon the performance of Texas cotton and found that fabrics knitted from various grades and colors of Texas cotton displayed bursting strength differently before and after being treated with some selected bleaching solutions. The experimental data revealed that caustic soda scoured plain-knit fabric when treated with sodium hypochlorite and hydrogen peroxide, respectively, displayed higher bursting strength values than did the greige fabrics. The fabrics treated with sodium hypochlorite alone displayed higher bursting strength values than did the fabrics previously scoured with caustic soda.

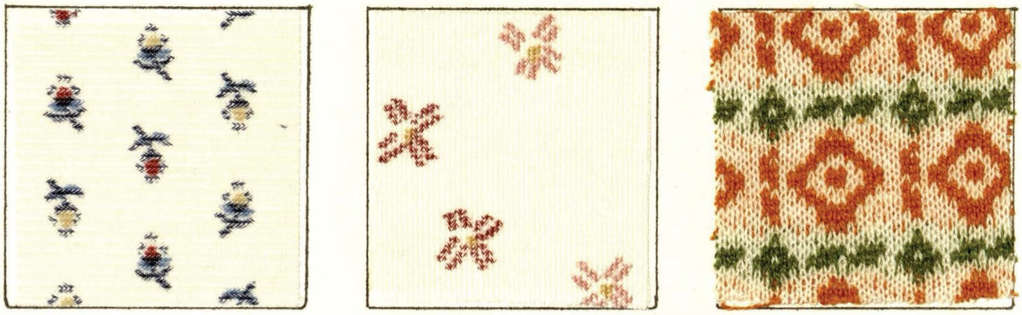
CHAPTER III

PLAN OF PROCEDURE

Description of Experimental Shirts

A total of 182 long-sleeve shirts constructed from fabrics representative of warp, circular, and interlock knitting constructions were used for the experimental purposes in this study. The shirts were composed of 100 per cent cotton, 100 per cent Arnel triacetate, 65/35 Arnel triacetate-Dacron polyester, and of 50/50 cotton-Dacron polyester. As shown in Figure 1, the shirts were classified into eight groups according to fiber content and knitting construction with little recognition given to the patterns and colors of the designs of the fabrics. They were categorized as Groups I, II, III, IV, V, VI, VII, and P respectively, with the shirts in Group IV divided into subgroups A and B. Four different styles as shown in Figure 2 were used in the construction of the experimental shirts.

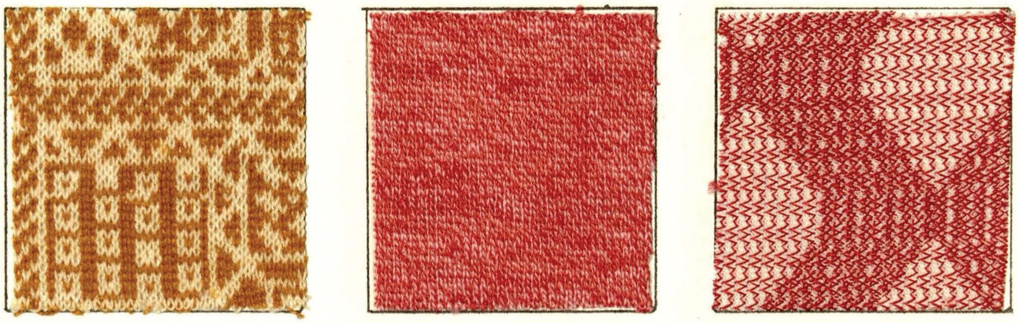
In preparation for the initiation of the study, the shirts were further divided into two categories--those to be laundered without previous wear and those to be laundered and worn. Summary I provides information concerning group designations and number of shirts in each group as well as characteristics of the experimental shirts.



Group I
65% Triacetate
35% Polyester

Group II
65% Triacetate
35% Polyester

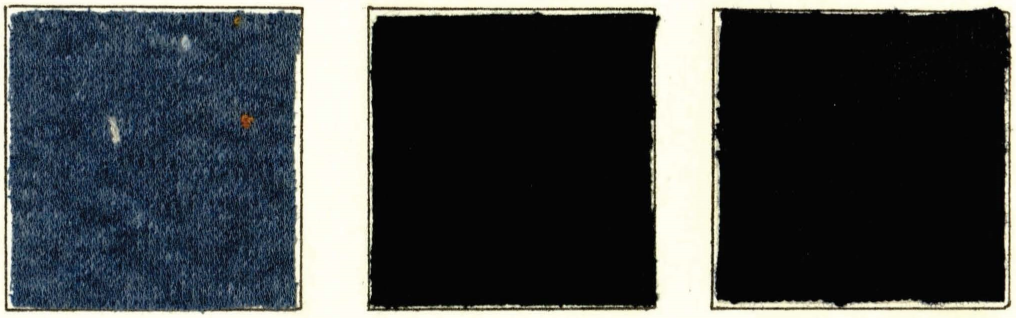
Group III
50% Cotton
50% Polyester



Group IV-A
50% Cotton
50% Polyester

Group IV-B
50% Cotton
50% Polyester

Group V
100% Triacetate

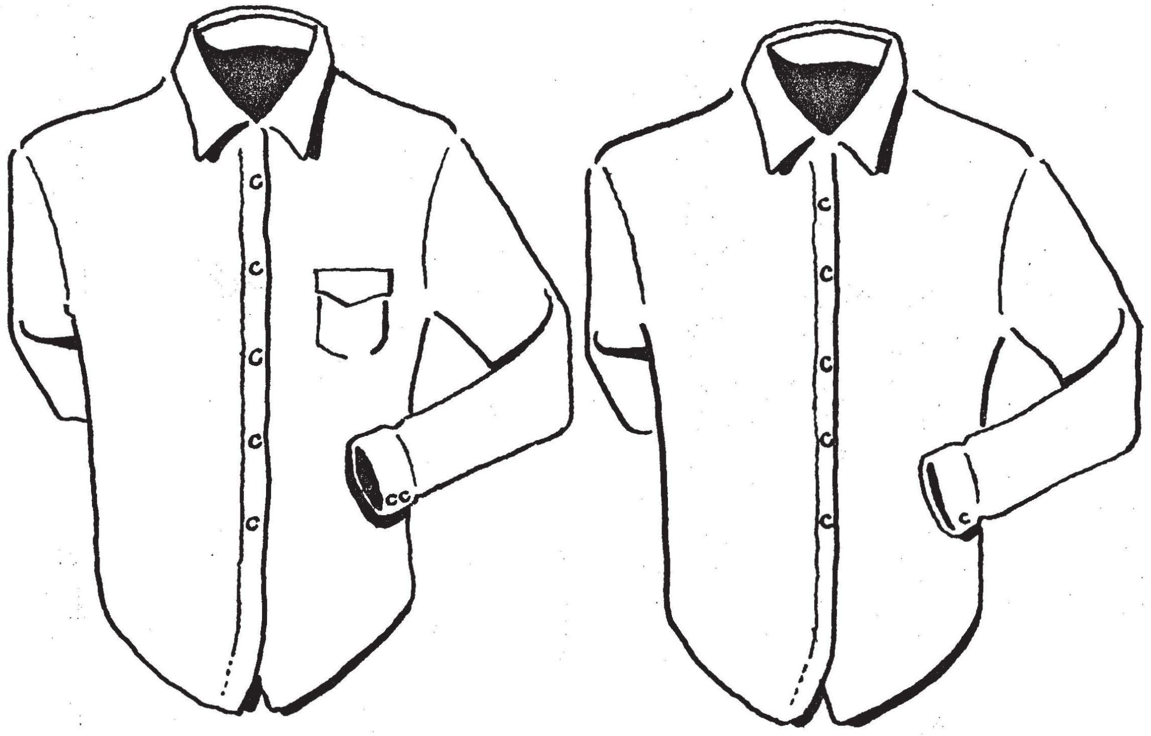


Group VI
50% Cotton
50% Polyester

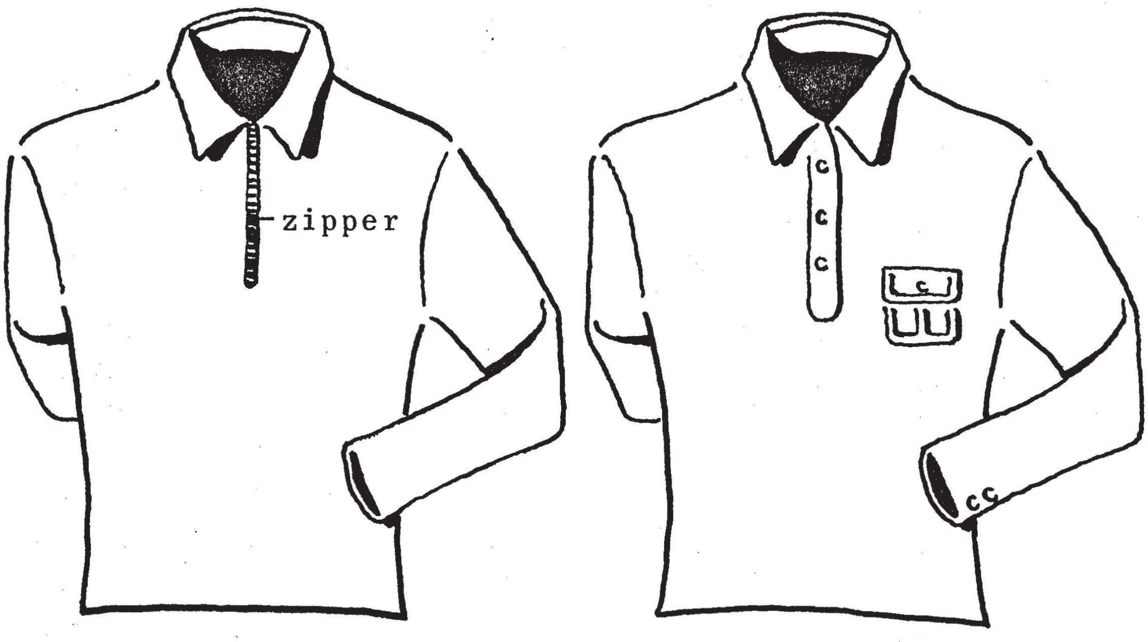
Group VII
100% Cotton

Group P
50% Cotton
50% Polyester

Fig. 1.--Shirt fabric specimens



Style A Style B



Style C Style D

Fig. 2.--Construction styles of experimental shirts

SUMMARY I

QUANTITIES AND CHARACTERISTICS OF THE EXPERIMENTAL SHIRTS

Designated Groups	Shirt Construction Style	Fabric Construction	Fiber Content (Per Cent)	Wale Count	Course Count	Number of Shirts in Study	
						Non-Worn	Worn
I	A	Warp Knit	65 triacetate 35 polyester	47.2	38.0	10	12
II	A	Warp Knit	65 triacetate 35 polyester	47.5	39.1	10	12
III	B	Circular Knit	50 cotton 50 polyester	23.8	24.9	12	12
IV-A	B	Circular Knit	50 cotton 50 polyester	24.6	23.6	4	8
IV-B	B	Circular Knit	50 cotton 50 polyester	23.5	30.0	4	4
V	A,B	Warp Knit	100 triacetate	33.6	24.6	8	12
VI	C	Interlock Knit	50 cotton 50 polyester	39.2	27.4	14	12
VII	D	Interlock Knit	100 cotton	37.2	29.2	14	12
P	A	Circular Knit	50 cotton 50 polyester	27.6	38.0	10	12

Wear Plan

The 96 shirts of the worn-laundered category were worn for 25 eight-hour periods by a panel composed of 24 men employed in white-collar positions at Texas Woman's University. Neither age nor size was considered in the selection of the panel members.

Each afternoon the shirts were issued to the wearers in order that they might wear them the following day. A log was kept on the men wearing specific shirts in order to be sure that each individual shirt was worn the designated number of times by the person to whom it was assigned. The shirts worn the previous day were returned to the textile laboratory each morning for laundering and evaluation.

Laundering Procedure

The shirts of approximately the same weight and color tone were grouped into four-pound loads for laundering without regard to whether or not they had been worn. Where there was an insufficient number of shirts to form a wash load, dummy shirts of similar size and weight were included to insure standard laundering conditions for all shirts.

Each shirt, whether worn or non-worn, was subjected to 25 washing and drying cycles (except those to be pulled at the specified laundering cycles for physical testing) in an Imperial Mark XII Whirlpool home-type washer and dryer. The procedure prescribed by AATCC Test Method 124-1969 (1c) was followed with some exceptions. Eighty grams of Tide XK were used for each wash load and the Permanent Press setting of the washer was used under the following conditions:

Agitator Speed	Low
Washing Temperature	110°F.
Water Level	High
Washing Time	10 minutes
Rinsing Temperature	$110 \pm 5^{\circ}$F.
Spin Speed	Low

The shirts were removed from the washer immediately after the final spin of the washer and loaded into the dryer. The Finishguard setting, including the following conditions, was employed for the drying operation:

Speed	Gentle
Cycle	Durable Press
Drying Temperature	Tumble Dry
Drying Time	30-35 minutes (light weight shirts) 40-45 minutes (heavy shirts)
Cooling Time	20 minutes

The dried shirts were removed from the dryer immediately upon the conclusion of the "cooling down period" and were hung on a standard wire coat hanger for a period of 24 hours at room temperature prior to evaluation.

Evaluations

The following tests and observations were conducted on the experimental shirts at designated periods of laundering throughout the study:

1. Durable Press Performance
2. Appearance of Seams
3. Color Retention
4. Pilling on Collar
5. Wale and Course Counts
6. Dimensional Stability
7. Abrasion at
    a. collar points and edges
    b. cuff points and edges
8. Bursting Strength

Durable Press Appearance

After the first and each fifth successive laundering cycle thereafter, the shirts were observed with reference to their smoothness by means of the procedure recommended by AATCC Test Method 124-1969 (1c). For this procedure, an overhead light was placed in a darkened room surrounded on either side by a black curtain as prescribed in the test method. The test shirts were hung at eye level on the mounting board, and three dimensional durable press replicas developed by the American Association of Textile Chemists and Colorists were placed on either side for comparative purposes. Two trained observers, instead of the three as recommended in the procedure, rated the respective specimens independently by making a comparison between the back area of the shirts as shown in Figure 3 and the standard plastic replicas.

Appearance of Seams

After each laundering interval specified previously for the evaluation of durable press smoothness, the left side seam of each shirt was examined with reference to its level of performance following the general procedure recommended by AATCC Test Method 88B-1970 (1b).

The test shirts were arranged on a standard wire coat hanger in a manner that the side seam to be evaluated was at eye-level on the mounting board with the photographic standards for single needle seams placed to the left for comparative purposes. Two trained panelists rated the level of seam appearance independently.

Color Retention

The color retention of the experimental shirts was observed by a well-trained observer after 1, 5, 10, 15, 20,

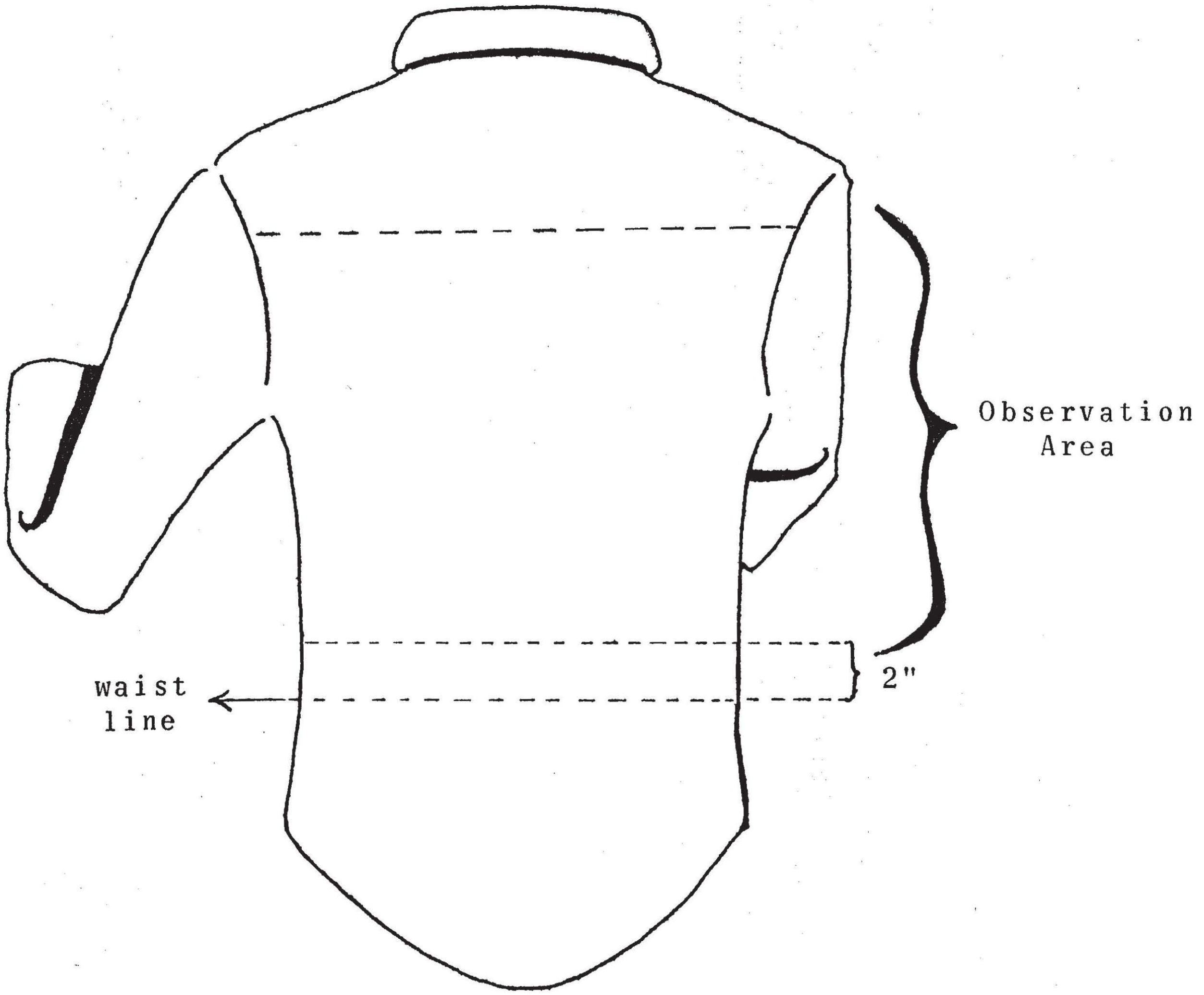


Fig. 3.--Observation area for durable press evaluations.

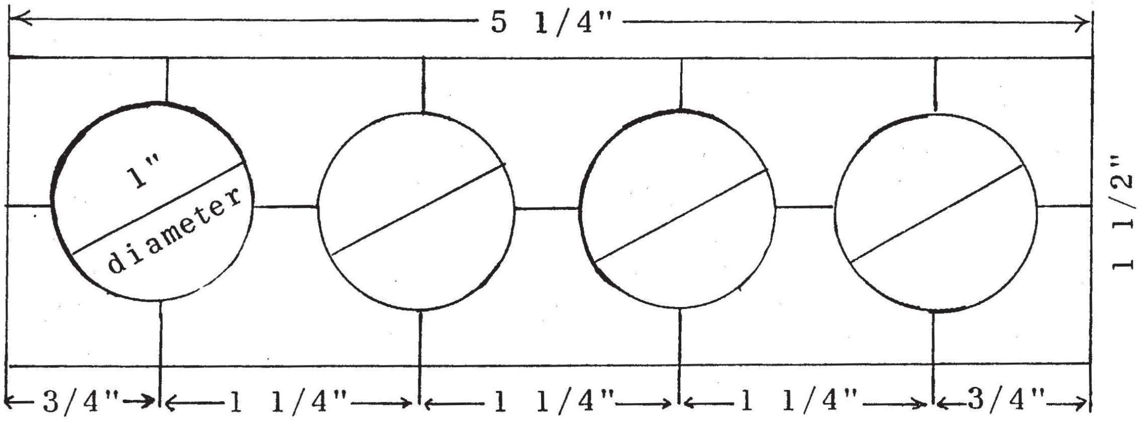
and 25 laundering cycles. The procedure recommended by AATCC Test Method 36-1972 (1a) was followed. In this evaluation the color of each washed shirt was compared with that of the control specimen. The difference in color or contrast between the washed shirt and the control was measured by means of the AATCC Gray Scale for Color Change.

Collar Pilling

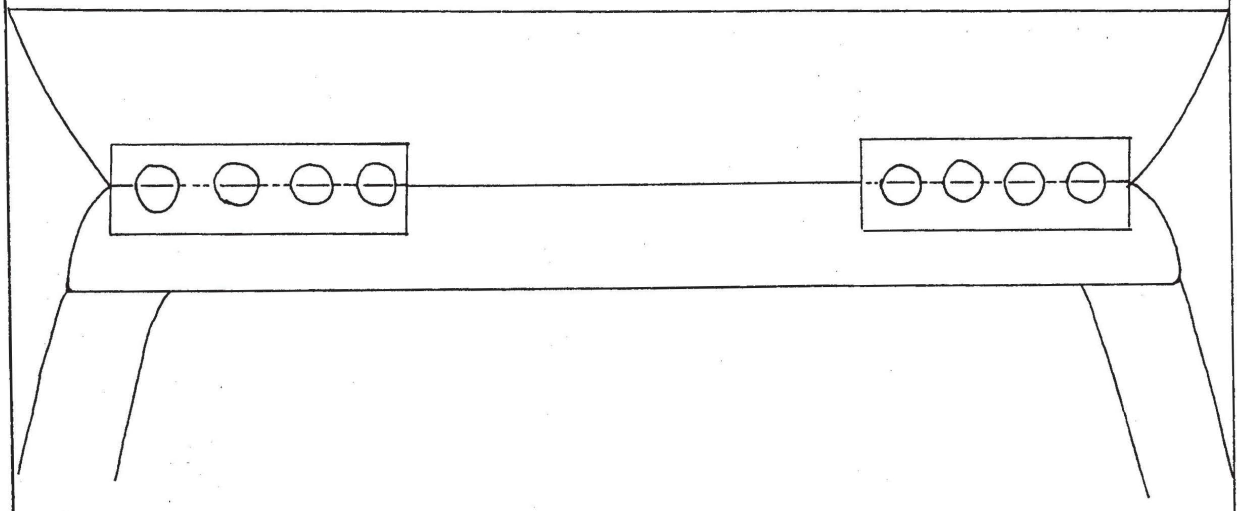
After the first and each fifth laundering interval thereafter, the experimental shirts were evaluated with respect to the number of pills which were visible within the limits of the template prepared especially for that purpose. Figure 4 illustrates the template dimensions and positions for counting collar pills. The number of the pills which were evident in the circular openings on the template at both ends of the collar were recorded as representative of the pilling properties of each shirt.

Wale and Course Counts

ASTM Designation: D 231-62 (2b) was followed to determine the wale and course counts of each experimental shirt prior to the first washing and after 1, 5, 10, 15, 20, and 25 laundering cycles. The counts were conducted for a distance of one inch at two different places on each shirt both in wale and course directions. The average of the two



A. Template for counting collar pills



B. Templates positioned for counting collar pills

Fig. 4.--Template and positions for counting collar pills

counts in each direction was reported as the wale and course counts of the experimental shirts. The Alfred Suter pick counter was the device employed in this process.

Dimensional Stability

The dimensional stability of the experimental shirts was determined by measuring the dimensional changes in the wale and in the course directions, respectively. The AATCC Test Method 135-1970 (1d) was followed with some variation. A 5 x 5 inch square was measured carefully and marked on the tail of each test shirt. Each corner of the marked square was secured by the application of embroidered knots. The dimensional change in each direction was measured after 1, 5, 10, 15, 20, and 25 laundering periods. The average of the two measurements in each direction was reported as the final measurement at each designated testing interval. The percentage of dimensional change both in wale and course directions was calculated from these measurements.

Abrasion of Collars and Cuffs

After each laundering cycle designated previously in this section of the manuscript, each shirt was inspected carefully for any evidence of wear at the points and edges of the collar and cuffs. The wear observed at these locations was classified and rated as follows:

Rating 5 - No evidence of visual wear

Rating 4 - Light abrasion at points and/or along edges

Rating 3 - Moderate abrasion at points and/or along edges with holes smaller than 3 mm.

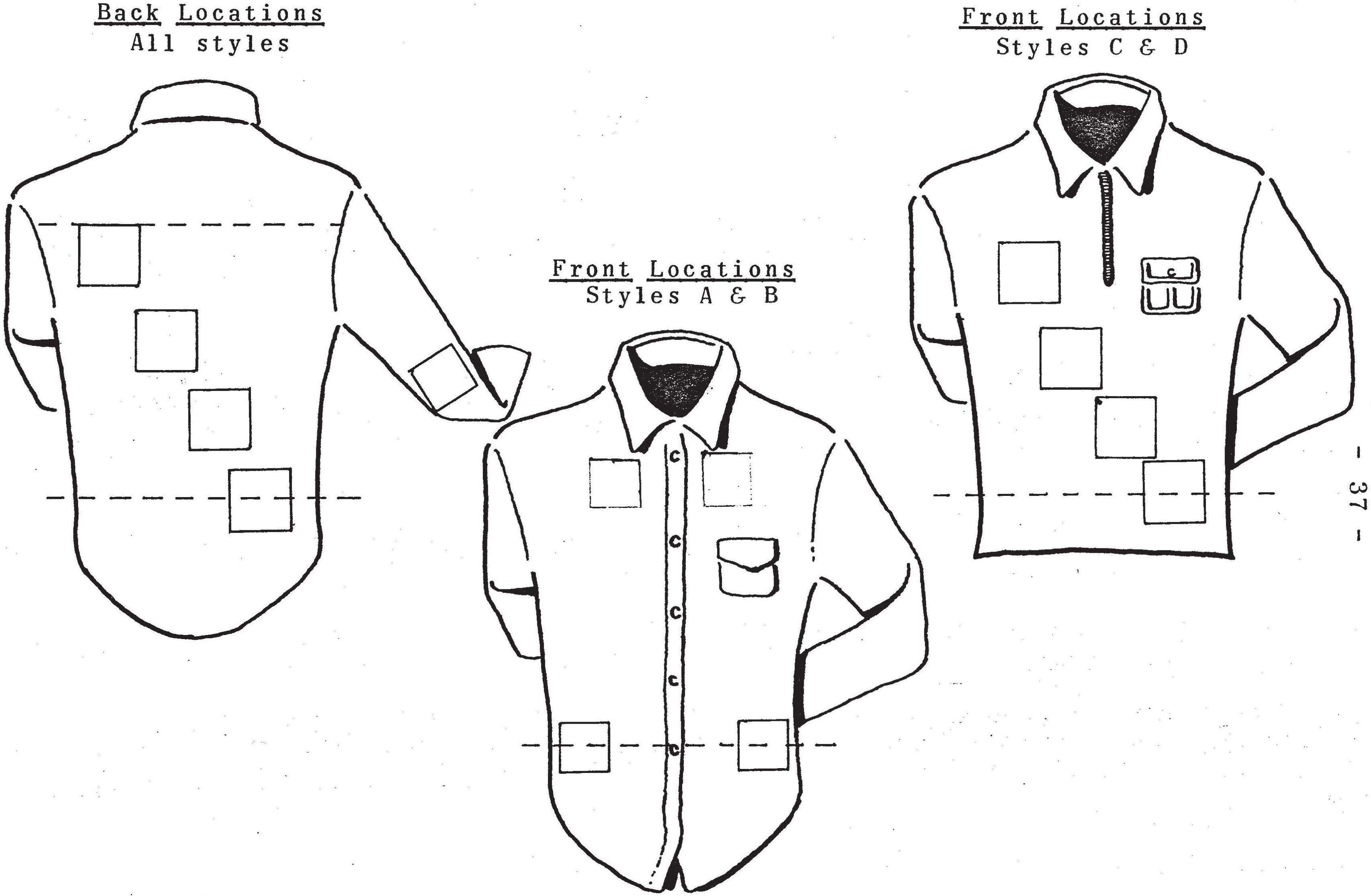
Rating 2 - Heavy abrasion at points and/or along edges with holes between 3 mm.- 13 mm.

Rating 1 - Extreme abrasion at points and/or along edges with hole greater than 13 mm.

Bursting Strength

The bursting strength of the fabrics which were used in the construction of the experimental shirts was determined initially and after 1, 5, 10, 15, 20, and 25 laundering cycles for the non-worn shirts and initially and after 25 wear-laundering cycles for the worn shirts.

The ASTM Designation: D 231-62 (2b) was followed for these tests. Ten specimens 4.2 by 4.2 inches in size were cut from the locations of each experimental shirt as defined in Figure 5. The prepared specimens were conditioned in a standard atmosphere of 70 ± 2°F. and 65 ± 2% R.H. prior to testing. The Scott Tensile Testing Machine with a Ball Burst attachment was employed in this operation. The arithmetic mean of the bursting weight of ten specimens was



Back Locations
All styles

Front Locations
Styles A & B

Front Locations
Styles C & D

Fig. 5.--Locations from which bursting strength specimens were cut

reported as the mean bursting strength of the fabric from which a particular test shirt was constructed.

Analysis of Data

The experimental data were analyzed by means of a one-way as well as a two-way analysis of variance (AOV). Significant differences between the shirt types and the number of launderings were determined at the alpha .05 level by means of Duncan's Multiple Comparison Test.

CHAPTER IV

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

The descriptive and statistical findings in this chapter and in the Appendix report the results of the evaluations of the durable press appearance, seam appearance, color retention, collar pilling, wale and course count, dimensional stability, abrasion resistance, and bursting strength of the 182 shirts in the study. All evaluations were conducted after 1, 5, 10, 15, 20, and 25 periods of laundering and of wear and laundering, respectively, except in the following cases. Wale and course counts were performed initially, whereas bursting strength evaluations of the worn and laundered shirts were assessed initially and after 25 periods of wear and laundering only. Data from the above-mentioned tests are reported in Tables I through XXXVII in the Appendix.

A comparison of the performance of the experimental shirts with respect to the previously-mentioned properties was made on the basis of fabric construction, fiber combination, and number of laundering and wear-laundering cycles by means of an analysis of variance (AOV) followed by Duncan's Multiple Range Test.

Durable Press Appearance

The smoothness of the experimental shirts after 1, 5, 10, 15, 20, and 25 periods of laundering only and of wear and laundering was observed and evaluated independently by a two-member panel by means of the procedures recommended by AATCC Test Method 124-1969 (1c). Mean values which resulted from these evaluations are presented in Tables I and II, with Table I being representative of the appearance of the shirts which were laundered without previous wear and Table II devoted to the results obtained from the worn and laundered shirts. Additional information based on a statistical treatment of the relative performance of the shirts on the basis of the cumulative mean scores from the first through the final laundering and wear-laundering cycles, respectively, is illustrated in Table III and in Figures 6, 7 and 8, while Figure 9 shows the relationship of the worn shirts in each category to those which were laundered without wear.

Durable Press Appearance of Shirts Laundered Without Previous Wear

As may be noted from Table I, in many instances the durable press appearance of the shirts was affected neither by the fiber content, by the knitting construction, nor by the number of launderings to which the shirts were subjected. The experimental shirts exhibited mean values of smoothness ranging from 4.0 to 5.0 after the first cycle of laundering and from 3.8 to 5.0 after the final period. The 50/50 cotton-polyester, circular knit shirts from Groups III and IV-A demonstrated an exceptionally high mean score of 5.0 throughout the study. The 65/35 triacetate-polyester shirts of warp knit construction in Groups I and II, as well as the 50/50 cotton-polyester shirts of interlock knit construction in Group VI, demonstrated perfection with respect to smoothness in a number of instances.

When an analysis of variance was applied to these data, significant differences were evident between the non-worn shirt types as shown in Table III. A further analysis of these data to define the differences was undertaken by the use of Duncan's Multiple Comparison Test. Since there was no variance between the exceptionally high mean score of 5.0, which was accredited to the experimental shirts from Groups III and IV-A at every interval of evaluation, an analysis of variance was not applicable. These shirts, therefore, along with the 65/35 triacetate-polyester warp knit shirts of Group I were rated as the best performers of the groups. The poorest performance was noted in the 50/50 cotton-polyester, circular knit shirts of Groups IV-B and P and in the 100 per cent cotton shirts of interlock construction. Intermediate smoothness values were accredited to the remainder of the shirts of the non-worn category. See Figure 6 for significant differences between the shirt types which were laundered but not worn.

Durable Press Appearance of Worn and Laundered Shirts

The mean data recorded in Table II represent the smoothness of the worn and laundered shirts at specified intervals of evaluation throughout the study. The shirts from Groups III and IV-A of 50/50 cotton-polyester, circular knit showed the same exceptionally high mean smoothness value of 5.0 as they did when they were laundered without being worn. Further observations of these data point to the lowest value of 3.9 being assigned to the 100 per cent cotton shirts of interlock construction after 20 and 25 periods of wear and laundering and to the 50/50 cotton-polyester, circular knit shirts of Group P after 10 and 25 wear-laundering periods.

The overall mean values of smoothness for the nine respective types of the shirts were compared statistically as described previously for the shirts which were laundered without wear. The results of such an analysis are demonstrated in Table III. Again shirt types III and IV-A could

Shirt Types in Rank Order

	I	II	VI	V	IV-B	VII
P	0.9*	0.8*	0.7*	0.6*	0.0	0.0
VII	0.9*	0.7*	0.6*	0.6*	0.0	
IV-B	0.9*	0.7*	0.6*	0.6*		
V	0.3*	0.1	0.0			
VI	0.2*	0.1				
II	0.2					
I						

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 6.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean durable press appearance values of experimental shirts after 25 periods of laundering.

not be included in the comparative analysis of the data which followed since a variance did not exist between the values of 5.0 which were representative of the smoothness of these shirts at all of the intervals of evaluation. These shirts along with those of 65/35 triacetate-polyester of Groups I and II (warp knit) and the 50/50 cotton-polyester, interlock knit shirts of Group VI displayed a performance superior to that of the remainder of the shirts during wear and laundering. See Figure 7 for further information concerning these intercomparisons.

When the various wear and laundering periods were compared on the basis of their effect upon the shirts as a whole, significant results were evident after 10 and 25 periods of wear and laundering. At these periods the smoothness values of the shirts were affected to the greatest extent.

Comparison of Shirt Types on the Basis of Overall Durable Press Appearance Values

The results of the analysis of variance which involved a combination of the durable press smoothness of the non-worn-laundered shirts with that of the worn and laundered shirts after 25 periods of laundering are shown in Table III. This analysis showed that there was a significant difference at the .05 confidence level between the

Shirt Types in Rank Order

	I	II	VI	V	P	IV-B	VII
VII	0.9*	0.9*	0.9*	0.8*	0.2*	0.1	
IV-B	0.8*	0.8*	0.8*	0.6*	0.1		
P	0.8*	0.7*	0.7*	0.6*			
V	0.2*	0.1*	0.1*				
VI	0.1	0.0					
II	0.0						
I							

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 7.--Duncan's Multiple Comparison table for differences between shirt types with respect to mean durable press appearance values of experimental shirts after 25 periods of wear and laundering.

respective shirt types. A rank order arrangement of the shirt types on the basis of these overall comparisons can be determined from Figure 8 for all shirts except those in Categories III and IV-A, which, because of their perfect scores throughout the study, must be considered along with the shirts in Group I as having maintained their smoothness to the greatest degree.

When the smoothness values of the nine types of shirts from the worn categories were pooled and compared with those which were laundered but not worn, wear proved to be a contributing factor to the smoothness of the shirts. See Figure 9 for a comparison of the worn and non-worn shirts of each category.

Seam Appearance

The appearance of the seams in the experimental shirts was appraised by a two-member panel at intervals of laundering and wear and laundering as described previously in Chapter III. The mean values derived from the evaluations of the appearance of the seams of each shirt type of the non-worn-laundered category are presented in Table IV; whereas, those of the shirts in the worn and laundered category are reported in Table V. Further information concerning the statistical treatment of the relative seam

Shirt Types in Rank Order

	I	II	VI	V	P	IV-B	VII
VII	0.9*	0.8*	0.8*	0.7*	0.1*	0.1	
IV-B	0.8*	0.8*	0.8*	0.6*	0.0		
P	0.8*	0.7*	0.7*	0.7*			
V	0.8*	0.1*	0.1				
VI	0.1*	0.1					
II	0.1*						
I							

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 8.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall durable press appearance values of worn and non-worn shirts after 25 periods of laundering.

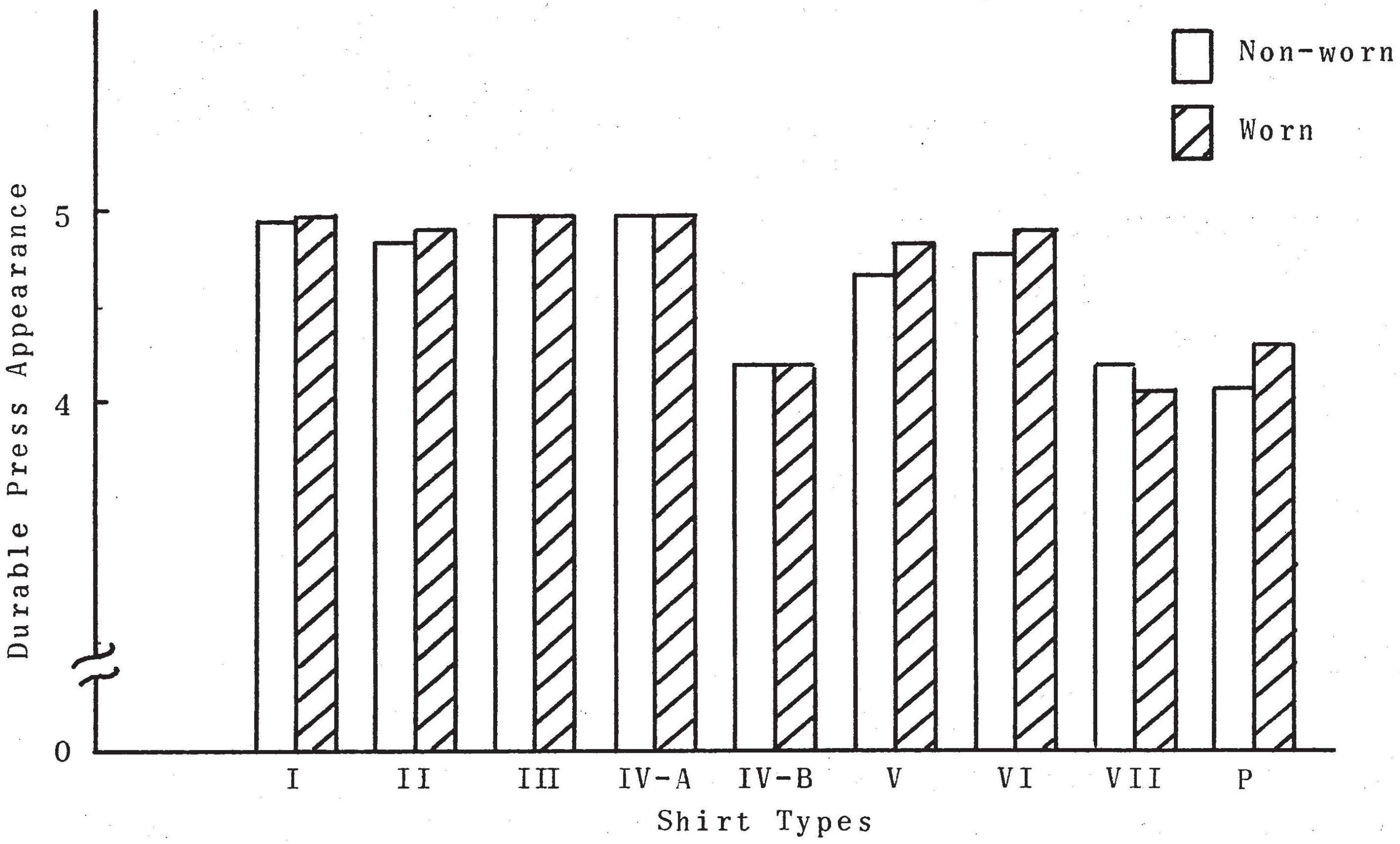


Fig. 9.--Comparison of durable press appearance values of non-worn and worn shirts after 25 periods of laundering.

performance values of the shirts is given in Table VI and in Figures 10 and 11, while Figure 12 demonstrates the relationship of the seam appearance values exhibited by the non-worn-laundered shirts with those of the worn and laundered shirts.

Seam Appearance of Shirts Laundered Without Previous Wear

Mean values of the seam appearance for each shirt type in the laundered but not worn category are recorded in Table IV. It is evident from these data that in many cases neither the number of launderings nor the fiber content of the shirts influenced the seam performance. Knitting construction, however, seemed to play a minor role in this respect as reflected by the perfect score of 5.0 assigned throughout the study to the warp knit shirts of 65/35 triacetate-polyester content in Groups I and II and to those of 100 per cent triacetate in Group V. Lesser values are evident for the shirts constructed by means of the interlock and circular knit procedures. Further examination of these data revealed that the interlock knit shirts of Groups VI (50/50 cotton-polyester) and VII (100 per cent cotton) improved in seam appearance value after 10 periods of laundering. The circular knit shirts of Group IV-B (50/50 cotton-polyester) displayed a perfect mean score of

5.0 through the first 10 cycles of laundering and demonstrated after 15 laundering cycles a mean value of 4.0 throughout the remainder of the study. A further observation of these data showed that the seams of the non-worn shirts of Group P (50/50 cotton-polyester, circular knit) were harmed by laundering as demonstrated by the seam performance value of 4.9 after the first period of laundering and a mean value of 4.0 from the fifth through the final laundering cycles.

Results of an analysis of variance on the basis of the seam appearance values of the non-worn shirts after 25 periods of laundering are reported in Table V, and Figure 10 provides information concerning the results of Duncan's Multiple Comparison Test which followed. Since there was no variance between the perfect mean score of 5.0, which was assigned to the experimental shirts of Groups I, II, and V at every interval of evaluation, the Duncan's Multiple Comparison Test was not applicable. These shirt groups, therefore, along with the circular knit shirts of 50/50 cotton-polyester of Groups III and IV-A, were considered as being the best performers of the shirt groups with respect to seam appearance. The 50/50 cotton-polyester shirts of Groups VI (interlock knit) and P (circular knit) displayed the least acceptable seams while an intermediate

Shirt Types in Rank Order

	III	IV-A	IB-B	VII	VI	P
P	0.7*	0.6*	0.4*	0.2*	0.2	
VI	0.5*	0.4*	0.3	0.1		
VII	0.5*	0.4*	0.2			
IV-B	0.3	0.2				
IV-A	0.1					
III						

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 10.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean seam appearance values of experimental shirts after 25 periods of laundering.

performance was noted for the remainder of the shirt types in the non-worn category.

Seam Appearance of Worn and Laundered Shirts

As demonstrated by the mean seam appearance values recorded in Table V, all of the warp and circular knit shirts of various fiber content, except those of Groups V and P, were accredited with an exceptionally high mean score of 5.0 at all specified evaluation intervals. The warp knit shirts of 100 per cent triacetate of Group V exhibited a perfect mean score of 5.0 throughout the study except at the first period of laundering. The interlock knit shirts of Groups VI (50/50 cotton-polyester) and VII (100 per cent cotton) as well as the 50/50 cotton-polyester, circular knit shirts of Group P were rated with lower mean scores than were the above-mentioned shirt groups.

The overall mean values of seam appearance for the worn-laundered experimental shirts, except those in Groups I, II, III, IV-A, and IV-B which demonstrated a perfect mean value of 5.0, were statistically analyzed as described previously for the shirts which were laundered without previous wear. The results of these analyses are presented in Table VI. Figure 11 provides further information concerning the intercomparison of the worn and laundered

Shirt Types in Rank Order

	V	VII	VI	P
P	0.8*	0.7*	0.4*	
VI	0.4*	0.3*		
VII	0.1			
V				

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 11.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean seam appearance values of experimental shirts after 25 periods of wear and laundering.

experimental shirts with respect to seam performance after 25 periods of wear-laundering. Again shirt Types I, II, III, IV-A, and IV-B could not be included in the comparative analysis of the data, since a variance did not exist between the value of 5.0 which was representative of the seam appearance of these shirts at all of the intervals of evaluation. These shirts along with the warp knit of 100 per cent triacetate (Group V) and the 100 per cent cotton of interlock construction demonstrated a seam performance superior to that of the remainder of the shirts during wear and laundering.

Comparison of Shirt Types on the Basis of Overall Seam Appearance Values

The results of the analysis of variance which involved a combination of the performance of the seam appearance of the non-worn experimental shirts with that of the worn shirts after 25 periods of laundering are presented in Table VI. This analysis showed that there was a significant difference at the .05 confidence level between the respective shirt types. A rank order arrangement of the shirt types on the basis of these overall comparisons showed that the shirts in Groups I, II, III, IV-A, and IV-B, along with those in Group VII, maintained their performance of seam appearance to the greatest degree.

Figure 12 provides further information concerning the relationship of the worn and non-worn experimental shirts of each type with regard to their mean seam appearance values. When the seam appearance values of all of the experimental shirt types from the non-worn group were compared with those in the worn categories, wear proved to be a contributing factor to the performance of the seams in the experimental shirts.

Color Retention

The color retention of the shirts was evaluated after 1, 5, 10, 15, 20, and 25 periods of laundering both for the non-worn and the worn shirts. The mean values of each experimental shirt group were calculated from such evaluations and are reported in Tables VII and VIII. Table VII presents the mean values representative of the color retention of the non-worn-laundered shirts, whereas Table VIII reports the calculated mean data of the worn and laundered shirts after specified wear and laundering cycles. These data both from the non-worn and worn shirt categories were analyzed as described for previous tests. Results of these analyses are shown in Table IX as well as in Figures 13, 14, and 15. Figure 16 illustrates the relationship of the non-worn shirt types to those in the

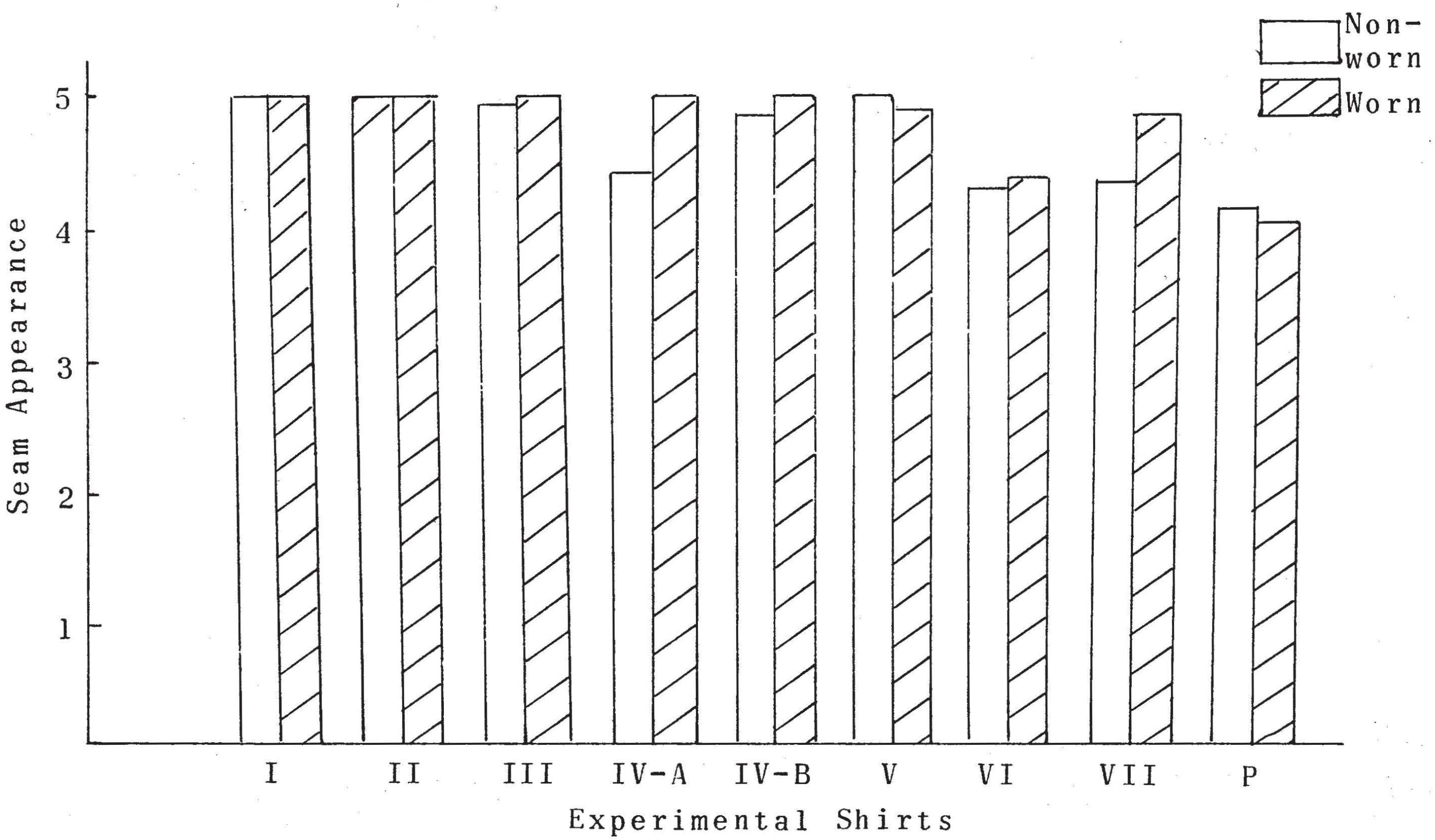


Fig. 12.--Comparison of seam appearance values of non-worn-laundered and worn-laundered shirts after 25 periods of laundering.

worn and laundered category with reference to mean color retention values after 25 periods of laundering.

Color Retention of Shirts Laundered Without Previous Wear

As evidenced by the mean color retention values tabulated in Table VII, the experimental warp knit shirts of Group I (65/35 triacetate-polyester) demonstrated a perfect mean score of 5.0 from the first through 20 periods of laundering and displayed a 4.5 mean score after the final cycle. Further examination of these data revealed that the mean color retention values of the experimental shirts in Group VII decreased and no particular pattern of performance was noticeable for the remainder of the shirt types except that generally color loss was related to the number of launderings from 15 through 25 periods, while shirts in Group VII demonstrated a lower mean score (3.4) after 20 periods of laundering than they did after the final cycle (3.5). These data were analyzed statistically and the results are given in Table IX.

Further analyses to define the differences between the respective shirt types on the basis of the overall mean color retention values were conducted by the use of Duncan's Multiple Comparison Test (see Figure 13). It is evident from these data that the warp knit shirts of

Shirt Types in Rank Order	V	I	II	III	P	IV	VII	VI
VI	0.9*	0.9*	0.9*	0.9*	0.4*	0.2	0.0	
VII	0.9*	0.9*	0.9*	0.9*	0.4*	0.2		
IV	0.7*	0.7*	0.7*	0.7*	0.2			
P	0.5*	0.5*	0.5*	0.4*				
III	0.0	0.0	0.0					
II	0.0	0.0						
I	0.0							
V								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 13.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean color retention values of experimental shirts after 25 periods of laundering.

Groups I, II, and V, as well as the circular knit shirts of Group III, retained their color to the greatest extent, but shirts in Groups IV, VI, and VII proved to be inferior with regard to their color retention values during laundering periods.

Color Retention of Worn and Laundered Shirts

The data recorded in Table VIII are the mean scores representative of the color retention of the experimental shirts which were worn and laundered for 25 periods. A study of these data revealed that the experimental shirts faded appreciably during 25 periods of wear and laundering. The greatest degree of fading was evident in the 50/50 cotton-polyester, circular knit shirts of Group III after the final period of wear and laundering as exemplified by a rating of 3.0. A further examination of these data points to perfection in color retention through five periods of wear and laundering for the 65/35 triacetate-polyester, warp knit shirts in Groups I and II, for the 50/50 cotton-polyester, circular knit shirts of Groups IV and P, and for the 100 per cent triacetate, warp knit shirts of Group V. From this point through the remainder of the study, the colors of these respective shirts deteriorated progressively in most instances as the number of wear-laundering periods increased from 10 through 25. Color retention values ranging from 4.5 to 3.6 and 3.3, respectively, were found in the 50/50 cotton-polyester, interlock knit shirts of Group VI and in the 100 per cent cotton shirts in Group VII.

When an analysis of variance was applied to these data, significant differences between shirt types were evident as shown in Table IX. Intercomparisons of the data to determine the relative performance of the eight shirt types with respect to color retention provided the results given in Figure 14. The shirts of Groups I, II, V, and P were accredited as being the best performers with respect to their color retention during 25 periods of wear and laundering.

Comparison of Shirt Types on the Basis of Overall Color Retention Values

When the shirt types were compared on the basis of worn and non-worn color retention values, significant differences were evident as shown in Table IX. Figure 15 provides supplementary information concerning statistical intercomparisons of the respective shirt types on this basis. The warp knit shirts of Groups I, II, and V proved to maintain their color retention values to the greatest degree after 25 periods of wear and laundering. Ranking next in line with respect to color retention were the shirts of

Shirt Types in Rank Order

	II	V	I	P	VI	IV	III	VII
VII	0.9*	0.8*	0.7*	0.7*	0.4*	0.3*	0.2	
III	0.7*	0.6*	0.5*	0.5*	0.2	0.1		
IV	0.6*	0.5*	0.4*	0.4*	0.0			
VI	0.5*	0.5*	0.4*	0.3*				
P	0.2	0.1	0.0					
I	0.2	0.1						
V	0.1							
II								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 14.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean color retention values of experimental shirts after 25 periods of wear and laundering.

Shirt Types in Rank Order

	V	II	I	P	III	IV	VI	VII
VII	0.8*	0.8*	0.8*	0.6*	0.3*	0.3*	0.2*	
VI	0.6*	0.6*	0.6*	0.4*	0.1	0.0		
IV	0.6*	0.6*	0.5*	0.3*	0.0			
III	0.6*	0.6*	0.5*	0.3*				
P	0.3*	0.3*	0.2*					
I	0.1	0.0						
II	0.0							
V								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 15.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall color retention values of worn and non-worn shirts after 25 periods of laundering.

Group P, and the poorest color retention values were found in the shirts of Group VII.

Further examination of the data concerning the effect of wear and laundering upon the color retention of the experimental shirts was conducted statistically. The overall result revealed that wear contributed to the loss of color by the experimental shirts. This finding is evident in Figure 16 where the worn and non-worn shirts of each type are compared on the basis of mean color retention values.

Collar Pilling

The experimental shirts both from the non-worn and worn categories were examined for pilling of their collars by the use of a template as previously described in Chapter III. The number of pills was counted on both ends (right and left) of the collar after designated intervals of laundering and wear and laundering, respectively. They were combined and reported as the number of pills evident on the collars of each shirt type. Table X contains the data for the non-worn shirt types, while Table XI presents that for the worn and laundered shirts. An analysis of variance, as well as the Duncan's Multiple Comparison Test, was performed to define the significant differences between

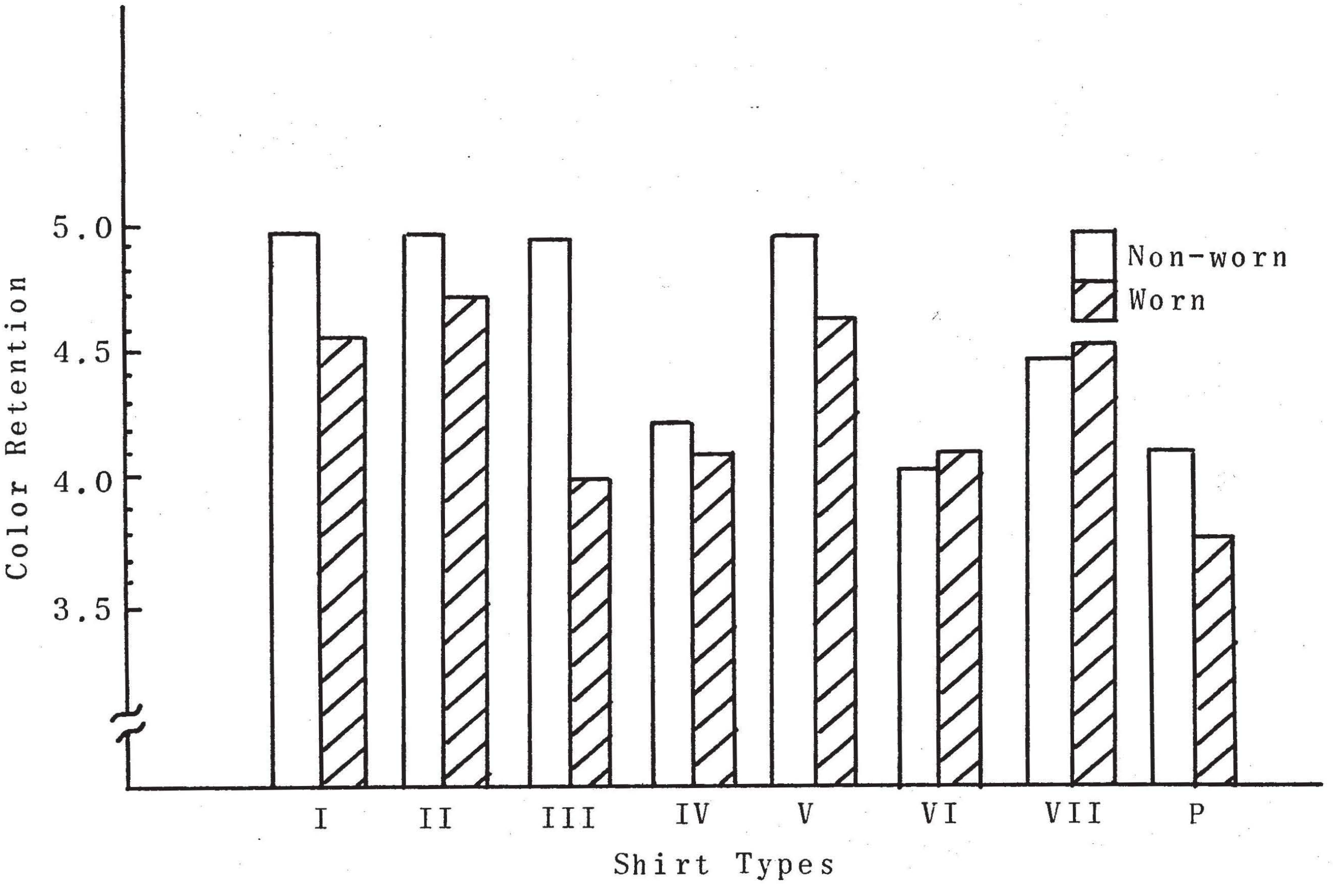


Fig. 16.--Comparison of color retention values of non-worn and worn shirts after 25 periods of laundering.

the shirt types as well as between the worn and non-worn categories with respect to the number of pills evidenced on the collars. Table XII and Figure 17 provide the results of these statistical treatments.

Collar Pilling of the Shirts Laundered Without Previous Wear

It is evident from the means reported in Table X that only the non-worn interlock knit shirts in Groups VI (50/50 cotton-polyester) and VII (100 per cent cotton) formed collar pills. These two shirt groups, however, did not show any pilling after the first cycle of laundering. The shirts in Group VI demonstrated pilling at the fifth interval of laundering; however, the all-cotton interlock knit shirts in Group VII exhibited pills at the fifteenth period of laundering. The greatest amount of pilling displayed by these particular shirt types was evident after 20 periods of laundering as indicated by mean values of 5.8 and 9.8, respectively. The pills on both shirt types, however, became disengaged from the shirts at the final interval of evaluation as shown by the lower mean value of 2.5 for the shirts in Group VI and by a value of 0.5 for those in Group VII.

A statistical treatment was performed to show whether or not there was a significant difference between these two shirt types with regard to their pilling performance. The results shown in Table XII indicated that there was no significant difference between the shirts of interlock knit construction in Groups VI (50/50 cotton-polyester) and VII (100 per cent cotton) with respect to the number of pills formed on the collars after 25 periods of laundering.

Collar Pilling of the Worn and Laundered Shirts

As demonstrated by the mean number of pills formed on the collars of the worn and laundered shirt types tabulated in Table XI, only the interlock knit shirts of Groups VI and VII displayed any pilling at the first wear and laundering period. The remainder of the shirt types, with the exception of those in Group V, exhibited a number of pills at the fifth period of evaluation. The all-triacetate warp knit shirts of Group V failed to show any pills until the tenth wear and laundering period, and from that period on the mean values ranged from 0.2 at the tenth period to 1.5 after the final wear and laundering cycle.

Further examination of these mean data revealed that the experimental interlock knit shirts of 50/50 cotton-polyester in Group VI exhibited mean pilling values considerably high throughout the study as exemplified by the mean value of 7.5 after the first period of wear and laundering and by a value of 132.8 at the final period. A further study of the mean values reported in Table XI reveals that the number of pills formed on the collars of the experimental shirts fluctuated. This indicated that the pills became disengaged from the shirts as well as re-formed during periods of wear and laundering.

The statistical results reported in Table XII showed that there was a significant difference between shirt types with regard to the pill-resistance performance of their collars. The worn experimental shirts in Groups I, II, V, and P displayed the greatest resistance to pilling; however, the shirts from Group VI were the poorest in this respect. See Figure 17 for further information. When the number of wear and laundering periods were compared statistically on the basis of their effect on pilling of the shirts, it was evident that as the number of wear and laundering periods increased from one through 25, so did the degree of pilling.

Comparison of Shirt Types on the Basis of Overall Collar Pilling Values

Since the non-worn experimental shirts in Groups I, II, III, IV-A, IV-B, V, and P did not show any evidence of pills on their collars during 25 periods of laundering,

Shirt Types in Rank Order

V	83.8*	27.1*	22.5*	19.9*	2.3	2.4	0.4	
II	83.4*	26.6*	22.1*	19.5*	2.2	2.0		
I	81.4*	24.7*	20.1*	17.5*	0.2			
P	81.2*	24.4*	19.9*	17.2*				
VII	63.9*	7.2*	2.7					
III	61.3*	4.5						
IV	56.7*							
VI								
	VI	IV	III	VII	P	I	II	V

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 17.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean collar pills of experimental shirts after 25 periods of wear and laundering.

they could not, therefore, be included in the statistical program used for a comparison of these shirts with those of the same types in the worn shirt category. The results shown in Table XII present the statistical analysis of the pills formed on the collars of the shirts in Groups VI and VII only. Such results showed that the shirts of all-cotton interlock knit in Group VII displayed a significantly greater resistance to pilling than did the shirts in Group VI.

As evidenced by the statistical treatment as well as the tabulations of the mean number of collar pills given in Table X for non-worn and in Table XI for worn shirts, wear proved to be a contributing factor in the collar pilling of the experimental shirts during 25 periods of laundering.

Wale and Course Counts

The wale and course counts of the experimental shirts were determined per inch in two different places on each shirt initially and after 1, 5, 10, 15, 20, and 25 periods of wear and laundering and of laundering only. The means as recorded in Tables XIII, XV, XVII, and XIX were used as the basis for determining the per cent change both in the wale and course directions due to laundering and due to wear and laundering tabulated in Tables XIV, XVI, XVIII, and XX. A statistical analysis of these data was executed to illustrate the significant differences between the performance of the shirt types with reference to the stability both in the wale and course directions of the experimental shirts.

Wale and Course Counts of Shirts Laundered Without Previous Wear

Wale Count.--As indicated by the data given in Table XIV, the non-worn shirts of 100 per cent triacetate warp knit in Group V displayed the greatest mean per cent wale change at the first period of laundering. The changes in the shirts of this group increased progressively in the wale direction as the number of laundering cycles increased from one through 20 periods. At the final laundering interval, these shirts displayed a lower mean per cent wale change than they did after 20 laundering periods. The circular knit shirts of 50/50 cotton-polyester in Group P exhibited no change in the wale count at the first period but displayed an increasingly greater change from the fifth cycle throughout the study. The remaining shirt types did not display any particular pattern with respect to wale count change during laundering; but, generally, the mean per cent change in the wale count of the experimental shirts of most types increased to some extent during the laundering cycles except in the shirts of Group III, which displayed only negligible changes (some representative of increases and others of decreases). See Table XIV.

When these shirt types were compared statistically on the basis of the mean per cent change in wale count, the non-worn circular knit shirts of 50/50 cotton-polyester in Group III proved to be the most stable shirt type. The all-cotton interlock knit shirts in Group VII, along with those in Groups II, VI, and P, were ranked second in regard to their stability in the wale direction during laundering. The greatest change in the mean per cent wale count was found in the all-triacetate warp knit shirts in Group V. See Table XXI and Figure 18 for further information concerning these statistical intercomparisons.

Course Count.--The mean data presented in Table XVI indicates that the course count of the non-worn 50/50 cotton-polyester circular knit shirts in Group IV experienced the greatest mean per cent change at the first laundering cycle, and this mean value increased as the number of laundering cycles progressed from one through 20. At the final period of laundering the mean change in course count of these shirts dropped to half the amount displayed after 20 periods of laundering. The 65/35 triacetate-

Shirt Types in Rank Order

III	9.8*	4.6*	3.7*	3.2*	2.9*	1.9*	1.9*	
VI	7.9*	2.7*	1.8*	1.4	1.0	0.0		
II	7.9*	2.7*	1.8	1.3	1.0			
P	6.9*	1.7	0.8	0.4				
VII	6.5*	1.3	0.4					
I	6.1*	0.9						
IV	5.2*							
V								
	V	IV	I	VII	P	II	VI	III

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 18.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean per cent change in wale count of experimental shirts after 25 periods of laundering.

polyester warp knit shirts in Groups I and II, along with the 50/50 cotton-polyester interlock knit shirts of Group VI, exhibited the lowest mean per cent change in course count at the first cycle of laundering. From the fifth through the final period of laundering, the data recorded in Table XIV failed to follow any particular pattern except in a few instances. The shirts of Group IV became more compact coursewise than did the remainder of the shirt types through 20 laundering cycles. Progressive stretching obviously occurred in the shirts of Group VI, and little change was noted in the course count of the shirts in Groups I, II, and III.

The statistical results given in Table XXII showed significant differences between the shirt types with respect to change in course count. The warp knit shirts of 65/35 triacetate-polyester in Groups I and II and the 50/50 cotton-polyester shirts of Groups III and VI exhibited the greatest degree of stability coursewise, while the 50/50 cotton-polyester circular knit shirts in Group IV displayed the greatest increase in the number of courses per inch. The remaining shirt types were intermediate performers with regard to the stability of their course count. See Figure 19 for further information concerning these analyses.

Shirt Types in Rank Order

VI	7.4*	5.6*	5.6*	5.1*	1.3	1.2	0.8	
II	6.6*	4.8*	4.8*	4.3*	0.5	0.4		
III	6.2*	4.4*	4.4*	3.9*	0.2			
I	6.0*	4.3*	4.2*	3.7*				
V	2.3*	0.5	0.5					
VII	1.8*	0.0						
P	1.7*							
IV								
	IV	P	VII	V	I	III	II	VI

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 19.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean per cent change in course count of experimental shirts after 25 periods of laundering.

Wale and Course Counts of the Worn and Laundered Shirts

Wale Count.--An examination of the mean data tabulated in Table XVIII reveals that the worn and laundered experimental shirts, without regard to the fiber content or knit construction, displayed some variations in mean per cent change in wale count from one evaluation period to the next. After the first period of wear and laundering, the all-triacetate warp knit shirts in Group V displayed the highest per cent change in warp count of 4.50 per cent, whereas the shirts of 65/35 triacetate-polyester, warp knit in Group II revealed the lowest change of 0.36 per cent after the same period of wear and laundering. The mean per cent change in wale count of the shirts in these groups increased progressively as the number of wear laundering cycles increased, while changes in other categories followed no particular pattern.

A statistical analysis of these data showed that the 100 per cent triacetate, warp knit shirts of Group V displayed the greatest percentage of wale changes per inch, whereas the 50/50 cotton-polyester, interlock knit shirts of Group VI exhibited the least amount of change in this direction. See Figure 20 and Table XXI.

When the number of wear and laundering cycles were analyzed on the basis of their effect upon the wale count

VI	8.6*	6.5*	5.5*	5.1*	3.7*	3.3*	3.1*	
III	5.5*	3.4*	2.4*	2.0*	0.6	0.2		
II	5.3*	3.2*	2.2*	1.8*	0.4			
P	4.9*	2.8*	1.8*	1.4*				
I	3.5*	1.4*	0.4					
IV	3.1*	1.0						
VII	2.1*							
V								
	V	VII	IV	I	P	II	III	VI

Shirt Types in Rank Order

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 20.--Duncan's Multiple Comparison Table of difference between shirt types with respect to mean per cent change in wale count of experimental shirts after 25 periods of wear and laundering.

of the experimental shirts, the results showed that the final period of wear and laundering displayed the greatest degree of harm to the stability of the wale count. The fifteenth period of wear and laundering was ranked second in regard to severity on the wale count, while the first period of wear and laundering affected the stability of the wale count the least.

Course Count.--The experimental shirts in the worn and laundered category demonstrated, in many instances, a variation in the mean per cent change in course count from one evaluation period to the next as indicated by the mean data given in Table XX. The change in course count in the worn and laundered shirts, without regard to the fiber content or knit construction, increased in most instances as the number of wear and laundering cycles increased. Shirts in Group VI (50/50 cotton-polyester, interlock knit) were an exception in that they displayed fewer courses per inch with successive wear and laundering periods. The 100 per cent triacetate warp knit shirts of Group V exhibited the widest range of wale count change from the first through the final period of wear and laundering as exemplified by the mean value of 3.86 per cent for the first period and by a value of 11.59 per cent at the final interval of wear and laundering.

When the mean data were compared statistically, the results shown in Table XXII and in Figure 21 were evident. The 100 per cent triacetate warp knit shirts of Group V displayed the greatest per cent increase in course count after being subjected to 25 periods of wear and laundering cycles; however, the 50/50 cotton-polyester interlock knit shirts of Group VI exhibited a change in the opposite direction which represented stretching coursewise. The 65/35 triacetate-polyester, warp knit shirts in Groups I and II and the 50/50 cotton-polyester, circular knit shirts in Group III were accredited with the greatest degree of stability in the course direction of the worn and laundered shirts.

When the number of wear and laundering periods were compared statistically on the basis of their effect upon the course count of the worn and laundered shirts, the results revealed that 20 and 25 periods of wear and laundering provided the severest conditions. The least amount of change in the course count was negligible after one, five, and 10 cycles of wear and laundering.

Comparison of Shirt Types on the Basis of Overall Wale and Course Count Values

Wale Count.--As can be noted from Table XXI, a statistical comparison of the cumulative mean values

Shirt Types in Rank Order

	V	VII	P	IV	I	III	II	VI
VI	10.6*	9.4*	8.6*	7.8*	5.7*	5.5*	5.1*	
II	5.4*	4.3*	3.5*	2.7*	0.5	0.4		
III	5.0*	3.9*	3.2*	2.3*	0.2			
I	4.9*	3.8*	3.0*	2.2*				
IV	2.7*	1.6*	0.8					
P	1.9*	0.8						
VII	1.1							
V								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 21.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean per cent change in course count of experimental shirts after 25 periods of wear and laundering.

representative of wale change of the non-worn and the worn shirts combined after 25 periods of laundering showed that differences were evident between the shirt types. The 100 per cent triacetate, warp knit shirts displayed the greatest increase in wale count per inch, while those in Group VI (50/50 cotton-polyester, interlock knit) illustrated the greatest degree of stability in regard to wale count. See Figure 22.

Further comparison of these data showed that the change in wale count of the worn and laundered shirts was significantly higher than that of the non-worn shirts. Wear, therefore, proved to be a contributing factor to the instability of the wale count.

Course Count.--As was found in the wale direction, the 100 per cent triacetate, warp knit shirts of Group V demonstrated the greatest change in course count when data both from the non-worn and worn shirt categories were considered, while the 50/50 cotton-polyester, interlock knit shirts in Group VI displayed the lowest values in this respect. See Table XXII and Figure 23 for additional information concerning these statistical intercomparisons.

When the cumulative mean change in course count of the non-worn but laundered shirts was compared with that from the worn and laundered shirts, the result revealed

Shirt Types in Rank Order

VI	8.1*	4.6*	4.5*	4.0*	2.7*	2.2*	1.3*	
III	6.9*	3.3*	3.2*	2.7*	1.4*	0.9		
II	6.0*	2.4*	2.3*	1.8*	0.6			
P	5.4*	1.9*	1.8*	1.2*				
I	4.2*	0.6	0.5					
IV	3.6*	0.1						
VII	3.5*							
V								
	V	VII	IV	I	P	II	III	VI

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 22.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall per cent change in wale count values of worn and non-worn shirts after 25 periods of laundering.

Shirt Types in Rank Order

VI	8.9*	8.0*	7.6*	7.4*	4.2*	3.9*	3.7*	
II	5.2*	4.3*	3.9*	3.7*	0.5	0.2		
III	5.0*	4.1*	3.6*	3.5*	0.3			
I	4.7*	3.8*	3.4*	3.2*				
IV	1.5*	0.6	0.1					
P	1.3*	0.4						
VII	0.9							
V								
	V	VII	P	IV	I	III	II	VI

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 23.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall per cent change in course count values of worn and non-worn shirts after 25 periods of laundering.

that the shirts in the later category displayed significantly higher mean values than did those of the non-worn group. The stability of the course count, therefore, was affected to the greatest extent by wear.

Dimensional Stability

The experimental shirts from the non-worn and worn categories were subjected to 25 periods of laundering and wear and laundering, respectively, in order to determine their dimensional stability as described previously in Chapter III. The measurements of the two marked distances, both in the wale and course directions (a 5-inch square, originally) on each individual shirt, were performed after 1, 5, 10, 15, 20, and 25 periods of laundering and of wear and laundering. The changes obtained from these two measurements from the initial in either direction (wale and course) then were reported as the percentage of dimensional change in each direction on each individual shirt. Tables XXIII and XXIV present the mean per cent dimensional changes obtained from the above-mentioned evaluations of the non-worn shirts, while Tables XXV and XXVI are devoted to data obtained from the worn experimental shirts. Supplementary information concerning the statistical treatments of these data are provided in Tables XXVII and XXVIII and in Figures 24 through 33.

Dimensional Stability of Shirts Laundered Without Previous Wear

Wale Direction.--The mean values of the per cent dimensional change in the wale direction of the non-worn experimental shirts given in Table XXIII indicate that at the first period of laundering, all of the experimental shirts, with the exception of those in Groups I and II, shrank to some extent. The warp knit shirts of 65/35 triacetate-polyester of Group I demonstrated no dimensional change at the first interval of evaluation, whereas those in Group II stretched slightly as indicated by a mean value of +0.10 per cent. The greatest per cent shrinkage which occurred at the first interval of laundering was found in the 100 per cent cotton, interlock knit shirts of Group VII (-5.36 per cent).

A further examination of the data, as well as the graphical illustration shown in Figure 24 and based upon mean per cent dimensional changes and the number of launderings, demonstrated that, generally, the non-worn experimental shirts shrank increasingly as the number of launderings progressed from one through 20 cycles. From this point throughout the remainder of the laundering periods, the dimensions of the shirts in the wale direction changed little.

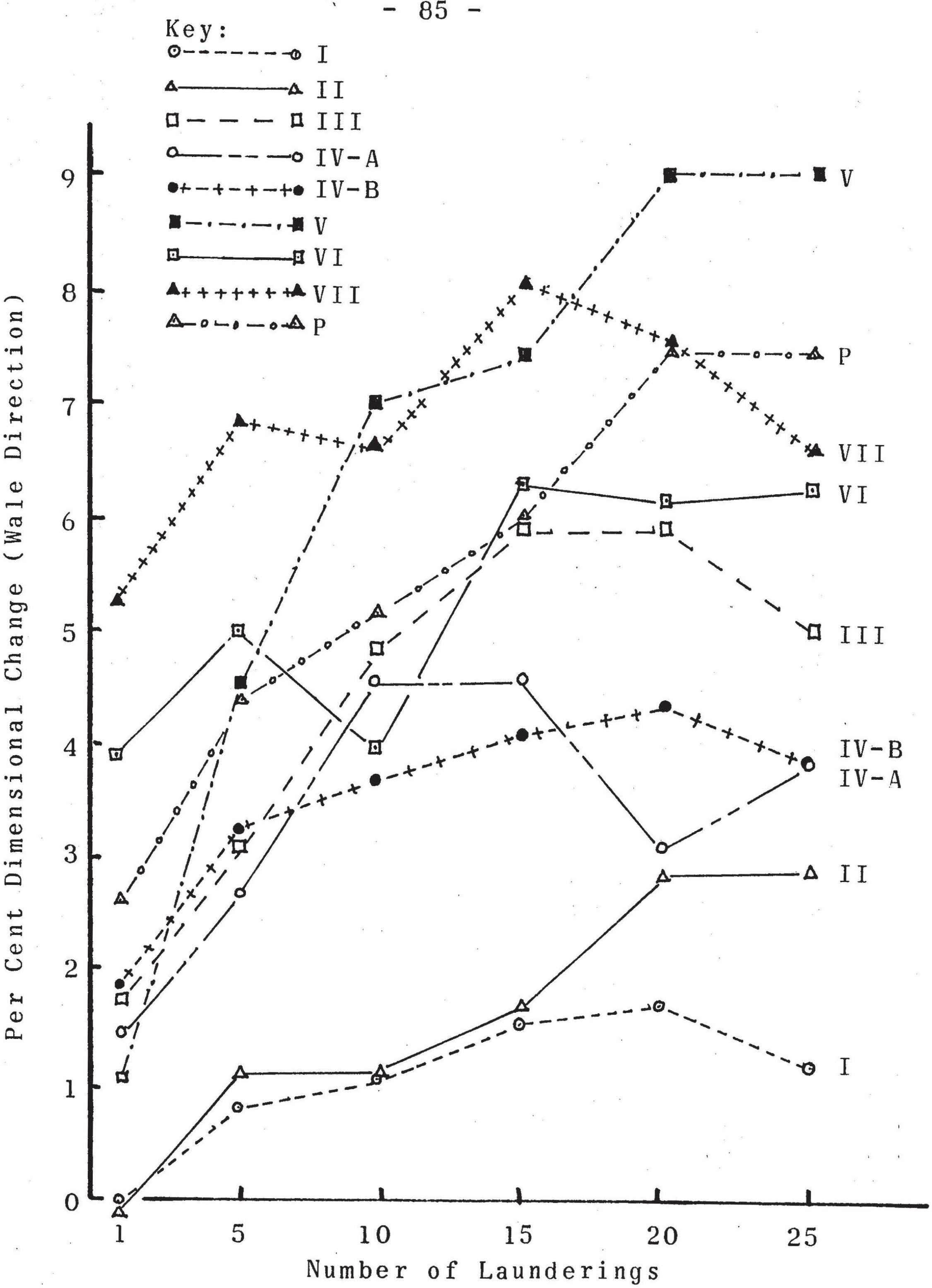


Fig. 24.--Comparison of shirt types with regard to dimensional change in the wale direction after designated periods of laundering.

The results of the statistical analysis of these data as shown in Table XXVII as well as in Figure 25 substantiated the above observations that the 65/35 triacetate-polyester, warp knit shirts in Groups I and II were accredited as being the best shirt types with respect to their dimensional stability in the wale direction. Ranked secondly were the circular knit shirts in Groups III, IV-A, and IV-B. The greatest degree of shrinkage during laundering was found in the interlock knit shirts of 100 per cent cotton in Group VII. See Figure 25.

Course Direction.--As verified by the data tabulated in Table XXIV and graphically illustrated in Figure 26, the non-worn experimental shirts of all fiber contents and knit constructions shrank to some extent in the course direction after the first period of laundering. The pattern of performance was similar to that found in the wale direction in that the per cent shrinkage in the majority of shirt types increased progressively as the number of launderings increased from one to 25 cycles.

The 50/50 cotton-polyester, interlock knit shirts in Group VI displayed the highest mean shrinkage value (4.27 per cent) in the course direction after the first cycle of laundering. Although the circular knit shirts of 50/50 cotton-polyester in Group P failed to reveal the highest

Shirt Types in Rank Order

	I	II	IV-A	IV-B	III	P	VI	V	VII
VII	5.7*	5.2*	3.6*	3.3*	2.7*	1.8*	1.8*	1.2*	
V	4.5*	4.3*	2.3*	2.1*	1.5*	0.6	0.6		
VI	3.9*	3.7*	1.7*	1.5*	0.9*	0.0			
P	3.9*	3.7*	1.7*	1.4*	0.8*				
III	3.0*	2.8*	0.9	0.6					
IV-B	2.4*	2.2*	2.3						
IV-A	2.2*	2.0*							
II	0.2								
I									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 25.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean dimensional change in the wale direction of experimental shirts after 25 periods of laundering.

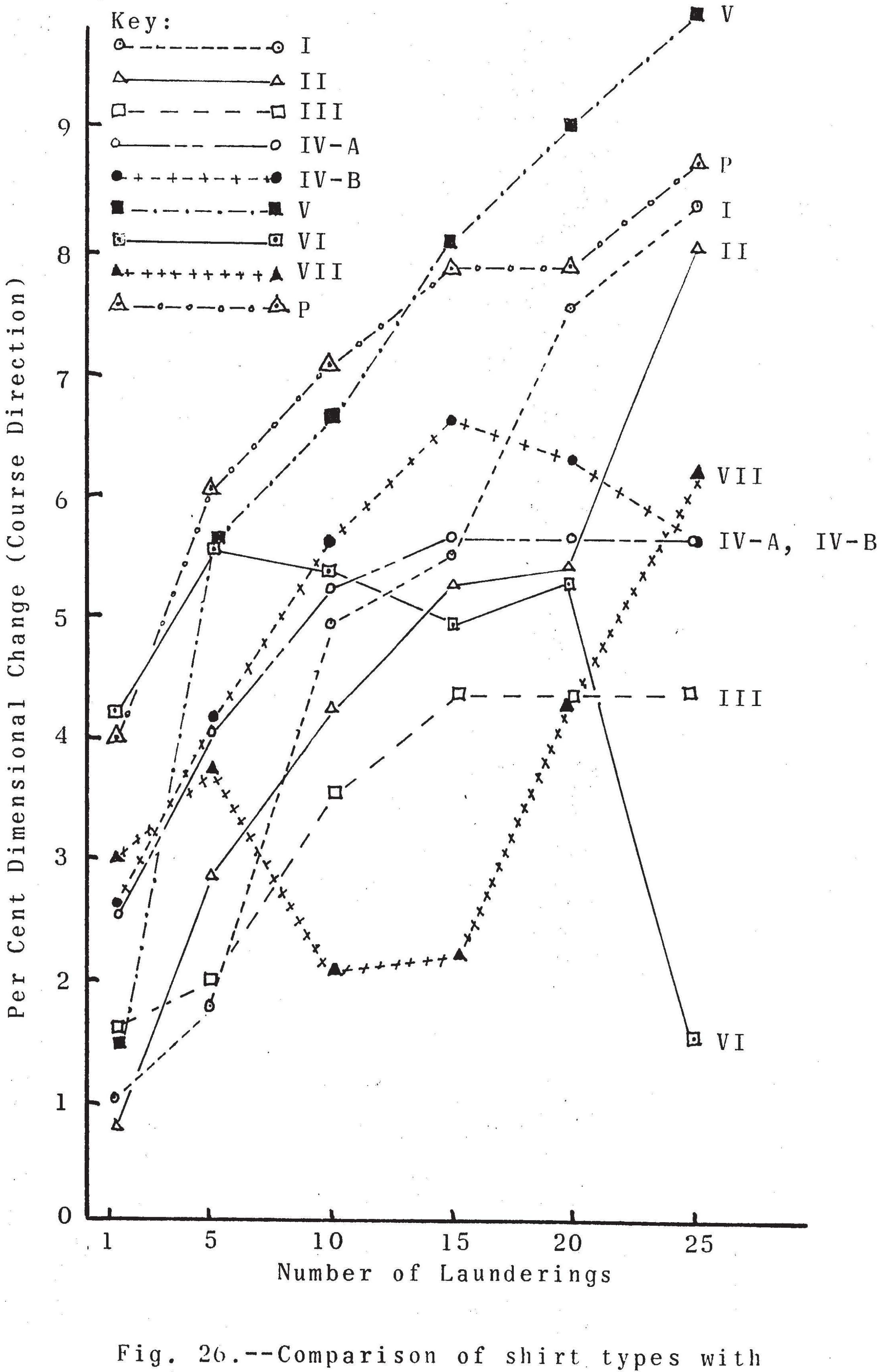


Fig. 26.--Comparison of shirt types with regard to dimensional change in the course direction after designated periods of laundering.

shrinkage value in the course direction at this period of laundering, their shrinkage, however, was relatively high. The shirts of 65/35 triacetate-polyester, warp knit in Group II displayed the least amount of shrinkage after the first laundering cycle.

A further scrutiny of the mean values given in Table XXIV, as well as the graphical presentation in Figure 26, revealed that the non-worn experimental shirts in Groups I, II, V, and P exhibited a continuing upward trend of shrinkage in the course direction during laundering, whereas the interlock knit shirts of 50/50 cotton-polyester in Group VI and the circular knit shirts of the same fiber content in Group IV-B displayed a downward trend in shrinkage during the last five periods of launderings. The 50/50 cotton-polyester, circular knit shirts in Groups III and IV-A reached their relaxed state in the course direction after 15 periods of launderings.

As evidenced by the statistical results presented in Table XXVIII and in Figure 27, the non-worn experimental shirts of 50/50 cotton-polyester, circular knit, in Groups III and VII (100 per cent cotton, interlock knit) were accredited as the best with regard to their overall dimensional stability in the course direction. The warp knit shirts of 65/35 triacetate-polyester in Group II were

Shirt Types in Rank Order

P	3.2*	3.1*	3.0*	2.3*	1.9*	1.6*	1.4*	0.5	
V	2.7*	2.6*	2.5*	1.8*	1.4	1.1	0.9		
VI	1.8*	1.6*	1.6*	0.9	0.4	0.2			
IV-B	1.6*	1.5	1.4*	0.7	0.3				
IV-A	1.3	1.2	1.2	0.5					
I	0.9	0.8	0.7						
VII	0.2	0.0							
II	0.1								
III									
	III	II	VII	I	IV-A	IV-B	VI	V	P

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 27.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean dimensional change in the course direction of experimental shirts after 25 periods of laundering.

ranked secondly along this line, and the poorest dimensional stability in the course direction was evident in the shirts of 50/50 cotton-polyester, circular knit construction in Group P. Other shirt groups were intermediate with regard to their dimensional stability in the course direction. Figure 27 furnishes further information concerning these intercomparisons.

Dimensional Stability of Worn and Laundered Shirts

Wale Direction.--As evidenced by the data shown in Table XXV and in Figure 28, the worn and laundered experimental shirts, without regard to the fiber content or knit construction, shrank to some degree in the course direction after being subjected to the first wear and laundering cycle. As found in the shirts of the non-worn category, the worn and laundered experimental shirts of all types increased in shrinkage in the wale direction progressively as the number of wear and laundering cycles increased except in some instances.

The interlock knit shirts of all-cotton in Group VII displayed the highest per cent shrinkage (5.20 per cent) in the wale direction after the first period of wear and laundering, while the warp knit shirts in Group I (65/35 triacetate-polyester) exhibited the smallest amount.

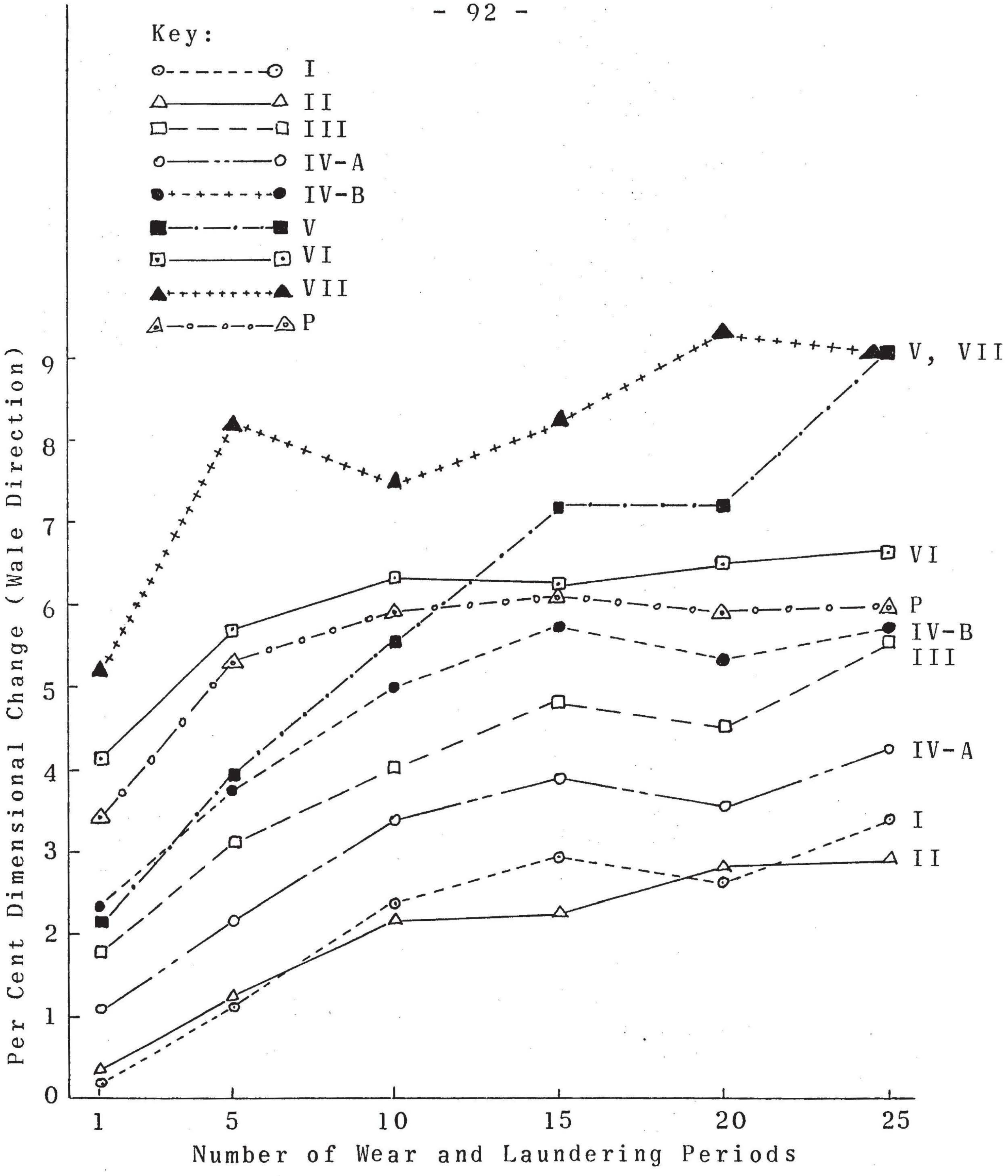


Fig. 28.--Comparison of shirt types with regard to dimensional change in the wale direction after designated periods of wear and laundering.

A further study of the mean data tabulated in Table XXV and diagrammed in Figure 28 revealed that the experimental shirts from the worn category, generally, demonstrated their highest shrinkage values at the fifteenth and the final periods of wear and laundering. As found in the non-worn category, the shirts of Group V (100 per cent triacetate, warp knit) shrank progressively from one through 15 periods of wear and laundering. The shirts in this group, however, demonstrated a measure of stabilization from 15 through 20 periods of wear and laundering. See Figure 28.

A statistical analysis of the data, as can be noted from the results given in Table XXVII, revealed that there was a significant difference between the worn and laundered shirt types with respect to their dimensional stability in the wale direction. The warp knit shirts in Groups I and II (65/35 triacetate-polyester) performed significantly better with respect to their dimensional stability in the wale direction than did the remaining shirt types. The circular knit shirts of 50/50 cotton-polyester in Group IV-B ranked secondly with respect to their dimensional performance, and the poorest dimensional stability during wear and laundering was found in the shirts of Group VII which were made from 100 per cent cotton in an interlock knit construction. See Figure 29 for additional information.

Shirt Types in Rank Order

	I	II	IV-A	III	IV-B	P	V	VI	VII
VII	5.9*	5.9*	4.7*	3.8*	3.1*	2.4*	2.1*	1.9*	
VI	3.9*	3.9*	2.8*	1.9*	1.2*	0.4	0.2		
V	3.8*	3.8*	2.6*	1.7*	1.0*	0.3			
P	3.5*	3.5*	2.4*	1.5*	0.8*				
IV-B	2.7*	2.7*	1.6	0.7*					
III	2.0*	2.0*	0.9*						
IV-A	1.1*	1.1*							
II	0.0								
I									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 29.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean dimensional change values in the wale direction of experimental shirts after 25 periods of wear and laundering.

Course Direction.--As evidenced by the per cent dimensional change in the course direction tabulated in Table XXVI and substantiated by the graphical illustration in Figure 30, all of the worn and laundered shirt types displayed a shrinkage pattern in the course direction similar to that of the non-worn-laundered shirts. In most instances instability in the course direction of the worn and laundered shirts increased as the number of wear and laundering periods increased from the first period throughout the remainder of the wear and laundering intervals. See Figure 30 for further information concerning patterns of shrinkage in the course direction of the worn and laundered shirts.

At the first evaluation period the highest per cent shrinkage in the course direction was observed in the shirts of Groups VI (50/50 cotton-polyester, interlock knit) and P (50/50 cotton-polyester, circular knit). The shirts in Group V which failed to display the greatest shrinkage value at the first period of wear and laundering, however, revealed the highest per cent of shrinkage at the final interval.

Statistical results shown in Table XXVIII demonstrate that there were significant differences between the shirt types with regard to their dimensional stability in the

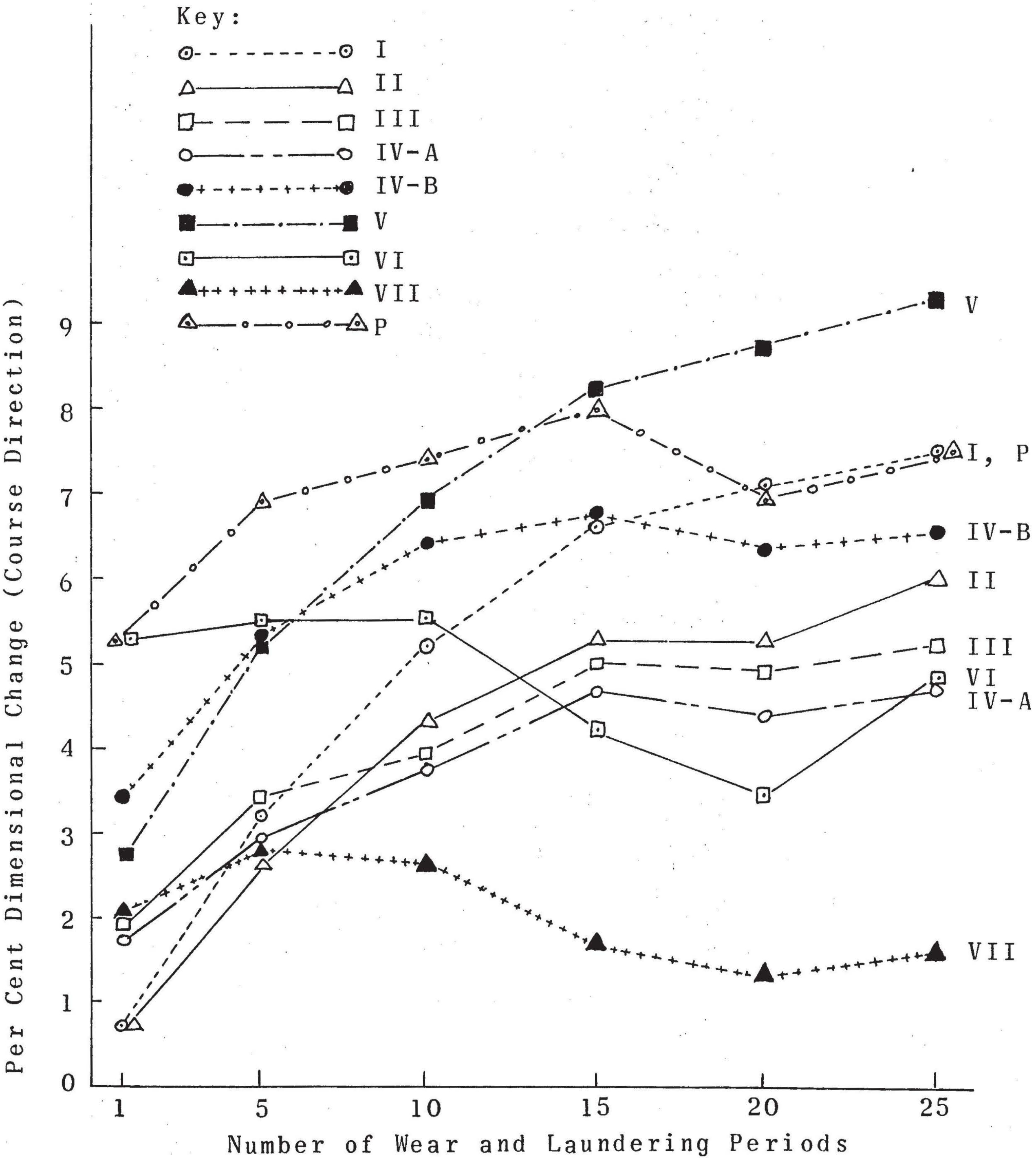


Fig. 30.--Comparison of shirt types with regard to dimensional change in the course direction after designated periods of wear and laundering.

course direction. The 100 per cent cotton interlock knit shirts in Group VII were found to be the best with respect to their dimensional performance, whereas the shirts in Groups II, III, and IV-A were ranked next in line. The all-triacetate, warp knit shirts in Group V and the 50/50 cotton-polyester circular knit shirts in Group P proved to be the poorest with reference to their dimensional stability in the course direction during wear and laundering periods. See Figure 31.

When the mean shrinkage values of the experimental shirts which were worn and laundered were compared statistically on the basis of the number of wear and laundering periods, the results proved that, overall, the experimental shirts displayed the greatest percentage of shrinkage in the course direction after 15 and 25 periods of wear and laundering, respectively.

Comparison of Shirt Types on the Basis of Overall Dimensional Stability Values

Wale Direction.--The experimental shirt types were compared with respect to their dimensional change in the wale direction on the basis of data from the non-worn-laundered and the worn and laundered categories, and the results as given in Table XXVII indicate that there were

Shirt Types in Rank Order

P	5.0*	3.3*	3.0*	3.0*	2.2*	2.0*	1.3*	0.2	
V	4.8*	3.2*	2.9*	2.8*	2.0*	1.8*	1.1*		
IV-B	3.7*	2.1*	1.8*	1.7*	0.9*	0.7*			
I	3.0*	1.4*	1.1*	1.0*	0.2				
VI	2.8*	1.2*	0.9*	0.8*					
III	2.0*	0.4	0.1						
II	1.9*	0.3							
IV-A	1.6*								
VII									
	VII	IV-A	II	III	VI	I	IV-B	V	P

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 31.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean dimensional change in the course direction of experimental shirts after 25 periods of wear and laundering.

significant differences between the experimental shirt types with respect to their shrinkage properties. The shirts in Groups I and II (65/35 triacetate-polyester, warp knit) were superior to the remainder of the shirt types with regard to their dimensional performance. Ranked secondly along this line were the shirts in Group IV-A (50/50 cotton-polyester, circular knit). The poorest dimensional stability in the wale direction was found in the shirts of Group VII, which were made from 100 per cent cotton in the interlock knit construction. See Figure 32 for further information.

When the cumulative mean shrinkage of all the shirt types in the non-worn-laundered category was compared with that of the worn and laundered group, the results revealed that the mean shrinkage of the non-worn group was lower than that of the worn and laundered shirt group. The dimensional performance of the experimental shirts, therefore, was affected by wear.

Course Direction.--When the dimensional change in the course direction of the experimental shirts from the worn and non-worn categories was compared statistically as described previously for the wale direction, the result as reported in Table XXVIII demonstrated that the interlock knit shirts made from the 100 per cent cotton were

Shirt Types in Rank Order

	I	II	IV-A	III	IV-B	P	VI	V	VII
VII	5.7*	5.7*	4.3*	3.4*	3.2*	2.1*	1.9*	1.8*	
V	4.0*	3.9*	2.5*	1.7*	1.4*	0.4	0.2		
VI	3.8*	3.8*	2.4*	1.5*	1.3*	0.2			
P	3.6*	3.5*	2.2*	1.3*	1.0*				
IV-B	2.6*	2.5*	1.1*	0.2					
III	2.3*	2.3*	0.9*						
IV-A	1.4*	1.4*							
II	0.1								
I									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 32.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall per cent dimensional change in the wale direction of worn and non-worn shirts after 25 periods of laundering.

accredited with the best dimensional stability in the course direction. In second rank position with respect to the above-described comparisons were the experimental shirts of 50/50 cotton-polyester, circular knit in Group III; the 65/35 triacetate-polyester, warp knit shirts of Group II; and the 50/50 cotton-polyester, circular knit shirts of Group IV-A. The 100 per cent triacetate, warp knit shirts in Group V and those of 50/50 cotton-polyester, circular knit of Group P were inferior in their dimensional stability performance in the course direction. See Figure 33 for further information concerning these comparisons.

When the experimental shirts in the non-worn category were compared with those in the worn and laundered group on the basis of the cumulative mean value of each category, the results revealed that the worn and laundered shirts were significantly less stable than those shirts which were laundered only. Wear, therefore, proved to be a contributing factor to the dimensional instability of the experimental shirts in the course direction.

Abrasion Resistance

The abrasion resistance of the experimental shirts during laundering and during wear and laundering was determined at collar points, collar edges, cuff points, and

Shirt Types in Rank Order	VII	III	II	IV-A	I	VI	IV-B	V	P
P	4.3*	3.1*	3.0*	3.0*	2.1*	2.0*	1.4*	0.2	
V	4.1*	2.9*	2.8*	2.8*	1.8*	1.7*	1.2		
IV-B	2.9*	1.7*	1.6*	1.6*	0.7	0.6			
VI	2.4*	1.1*	1.1*	1.0*	0.1				
I	2.2*	1.0*	1.0*	0.9*					
IV-A	1.3*	0.1	0.1						
II	1.3*	0.0							
III	1.2*								
VII									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 33.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall dimensional change in the course direction of worn and non-worn shirts after 25 periods of laundering.

cuff edges. A scale representative of values from 1.0 to 5.0, as described previously in Chapter III of this manuscript, was used in measuring the degree of abrasion. Data which were obtained from these evaluations of the laundered shirts are tabulated in Tables XXIX and XXX, while Tables XXXI and XXXII contain the results obtained from an evaluation of the worn and laundered shirts. Further information concerning the statistical treatment of the data and the relative performance of the various shirt types can be found in Tables XXXIII and XXXIV as well as in Figures 34 through 43, respectively.

Abrasion Resistance of Collars and Cuffs of Shirts Laundered Without Previous Wear

Collars.--As demonstrated by the mean values tabulated in Table XXIX generally the abrasion resistance of the collars of the non-worn experimental shirts, except those in Group IV-A, decreased progressively as the number of launderings increased. Figure 34 presents a graphical comparison of the shirts on the basis of mean abrasion resistance values obtained at various intervals of laundering.

A further scrutiny of these data revealed that the 50/50 cotton-polyester, circular knit shirts of Group IV-A

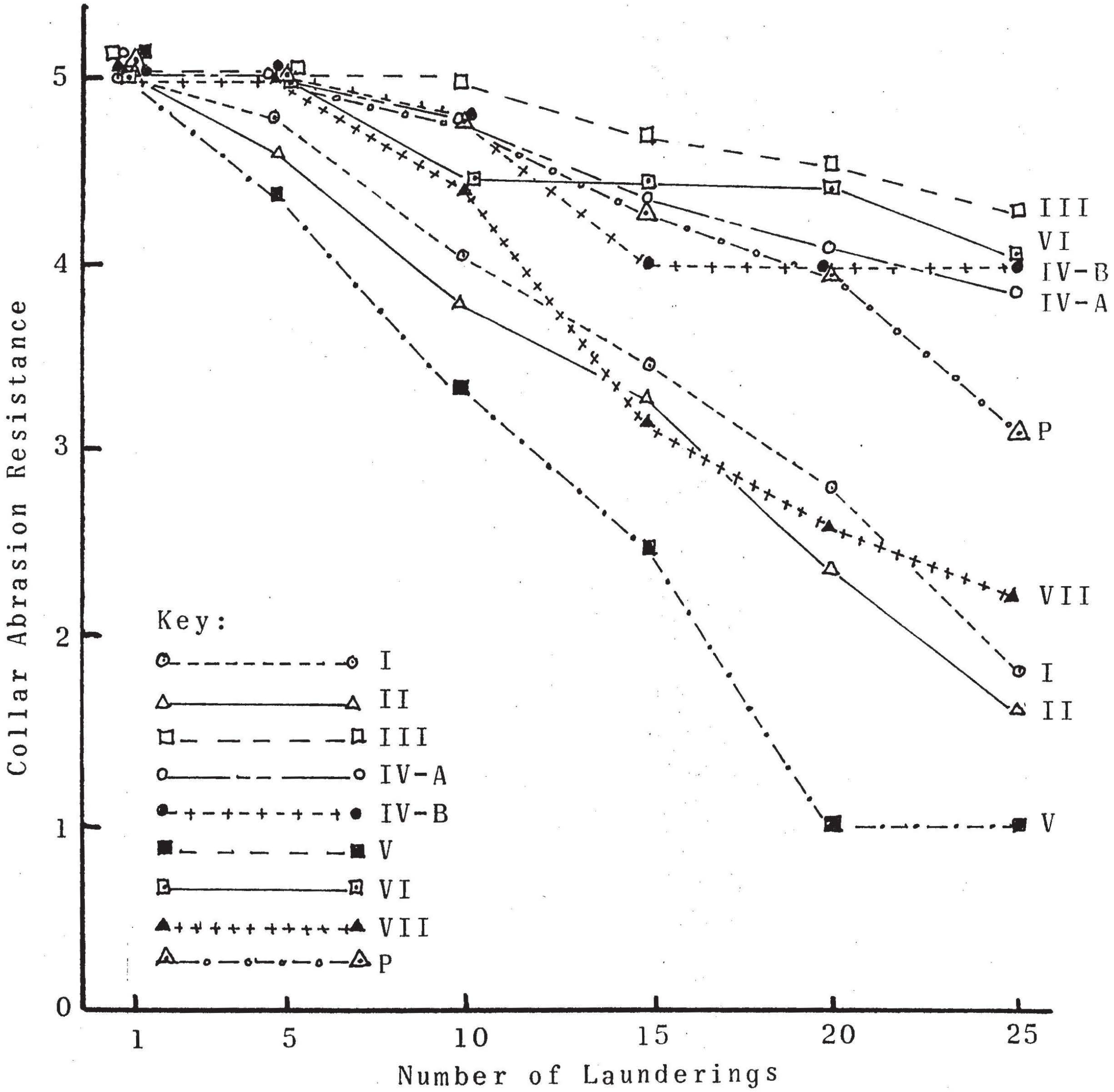


Fig. 34.--Comparison of shirt types with regard to collar abrasion after designated periods of laundering.

were the most desirable shirts with respect to the abrasion resistance of their collars. These shirts showed no evidence of wear due to laundering until after the fifteenth cycle. The warp knit shirts of 100 per cent triacetate in Group V suffered the most obvious degree of collar abrasion with the mean score ranging from 4.5 after the first laundering to 1.5 after the final period.

An analysis of variance of these data, as reported in Table XXXIII and followed by the Duncan's Multiple Comparison Test, supported the observations mentioned above that the 50/50 cotton-polyester, circular knit shirts of Group IV-A were superior to the remainder of the shirt types as far as the cumulative mean value was concerned (4.6). This measure of abrasion resistance, however, was not found to be superior to a significant degree to that of five other shirt types (I, II, III, IV-B, and P). The all-cotton interlock knit shirts of Group VII and the warp knit shirts of all-triacetate in Group V exhibited the poorest resistance to collar abrasion due to laundering. See Figure 35.

Cuffs.--A tabulation of the mean scores resulting from the evaluations of the non-worn shirts with respect to the resistance of the cuffs to abrasion during laundering appears in Table XXX. Figure 36 provides a graphical

Shirt Types in Rank Order

	IV-A	VI	P	III	IV-B	I	II	VII	V
V	1.2*	1.2*	1.0*	0.9*	0.9*	0.8*	0.8*	0.3	
VII	1.0*	0.9*	0.7*	0.7*	0.6*	0.5*	0.5*		
II	0.4	0.4	0.2	0.2	0.1	0.0			
I	0.4	0.4	0.2	0.1	0.1				
IV-B	0.3	0.3	0.1	0.0					
III	0.3	0.2	0.0						
P	0.2	0.2							
VI	0.0								
IV-A									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 35.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean collar-abrasion resistance values of experimental shirts after 25 periods of laundering.

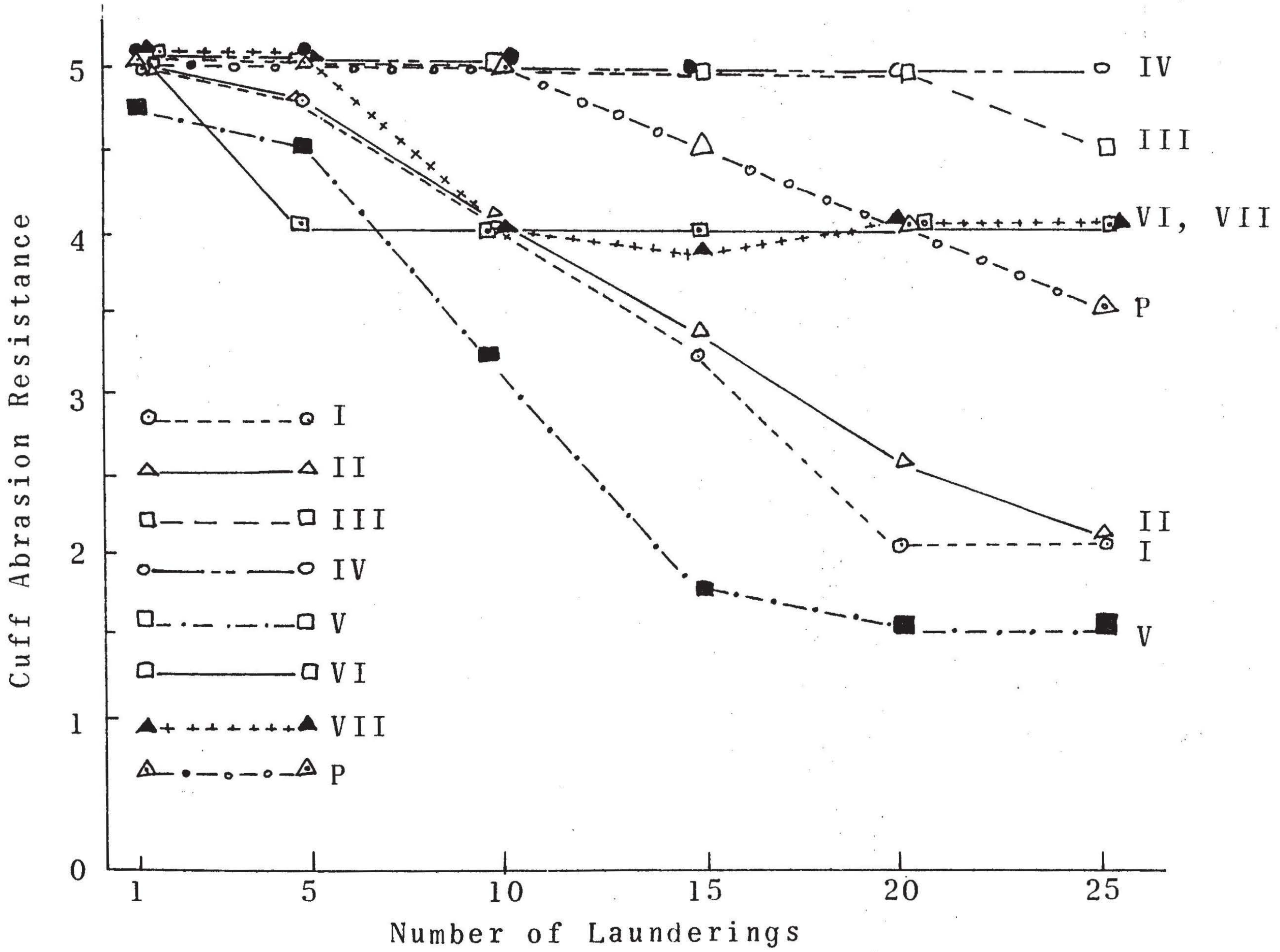


Fig. 36.--Comparison of shirt types with regard to cuff abrasion after designated periods of laundering.

illustration on the basis of the mean values of the shirts. These data demonstrated that the 50/50 cotton-polyester, circular knit shirts in Groups III, IV-A, and IV-B led in perfect mean scores (5.0) throughout the study. A further observation of the abrasion resistance values revealed that generally the resistance of the remainder of the experimental shirts to cuff abrasion during laundering diminished progressively as the number of launderings increased. The all-triacetate warp knit shirts in Group V were the only shirts that showed cuff abrasion at the first laundering cycle with the mean score of 4.8 and displayed heavy abrasion after the fifteenth laundering period with a mean score of 1.8. The interlock knit shirts of 50/50 cotton-polyester in Group VI displayed a slight amount of abrasion (4.0) at cuffs after five periods of laundering and maintained that value through the final cycle.

The statistical results recorded in Table XXXIV and the intercomparisons based on the cumulative mean values shown in Figure 37 prove that the circular knit shirts of 50/50 cotton-polyester in Groups III and IV were the best shirt types with respect to the resistance of their cuffs. The 50/50 cotton-polyester shirts in Groups P and VI were next in the line with reference to the cuff

Shirt Types in Rank Order	V	1.6*	1.6*	1.4*	1.1*	0.8*	0.8*	0.7*
	I	0.9*	0.9*	0.7*	0.4	0.1	0.1	
	VI	0.8*	0.8*	0.6*	0.4	0.0		
	II	0.8*	0.8*	0.6*	0.4			
	VII	0.5	0.4*	0.2				
	P	0.2	0.2					
	III	0.2						
	IV							
		IV	III	P	VII	II	VI	I	V

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 37.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean cuff-abrasion resistance values of experimental shirts after 25 periods of laundering.

abrasion resistance. The poorest performer of the non-worn shirt types was found to be the shirts in Group V (100 per cent triacetate, warp knit).

Abrasion Resistance of Collars and Cuffs of Worn and Laundered Shirts

Collars.--Data reported in Table XXXI and plotted in Figure 38 reveal that the abrasion resistance of the shirt collars decreased progressively as the number of wear and laundering periods progressed from one to 25 except in one instance. Although the 50/50 cotton-polyester shirts of interlock knit construction in Group VI displayed a greater amount of collar abrasion after the first wear-laundering period than did the remainder of the shirt types, from that period on no change was noted with respect to abrasion damage to the collars of these sheets. As was found to be the case of the non-worn shirt types, shirts of Group V composed of all-triacetate warp knit construction suffered the greatest amount of collar damage as demonstrated by the lowest mean value of 1.0 after the final period of wear and laundering. A further examination of these data led to the finding that the fiber content of the experimental shirts in this category played a major role with respect to their resistance to collar damage.

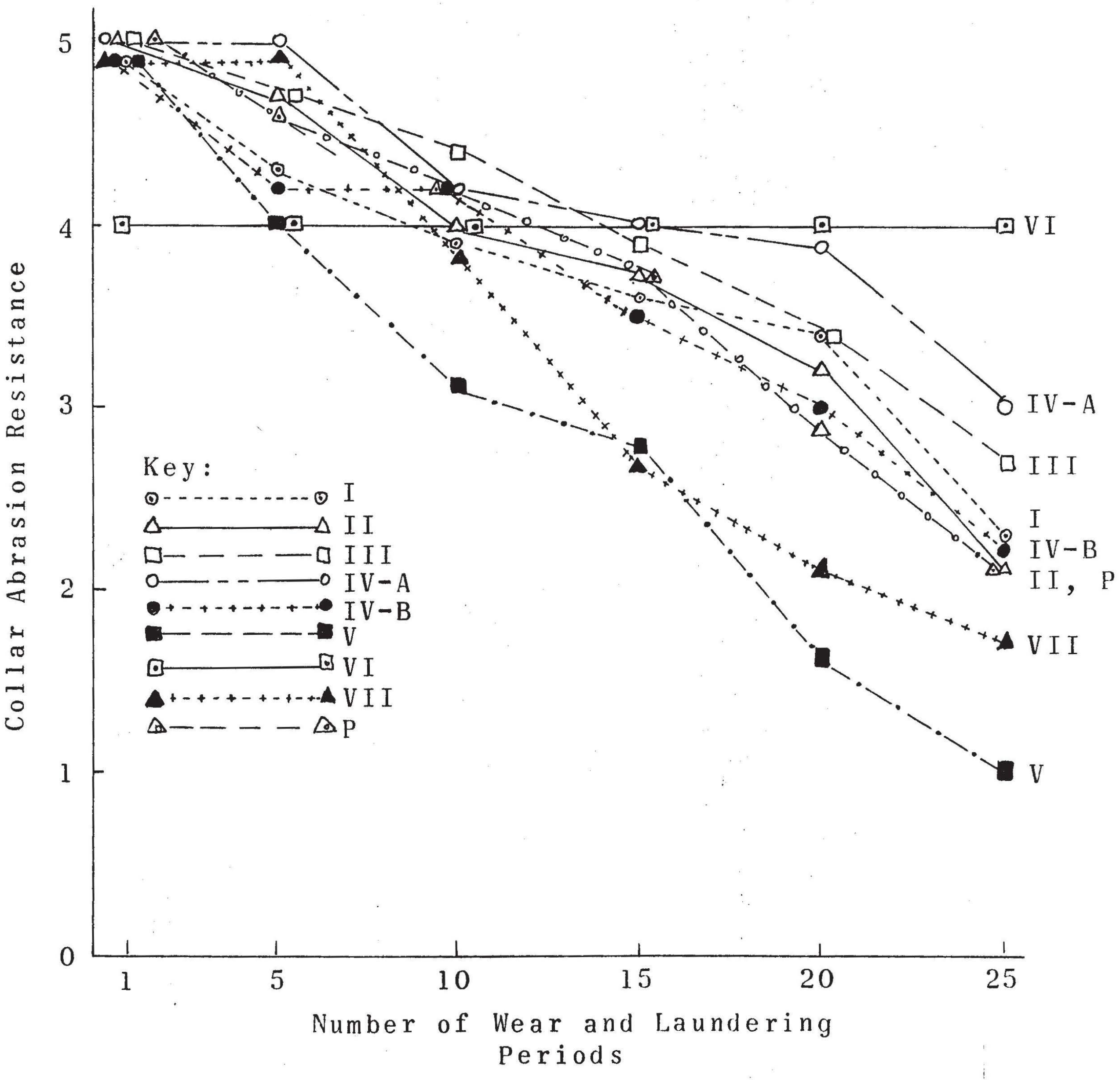


Fig. 38.--Comparison of shirt types with regard to collar abrasion after designated periods of wear and laundering.

Results of the statistical analysis of the data as shown in Table XXXIII and in Figure 39 substantiate the above-mentioned observation that the 50/50 cotton-polyester shirts of Groups VI (interlock knit), III, and IV (circular knit) proved to be the best performers with respect to their resistance to collar abrasion, whereas the 100 per cent triacetate, warp knit shirts in Group V demonstrated the poorest resistance to abrasion during wear and laundering. The remainder of the shirt types held intermediate positions with respect to collar abrasion as is evident in Figure 39.

When the wear-laundering periods were compared with respect to the abrasion of the shirt collars, all shirt types displayed their greatest resistance after the first wear-laundering period, and this resistance decreased as the number of wear-laundering periods increased. The twenty-fifth period exerted the greatest degree of wear on the collars of the shirts.

Cuffs.--In the category of cuff abrasion resistance, the worn and laundered experimental shirts exhibited a mean score comparative to the pattern demonstrated by the previously discussed non-worn and laundered shirts. See Table XXXII. After the first wear and laundering cycle, no abrasion was observed on the cuffs of any of the shirts

Shirt Types in Rank Order

V	1.1*	1.1*	1.1*	0.8*	0.8*	0.8*	0.4*	
VII	0.6*	0.6*	0.6*	0.4*	0.4*	0.4*		
I	0.3*	0.3*	0.3*	0.1	0.0			
II	0.3*	0.2*	0.2*	0.0				
P	0.2*	0.2*	0.2*					
IV	0.0	0.0						
III	0.0							
VI								
	VI	III	IV	P	II	I	VII	V

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 39.--Duncan's Multiple Comparison Table for differences between shirt types with respect to collar-abrasion resistance values of experimental shirts after 25 periods of wear and laundering.

except those of Groups I and II (65/35 triacetate-polyester, warp knit). Further examination of the mean values in Table XXXII revealed that the effect of wear and laundering upon the cuff abrasion of the experimental shirts was more pronounced after the final period with the exception of the shirts in Group V (all-triacetate, warp knit) which demonstrated excessive cuff damage after 15 wear and laundering periods. See Figure 40.

A statistical comparison of the shirt types on the basis of the amount of resistance to cuff abrasion indicated that the circular knit shirts of 50/50 cotton-polyester in Group III displayed the best resistance to cuff damage, followed by the shirts in Groups IV, VI, and P. The all-triacetate, warp knit shirts in Group V proved to be the poorest with reference to their resistance to cuff abrasion during wear and laundering periods. See Figure 41.

Comparison of Shirt Types on the Basis of Overall Collar and Cuff Abrasion Resistance Values

Collars.--A statistical treatment of the values representative of the collar-abrasion resistance of all of the experimental shirts both from the non-worn and worn categories revealed that the 50/50 cotton-polyester, interlock knit shirts of Group VI were the best shirts with

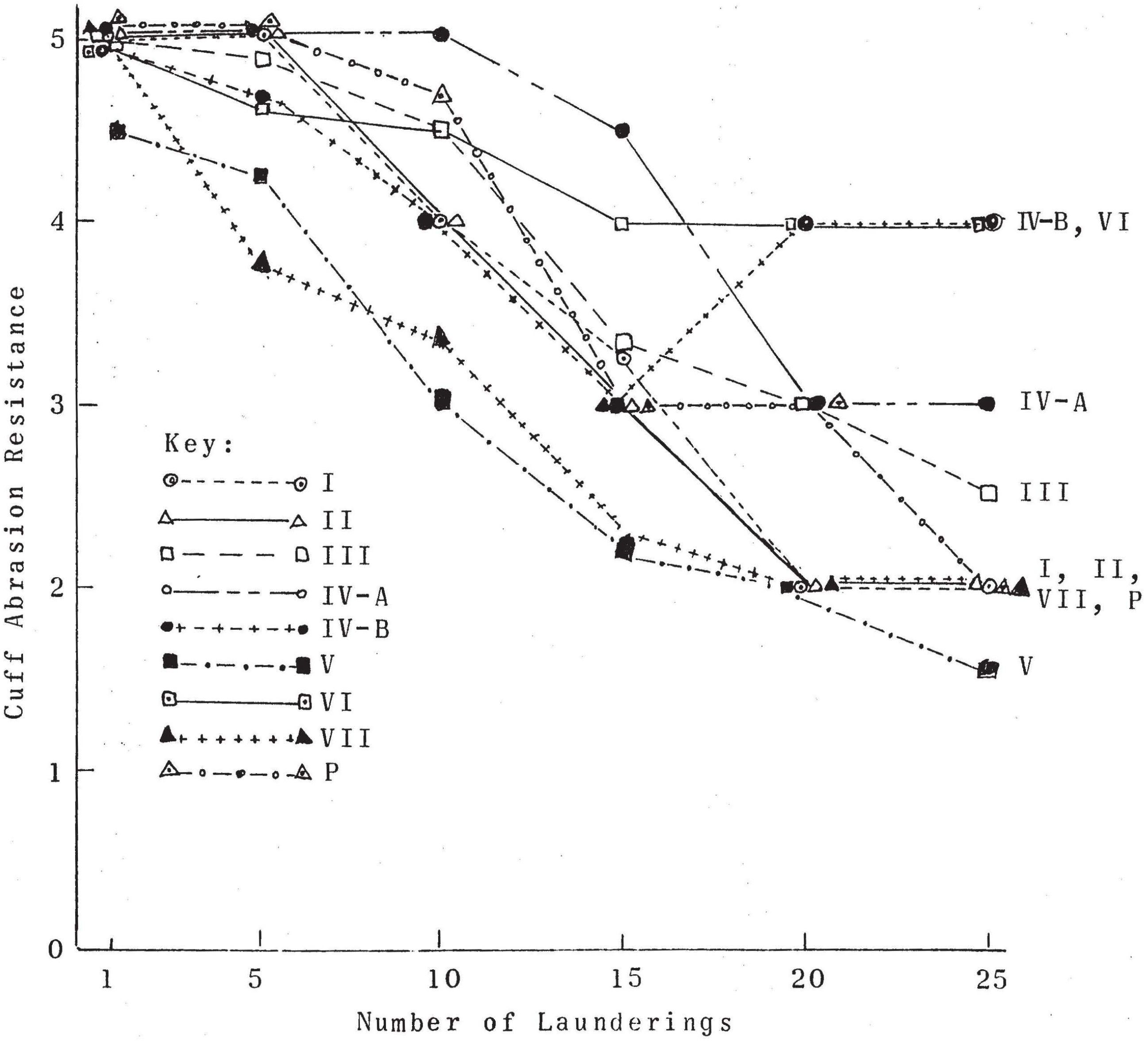


Fig. 40.--Comparison of shirt types with regard to cuff abrasion after designated periods of wear and laundering.

Shirt Types in Rank Order	III	VI	IV	P	VII	I	II	V
V	1.8*	1.6*	1.6*	1.4*	0.8*	0.7*	0.5*	
II	1.3*	1.1*	1.1*	1.0*	0.3*	0.2*		
I	1.1*	0.9*	0.8*	0.7*	0.1			
VII	1.0*	0.8*	0.8*	0.6*				
P	0.4*	0.2*	0.1					
IV	0.2*	0.0						
VI	0.2*							
III								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 41.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean cuff-abrasion resistance values of experimental shirts after 25 periods of wear and laundering.

respect to resistance to collar damage, and were superior in their performance to those of Groups I, II, V, and VII but not significantly better than the shirts of Groups P and IV (50/50 cotton-polyester, circular knit) which ranked next in the line with respect to their resistance to collar damage. The all-triacetate, warp knit shirts in Group V proved to be the inferior type with regard to collar abrasion. Further information on this aspect of abrasion is illustrated in Figure 42 and in Table XXXIII.

When the non-worn and laundered shirts as a whole were compared at every interval of evaluation with those which were worn and laundered, the results showed that wear exhibited a greater effect upon the abrasion of the collars of the experimental shirts than did laundering without wear.

Cuffs.--In a comparison of the mean abrasion resistance values of the non-worn shirt cuffs with those of the worn shirt cuffs of each shirt type during 25 periods of laundering, the worn shirts exhibited greater cuff damage than did the non-worn shirts. Additional information concerning such comparisons can be found in Figure 43.

An overall ranking with respect to the abrasion resistance of the experimental shirt cuffs on the basis of cumulative mean values for the non-worn and worn shirts

Shirt Types in Rank Order

	VI	III	IV	P	II	I	VII	V
V	1.2*	1.0*	1.0*	0.9*	0.8*	0.8*	0.4*	
VII	0.7*	0.6*	0.6*	0.5*	0.4*	0.4*		
I	0.4*	0.2	0.2	0.1	0.0			
II	0.4*	0.2	0.2	0.1				
P	0.3	0.2	0.2					
IV	0.1	0.0						
III	0.1							
VI								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 42.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall collar abrasion resistance values of worn and non-worn shirts after 25 periods of laundering.

Shirt Types in Rank Order

	III	IV	P	VI	VII	I	II	V
V	1.8*	1.5*	1.4*	1.4*	1.0*	0.7*	0.6*	
II	1.2*	0.9*	0.8*	0.8*	0.4*	0.2		
I	1.0*	0.8*	0.7*	0.7*	0.2			
VII	0.8*	0.6*	0.5*	0.5*				
VI	0.3*	0.1	0.0					
P	0.3*	0.1						
IV	0.2							
III								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 43.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall cuff abrasion resistance values of worn and non-worn shirts after 25 periods of laundering.

demonstrated that the circular knit shirts of 50/50 cotton-polyester from Group III were significantly superior to shirts from Groups I, II, V, VI, VII, and P. They were, however, not significantly better than the circular knit shirts of 50/50 cotton-polyester from Groups IV which ranked second. Shirts from Groups VI (50/50 cotton-polyester, interlock knit), and P (50/50 cotton-polyester, circular knit) also fell in second place with respect to their resistance to cuff abrasion. These shirt types were significantly superior to the shirts of Groups V (100 per cent triacetate, warp knit), I and II (65/35 triacetate-polyester, warp knit), and VII (100 per cent cotton, interlock knit). The interlock knit shirts of 100 per cent cotton from Group VII were found to be significantly better than the shirts of Groups II and V. The poorest resistance to cuff abrasion was noted in the shirts from Groups I, II, and V when the cuff abrasion values for the worn and non-worn shirts were combined and compared.

Bursting Strength

The bursting strength of the experimental shirts was determined initially and after 5, 15, and 25 periods of laundering on the shirts which were laundered only. The shirts from the worn and laundered category were examined with respect to their resistance to bursting only after 25 periods of wear and laundering.

Table XXXV includes the mean initial values of such evaluations as well as those obtained after specified periods of laundering from the non-worn shirts, while the data tabulated in Table XXXVI is representative of the bursting strength of the shirts which withstood 25 periods of wear and laundering. Supplementary information concerning the statistical analysis of the above-mentioned sets of data are provided in Table XXXVII as well as in Figures 44 through 46.

Bursting Strength of the Shirts Laundered Without Previous Wear

As can be observed in Table XXXV, the highest initial bursting strength value (90.4) was accredited to the circular knit shirts of 50/50 cotton-polyester in Group IV-A, and the warp knit shirts of 100 per cent triacetate in Group V received the lowest value of 42.1. The bursting strength of the shirts in these two groups increased after being subjected to a number of laundering periods. The non-worn experimental shirts in Group IV-A, however, displayed a lower mean value at the fifteenth laundering interval than they did at the fifth period of laundering, while the shirts in Group V gradually increased in bursting strength as the number of laundering cycles increased from five to 25.

A further study of these data points to the finding that, generally, the non-worn experimental shirts, without regard to the fiber content or knit construction, demonstrated an increase in bursting strength as the number of laundering cycles increased.

Statistical treatments of these data were executed to determine whether or not there were any significant differences between the shirt types with regard to their bursting strength on the basis of initial data and that obtained after 5, 15, and 25 periods of laundering, respectively. The results summarized in Table XXXVII and in Figure 44 revealed that the non-worn shirts of 50/50 cotton-polyester, circular knit in Groups III and IV-A displayed bursting strength values significantly higher than did the remaining shirt types. An intermediate performance in this respect was found in the shirts from Groups IV-B, VI, and P. The 100 per cent triacetate, warp knit shirts in Group V proved to be the poorest with regard to their bursting strength values after 25 periods of launderings.

When the effect of laundering on the bursting strength of various shirt types was analyzed statistically

Shirt Types in Rank Order

	IV-A	III	P	IV-B	VI	VII	I	II	V
V	46.0*	45.2*	29.3*	27.4*	26.6*	21.0*	18.5*	12.5*	
II	33.5*	32.8*	16.8*	15.0*	14.1*	8.5*	6.0*		
I	27.5*	26.8*	10.8*	9.0*	8.1*	2.5*			
VII	25.0*	24.3*	8.4*	6.5*	5.7*				
VI	19.4*	18.6*	2.7*	0.8					
IV-B	18.6*	17.8*	1.9						
P	16.7*	15.9*							
III	0.8								
IV-A									

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 44.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean bursting strength values of the initial and after 5, 15 and 25 periods of laundering.

in the non-worn category, the results revealed that as the laundering periods increased from five through 25 so did the bursting strength values except in one instance of comparison. The bursting strength values after 15 laundering cycles were not significantly different from those obtained after 25 periods of laundering. The initial values of the bursting strength performance of the experimental shirts proved to be inferior to those evident at other periods of evaluations.

Bursting Strength of the Worn and Laundered Shirts

The bursting strength values which were determined from the experimental shirts after 25 periods of wear and laundering are presented in Table XXXVI. These data indicate that, as a rule, the worn and laundered experimental shirt types without regard to the fiber content or knit construction displayed higher bursting strength values after being subjected to 25 periods of wear and laundering than they exhibited prior to wear and laundering. Exceptions to this observation were found in the shirts of Groups III, IV-A, and VII. The 50/50 cotton-polyester, circular knit shirts in Group III demonstrated a negliglble change in their bursting strength values as exemplified by the initial value of 89.30 and by 89.11 obtained after 25 periods of wear and laundering. Only the 50/50 cotton-polyester, circular knit shirts of Group IV-A and those of all-cotton, interlock knit in Group VII displayed lower values of bursting strength after being subjected to 25 periods of wear and laundering than those determined initially.

Results of the statistical intercomparisons performed on the data which were obtained from the worn and laundered shirt categories are shown in Table XXXVII and in Figure 45. The findings are similar to those of the non-worn shirts. The 50/50 cotton-polyester, circular knit shirts in Group III and IV-A were accredited as the best according to their bursting strength values. An intermediate performance was noted in the 50/50 cotton-polyester, circular knit shirts in Groups IV-B and P and in those of interlock knit in Group VI. The all-triacetate, warp knit shirts in Group V were concluded to be inferior with regard to their bursting performance. See Figure 45 for further information on this analysis.

Comparison of Shirt Types on the Basis of Overall Bursting Strength Values

The mean values of the bursting strength obtained from the evaluations of the worn and laundered shirts were

Shirt Types in Rank Order

	III	IV-A	IV-B	VI	P	I	VII	II	V
V	44.3*	43.2*	27.8*	27.7*	27.3*	19.6*	16.2*	14.0*	
II	30.3*	29.2*	13.8*	13.8*	13.3*	5.6*	2.3*		
VII	28.0*	26.9*	11.5*	11.5*	11.0*	3.3*			
I	24.7*	23.6*	8.2*	8.2*	7.7*				
P	17.0*	15.9*	0.5	0.4					
VI	16.6*	15.5*	0.0						
IV-B	16.5*	15.4*							
IV-A	1.1								

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 45.--Duncan's Multiple Comparison Table for differences between shirt types with respect to mean bursting strength values of experimental shirts after 25 periods of wear and laundering.

compared statistically with those from the shirts which were laundered for 25 periods without previous wear. The results revealed that the bursting values of the non-worn shirts were superior to those of the worn and laundered shirts. Wear, therefore, proved to be a factor that affected the bursting strength of the experimental shirts.

Intercomparisons of the shirt types on the basis of the two sets of data described above showed that the 50/50 cotton-polyester, circular knit shirts in Groups III and IV-A still were the best according to their bursting strength values, and the all-triacetate warp knit shirts in Group V proved to be inferior with reference to their bursting values. See Table XXXVII and Figure 46 for further information concerning these comparisons.

Shirt Types in Rank Order

V	44.0*	43.1*	28.0*	27.2*	27.2*	20.4*	16.3*	14.0*	
II	30.0*	29.1*	14.0*	13.2*	13.2*	6.5*	2.4*		
VII	27.6*	26.8*	11.7*	10.9*	10.8*	4.1*			
I	23.5*	22.6*	7.5*	6.7*	6.7*				
VI	16.8*	15.9*	0.8	0.0					
P	16.8*	15.9*	0.8						
IV-B	16.0*	15.1*							
IV-A	0.9								
III									
	III	IV-A	IV-B	P	VI	I	VII	II	V

Shirt Types in Rank Order

*Significant at .05 level.

Fig. 46.--Duncan's Multiple Comparison Table for differences between shirt types with respect to overall bursting strength values of worn and non-worn shirts after 25 periods of laundering.

CHAPTER V

SUMMARY AND CONCLUSION

Nine types of men's long-sleeve knit shirts (182 in number) were evaluated in this study with respect to durable press, seam appearance, color retention, collar pilling, abrasion resistance, wale and course count, dimensional stability and bursting strength after 25 periods of laundering without wear and after 25 periods of wear and laundering, respectively. The shirts representative of warp, circular, and interlock knitting constructions were composed of 100 per cent cotton, 100 per cent triacetate, 65/35 triacetate-polyester and 50/50 cotton-polyester.

Ninety-six shirts which were classified in the worn and laundered group were worn by a white-collar positioned wear panel for 25 eight-hour periods. After each period of wear they were laundered. The remainder of the shirts were subjected to 25 periods of laundering without previous wear. The shirts were laundered in a Whirlpool home-type washer and dryer. The "Durable Press" cycle was used for both washing and drying. At specified intervals throughout the study the nine types of shirts from the non-worn-laundered and the worn-laundered groups, respectively, were evaluated with regard to the previously mentioned properties.

The data were computed by means of an analysis of variance (AOV), and significant differences between the performance of the shirt types were determined at the .05 confidence level by means of Duncan's Multiple Range Test. As a means of summarizing the findings of the study, a system of ranking was devised with regard to the consistency reflected by the standard deviations.

The overall comparisons of the shirt types on the basis of their durable press appearance revealed that in many instances the smoothness of the shirts which were laundered without previous wear was affected neither by the fiber content, by the knitting construction, nor by the number of launderings to which the shirts were subjected. An analysis of these data revealed that the 50/50 cotton-polyester, circular knit shirts of Groups III and IV-A along with the 65/35 triacetate-polyester, warp knit shirts of Group I were rated as the best performers. The poorest performance, however, was noted in the 50/50 cotton-polyester, circular knit shirts in Group IV-B and P and in the 100 per cent cotton interlock knit shirts of Group VII.

With respect to the worn and laundered shirts, the best performers mentioned above, along with the 50/50 cotton-polyester, warp knit shirts of Group I and the 50/50 cotton-polyester, interlock knit shirts of Group VI, displayed a durable press performance superior to that of the remainder of the shirt types. The all-cotton shirts in Group VII displayed the lowest level of performance.

The rank order of the worn and laundered shirt groups on the basis of smoothness performance was generally the same as that of the shirts which were laundered without previous wear. The shirts in Groups I, II, III, IV-A, and VI were superior to the rest of the shirt types, while the shirts in Group VII displayed the poorest performance.

Without regard to the shirt types, the worn and laundered shirts as a group demonstrated durable press appearance ratings superior to those which were laundered without previous wear. When a rank order arrangement was devised based upon cumulative mean durable press ratings of the worn and laundered shirts and those which were laundered only, the shirts in Groups I, III, and IV-A were accredited as having maintained their performance to the greatest degree.

The smoothest seams for the non-worn-laundered shirts were observed in the 65/35 triacetate-polyester, warp knit shirts of Groups I and II, in the 50/50 cotton-polyester, circular knit shirts in Groups III and IV-B, and in the 100 per cent triacetate, warp knit shirts in Group V. The shirts in Group VI (50/50 cotton-polyester, circular knit) performed the poorest with regard to the appearance of their seams.

The worn and laundered shirts in Groups I, II, III, IV-A, IV-B, and V, along with the 100 per cent cotton shirts of Group VII, displayed seams which were smoother than the remainder of the shirt types during 25 periods of wear and laundering, whereas shirts in Group P displayed the lowest level of seam appearance.

A comparison of the performance of the two major categories of shirts (non-worn-laundered and worn-laundered groups) showed wear to be a contributing factor in the performance of the seams of the experimental shirts. A comparison of the respective shirt types on the basis of a combination of the non-worn-laundered and worn and laundered data showed that the shirts in Groups I, II, III, IV-A, IV-B, and VII maintained smoother seams throughout the study.

The degree of color deterioration was found to increase as the number of laundering and wear and laundering cycles increased. The non-worn warp knit shirts in Groups I, II and V, as well as the circular knit shirts of Group III, retained their color to the greatest extent, while the shirts in Groups IV, VI and VII proved to be inferior with regard to their color retention values during laundering.

The worn and laundered shirts in Groups I, II, V, and P were accredited as being the best shirt types with regard to their color retention values during 25 periods of wear and laundering, while the shirts in Groups III and VII were found to display the poorest degree of color retention.

A comparison of the overall mean color retention values (a combination of the values from the worn and non-worn shirts) revealed the shirts in Groups I, II and V as being the best shirt types according to their degree of color retention, but the poorest performance in this respect was observed in the shirts of Groups III and VII. In an overall comparison of the shirt categories, without regard to shirt types, the non-worn-laundered shirts displayed a greater degree of color retention than that displayed by the worn and laundered group. Wear was concluded as being a contributing factor to color deterioration.

An evaluation of the shirts with respect to collar pilling revealed that only the non-worn interlock knit shirts in Groups VI (50/50 cotton-polyester) and VII (100 per cent cotton) formed collar pills. These two shirt groups, however, did not show any pills after the first cycle of laundering.

Statistical comparisons revealed non-significant differences between the pilling of the shirts in these two groups. The findings revealed that the degree of collar pilling was affected by the number of wear and laundering periods. The number of shirt collar pills increased as the number of wear and laundering periods increased, as was found to be the case in a study conducted by Richards (34). Wear was evident as a contributing factor with respect to collar pilling.

The statistical results regarding the worn and laundered shirts showed significant differences between shirt types with respect to the pill resistance of their collars. The shirts in Groups I, II, V and P displayed the greatest resistance to pilling; while on the contrary, the shirts from Group VI had the poorest resistance.

In line with the findings of Markezich and Smith (24), the degree of abrasion damage at collar and cuff points and edges of the shirts from both categories (worn and non-worn) increased as the number of laundering and wear and laundering periods increased. The shirts in Groups V and VII in the non-worn-laundered category proved to have the lowest degree of resistance both to collar and cuff abrasion. The 50/50 cotton-polyester, circular knit shirts in Group IV-A were superior to the remainder of the shirt types as far as the collar abrasion was concerned. This measure of abrasion resistance, however, was not found to be superior to a significant degree to that of five other non-worn-laundered shirt types (I, II, III, IV-B, and P).

Cuff abrasion results showed that in the non-worn-laundered group the circular knit shirts of 50/50 cotton-polyester in Groups III and IV were the most resistant shirt types with respect to abrasion. The poorest performers proved to be the shirts in Group V (100 per cent triacetate).

A comparison between the shirt types in the worn and laundered category revealed the shirts in Group V as being inferior in both collar and cuff resistance and proved that those in Groups III, IV, and VI had the greatest degree of abrasion resistance on collars. Only shirts in Group III were accredited with the best resistance to cuff abrasion.

The findings further indicated that the experimental shirts which were constructed from 100 per cent triacetate warp knit were the weakest shirt type with respect to abrasion resistance. The stronger types were those constructed from the 50/50 cotton-polyester in the circular as well as in the interlock knit fabrics.

A comparison based on the stability of the wale count of the non-worn-laundered shirts revealed that the circular knit shirts of 50/50 cotton-polyester in Group III displayed the greatest degree of stability of the wale count during 25 periods of laundering. The all-cotton, interlock knit shirts in Group VII along with the shirts in Groups II, VI and P were ranked second. The greatest change in wale count was found in the all-triacetate warp knit shirts in Group V. Coursewise the non-worn-laundered warp knit shirts of 65/35 triacetate-polyester in Groups I and II and the 50/50 cotton-polyester shirts of Groups III and VI exhibited the least amount of change in course count, while the 50/50 cotton-polyester, circular knit shirts in Group IV displayed the greatest increase in the number of courses per inch during 25 periods of laundering.

The wale count of the shirts in Group VI which were worn and laundered were accredited with the least amount of change in the wale direction, while those in Group V displayed the greatest amount of change during 25 periods of wear and laundering.

The lowest level of change in the course direction after 25 periods of wear and laundering was found in the 65/35 triacetate-polyester, warp knit shirts in Groups I and II and in the 50/50 cotton-polyester, circular knit shirts in Group III. Shirts in Group V displayed the poorest performance in this respect.

Shrinkage occurred in all types of the experimental shirts (both worn and non-worn) after they were subjected to the number of laundering and wear and laundering cycles required by the study. Intercomparisons of the shirts on this basis showed that wear had a strong influence on the shrinkage of the shirts. These findings are consistent with those of previous studies conducted by Doyle, Fletcher, Grousberg, Munden, and Nutting (9, 12, 13, 26, 29, 30).

The greatest degree of walewise shrinkage in the non-worn-laundered shirts was found in the shirts of Group VII, whereas the lowest amount of shrinkage in the same direction was found in the shirts of Groups I and II. Coursewise the shirts of Group P displayed the least desirable performance with respect to dimensional stability, while shirts in Groups III and VII proved to be the most stable through 25 periods of laundering.

The warp knit shirts in Groups I and II (65/35 triacetate-polyester) performed significantly better with respect to their dimensional stability in the wale direction than did the remaining worn and laundered shirt types. The poorest stability during wear and laundering was demonstrated by the 100 per cent cotton shirts in Group VII.

A comparison of the coursewise shrinkage values of the worn and laundered shirts showed that the greatest degree of shrinkage was in the shirts of Groups V and P, while the lowest value was found in the shirts of Groups IV and VII.

With respect to bursting strength values of the experimental shirts, those in Group IV-A demonstrated the highest bursting strength value, initially. The bursting strength of the shirts, in most cases, increased to some extent as the number of laundering and wear and laundering periods increased, respectively. This phenomenon, perhaps, was due to an increase in the number of stitches on the surface of the specimens which shared the composite bursting force exerted perpendicularly on the surface area.

Comparisons of the bursting values of the shirt types on the basis previously mentioned revealed the greatest bursting value in the shirts of Groups III and IV-A, while the lowest value was found in the shirts of Group V.

In an effort to provide an overall summary of the findings of the study, the information in Summary II is provided. The rank order of each shirt type which resulted from statistical intercomparisons of the data for each respective type of evaluation is included therein. These ranks are based upon the number of times a particular shirt type displayed a superior performance to that of another when the overall values from the non-worn-laundered and the worn and laundered shirts were considered.

As can be noted from these data, the shirt types ranked in the following order with respect to their overall performance: Group III, 50/50 cotton-polyester, circular knit; Group IV-A, 50/50 cotton-polyester, circular knit; Group II, 65/35 triacetate-polyester, warp knit; Group I, 65/35 triacetate-polyester, warp knit; Group IV-B, 50/50 cotton-polyester, circular knit; Group VI, 50/50 cotton-polyester, interlock knit; Group P, 50/50 cotton-polyester, circular knit; Group VII, 100 per cent cotton, interlock knit; and Group V, 100 per cent triacetate, warp knit.

SUMMARY II

RANKING OF SHIRTS FOR EACH TYPE OF EVALUATION

Type of Evaluation		Shirt Types								
		Group I	Group II	Group III	Group IV-A	Group IV-B	Group V	Group VI	Group VII	Group P
Durable Press Smoothness		1	4	1	1	8	5	5	8	7
Seam Appearance		1	1	1	1	1	1	8	1	9
Color Retention		1	1	5	5	5	1	5	8	4
Collar Pilling		1	1	1	1	1	1	1	1	1
Wale Count		5	2	2	5	5	8	1	5	4
Course Count		1	1	1	5	5	8	4	5	5
Dimensional Stability	Wale Direction	1	1	4	3	4	6	6	9	6
	Course Direction	5	2	2	2	5	8	5	1	8
Abrasion Resistance	Collar	2	2	2	2	2	8	1	7	2
	Cuffs	6	6	1	2	2	8	2	5	2
Bursting Strength		6	8	1	1	3	9	3	7	3
Total		30	29	21	28	41	63	48	57	51
Overall Rank		4	3	1	2	5	9	6	8	7

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APPENDIX

TABLE I

MEAN DURABLE PRESS APPEARANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	4.8	5.0	5.0	5.0
II: 65/35 Triacetate-Polyester Warp Knit	4.9	4.8	4.7	5.0	4.8	5.0
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-B: 50/50 Cotton-Polyester Circular Knit	4.2	4.2	4.0	4.0	3.5	4.0
V: 100 Per Cent Triacetate Warp Knit	4.8	4.8	4.6	4.5	4.5	4.8
VI: 50/50 Cotton-Polyester Interlock Knit	4.5	4.6	5.0	4.9	5.0	5.0
VII: 100 Per Cent Cotton Interlock Knit	4.0	4.0	4.3	4.1	4.1	4.2
P: 50/50 Cotton-Polyester Circular Knit	4.3	4.1	4.0	3.9	3.8	3.8

TABLE II

MEAN DURABLE PRESS APPEARANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	4.9
II: 65/35 Triacetate-Polyester Warp Knit	4.9	4.9	4.9	5.0	5.0	4.9
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-B: 50/50 Cotton-Polyester Circular Knit	4.4	4.1	4.0	4.1	4.2	4.1
V: 100 Per Cent Triacetate Warp Knit	4.6	4.8	4.8	5.0	4.9	4.8
VI: 50/50 Cotton-Polyester Interlock Knit	5.0	4.9	4.9	4.9	4.9	4.8
VII: 100 Per Cent Cotton Interlock Knit	4.2	4.1	4.1	4.0	3.9	3.9
P: 50/50 Cotton-Polyester Circular Knit	4.4	4.1	3.9	4.4	4.5	3.9

TABLE III

AN ANALYSIS OF VARIANCE OF THE DURABLE PRESS APPEARANCE OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	6	27.43	4.57	49.13*
Within	199	18.52	0.09	-
Total	205	45.95	-	-
Worn-Laundered				
Between	6	65.80	10.97	169.48*
Within	446	28.86	0.06	-
Total	452	94.66	-	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	6	69.17	11.53	156.93*
Laundering Interval	1	1.28	1.28	17.44*
Interaction	6	0.68	0.11	1.54
Within	645	47.38	0.07	

*Significant at .001.

TABLE IV

MEAN SEAM APPEARANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	5.0
II: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	5.0
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.8	4.8	5.0
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.0	5.0	5.0
IV-B: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.0	4.0	4.0
V: 100 Per Cent Triacetate Warp Knit	5.0	5.0	5.0	5.0	5.0	5.0
VI: 50/50 Cotton-Polyester Interlock Knit	4.8	4.2	4.8	5.0	5.0	5.0
VII: 100 Per Cent Cotton Interlock Knit	4.0	4.0	5.0	5.0	5.0	5.0
P: 50/50 Cotton-Polyester Circular Knit	4.9	4.0	4.0	4.0	4.0	4.0

TABLE V

MEAN SEAM APPEARANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	5.0
II: 65/35 Triacetate Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	5.0
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-B: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
V: 100 Per Cent Triacetate Warp Knit	4.8	5.0	5.0	5.0	5.0	5.0
VI: 50/50 Cotton-Polyester Interlock Knit	3.7	4.1	4.2	4.9	4.9	5.0
VII: 100 Per Cent Cotton Interlock Knit	5.0	4.7	5.0	5.0	4.8	4.7
P: 50/50 Cotton-Polyester Circular Knit	4.6	4.1	4.1	4.0	4.2	4.1

TABLE VI

AN ANALYSIS OF VARIANCE OF THE SEAM APPEARANCE OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	5	11.64	2.33	10.64**
Within	170	37.18	0.22	-
Total	175	48.81	-	-
Worn-Laundered				
Between	3	28.36	9.45	68.18**
Within	281	38.96	0.14	-
Total	284	67.33	-	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	2	11.03	5.52	26.41**
Laundering Interval	1	1.56	1.56	7.46*
Interaction	2	2.62	1.31	6.29*
Within	321	67.04	0.21	

*Significant at .01.
**Significant at .001.

TABLE VII

MEAN COLOR RETENTION VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	5.0	5.0	4.5
II: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	4.5	*	*
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.5	*	*	*
IV: 50/50 Cotton-Polyester Circular Knit	5.0	4.25	4.5	4.0	3.5	3.5
V: 100 Per Cent Triacetate Warp Knit	5.0	5.0	5.0	5.0	5.0	4.5
VI: 50/50 Cotton-Polyester Interlock Knit	4.5	4.0	4.0	4.0	3.5	3.0
VII: 100 Per Cent Cotton Interlock Knit	4.5	4.2	4.1	3.6	3.4	3.5
P: 50/50 Cotton-Polyester Circular Knit	5.0	4.5	4.5	4.0	4.0	3.8

*No data.

TABLE VIII

MEAN COLOR RETENTION VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	5.0	4.4	4.1	3.8
II: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	4.9	4.9	4.2	4.2
III: 50/50 Cotton-Polyester Circular Knit	5.0	4.9	4.1	3.8	3.2	3.0
IV: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.6	4.2	3.6	3.5
V: 100 Per Cent Triacetate Warp Knit	5.0	5.0	4.6	4.5	4.5	4.1
VI: 50/50 Cotton-Polyester Interlock Knit	4.5	4.5	4.5	4.1	3.8	3.6
VII: 100 Per Cent Cotton Interlock Knit	4.5	4.2	3.9	3.5	3.4	3.3
P: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.5	4.4	4.3	3.8

TABLE IX

AN ANALYSIS OF VARIANCE OF THE COLOR RETENTION OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	7	27.35	3.91	28.86**
Within	169	22.88	0.14	-
Total	176	50.23	-	-
Worn-Laundered				
Between	7	35.84	5.12	16.41**
Within	375	117.00	0.31	-
Total	382	152.85	-	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	7	34.12	4.87	18.96**
Laundering Interval	1	6.37	6.37	24.79**
Interaction	7	7.57	1.08	4.21*
Within	544	139.88	0.26	-

*Significant at .01.
**Significant at .001.

TABLE X

MEAN NUMBER OF PILLS EVIDENT ON COLLARS OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	0	0	0	0	0	0
II: 65/35 Triacetate-Polyester Warp Knit	0	0	0	0	0	0
III: 50/50 Cotton-Polyester Circular Knit	0	0	0	0	0	0
IV-A: 50/50 Cotton-Polyester Circular Knit	0	0	0	0	0	0
IV-B: 50/50 Cotton-Polyester Circular Knit	0	0	0	0	0	0
V: 100 Per Cent Triacetate Warp Knit	0	0	0	0	0	0
VI: 50/50 Cotton-Polyester Interlock Knit	0.0	0.5	0.5	2.8	5.8	2.5
VII: 100 Per Cent Cotton Interlock Knit	0.0	0.0	0.0	7.3	9.8	0.5
P: 50/50 Cotton-Polyester Circular Knit	0	0	0	0	0	0

TABLE XI

MEAN NUMBER OF PILLS EVIDENT ON COLLARS OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	0.0	0.6	2.6	2.8	5.8	6.6
II: 65/35 Triacetage-Polyester Warp Knit	0.0	0.2	0.1	0.5	1.3	3.7
III: 50/50 Cotton-Polyester Circular Knit	0.0	2.1	12.3	31.7	37.6	54.4
IV-A: 50/50 Cotton-Polyester Circular Knit	0.0	5.1	18.8	30.5	44.1	62.8
IV-B: 50/50 Cotton-Polyester Circular Knit	0.0	11.3	13.0	23.0	44.0	86.5
V: 100 Per Cent Triacetate Warp Knit	0.0	0.0	0.2	1.5	0.1	1.5
VI: 50/50 Cotton-Polyester Interlock Knit	7.5	40.5	116.0	99.2	137.0	132.8
VII: 100 Per Cent Cotton-Interlock Knit	0.1	3.1	23.3	25.2	31.0	37.6
P: 50/50 Cotton-Polyester Circular Knit	0.0	4.2	0.9	0.9	6.0	6.4

TABLE XII

AN ANALYSIS OF VARIANCE OF THE COLLAR PILLING OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	1	14.45	14.45	1.04
Within	78	1079.75	13.84	-
Total	79	1094.20	-	-
Worn-Laundered				
Experimental Shirt Type	7	403361.59	57623.08	170.56**
Laundering Interval	5	110372.37	22074.47	65.34**
Interaction	35	151232.09	4320.92	12.79**
Within	525	177367.75	337.84	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	1	51018.63	51018.63	35.47**
Laundering Interval	1	132298.62	132298.62	91.98**
Interaction	1	53805.93	53805.93	37.41**
Within	219	314998.65	1438.35	-

**Significant at .001.

TABLE XIII

MEAN WALE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING (Per Inch)

Shirt Identification	Periods of Laundering						
	0	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	48.1	48.8	49.2	50.2	50.8	51.5	50.5
II: 65/35 Triacetate-Polyester Warp Knit	48.0	47.7	48.6	48.6	49.0	49.5	50.0
III: 50/50 Cotton-Polyester Circular Knit	24.2	24.3	24.0	24.0	24.1	24.0	24.5
IV-A: 50/50 Cotton-Polyester Circular Knit	24.0	24.3	24.6	24.5	25.0	25.0	25.0
IV-B: 50/50 Cotton Polyester Circular Knit	24.0	25.3	25.6	26.0	25.5	26.0	26.0
V: 100 Per Cent Triacetate Warp Knit	34.1	35.6	37.0	37.7	38.0	38.5	38.0
VI: 50/50 Cotton-Polyester Interlock Knit	37.8	38.1	38.8	38.6	38.6	38.0	38.5
VII: 100 Per Cent Cotton Interlock Knit	37.9	38.7	39.8	39.0	39.0	38.0	37.0
P: 50/50 Cotton-Polyester Circular Knit	27.9	27.9	28.6	28.6	28.7	28.5	29.5

TABLE XIV

MEAN PER CENT CHANGE IN WALE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	1.30	2.33	4.16	5.16	7.29	5.20
II: 65/35 Triacetate-Polyester Warp Knit	-0.50	0.80	-2.09	3.15	4.20	5.27
III: 50/50 Cotton-Polyester Circular Knit	0.50	0.80	-0.96	-0.58	-0.00	0.08
IV: 50/50 Cotton-Polyester Circular Knit	3.56	4.92	5.30	3.17	4.08	4.08
V: 100 Per Cent Triacetate Warp Knit	3.81	8.23	11.78	12.56	14.82	13.39
VI: 50/50 Cotton-Polyester Interlock Knit	0.90	2.39	1.64	1.74	0.68	1.32
VII: 100 Per Cent Cotton Interlock Knit	2.20	4.75	2.64	3.06	1.75	0.00
P: 50/50 Cotton-Polyester Circular Knit	0.60	2.69	3.00	3.60	3.64	7.27

TABLE XV

MEAN COURSE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING (Per Inch)

Shirt Identification	Periods of Wear-Laundering						
	0	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	38.1	38.4	38.5	38.7	38.2	38.5	38.0
II: 65/35 Triacetate-Polyester Warp Knit	38.6	38.8	38.7	38.5	39.0	38.0	38.0
III: 50/50 Cotton-Polyester Circular Knit	25.2	25.2	24.7	24.7	24.8	24.5	25.0
IV-A: 50/50 Cotton-Polyester Circular Knit	22.3	23.0	24.0	24.5	24.5	25.0	25.0
IV-B: 50/50 Cotton Polyester Circular Knit	30.3	31.6	32.3	32.0	32.0	34.0	34.0
V: 100 Per Cent Triacetate Warp Knit	42.0	42.5	43.5	44.0	44.7	45.5	45.5
VI: 50/50 Cotton-Polyester Interlock Knit	26.8	25.6	25.4	25.2	26.3	25.5	25.0
VII: 100 Per Cent Cotton Interlock Knit	28.3	28.8	30.7	30.7	30.6	28.6	28.5
P: 50/50 Cotton-Polyester Circular Knit	38.1	39.2	40.5	40.0	40.0	40.5	41.0

TABLE XVI

MEAN PER CENT CHANGE IN COURSE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	0.67	1.00	0.88	0.00	1.32	0.00
II: 65/35 Triacetate-Polyester Warp Knit	0.66	0.33	-0.44	0.00	0.00	0.00
III: 50/50 Cotton-Polyester Circular Knit	2.07	0.07	-0.46	0.69	0.08	0.00
IV: 50/50 Cotton-Polyester Circular Knit	3.70	7.03	8.65	8.65	9.18	4.84
V: 100 Per Cent Triacetate Warp Knit	1.13	3.59	5.31	7.16	8.30	7.50
VI: 50/50 Cotton-Polyester Interlock Knit	0.67	-0.38	-1.92	-0.69	-1.92	-3.84
VII: 100 Per Cent Cotton Interlock Knit	1.83	7.51	6.53	6.41	1.82	3.70
P: 50/50 Cotton-Polyester Circular Knit	2.95	6.24	4.81	4.59	6.58	7.89

TABLE XVII

MEAN WALE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

(Per Inch)

Shirt Identification	Periods of Wear-Laundering						
	0	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	47.2	47.9	48.5	49.5	50.0	49.8	50.2
II: 65/35 Triacetate-Polyester Warp Knit	47.5	47.7	48.2	48.7	48.9	49.1	49.5
III: 50/50 Cotton Polyester Circular Knit	23.8	24.2	24.0	24.0	24.4	24.5	25.1
IV-A: 50/50 Cotton-Polyester Circular Knit	24.6	25.0	25.1	24.8	25.3	25.0	26.2
IV-B: 50/50 Cotton-Polyester Circular Knit	23.5	25.0	24.8	25.2	25.8	25.2	26.0
V: 100 Per Cent Triacetate Warp Knit	33.6	35.0	35.0	35.8	36.5	37.0	37.6
VI: 50/50 Cotton-Polyester Interlock Knit	39.2	39.8	40.0	39.1	38.1	37.5	38.0
VII: 100 Per Cent Cotton Interlock Knit	37.2	37.7	39.4	39.2	40.3	39.1	39.5
P: 50/50 Cotton-Polyester Circular Knit	27.6	28.2	28.2	28.4	28.5	28.3	28.3

TABLE XVIII

MEAN PER CENT CHANGE IN WALE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	1.46	2.69	4.82	5.84	4.78	5.66
II: 65/35 Triacetate-Polyester Warp Knit	0.36	1.58	2.47	2.99	3.34	3.68
III: 50/50 Cotton-Polyester Circular Knit	1.45	0.72	0.72	2.46	2.78	4.86
IV: 50/50 Cotton-Polyester Circular Knit	3.27	3.28	2.99	5.38	5.04	7.42
V: 100 Per Cent Triacetate Warp Knit	4.21	5.98	6.83	8.68	9.44	11.38
VI: 50/50 Cotton-Polyester Interlock Knit	2.43	2.19	0.28	-2.68	-4.16	-2.90
VII: 100 Per Cent Cotton Interlock Knit	1.41	6.20	5.47	8.63	5.29	6.46
P: 50/50 Cotton-Polyester Circular Knit	2.43	2.43	3.05	3.33	2.73	2.74

TABLE XIX

MEAN COURSE COUNT OF EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING (Per Inch)

Shirt Identification	Periods of Wear-Laundering						
	0	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	38.0	38.8	38.4	38.9	39.4	39.7	39.9
II: 65/35 Triacetate-Polyester Warp Knit	39.1	39.5	39.8	39.6	39.6	40.3	40.8
III: 50/50 Cotton-Polyester Circular Knit	24.9	25.2	24.9	25.1	25.5	25.8	26.1
IV-A: 50/50 Cotton-Polyester Circular Knit	23.6	24.2	24.7	23.8	24.5	24.2	24.7
IV-B: 50/50 Cotton-Polyester Circular Knit	30.0	31.5	31.8	32.2	32.2	32.7	34.0
V: 100 Per Cent Triacetate Warp Knit	42.6	47.8	44.5	45.4	46.2	46.9	47.4
VI: 50/50 Cotton-Polyester Interlock Knit	27.4	27.4	26.5	26.3	26.6	26.1	25.5
VII: 100 Per Cent Cotton Interlock Knit	29.2	29.9	30.9	31.1	31.5	31.7	31.0
P: 50/50 Cotton-Polyester Circular Knit	38.0	39.5	39.9	40.2	40.1	40.0	41.0

TABLE XX

MEAN PER CENT CHANGE IN COURSE COUNT OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	1.09	0.46	1.76	3.28	3.73	4.59
II: 65/35 Triacetate-Polyester Warp Knit	0.86	1.51	1.08	1.08	3.01	4.25
III: 50/50 Cotton-Polyester Circular Knit	1.45	0.07	0.76	2.71	3.77	5.19
IV: 50/50 Cotton-Polyester Circular Knit	3.21	4.89	3.05	4.85	4.64	7.38
V: 100 Per Cent Triacetate Warp Knit	3.86	4.44	6.39	8.47	10.21	11.59
VI: 50/50 Cotton-Polyester Interlock Knit	0.69	-2.94	-3.69	-2.51	-4.44	-6.45
VII: 100 Per Cent Cotton Interlock Knit	2.38	5.71	6.57	7.98	8.49	6.44
P: 50/50 Cotton-Polyester Circular Knit	3.94	4.82	5.69	5.47	5.04	7.88

TABLE XXI

AN ANALYSIS OF VARIANCE OF THE PER CENT CHANGE IN WALE COUNT OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	7	1625.97	232.28	20.37**
Within	253	2885.49	11.41	-
Total	260	4511.46	-	-
Worn-Laundwred				
Experimental Shirt Type	7	483.53	483.53	36.08**
Laundering Interval	5	96.05	96.05	7.17**
Interaction	35	36.44	36.44	2.72**
Within	525	13.40	13.40	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	7	4063.58	580.51	40.70**
Laundering Interval	1	30.92	30.92	2.17
Interaction	7	495.34	70.76	4.96**
Within	818	11665.98	14.26	-

**Significant at .001.

TABLE XXII

AN ANALYSIS OF VARIANCE OF PER CENT CHANGE IN COURSE COUNT OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	7	1770.11	252.87	29.52**
Within	252	2158.71	8.57	-
Total	259	3928.82	-	-
Worn-Laundered				
Experimental Shirt Type	7	5628.18	804.03	52.16**
Laundering Interval	5	669.32	133.86	8.68**
Interaction	35	1267.37	36.21	2.35**
Within	525	8093.39	15.42	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	7	5160.72	737.24	49.52**
Laundering Interval	1	81.25	81.25	5.46*
Interaction	7	584.84	83.55	5.61*
Within	817	12164.18	14.89	-

*Significant at .05.
**Significant at .001.

TABLE XXIII

MEAN PER CENT DIMENSIONAL CHANGE IN THE WALE DIRECTION OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	0.00	-0.84	-1.14	-1.56	-1.88	-1.25
II: 65/35 Triacetate-Polyester Warp Knit	+0.10	-1.09	-1.14	-1.71	-2.81	-2.18
III: 50/50 Cotton-Polyester Circular Knit	-1.74	-3.12	-4.68	-5.94	-5.94	-5.00
IV-A: 50/50 Cotton-Polyester Circular Knit	-1.24	-2.70	-4.38	-4.38	-3.12	-3.74
IV-B: 50/50 Cotton-Polyester Circular Knit	-1.87	-3.32	-3.74	-4.06	-4.38	-3.74
V: 100 Per Cent Triacetate Warp Knit	-1.14	-4.48	-7.04	-7.50	-9.05	-9.05
VI: 50/50 Cotton-Polyester Interlock Knit	-3.39	-5.18	-3.98	-6.35	-6.09	-6.25
VII: 100 Per Cent Cotton Interlock Knit	-5.36	-6.87	-6.48	-8.02	-7.50	-6.54
P: 50/50 Cotton-Polyester Circular Knit	-2.73	-4.38	-5.21	-5.94	-7.50	-7.50

TABLE XXIV

MEAN PER CENT DIMENSIONAL CHANGE IN THE COURSE DIRECTION OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	-1.01	-2.89	-4.99	-6.56	-7.50	-8.34
II: 65/35 Triacetate-Polyester Warp Knit	-0.80	-2.65	-4.20	-5.31	-5.62	-6.55
III: 50/50 Cotton-Polyester Circular Knit	-1.62	-2.69	-3.53	-4.37	-4.37	-4.37
IV-A: 50/50 Cotton-Polyester Circular Knit	-2.50	-4.16	-5.31	-5.62	-5.62	-5.62
IV-B: 50/50 Cotton-Polyester Circular Knit	-2.50	-4.16	-5.63	-6.61	-6.24	-5.62
V: 100 Per Cent Triacetate Warp Knit	-1.56	-5.52	-6.59	-8.12	-9.07	-9.68
VI: 50/50 Cotton-Polyester Interlock Knit	-4.27	-5.55	-5.38	-4.99	-5.30*	-1.56
VII: 100 Per Cent Cotton Interlock Knit	-3.07	-3.75	-2.21	-2.39	-4.53	-6.25
P: 50/50 Cotton-Polyester Circular Knit	-4.09	-6.09	-7.09	-7.96	-7.82	-8.74

*Shirts with high shrinkage values were pulled at this point for testing.

TABLE XXV

MEAN PER CENT DIMENSIONAL CHANGE IN THE WALE DIRECTION OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	-0.19	-1.14	-2.39	-2.96	-2.60	-3.43
II: 65/35 Triacetate-Polyester Warp Knit	-0.36	-1.24	-2.18	-2.24	-2.80	-2.90
III: 50/50 Cotton-Polyester Circular Knit	-1.76	-3.12	-4.05	-4.89	-4.53	-5.51
IV-A: 50/50 Cotton-Polyester Circular Knit	-1.16	-2.18	-3.35	-3.90	-3.52	-4.25
IV-B: 50/50 Cotton-Polyester Circular Knit	-2.34	-3.74	-4.99	-5.78	-5.31	-5.78
V: 100 Per Cent Triacetate Warp Knit	-2.13	-3.95	-5.57	-7.1	-7.15	-9.02
VI: 50/50 Cotton-Polyester Interlock Knit	-4.11	-5.67	-6.30	-6.19	-6.48	-6.65
VII: 100 Per Cent Cotton Interlock Knit	-5.20	-8.12	-7.49	-8.17	-9.29	-9.01
P: 50/50 Cotton-Polyester Circular Knit	-3.38	-5.30	-5.93	-6.14	-5.88	-5.96

TABLE XXVI

MEAN PER CENT DIMENSIONAL CHANGE IN THE COURSE DIRECTION OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	-0.73	-3.17	-5.15	-6.61	-7.08	-7.50
II: 65/35 Triacetate-Polyester Warp Knit	-0.72	-2.65	-4.32	-5.31	-5.20	-6.00
III: 50/50 Cotton-Polyester Circular Knit	-1.92	-3.43	-3.90	-5.00	-4.89	-5.15
IV-A: 50/50 Cotton-Polyester Circular Knit	-1.71	-2.89	-3.72	-4.68	-4.37	-4.68
IV-B: 50/50 Cotton-Polyester Circular Knit	-3.43	-5.37	-6.40	-6.71	-6.25	-6.56
V: 100 Per Cent Triacetate Warp Knit	-2.70	-5.25	-6.92	-8.22	-8.75	-9.30
VI: 50/50 Cotton-Polyester Interlock Knit	-5.20	-5.52	-5.51	-4.26	-3.67	-4.77
VII: 100 Per Cent Cotton Interlock Knit	-2.31	-2.81	-2.60	-1.64	-1.32	-1.67
P: 50/50 Cotton-Polyester Circular Knit	-5.20	-6.92	-7.39	-8.02	-7.03	-7.50

TABLE XXVII

AN ANALYSIS OF VARIANCE OF THE PER CENT DIMENSIONAL CHANGE IN THE WALE DIRECTION OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	8	931.65	116.46	38.88**
Within	253	757.75	3.00	-
Total	261	1689.39	-	-
Worn-Laundered				
Experimental Shirt Type	8	1725.62	215.70	136.11**
Laundering Interval	5	663.34	132.67	83.71**
Interaction	40	124.26	3.11	1.96**
Within	519	822.51	1.58	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	8	1942.79	242.85	79.95**
Laundering Interval	1	90.15	90.15	29.68**
Interaction	8	32.54	4.07	1.34
Within	817	2481.69	3.04	-

**Significant at .001.

TABLE XXVIII

AN ANALYSIS OF VARIANCE OF THE PER CENT DIMENSIONAL CHANGE IN THE COURSE DIRECTION OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	8	328.77	41.10	10.05***
Within	253	1034.86	4.09	-
Total	261	1363.63	-	-
Worn-Laundered				
Experimental Shirt Type	8	1134.26	141.78	63.21***
Laundering Interval	5	613.06	122.61	54.66***
Interaction	40	477.40	11.94	5.32***
Within	519	1164.18	2.24	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	8	916.12	114.51	26.64***
Laundering Interval	1	24.18	24.18	5.63*
Interaction	8	99.12	12.39	2.88**
Within	817	3511.78	4.30	-

*Significant at .05.
**Significant at .01.
***Significant at .001.

TABLE XXIX

MEAN COLLAR ABRASION RESISTANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	4.0	3.3	2.0	2.0
II: 65/35 Triacetate-Polyester Warp Knit	5.0	5.0	4.0	3.0	2.0	2.0
III: 50/50 Cotton-Polyester Circular Knit	5.0	4.9	4.5	3.3	3.0	2.5
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.5	3.0	3.0
IV-B: 50/50 Cotton-Polyester Circular Knit	5.0	4.7	4.0	3.0*	4.0	4.0
V: 100 Per Cent Triacetate Warp Knit	4.5	4.3	3.0	2.2	2.0	1.5
VI: 50/50 Cotton-Polyester Interlock Knit	5.0	4.7	4.5	4.0	4.0	4.0
VII: 100 Per Cent Cotton Interlock Knit	5.0	3.8	3.4	2.3	2.0	2.0
P: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.7	3.0	3.0	2.0

*A badly abraded shirt was withdrawn at this point; values thereafter were higher.

TABLE XXX

MEAN CUFF ABRASION RESISTANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	5.0	4.8	4.0	3.2	2.0	2.0
II: 65/35 Triacetate-Polyester Warp Knit	5.0	4.8	4.2	3.3	2.5	2.0
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	4.5
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
IV-B: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	5.0	5.0	5.0
V: 100 Per Cent Triacetate Warp Knit	4.8	4.5	3.2	1.8	1.5	1.5
VI: 50/50 Cotton-Polyester Interlock Knit	5.0	4.0	4.0	4.0	4.0	4.0
VII: 100 Per Cent Cotton Interlock Knit	5.0	5.0	4.1	3.8*	4.0	4.0
P: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.5	4.0	3.5

*A badly abraded shirt was withdrawn at this point. The values thereafter were higher.

TABLE XXXI

MEAN COLLAR ABRASION RESISTANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	4.9	4.3	3.9	3.6	3.4	2.3
II: 65/35 Triacetate-Polyester Warp Knit	5.0	4.7	4.0	3.7	3.2	2.1
III: 50/50 Cotton-Polyester Circular Knit	5.0	4.7	4.4	3.9	3.4	2.7
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.2	4.0	3.9	3.0
IV-B: 50/50 Cotton-Polyester Circular Knit	4.9	4.2	4.2	3.5	3.0	2.2
V: 100 Per Cent Triacetate Warp Knit	4.9	4.0	3.1	2.8	1.6	1.0
VI: 50/50 Cotton-Polyester Interlock Knit	4.0	4.0	4.0	4.0	4.0	4.0
VII: 100 Per Cent Cotton Interlock Knit	4.9	4.9	3.8	2.7	2.1	1.8
P: 50/50 Cotton-Polyester Circular Knit	5.0	4.6	4.2	3.7	2.9	2.1

TABLE XXXII

MEAN CUFF ABRASION RESISTANCE VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering					
	1	5	10	15	20	25
I: 65/35 Triacetate-Polyester Warp Knit	4.9	4.8	4.1	3.5	2.8	1.8
II: 65/35 Triacetate-Polyester Warp Knit	4.9	4.6	3.8	3.3	2.4	1.6
III: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.7	4.5	4.3
IV-A: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	5.0	4.2	4.1	3.9
IV-B: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.8	4.0	4.0	4.0
V: 100 Per Cent Triacetate Warp Knit	5.0	4.4	3.3	2.5	1.0	1.0
VI: 50/50 Cotton-Polyester Interlock Knit	5.0	5.0	4.4	4.4	4.4	4.0
VII: 100 Per Cent Cotton Interlock Knit	5.0	5.0	4.0	3.9	2.6	2.2
P: 50/50 Cotton-Polyester Circular Knit	5.0	5.0	4.8	4.3	4.0	3.1

TABLE XXXIII

AN ANALYSIS OF VARIANCE OF THE COLLAR ABRASION RESISTANCE OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	8	36.16	4.52	4.46**
Within	252	255.41	1.01	-
Total	260	291.57	-	-
Worn-Laundered				
Experimental Shirt Type	7	74.19	10.60	42.38**
Laundering Interval	5	417.49	83.50	333.88**
Interaction	35	90.50	2.59	10.34**
Within	525	131.30	0.25	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	7	89.99	12.86	11.78**
Laundering Interval	1	28.04	28.04	25.69**
Interaction	7	1.60	0.23	0.21
Within	818	892.82	1.09	-

**Significant at .001.

TABLE XXXIV

AN ANALYSIS OF VARIANCE OF THE CUFF ABRASION RESISTANCE OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Between	7	50.34	7.19	10.22**
Within	212	149.18	0.70	-
Total	219	199.53	-	-
Worn-Laundered				
Experimental Shirt Type	7	215.00	30.71	162.74**
Laundering Interval	5	376.10	75.22	398.56**
Interaction	35	118.74	3.39	17.96**
Within	525	99.08	0.19	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	7	151.71	21.67	22.81**
Laundering Interval	1	20.81	20.81	21.90**
Interaction	7	15.52	2.22	2.33*
Within	777	738.28	0.95	-

*Significant at .05.
**Significant at .001.

TABLE XXXV

MEAN BURSTING STRENGTH VALUES OF THE EXPERIMENTAL SHIRTS AFTER DESIGNATED PERIODS OF LAUNDERING

Shirt Identification	Periods of Laundering			
	0	5	15	25
I: 65/35 Triacetate-Polyester Warp Knit	52.7	58.8	70.1	74.4
II: 65/35 Triacetate Polyester Warp Knit	47.2	57.6	59.2	62.6
III: 50/50 Cotton-Polyester Circular Knit	89.3	89.7	93.3	91.2
IV-A: 50/50 Cotton-Polyester Circular Knit	90.4	92.7	90.9	92.2
IV-B: 50/50 Cotton-Polyester Circular Knit	69.8	73.2	72.4	76.4
V: 100 Per Cent Triacetate Warp Knit	42.1	43.2	48.4	48.4
VI: 50/50 Cotton-Polyester Interlock Knit	70.4	70.9	74.7	72.5
VII: 100 Per Cent Cotton Interlock Knit	63.0	70.9	66.6	65.4
P: 50/50 Cotton-Polyester Circular Knit	71.4	76.8	76.0	75.3

TABLE XXXVI

MEAN BURSTING STRENGTH VALUES OF THE EXPERIMENTAL SHIRTS INITIALLY AND AFTER 25 PERIODS OF WEAR AND LAUNDERING

Shirt Identification	Periods of Wear-Laundering	
	0	25
I: 65/35 Triacetate-Polyester Warp Knit	52.7	64.4
II: 65/35 Triacetate Polyester Warp Knit	47.2	58.8
III: 50/50 Cotton-Polyester Circular Knit	89.3	89.1
IV-A: 50/50 Cotton-Polyester Circular Knit	90.4	88.0
IV-B: 50/50 Cotton-Polyester Circular Knit	69.8	72.6
V: 100 Per Cent Triacetate Warp Knit	42.1	44.8
VI: 50/50 Cotton-Polyester Interlock Knit	70.4	73.2
VII: 100 Per Cent Cotton Interlock Knit	63.0	51.1
P: 50/50 Cotton-Polyester Circular Knit	71.4	72.1

TABLE XXXVII

AN ANALYSIS OF VARIANCE OF THE BURSTING STRENGTH OF THE EXPERIMENTAL SHIRTS

Source of Variation	df	SS	MS	F-Value
Non-Worn-Laundered				
Experimental Shirt Type	8	112295.82	14036.98	532.45**
Laundering Interval	3	4101.77	1367.26	51.86**
Interaction	24	4911.74	204.66	7.76**
Within	594	15649.72	26.36	-
Worn-Laundered				
Between	8	167073.94	20884.24	435.49**
Within	931	44646.37	47.96	-
Total	939	211720.31	-	-
Comparison of Non-Worn and Worn				
Experimental Shirt Type	8	83932.74	10491.59	235.52**
Laundering Interval	1	1837.36	1837.36	41.25**
Interaction	8	816.58	102.07	2.29*
Within	1082	48198.92	44.55	-

*Significant at .05.
**Significant at .001.