THE "IN-USE" PERFORMANCE OF DURABLE PRESS SHEETS CONSTRUCTED OF ALL-COTTON AND OF COTTON POLYESTER BLENDS

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BY

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We hereby recommend that the dissertation prepared under our supervision by CHOUNG-HIE (JANICE) KIM entitled THE "IN-USE" PERFORMANCE OF DURABLE PRESS SHEETS CONSTRUCTED OF ALL-COTTON AND OF COTTON-POLYESTER BLENDS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I N T R O D U C T I O N

The introduction of the durable press concept into the textile industry constitutes one of the most explosive developments during the past two decades. The research and development leading up to the production of the early durable press finishes has involved the introduction of new reactants, new catalysts, new additives, new finishing techniques, and new fabric design into the textile industry.

In the late 1950's, when interest in wash-and-wear fabrics was on the increase, permanent pleated fabrics were introduced, from which the concept of the durable press finish was derived. At the 1956 Chemical Finishing Conference the durable press finishing process was presented by Reid, Mazzeno, Reinhardt, and Markezich (13) of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture. From this point on, the work of many laboratories converged upon the problem, with the result that great strides have been made in this field of endeavor.

The problem described in this dissertation is concerned with the "in use" study of durable press bed sheets

composed of cotton and polyester blends in comparison with sheets composed of all-cotton given a durable press finish, and all-cotton sheets not given the durable press finish.

The specific objectives of the study were the following:

1. To purchase Type 180 durable press bed sheets composed (a) of a 50% cotton and 50% polyester blend, and (b) of a 100% cotton;

2. To purchase all-cotton sheets without a durable press finish, Type 180, and with construction comparable to the durable press sheets described above;

3. To distribute the experimental sheets to the Texas Woman's University students in textiles for use as a bottom sheet only;

4. To launder the sheets after a certain period of use, generally five to seven nights, in a Whirlpool home washer, Model 1967, at a temperature of 140^{o} F. $\pm$ 2^{o} F.;

5. To apply the laundered sheets to two methods of drying, namely, tumble and line drying;

6. To measure the effects of wear and laundering upon the experimental sheets with reference to

the following laboratory tests at specified intervals of use and laundering:

a) Wash-and-wear evaluations by two methods--Cranston side light, and fluorescent overhead light;

b) Whiteness--before and after every fifth laundering;

c) Crease recovery--dry and wet;

d) Strength tests--Breaking strength--dry and wet,
Tearing strength--dry and wet,
Flat abrasion.

HISTORICAL REVIEW

Many different processes are used to produce permanent press properties in textile fabrics at the present time. All of them, however, can be classified under two basic categories: (a) the post-cured and (b) the pre-cured groups.

The fundamental principle of post-curing was presented for the first time in the report of Reid, Mazzeno, Reinhardt, and Markezich (13), to which reference has been made in the Introduction to this report.

The following is taken from Marsh (10) in an article on The Permanent Press Finish. In the first edition of An Introduction to Textile Finishing by this same author, published in 1947, it is stated that "resistance to and recovery from creasing are only examples of a decreased response to forces which tend to change the form of the treated material." The passage notes that if goods are creased, pleated, embossed or otherwise distorted before the final heating stage of the process, then the methods previously outlined are capable of producing permanent creases or a crease-restoring effect.

"Permanent effects of this type have been produced commercially by the well-known Everglaze process, and its many variations, and more recently, on machines of the Rabofsky type.

"The manufacture of garments from permanently creased materials presents certain practical difficulties, and when the production of permanently creased garments is envisaged, it is necessary to consider a modification of the usual technique.

"The first of the methods to be explored in the new field of the permanent press finish is the apparently simple technology of garment treatment. This generally involves impregnation of the garment in a solution of chemical reagent and catalyst, followed by centrifuging to remove excess liquor. The damp garments are then pressed into shape by ironing or pressing, and are finally cured in a hot-air oven or cabinet. The best results involve subsequent washing and drying during which excess reagents are removed and the catalyst neutralized, but this step interferes with the pristine appearance of the garment; it is also rather costly. Other objections are the odours of formaldehyde which can prove unpleasant during the pressing operation.

"These and similar methods were first suggested in 1957 in the publications of Reid et al. (13), and by Graham

et al. (8). There also were some patent specifications for the treatment of garments, e. g. USP 2,917,412; 2,950,553; 3,025,662, and 3,096,524.

"Several gaseous treatments have also been examined for the finishing of manufactured garments, and usually depend on the use of formaldehyde and a volatile acid catalyst as described by Gonzales and Guthrie (7) and by Reid and his colleagues (13). In general, however, the treatment of manufactured garments does not appear to be considered practical on a large commercial scale, although excellent demonstration samples have been produced.

"Treatment of cotton in the form of piece-goods is much more attractive than the treatment of garments, and the setting of creases in the treated goods by a local breakdown of the cross-links under the influence of an acid catalyst and heat has been suggested. Thus, after the manufacture of the garment from crease-resisting cotton, a solution of an acidic or potentially acidic catalyst is applied to the appropriate area by wetting or spraying; the creases are heat-pressed and cured, when the acid catalyst breaks the cross-links in the flat-treated fabric, but they are reformed in the crease of the garment on heating. Sometimes a small amount of cross-linking reagent may be added to the re-curing solution.

"Buck and Getchell of the National Cotton Council have described this type of re-cure in USP 2,957,746 and a somewhat similar method is due to the work of Reid, Reinhardt and Kullman (14)."

In 1964, Koret of California was issued the first patent for post-curing of durable press fabrics.

Fiber modification is another approach to durable press, which can be classified as a post-cured process. This method involves the treatment of fabrics with a symmetrical sulfone and an alkali. After treatment, the fabrics are dried, neutralized, rinsed, and then again treated with an alkaline catalyst together with any other desirable finishing agent. The fabric is dried for a second time with care being taken to prevent additional curing.

Tesoro and Pensa (16) in 1964, through a study of the process employing sulfones, showed that the method was applicable in principle to any fabric or yarn of appreciable cellulosic content for any type of permanent deformation. They reported several advantages of this over other processes. Such advantages were said to include complete storage stability of the fabric, lack of odor during the final heating step, and requirement of a brief heating cycle.

Several other methods for setting cotton which are applicable to the post-cured process of permanent press have

been suggested. Pensa, Tesoro, Rau, and Egrie (11) in 1966 studied two-stage curing in the cross-linking of cellulosic fabric. The purpose of this study was to define a partly reacted chemical system where the reagent present had been reacted with cellulose without sufficient polymerization to form a stable intermediate capable of further reaction under suitable conditions. The study showed that this process has several desirable features, including flexibility in the choice of reagent and additives, ease of control, good storage stability of the fabric, short heating cycles for the setting of garments, and excellent performance of the set garment.

During the early stages of permanent press technology interest was focused exclusively upon the post-cured process as applied to medium and heavyweight fabrics used in the manufacture of men's and boy's casual slacks. With the extension of permanent press into men's dress shirts, children's wear, and blouses and skirts for women, research interest has been directed toward the lighter-weight fabrics, and as a result the pre-cured type of finish has evolved as the most desirable type for fabrics in this weight category.

Tewksbury and Kidda (17) reported in 1965 that the best results come from the pre-curing process when fabrics are subjected to temperatures of 450° F. to 525° F. at

pressures of 600 to 900 pounds per square inch. Tewksbury also proved that no chemical setting or finishing agent is required in the process of elevated temperatures and mechanical pressure and demonstrated that durable creases could be produced both in untreated cellulosic fabrics, and in fabrics which had been treated with permanent press finishes. The effectiveness of the crease setting was dependent on an optimum pressure-time-temperature relationship.

The textile literature is increasing remarkably in the field of durable press research during the past few years. Thus Blanchard et al. (3) have published in 1967 on the substantial improvement in abrasion resistance, wrinkle-recovery performance, and other properties of all-cotton durable press fabrics if first they are impregnated with urethane latex before the application of a cross-linking resin.

Reeves (12) has reported in 1968 on Some New Techniques in Cotton Finishing, with three techniques described which improve abrasion resistance. These include the following:

(a) Proper selection of fabric;

(b) Use of polymers which coat the surface of the fibers in combination with cross-linking agents; and

(c) Use of monomers which penetrate the fiber and polymerize prior to or simultaneously with the formation of cross-links between cellulose molecules.

Schrum and Queen (15) have discussed polyethylene converted into an emulsion to serve as a softener for durable press fabrics.

Getchell of the National Cotton Council, collaborating with Hallies and Oliva of Harris Research Laboratories (6) have developed a method for imparting durable press to cottons in which finishing resins have been deposited inside the wet, swollen cotton fibers.

Gagliardi and Jutras (9) have described a wet-processing technique for cotton which involves the vapor phase grafting of this fiber with acrylic monomers, chlorosilanes, perfluoroacrylates, and ethylene oxide as a means of improving various properties of permanent press cotton.

Welch et al. (19) have described the formation of cross-linked films of dimethyl silicone on a variety of cotton fabrics. These studies have shown that DMDMEU applied in conjunction with the cross-linked silicone, in the absence of added metal salt catalysts, imparts an unexpected degree of crease-retention as well as high wrinkle resistance.

Walsh and Rutherford (18) have described the use of ionizing radiation as a delayed step in a durable press process. The radiation curing system is based on the addition of an unsaturated or polymerizing side group to the cellulose chain which cross-links cellulose on exposure to ionizing radiation.

Various research projects have been undertaken in the Cotton Utilization and Finishing Laboratories of Texas Woman's University related primarily to the "in use" performance of fabrics with durable press finishes during wear and laundering. Hearne and Broome (9) compared the performance of permanent press and regular wash-and-wear finishes as applied to fabrics of cotton and polyester blends. Eighteen pairs of trousers were constructed from each of the two types of experimental fabrics used in the study. Nine pairs of trousers of each type were worn by junior high school girls and laundered in an automatic home washer at 140° F. after each eight-hour wear period. Experimental garments, both worn and non-worn, were evaluated for appearance after each laundering; whereas strength tests were performed on the non-worn garments at intervals of five launderings.

The findings of this study showed that the permanent press trousers exhibited appearance values superior to those given the wash-and-wear finish, particularly in performance,

crease retention, and seam smoothness. The wash-and-wear slacks showed more better strength qualities in most instances.

A study similar in nature to that described above is nearing completion at the present time in the Cotton Utilization and Finishing Laboratories of Texas Woman's University. Broome and Roch (4) are evaluating the in-use performance of boys' permanent press trousers representing a variety of fiber combinations and brands. Sixty-four of the 121 pairs of experimental trousers are being worn for eight-hour periods by third-grade boys. After each period of wear, the garments are laundered in a home washer at 140° F., tumble dried, and evaluated.

A study involving men's casual slacks is just being inaugurated in these laboratories, with several of the newer finishes represented in these garments.

Also at the present time an extensive study of five fabrics with major durable press finishes, with oil-borne and water-borne soil applied to certain areas, and with major stain types are being laundered at different drying methods. The finishes on these fabrics also include anti-soiling agents impregnated with the durable press finishing reagents.

PLAN OF PROCEDURE

DESCRIPTION OF EXPERIMENTAL SHEETS

A total of 200 flat white sheets, of Type 180 and composed of a blend of 50/50 cotton-polyester and of 100 per cent cotton, served as the experimental textiles in this study. The majority of these sheets (160) were finished with a durable press finish and were equally divided with reference to number between the blends and the 100 per cent cotton. The remainder of the sheets (40) were untreated and of 100 per cent cotton.

The experimental sheets were categorized and coded according to their fiber content and finishing treatment. The letters A and B represented two respective brands of durable press sheets composed of a blend of 50/50 cotton polyester, while C and D represented two brands of 100 per cent cotton with a durable press finish. All-cotton sheets without the durable press finish were designated by the letter E.

The sheets used in this study were purchased on the Dallas and Fort Worth retail market in sizes to fit twin and double beds. They were used as bottom sheets only, for

from five to seven nights, on the dormitory beds of students enrolled at Texas Woman's University and majoring in textiles and related areas.

The following data are related to the five types of sheets:

Sheets	Brand	Fiber Content	Yarn Count	
			Warp	Filling
Durable Press				
A	Sears	Cotton- 50% Fortrel-50%	95.3	86.9
B	Springmaid	Cotton —50% Kodel —50%	99.7	75.4
C	Fieldcrest	Cotton-100%	96.0	85.5
D	Springmaid	Cotton-100%	101.1	78.1
Untreated				
E	Lady Pepperell	Cotton-100%	100.2	80.0

METHOD OF LAUNDERING EXPERIMENTAL SHEETS

Washing Procedure

Two of each of the five types of experimental sheets were reserved for initial testing purposes and the remaining

38 were numbered from one through 38 and subjected to a series of 35 periods of use followed by laundering. The sheets were laundered in six-pound wash loads in a 1967 model R.C.A. Whirlpool washer which provided a durable-press wash cycle and a selection of agitator and spin speeds. The experimental sheets were laundered at 140° F. ± 2° F., and rinsed at 80° F. During the process the washer was set for high agitation and low spin speeds.

For the first five laundering periods water softened by means of the Zeolite treatment was used with one-fourth cup of Tide as the detergent for each wash load. For the remaining 30 laundering periods ordinary tap water and three-fourths cup of Tide were used per load.

At the conclusion of the laundering cycle the experimental sheets were removed immediately from the washer and subjected to one of two drying procedures designed for the study.

Drying Procedure

Nineteen sheets of each of the respective types (numbers one through 19) were line dried inside the textile laboratory. To prevent the sheets from touching the floor during drying approximately one-sixth of the width of each sheet was placed over the line and fastened in this position with straight pins.

The experimental sheets which were assigned numbers from 20 through 38 were subjected to tumble drying in six-pound loads. For this procedure a 1967 model R.C.A. Whirlpool dryer set on the durable press cycle was used. Care was taken to remove the sheets from the dryer immediately after drying to prevent wrinkling.

WASH-AND-WEAR EVALUATION

The experimental sheets were evaluated with reference to their wash-and-wear appearance before and after each of the 35 consecutive laundering periods by a panel composed of two textile technologists. All ratings were made without any consultation on the part of the evaluators.

Two methods representative of the conditions under which the sheets were viewed during use were employed for these evaluations. One of these procedures involved the use of the Cranston sidelighting device and the Monsanto three-dimensional replicas as described in AATCC Tentative Test Method 88A-1964T (1a). For these evaluations the experimental sheets were folded in half lengthwise. On each side of the fold the three areas which were subjected to the greatest degree of wear by the shoulders, hips, and feet were evaluated making a total of six evaluations for each sheet per panel member.

The second method used in evaluating the wash-and-wear appearance of the sheets was conducted with each experimental sheet draped over a bed in the textile laboratory. The surface of the sheet being evaluated was illuminated by means of a fluorescent light suspended over the bed and shining on the surface to be evaluated from an overhead distance of approximately 20 inches. A comparison between the overall appearance of the sheet and the Monsanto three-dimensional replicas was made by each evaluator who stood at the foot of the bed during the procedure.

The appearance of the experimental sheets was evaluated before and after each laundering period following the two procedures described above as a means of determining the effects of use and laundering, respectively, upon the resistance of the sheets to wrinkling. An average of the ratings given each sheet by the two evaluators served as the rating for a particular sheet in each instance.

REFLECTANCE MEASUREMENT

The whiteness of the experimental sheets was measured by means of the Hunterlab Model D-40 Reflectometer for Whiteness in accordance with the general procedure outlined in Tentative Test Method: AATCC 110-1964T (1b). Five areas of each sheet, those which were subjected to the greatest

wear, were evaluated before and after one, five, 10, 15, 20, 25, 30, and 35 laundering periods.

The whiteness of each respective sheet was calculated according to the following empirical formula:

$$\text{Whiteness} = 4\,B - 3\,G$$

WRINKLE RECOVERY

The experimental sheets were evaluated with reference to their ability to recover from wrinkles by means of the Monsanto Wrinkle Recovery Tester after each fifth period of laundering throughout the study.

Six wet and six dry test specimens measuring 1.5 centimeters by 4.0 centimeters were tested for both the warp and the filling directions according to the test procedure described in ASTM Designation D: 1295-67 (2b). In preparation for testing the dry specimens were preconditioned while the wet specimens were immersed in distilled water for two hours. Both types of specimens were tested in a relative humidity of 65 $\pm$ 2% and at a temperature of 70° F. $\pm$ 2° F.

An average of the six evaluations in each yarn direction was reported as the angle of recovery for a particular fabric at each period of evaluation.

STRENGTH TESTS OF EXPERIMENTAL SHEETS

The effects of wear and laundering upon the experimental sheets were determined by means of breaking, tearing, and flat abrasion tests conducted initially and after five, 10, 15, 20, 25, 30, and 35 periods of use and laundering.

At each testing period two sheets from each drying method were withdrawn from the study for the purpose of providing the required test specimens. The specimens were taken from the approximate areas of the sheets as shown in Figures I and II.

Breaking Strength

The wet and dry breaking strength determinations were made on two experimental sheets at each period of testing by the procedure described in ASTM Designation D: 1682-64 for the Raveled Strip Method (2d).

Two sets of specimens 12 inches long and 1.25 inches wide were prepared from each sheet with the long dimensions parallel to the direction of testing warpwise and fillingwise. Each of the specimens was cut into two six-inch lengths and raveled to one inch in width for both wet and dry testing. The Alfred Suter Yarn Counter was used in these measurements for accuracy.

Before testing, the specimens to be evaluated in the dry state were placed under standard conditions for at least six hours and those for the wet tests were immersed in distilled water for a minimum of two hours. The breaking strength in pounds per 100 yarns was calculated as follows:

$$\text{Breaking Strength per 100 Yarns} = \frac{\text{Average Breaking Strength}}{\text{Yarn Count}} \times 100$$

Tearing Strength

The tear resistance tests were made by using the Elmendorf Tear Tester with an NBS Augmenting Weight. The procedure as given in ASTM Designation: D 1424-63 (2c) was used as a guide.

Ten specimens from the warp and filling directions, respectively, measuring two inches in width and eight inches in length were cut with the longer dimension parallel to the testing direction of the sheets. The specimens were raveled to a width of 1.65 inches and divided into two four-inch lengths, thus providing 10 wet and 10 dry specimens for each testing period.

The tearing strength evaluations were determined under conditions described for the breaking strength tests, and data were calculated as force in grams required to tear 100 yarns in accordance with the following formula:

$$\text{Tearing Strength per 100 yarns} = \frac{2\ (\text{Average Tearing Strength} \times 32)}{\text{Yarn Count} \times 1.69} \times 100$$

Flat Abrasion

The Rotary Platform, Double Head Abraser was utilized for the determination of the resistance of the experimental sheets to flat abrasion, and the procedure outlined in ASTM Designation: D 1175-64T (2a) was followed.

Six test specimens seven inches square were cut from certain areas of the sheets which were considered relatively worn as shown in Figures 1 and 2. Care was taken in cutting the specimens so that each was representative of a different set of warp and filling yarns.

In preparation for testing the specimens were placed under standard conditions for the required length of time. The six specimens from each sheet were divided into three groups which provided two specimens for each of the three CS-10 abrasive wheels used in the study. Each specimen was abraded 100 cycles under 500 grams of pressure. After every 600 cycles of use the abrasive wheels were resurfaced for 25 revolutions with carborundum-coated paper.

The per cent loss of breaking strength due to flat abrasion was determined from two raveled-strip breaking strength specimens, one-half inch in width, taken from both

the warp and filling directions of each abraded square. The breaking strength values were determined by placing the path of abrasion on each specimen midway between the jaws of the Scott Tester which were adjusted one inch apart.

The per cent loss in breaking strength due to flat abrasion was determined by the following formula:

$$\text{Per Cent Loss in Breaking Strength Due to Flat Abrasion} = \frac{A-B}{A} \times 100$$

Where:

A = breaking strength before abrasion, and

B = breaking strength after abrasion

YARN COUNTS

The yarn counts which were used as the basis for determining the resistance of the experimental sheets to breaking, tearing, and flat abrasion were obtained by following the procedure described in ASTM Designation: D 1910-64 (2e) which incorporated the use of the Alfred Suter Pick Counter. The counts were taken initially and after each fifth laundering period by placing the experimental fabrics on a flat surface without tension and counting the number of yarns in one inch in five different places warpwise and fillingwise.

No counts were made outside of the area of the sheet which was subjected to wear during use. An average of the number of yarns per inch was reported separately for each yarn direction.

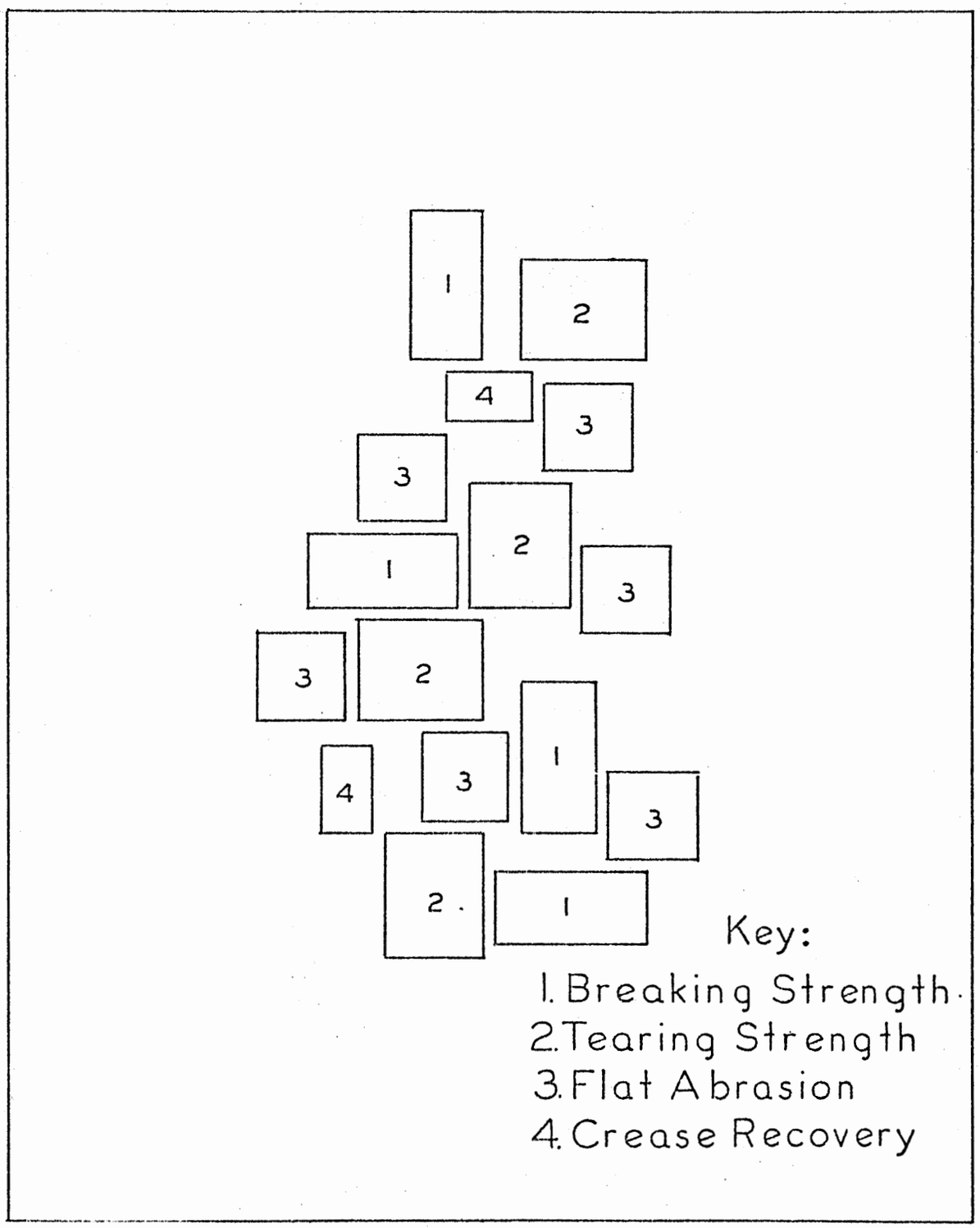

FIGURE 1

DIAGRAM SHOWING THE APPROXIMATE AREA OF THE TWIN-BED SHEETS FROM WHICH TEST SPECIMENS WERE TAKEN AT EACH DESIGNATED PERIOD OF EVALUATION

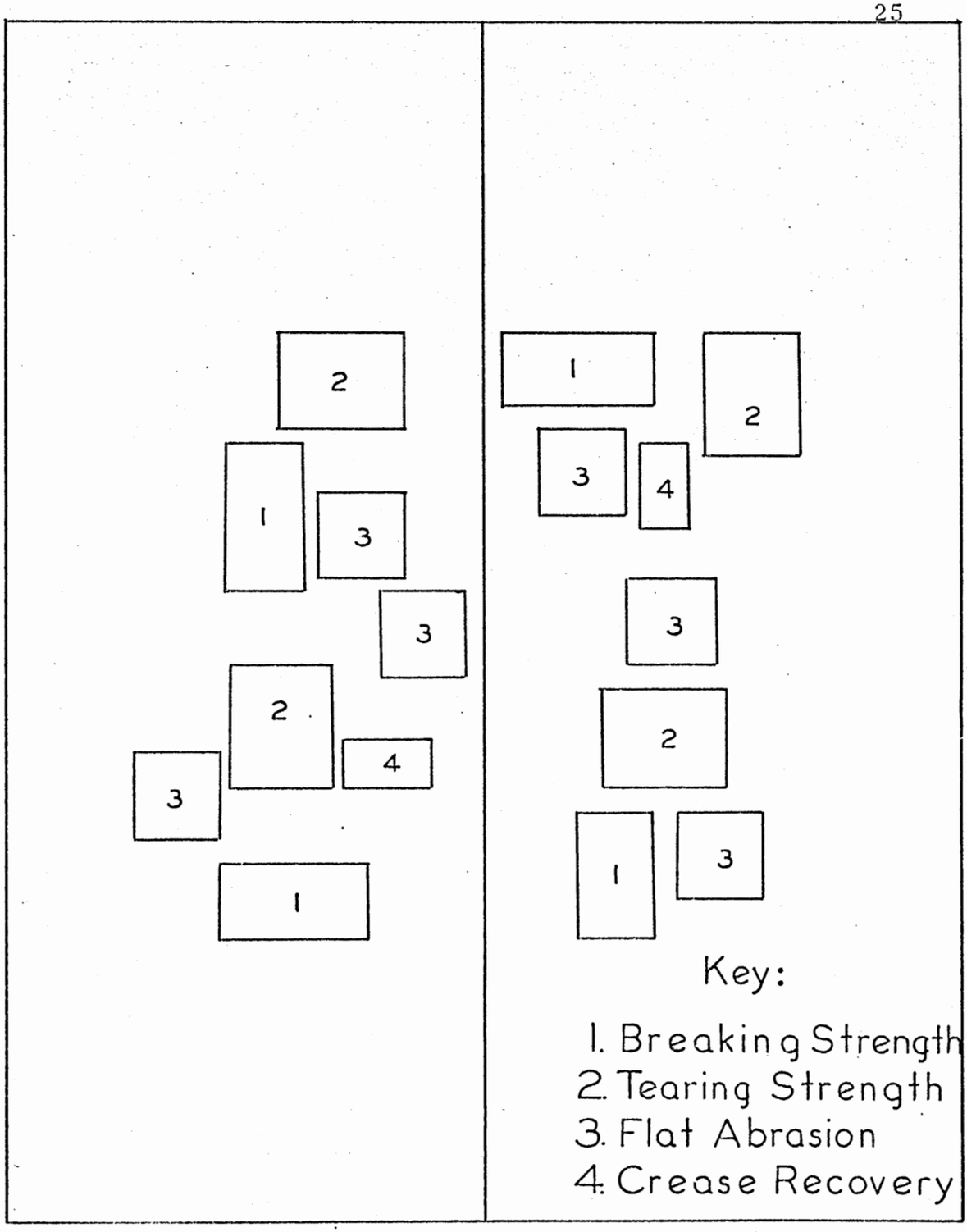

FIGURE 2

DIAGRAM SHOWING THE APPROXIMATE AREA OF THE DOUBLE-BED SHEETS FROM WHICH TEST SPECIMENS WERE TAKEN AT EACH DESIGNATED PERIOD OF EVALUATION

PRESENTATION OF DATA

WITH DISCUSSION

WASH-AND-WEAR RATINGS

Tables I and III give the results of the examination of the sheets before and after laundering, with drying by the line and tumble drying methods, respectively, when evaluated on the bed under fluorescent lighting for wash-and-wear results. The data were taken before and after laundering in each case, and are summarized as follows (Summary A):

Summary A

Ratings of Sheets for Wash-and-Wear Evaluated on the Bed under Fluorescent Light

	Before Laundering	After Laundering
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	4.2	4.0
Sheets C and D . . . . . (all-cotton, durable press finish)	3.4	3.6
Sheet E. . . . . (no durable press finish)	2.6	3.1
Mean Rating. . .	3.4	$3.5\frac{2}{3}$
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	4.3	3.9
Sheets C and D . . . . . (all-cotton, durable press finish)	3.2	2.5
Sheet E. . . . . (no durable press finish)	2.1	1.6
Mean Rating. . .	3.2	$2.6\frac{2}{3}$

Tables II and IV give comparable data for the wash-and-wear appearance of the sheets when they were evaluated by a side lighting device. An outline of these data are given in Summary B.

Summary B

Ratings of Sheets Evaluated by Side Lighting

	Before Laundering	After Laundering
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	4.2	4.0
Sheets C and D . . . . . (all-cotton, durable press finish)	3.2	3.2
Sheet E. . . . . (no durable press finish)	2.5	2.9
Mean Rating. . .	3.3	$3.3\frac{2}{3}$
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	4.2	4.0
Sheets C and D . . . . . (all-cotton, durable press finish)	2.9	2.5
Sheet E. . . . . (no durable press finish)	2.1	1.7
Mean Rating. . .	$3.0\frac{2}{3}$	$2.7\frac{1}{3}$

From the data in the cited tables as summarized above, it is seen that the following rank order is established for wash-and-wear according to the fiber content of the sheets:

Rank

(1) Cotton-polyester blends with a durable press finish

(2) All-cotton sheets with a durable press finish

The all-cotton sheet not given a durable press finish was surpassed markedly by the cotton sheets with the durable press treatment.

From a statistical analysis of the data, the sheets made of cotton and polyester blends and line dried had higher wash-and-wear ratings before laundering than after laundering, with the differences statistically significant regardless of the lighting method used in the evaluation. The ratings also were higher before than after laundering for the tumble dried cotton-polyester blends, although the differences were not statistically significant.

The 100 per cent cotton sheets with the durable press finish which had been tumble dried were greatly superior before than after laundering, regardless of the lighting method used during evaluation ($P<0.001$ in both evaluations).

The cotton sheets with no durable press tended to be somewhat higher in wash-and-wear ratings after laundering when they were line dried and distinctly higher before

laundering when they were tumble dried. When the sheets were viewed on the bed with fluorescent light, the difference was highly significant in behalf of the "before laundering" sheets ($P<0.001$). The same level of significance was found when the side lighting device was used.

The rank order according to fiber content, and presence or absence of a durable press finish was the same when it was established by statistical comparisons, as that shown above in connection with Summaries A and B.

For the cotton-polyester blends, there were no statistically significant differences in the wash-and-wear ratings whether the sheets were line dried or tumble dried, regardless of whether the evaluations were made before or after laundering.

Before laundering, the all-cotton sheets with the durable press finish which had been line dried were superior to those which had been tumble dried by a highly significant difference both before and after laundering, when the evaluation was made on the bed under a fluorescent light ($P<0.001$ in both cases). When the evaluations were made with side lighting, however, the differences were not so distinctive.

With the 100 per cent cotton sheet which had not been given a durable press finish, line drying was highly

superior to tumble drying in the maintenance of the wash-and-wear ratings. Both before and after laundering, the line dried sheets surpassed those which were tumble dried by a difference which was highly significant ($P<0.001$).

DRY WRINKLE RECOVERY ANGLES

Table V includes the data concerning the test for dry wrinkle recovery angles of experimental sheets in the warp direction after line drying. Similar data are given for the filling direction of the sheets in Table VI. The tests were made for these two tables by the vertical strip method.

The data from these tables are brought together in Summary C.

Summary C

Dry Wrinkle Recovery Angles as Measured by the Vertical Strip Method

LINE DRYING	Warp Direction	Filling Direction
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	136	136
Sheets C and D . . . . . (all-cotton, durable press finish)	103	101
Sheet E. . . . . (no durable press finish)	79	86
Mean Rating. . . .	106	107⅔
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	142	140
Sheets C and D . . . . . (all-cotton, durable press finish)	115	112
Sheet E.	88	92
Mean Rating. . . .	115	114⅔

There were no statistically significant differences between the line dried and tumble dried fabrics, regardless of fiber content or presence or absence of a durable press finish, with respect to dry wrinkle recovery angles as measured by the vertical strip method.

When the sheets were arranged in rank order as to the means of the dry wrinkle recovery angles between pairs of the sheets in the warp and filling directions, according to the statistical comparisons based on fiber content, the rank order was the same as that given in Summary C above, whether they were line dried or tumble dried.

The line dried cotton blends surpassed the durable pressed all-cotton fabrics by a difference which was highly significant ($P<0.001$). The cotton blends exceeded the all-cotton non-durable press sheets; and the all-cotton durable press sheets were higher in dry wrinkle recovery angle by similar probabilities both for line and tumble dried sheets.

WET WRINKLE RECOVERY ANGLES

Tables VII and VIII present the data for the results of the test for the wet wrinkle recovery angles for the line dried and the tumble dried sheets, respectfully, in the warp and filling directions of the fabrics. The tests were made for these two tables by the vertical strip method.

The data from these tables are given in Summary D, as follows:

Summary D

Wet Wrinkle Recovery Angles as Measured by the Vertical Strip Method

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	133	136
Sheets C and D . . . . . (all-cotton, durable press finish)	103	102
Sheet E. . . . . (no durable press finish)	89	94
Mean Rating. . . .	$108\frac{1}{3}$	$110\frac{2}{3}$
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	134	134
Sheets C and D . . . . . (all-cotton, durable press finish)	101	104
Sheet E. . . . . (no durable press finish)	93	94
Mean Rating. . . .	$109\frac{1}{3}$	$110\frac{2}{3}$

As in the case of the dry wrinkle recovery angles, there were no statistically significant differences between the line dried and the tumble dried sheets in the wet wrinkle recovery angles.

When the pairs of types of sheets were compared statistically, the rank order was the same for the wet

recovery angles as were given for means in Summary D above. The cotton-polyester blends surpassed the all-cotton sheets with the durable press finish by a difference which was highly significant ($P<0.001$). The blends also surpassed the all-cotton sheets with no permanent press finish by the same level of probability. The same was found for the difference in this factor between the permanently pressed all-cotton and the all-cotton without a permanent press finish, in both directions of the fabric following both methods of drying.

WHITENESS RETENTION OF SHEETS

Whiteness ratings, exclusive of fluorescence, are given for line dried sheets in Table IX and for tumble dried sheets in Table X. Each of the tables shows the results before and after laundering. The data from these two tables are brought together in Summary E, which follows.

Summary E

Whiteness Retention of Line Dried and Tumble Dried Sheets Before and After Laundering

	Before Laundering	After Laundering
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	56.6	60.0
Sheets C and D . . . . . (all-cotton, durable press finish)	65.2	69.0
Sheet E. . . . . (no durable press finish)	65.3	65.5
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	52.3	57.0
Sheets C and D . . . . . (all-cotton, durable press finish)	60.8	65.8
Sheet E. . . . . (no durable press finish)	61.7	59.0

There were no statistically significant differences between the whiteness status of the line dried or the tumble dried sheets by virtue of their having been laundered or just taken off the beds non-laundered. Nor were there any differences in whiteness before laundering and after laundering in the cotton-polyester blends, in the all-cotton durable press sheets, or in the all-cotton sheets non-durable pressed.

When the line dried durable pressed sheets were compared with the 100 per cent cotton line dried sheets with the durable press finish before laundering, the all-cotton sheets surpassed those made of cotton-polyester blends in whiteness status by a highly significant difference ($P<0.001$). The same was found for the tumble dried all-cotton sheets and the blends.

The all-cotton permanently pressed sheets exceeded the cotton-polyester permanently pressed blends in whiteness before and after laundering, although the difference was not statistically significant.

There was only a small difference, not significant, between the whiteness rating of the all-cotton line dried durable pressed sheets and the all-cotton sheets which had not been given the permanent press treatment.

The permanent pressed all-cotton sheets which had been dried throughout by tumble drying surpassed the cotton-polyester blends before drying by a difference which was statistically significant ($P<0.02$), although the difference had a lower probability of significance than did the sheets which had been line dried throughout.

For sheets which had been tumble dried throughout, the all-cotton permanently pressed sheets surpassed the cotton-polyester blends in whiteness, although the difference

was not statistically significant. The cotton permanent pressed sheets and the cotton sheets without a durable press finish were not significantly different from each other in whiteness before laundering.

After laundering and drying by the tumble dry technique, the all-cotton sheets surpassed the cotton-polyester blends in whiteness ($P<0.01$). The 100 per cent cotton sheet (untreated) was not significantly different from the cotton-polyester blends in whiteness retention after laundering and tumble drying.

The 100 per cent cotton sheets which had received the durable press treatment exceeded the non-treated all-cotton sheets in whiteness after laundering and tumble drying, although the difference was not statistically significant.

DRY BREAKING STRENGTH OF SHEETS

Tables XI and XII, Parts A and B, present the data on dry breaking strength of the sheets in the two directions of the fabric. The data of these two tables on line drying and on tumble drying, respectively, are brought together in Summary F, which follows. The data are in terms of pounds per 100 yarns.

Summary F

Dry Breaking Strength in the Two Directions of the Sheets After Laundering and Drying by the Line and Tumble Drying Methods

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	47.8	48.4
Sheets C and D . . . . . (all-cotton, durable press finish)	42.4	37.8
Sheet E. . . . . (no durable press finish)	41.2	45.0
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	46.4	47.5
Sheets C and D . . . . . (all-cotton, durable press finish)	34.8	29.5
Sheet E. . . . . (no durable press finish)	37.2	46.2

The 100 per cent cotton sheets gave slightly higher breaking strength values in the warp direction in the line dried group ($P<0.05$). This was true also of the untreated all-cotton sheets ($P<0.05$).

The cotton-polyester blends surpassed the all-cotton durable press sheets in dry breaking strength in the warp direction after line drying ($P<0.01$). The blends also were

higher in tensile or breaking strength in the filling direction than the all-cotton durable press treated sheets also after line drying. There were no statistically significant differences after line drying in the warp direction between the cotton-polyester blends and the all-cotton untreated fabrics, or between the durable press treated and non-treated fabrics.

In the filling direction, the cotton-polyester blends surpassed the all-cotton durable press sheets in dry breaking strength after line drying, by a highly significant difference ($P<0.001$).

The 100 per cent cotton sheets which had been given a durable press treatment also surpassed the non-treated cotton sheets in dry breaking strength after line drying, again by a highly significant difference ($P<0.001$).

There was no statistically significant difference in dry tensile strength between the cotton-polyester blends and the all-cotton sheets which had not had a durable press finish.

After tumble drying, the dry tensile strength differed somewhat from the results following line drying. The cotton-polyester blends exceeded the all-cotton durable press finished sheets in the warp direction again by a highly significant difference.

The cotton-polyester blends, however, surpassed the all-cotton durable pressed fabrics by a slightly significant difference ($P<0.10$), contrary to the fact that there was no significant difference between these two groups of fabrics in the warp direction after line drying.

In the filling direction, the cotton-polyester blends surpassed the all-cotton sheets in dry breaking strength by a highly significant difference following tumble drying. The same probability of difference was found between 100 per cent cotton with a durable press finish and the untreated all-cotton sheets ($P<0.001$). In this case, no significant difference in breaking strength was found between the cotton-polyester blends and the all-cotton non-durable press treated sheets.

WET BREAKING STRENGTH OF SHEETS

Tables XIII and XIV include the values in the two directions of the fabric on wet breaking strength. The first table gives the wet strength results of the line dried series and the second the results of the tumble dried series.

The overall data from these two tables are shown in Summary G. The results are in terms of pounds per 100 yarns.

Summary G

Wet Breaking Strength in the Two Directions of the Sheets After Laundering and Drying by the Line and Tumble Drying Methods

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B (cotton-polyester blends, durable press finish)	50.8	50.6
Sheets C and D (all-cotton, durable press finish)	48.7	41.8
Sheet E. (no durable press finish)	50.0	54.4
TUMBLE DRYING		
Sheets A and B (cotton-polyester blends, durable press finish)	49.8	48.4
Sheets C and D (all-cotton, durable press finish)	39.8	33.1
Sheet E. (no durable press finish)	41.6	55.8

There were no statistically significant differences between the two drying methods on the wet tensile strength of the cotton-polyester blends in either direction of the fabric, or on the untreated cotton sheets. With respect to the all-cotton sheets with the durable press finish, however, the wet strength of the fabric in the warp direction of the sheets which had been line dried surpassed that of

the fabric which had been tumble dried by a difference which was distinctly significant ($P<0.02$). In the filling direction, the line dried sheets surpassed the tumble dried sheets in wet tensile strength also by a statistically significant difference ($P<0.05$).

There were differences in the wet tensile strength values of the sheets according to fiber content in comparison with the dry strength values. No statistically significant difference was found in the warp direction between the cotton-polyester blends and the all-cotton durable press sheets. The 100 per cent cotton sheets without the durable press finish, however, exceeded the cotton-polyester blends in warp wet breaking strength ($P<0.02$). The untreated cotton sheets also surpassed the cotton durable press finished sheets by a statistically significant difference ($P<0.01$).

In the filling direction, the cotton-polyester blends surpassed the all-cotton sheets which were durable press finished by a highly significant difference ($P<0.001$). On the other hand, the 100 per cent non-durable press sheets surpassed both the cotton-polyester sheets and the durable press finished cotton sheets in wet tensile strength by the same level of significance ($P<0.001$).

DRY TEARING STRENGTH OF SHEETS

The data on dry tearing strength of the sheets are given in Tables XV and XVI. The first of the two tables includes the results of the line drying method, and the second of the tumble drying technique. The data are recorded in grams per hundred yarns.

The means of the dry tearing strength values in the two directions of the sheets are given in Summary H, which follows:

Summary H

Dry Tearing Strength in the Two Directions of the Sheets after Laundering and Drying by the Line and Tumble Drying Methods

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	988	1120
Sheets C and D . . . . . (all-cotton, durable press finish)	688	569
Sheet E. . . . . (no durable press finish)	897	825
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	1026	1182
Sheets C and D . . . . . (all-cotton, durable press finish)	584	445
Sheet E. . . . . (no durable press finish)	637	597

Dry tearing strength values were not significantly different whether the sheets were dried by the line or tumble drying methods. This was the case for all three types of fabrics as to fiber content, and for both directions of the fabric.

Comparisons of the pairs of fabrics on the basis of fiber content placed the sheets in the same rank order as that shown in the Summary above.

The cotton-polyester blends surpassed the 100 per cent cotton with the durable press finish by a difference which is statistically significant, whether the warp or filling is concerned, regardless of which drying method has been employed ($P<0.001$ in all cases).

The cotton-polyester blends also surpassed the untreated cotton sheets in dry tearing strength by the same level of probability of significance ($P<0.001$).

The untreated cotton, on the other hand, exceeded the cotton with the durable press finish in the warp and in the filling directions following line drying ($P<0.001$ in both cases).

Following tumble drying, the sheets of all-cotton exceeded the durable press cotton sheets in dry tearing

strength in the warp direction ($P<0.01$), and in the filling direction ($P<0.001$).

WET TEARING STRENGTH OF SHEETS

Tables XVII and XVIII contain the data on wet tearing strength of the sheets in the study. The first of the tables is based on sheets which were line dried and the second on those which were tumble dried. The values are in terms of grams per 100 yarns.

Summary I brings together the overall averages of the wet tearing strength values of the sheets in the two directions of the fabric, after the two respective methods of drying.

Summary I

Wet Tearing Strength in the Two Directions of the Sheets After Laundering and Drying by the Line and Tumble Drying Methods

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B (cotton-polyester blends, durable press finish)	982	1007
Sheets C and D (all-cotton, durable press finish)	824	776
Sheet E. (no durable press finish)	987	926
TUMBLE DRYING		
Sheets A and B (cotton-polyester blends, durable press finish)	1033	1074
Sheets C and D (all-cotton, durable press finish)	710	516
Sheet E. (no durable press finish)	1021	1087

No statistically significant differences were found in the wet tearing strength in the warp or in the filling between the effects of line drying and tumble drying on the cotton-polyester blends, or on the 100 per cent cotton with no durable press finish. Line drying gave somewhat superior results in wet tearing strength on the 100 per cent durable finish treated cotton in comparison with tumble drying ($P<0.05$ both for the warp and the filling).

The rank order of the sheet fabrics on the basis of fiber content for wet tearing strength as established by statistical comparisons was the same as that shown in the mean values given in Summary I. The cotton-polyester blends ranked first in wet tearing strength in both directions of the fabric, whether the sheets had been line dried or tumble dried. The 100 per cent untreated cotton ranked second, and the durable press treated cotton ranked third in both directions of the fabric following both drying methods.

After line drying, both in the warp and the filling directions, the cotton-polyester blends surpassed the all-cotton durable press finished fabrics ($P<0.001$). The same difference was found between the blends and the 100 per cent non-treated cotton sheets. In addition, the durable press cotton sheets which had been line dried were exceeded by the untreated cotton sheets by the same probability of significance.

The same general results were found for wet tearing strength following tumble drying.

PER CENT CHANGE IN DRY BREAKING STRENGTH FOLLOWING FLAT ABRASION

Tables XIX and XX include the data on changes in dry breaking strength values which followed the flat abrasion test. Summary J brings the data together in terms of per cent change in dry breaking strength following line and tumble drying in the two directions of the fabric for the three major types of fabric.

Summary J

Per Cent Change in Dry Breaking Strength During the Flat Abrasion Test

	Warp Direction	Filling Direction
LINE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	-14.0%	-19.4%
Sheets C and D . . . . . (all-cotton, durable press finish)	-26.5	-41.2
Sheet E. . . . . (no durable press finish)	-25.2	-33.3
TUMBLE DRYING		
Sheets A and B . . . . . (cotton-polyester blends, durable press finish)	-13.4	-26.8
Sheets C and D . . . . . (all-cotton, durable press finish)	-24.8	-37.8
Sheet E. . . . . (no durable press finish)	-29.6	-29.0

There was no statistically significant difference between line drying and tumble drying with respect to the dry breaking strength subsequent to the flat abrasion test.

In the warp direction, the per cent change in dry breaking strength of fabrics which had been line dried was least in the cotton-polyester blends, and greatest in the all-cotton durable press sheets.

In the filling direction of the line dried sheets, the cotton-polyester blends again showed the least loss in dry breaking strength as a result of flat abrasion, with the all-cotton durable press treated sheets showing the greatest loss.

The sheets which had been tumble dried showed the same rank order of performance of dry tensile strength following flat abrasion as did those which had been line dried.

S U M M A R Y

This report covers an "in use" study of five major types of sheets which were placed on dormitory beds of university students majoring in textiles. The sheets served only as under sheets in the interest of uniformity. They were kept on the beds for one week, after which they were laundered in a home washing machine in the textile laboratory, with the "use" and weekly laundering continued for 35 weeks.

There were five types of sheets in the study, namely--two kinds of cotton-polyester blends (50/50 per cent each), two kinds of all-cotton sheets with durable press finishes, and one type of cotton which had not been given a durable press finish. There was a total of 200 sheets in the study.

The sheets were laundered at 140°F., with one group dried by the method of line drying and one group by machine tumble drying. The factors for which tests were made included the following: (a) wash-and-wear by two methods; (b) dry wrinkle recovery; (c) wet wrinkle recovery; (d) whiteness; (e) dry breaking or tensile strength; (f) wet tensile strength; (g) dry tearing strength; (h) wet tearing

strength; and (i) dry tensile strength following flat abrasion.

The effects (a) of laundering and (b) of drying by two methods were studied.

WASH-AND-WEAR RESULTS

Comparison of Wash-and-Wear Ratings on All-Cotton Untreated Sheets According to the Drying Method

For all-cotton sheets which had not been given a durable press finish, which were line dried and evaluated on the bed under fluorescent light, the wash-and-wear ratings were higher after laundering and drying than before. The same was found when they were evaluated by means of the side lighting device. When the sheets were tumble dried, they had higher wash-and-wear ratings when they were evaluated before laundering, again no matter which lighting method was used in the testing.

In short, line drying enhanced the wash-and-wear ratings, while tumble drying reduced the results of the evaluations.

When the results of the drying methods were tested statistically, the wash-and-wear results obtained from the line dried sheets surpassed those of the tumble dried sheets

for the all-cotton non-durable press finish by highly significant differences, no matter whether the evaluations were made before or after laundering, or regardless of which lighting method was employed during the test.

Comparison of Wash-and-Wear Ratings on All-Cotton Durable Press Finished Sheets According to the Drying Method

For all-cotton sheets with the durable press finish, the same wash-and-wear results in general were obtained as for the all-cotton untreated sheets, whether the comparisons were made before or after laundering and drying.

Comparison of Cotton-Polyester Blends According to the Drying Method

When comparisons were made between line and tumble dried sheets made of cotton-polyester blends, somewhat different results were obtained. When the sheets were evaluated on the bed under fluorescent light, the line dried sheets were higher in wash-and-wear evaluations before laundering by differences which were statistically significant. There were no statistically significant differences, however, between the evaluations made before and after laundering when tumble dried sheets were compared.

Also, when the line dried and the tumble dried sheets were compared with each other, there were no statistically significant differences between the sheets of the

two types whether they were evaluated before or after laundering and drying, regardless of the lighting method used.

Comparison of Wash-and-Wear Ratings of the Three Types of Sheets

According to a statistical comparison of the three types of sheets in the study, the following rank order was obtained for wash-and-wear appearance before laundering and line drying, when evaluations were made on the bed under fluorescent light:

Rank 1. Cotton-polyester blends
Rank 2. All-cotton with a durable press finish
Rank 3. All-cotton untreated

Under all other conditions of drying or of evaluation, the same rank order was obtained except in one case. When the sheets were evaluated on the bed under fluorescent light, the line dried sheets after laundering gave this rank order:

Rank 1. Cotton-polyester blends
All-cotton durable pressed
Rank 3. All-cotton untreated

See Figure 3 for a graphic representation of wash-and wear results for all types of sheets before and after laundering.

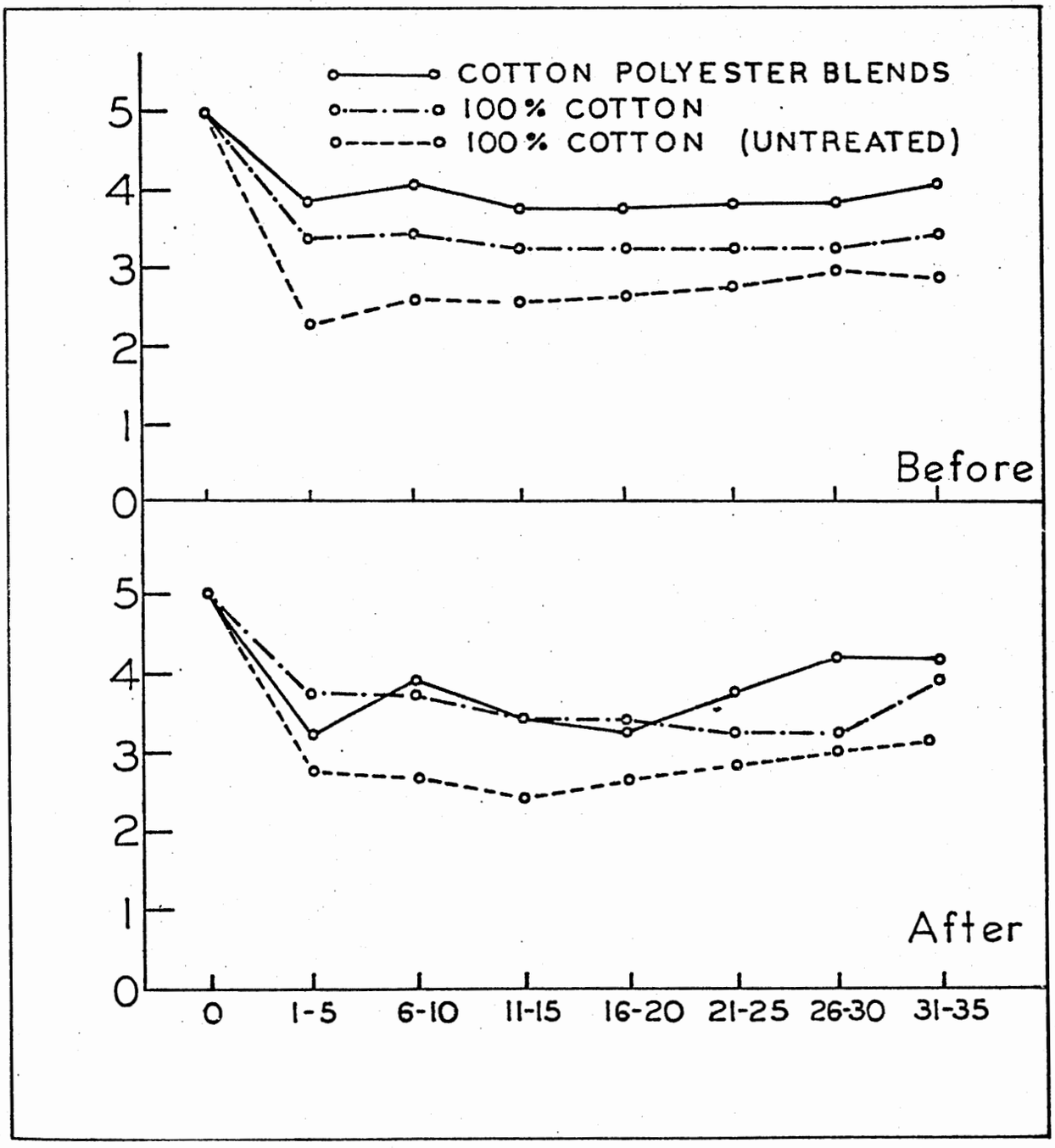

FIGURE 3. WASH AND WEAR RATINGS BEFORE AND AFTER LAUNDERING AND DRYING BY THE LINE METHOD, WITH THE RESULTS EVALUATED ON THE BED UNDER FLUORESCENT LIGHT

Comparison of Wrinkle Recovery Results

There were no statistically significant results in the dry wrinkle recovery tests made on any of the types of sheets, whether they were line dried or tumble dried. The same was found for wet wrinkle recovery results.

Whether the tests were made in the warp or filling direction of the fabric, or whether the sheets had been line or tumble dried, the following rank order was established statistically for the three types of sheets for this test:

Rank 1. Cotton-polyester blends

Rank 2. All-cotton durable press finished sheets

Rank 3. All-cotton untreated sheets

Comparison of Whiteness Measurements

For each separate type of sheet, there were no statistically significant differences in whiteness whether the measurements were made before or after laundering, or whether the sheets had been line dried or tumble dried.

When comparisons were made between pairs of the types of sheets, on the other hand, all-cotton sheets markedly outclassed the cotton-polyester blends. When

comparisons were made between the sheets of the line dried series before laundering, the 100 per cent cotton sheets which had been durable press finished surpassed the cotton-polyester blends by a highly significant difference ($P<0.01$). There was no significant difference, on the other hand, between the two types of all-cotton sheets in whiteness status.

After laundering, the line dried all-cotton durable press finished sheets again surpassed the blends by a difference which was highly significant ($P<0.001$), with the two groups of all-cotton sheets again not significantly different from each other in this respect.

Of the tumble dried series of sheets, those which were tested before laundering and drying gave these results. The all-cotton durable press treated sheets surpassed the cotton-polyester blends significantly, but not by as wide a margin as that found in the line dried series ($P<0.02$). Again the two types of all-cotton sheets did not differ significantly from each other in whiteness ratings.

After laundering, the difference in whiteness between the all-cotton durable pressed and the cotton-polyester blends was highly significant in behalf of the all-cotton ($P<0.01$), with no significant difference between the two types of all-cotton sheets in whiteness.

Comparison of Dry Breaking Strength Values

In comparing the tensile strength values of the different types of sheets of the line and tumble dried series, it was found that there were no statistically significant differences in the cotton-polyester blends in either direction of the fabric between the sheets which were line dried and those which were tumble dried. Of the all-cotton durable press finished and the untreated cotton sheets, however, the breaking strength in the warp direction of the fabric was significantly higher in the line dried sheets ($P<0.05$ in both instances). The line dried sheets also were higher in the filling direction, but the differences between the line and tumble dried in this instance were not significant.

After line drying, the rank order of dry breaking strength of the three types of sheets in both directions of the fabric was the following:

Rank 1. Cotton-polyester blends

Rank 2. 100 per cent cotton with no durable press finish

Rank 3. 100 per cent cotton with a durable press finish.

After tumble drying, the rank order for the three types of sheets was the same.

See Figure 4 for a drawing which shows the comparison between dry breaking strength of the different types of sheets following line and tumble drying.

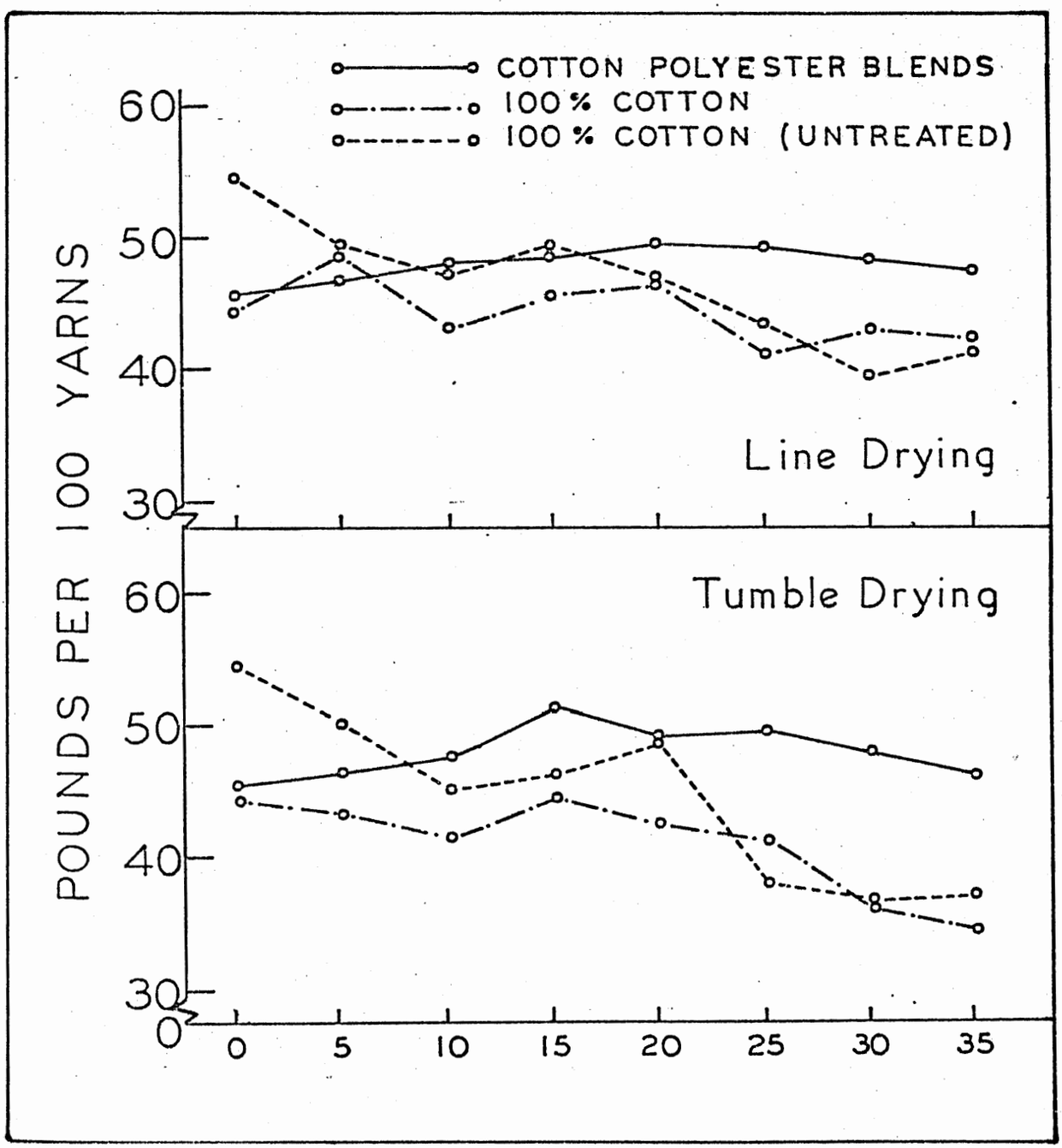

FIGURE 4. COMPARISON OF DRY BREAKING STRENGTH AFTER LINE DRYING (ABOVE) AND AFTER TUMBLE DRYING (BELOW)

Comparison of Wet Breaking Strength Values

In wet breaking strength, the line dried all-cotton durable press finished sheets surpassed the tumble dried sheets in the warp direction of the fabric ($P<0.02$), and in the filling direction ($P<0.05$).

The rank order of line dried sheets with respect to wet breaking strength of the warp differed from that of dry breaking strength as shown in the following:

Rank 1. 100 per cent cotton without a durable press finish

Rank 3. 100 per cent cotton sheets with a durable press finish; Cotton-polyester blends

The rank order in the filling direction was the following:

Rank 1. 100 per cent untreated cotton sheets

Rank 2. Cotton-polyester blends

Rank 3. All-cotton sheets with a durable press finish

The rank orders of the wet breaking strength of the sheets in the warp direction and in the filling direction were the same for the tumble dried as for the line dried sheets.

Comparison of Dry Tearing Strength Values

There were no statistically significant differences between the line or tumble dried sheets of all three types, either in the warp of filling directions with respect to dry tearing strength.

The line dried sheets in the warp and in the filling directions showed the following rank order with respect to dry tearing strength values:

Rank 1. Cotton-polyester blends

Rank 2. All-cotton untreated

Rank 3. All-cotton given a durable press finish

The tumble dried sheets also showed the same rank order of dry tearing strength values in the two directions of the fabric.

Comparison of Wet Tearing Strength Values

The 100 per cent cotton line dried durable press finished sheets surpassed those of the tumble dried series in wet tearing strength in both directions of the fabric ($P<0.05$ in both instances).

The rank order of the sheets with respect to wet tearing strength was the same as that for dry tearing strength in both directions of the fabric.

Comparison of Dry Breaking Strength Values Following Flat Abrasion

There were no significant differences between line drying and tumble drying in either direction of the fabric with respect to dry tensile strength following flat abrasion for any of the three types of fabrics.

For the line dried and the tumble dried sheets, the following rank order was found in the flat abrasion test in both directions of the fabric:

Rank 1. Cotton-polyester blends

All-cotton untreated

Rank 3. All-cotton durable press treated

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A P P E N D I X

TABLE I

WASH-AND-WEAR RATINGS OF LINE DRIED EXPERIMENTAL SHEETS EVALUATED ON BED UNDER FLUORESCENT LIGHT

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	3.9	3.9	3.6	3.5	3.6	3.6	3.7
Type B	4.1	4.4	4.0	4.0	4.4	4.4	4.6
Average	4.0	4.2	3.8	3.8	4.0	4.0	4.2
Durable Press All-Cotton							
Type C	3.3	3.4	3.2	3.2	3.2	3.2	3.3
Type D	3.6	3.6	3.2	3.2	3.2	3.1	3.5
Average	3.4	3.5	3.2	3.2	3.2	3.2	3.4
Untreated All-Cotton							
Type E	2.3	2.6	2.4	2.3	2.5	2.7	2.6

TABLE I, CONTINUED

WASH-AND-WEAR RATINGS OF LINE DRIED EXPERIMENTAL SHEETS EVALUATED ON BED UNDER FLUORESCENT LIGHT

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	3.1	3.8	3.3	3.0	3.3	3.8	3.9
Type B	3.2	4.0	3.4	3.5	3.9	4.2	4.2
Average	3.2	3.9	3.4	3.2	3.6	4.0	4.0
Durable Press All-Cotton							
Type C	3.7	3.5	3.1	3.0	2.9	3.0	3.2
Type D	4.0	4.1	3.6	3.6	3.4	3.4	3.9
Average	3.8	3.8	3.4	3.3	3.2	3.2	3.6
Untreated All-Cotton							
Type E	2.8	2.7	2.5	2.7	2.8	3.0	3.1

TABLE II

WASH-AND-WEAR RATINGS OF LINE DRIED EXPERIMENTAL SHEETS EVALUATED BY MEANS OF A SIDE-LIGHTING DEVICE

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	4.4	4.0	3.7	3.6	3.8	3.8	3.8
Type B	4.4	4.3	3.9	3.9	4.2	4.3	4.6
Average	4.4	4.2	3.8	3.8	4.0	4.0	4.2
Durable Press All-Cotton							
Type C	3.8	3.2	3.1	3.0	3.2	3.2	3.1
Type D	4.0	3.5	3.0	3.2	3.3	2.9	3.3
Average	3.9	3.4	3.0	3.1	3.2	3.0	3.2
Untreated All-Cotton							
Type E	2.6	2.4	2.2	2.3	2.5	2.5	2.5

T A B L E I I , CONTINUED

WASH-AND-WEAR RATINGS OF LINE DRIED EXPERIMENTAL SHEETS EVALUATED BY MEANS OF A SIDE-LIGHTING DEVICE

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	3.9	3.9	3.5	3.2	3.4	3.9	4.0
Type B	3.7	4.0	3.5	3.4	3.7	4.2	4.0
Average	3.8	4.0	3.5	3.3	3.6	4.0	4.0
Durable Press All-Cotton							
Type C	3.9	3.2	3.0	2.8	2.8	2.8	3.0
Type D	4.3	3.8	3.5	3.3	3.2	3.2	3.5
Average	4.1	3.5	3.2	3.0	3.0	3.0	3.2
Untreated All-Cotton							
Type E	2.7	2.5	2.7	2.6	2.7	2.9	2.9

TABLE III

WASH-AND-WEAR RATINGS OF TUMBLE DRIED EXPERIMENTAL SHEETS EVALUATED ON BED UNDER FLUORESCENT LIGHT

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	3.9	3.9	3.8	3.6	3.5	3.7	3.8
Type B	4.2	4.5	4.2	4.4	4.5	4.6	4.8
Average	4.0	4.2	4.0	4.0	4.0	4.2	4.3
Durable Press All-Cotton							
Type C	3.4	3.4	3.2	3.2	3.2	3.0	3.4
Type D	3.3	3.5	3.1	3.2	2.9	2.6	2.9
Average	3.4	3.4	3.2	3.2	3.0	2.8	3.2
Untreated All-Cotton							
Type E	1.5	2.1	2.3	2.3	2.2	2.1	2.1

TABLE III, CONTINUED

WASH-AND-WEAR RATINGS OF TUMBLE DRIED EXPERIMENTAL SHEETS EVALUATED ON BED UNDER FLUORESCENT LIGHT

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	3.6	3.5	3.2	3.0	3.0	3.1	3.2
Type B	4.1	4.4	4.2	4.0	4.4	4.6	4.6
Average	3.8	4.0	3.7	3.5	3.7	3.8	3.9
Durable Press All-Cotton							
Type C	2.6	2.7	2.8	2.5	2.5	2.5	2.8
Type D	2.5	2.7	2.5	2.3	2.1	2.2	2.2
Average	2.6	2.7	2.6	2.4	2.3	2.4	2.5
Untreated All-Cotton							
Type E	1.0	1.3	1.3	1.4	1.6	1.7	1.6

TABLE IV

WASH-AND-WEAR RATINGS OF TUMBLE DRIED EXPERIMENTAL SHEETS EVALUATED BY MEANS OF A SIDE-LIGHTING DEVICE

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	4.4	4.0	3.9	3.8	3.6	3.8	3.9
Type B	4.6	4.4	4.3	4.3	4.4	4.6	4.6
Average	4.5	4.2	4.1	4.0	4.0	4.2	4.2
Durable Press All-Cotton							
Type C	3.7	3.1	3.2	3.1	3.0	2.9	3.1
Type D	3.7	3.3	3.0	3.0	2.9	2.5	2.7
Average	3.7	3.2	3.1	3.0	3.0	2.7	2.9
Untreated All-Cotton							
Type E	1.8	1.9	2.1	2.0	2.1	2.0	2.1

T A B L E I V , CONTINUED

WASH-AND-WEAR RATINGS OF TUMBLE DRIED EXPERIMENTAL SHEETS EVALUATED BY MEANS OF A SIDE-LIGHTING DEVICE

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS						
	1-5	6-10	11-15	16-20	21-25	26-30	31-35
Durable Press Cotton-Polyester Blends							
Type A	4.1	3.8	3.5	3.4	3.3	3.4	3.4
Type B	4.6	4.4	4.3	4.1	4.3	4.6	4.7
Average	4.4	4.1	3.6	3.7	3.8	4.0	4.0
Durable Press All-Cotton							
Type C	3.1	2.7	2.8	2.6	2.5	2.6	2.7
Type D	3.1	2.8	2.6	2.7	2.3	2.3	2.3
Average	3.1	2.8	2.7	2.6	2.4	2.4	2.5
Untreated All-Cotton							
Type E	1.0	1.2	1.3	1.4	1.6	1.7	1.7

TABLE V

DRY WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER LINE DRYING

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	146	146	141	137	136	132	132	130
Type B	153	142	146	135	136	144	148	142
Average	150	144	144	136	136	138	140	136
Durable Press All-Cotton								
Type C	118	108	113	112	107	124	107	106
Type D	118	122	111	102	106	125	104	103
Average	118	115	112	107	106	124	106	103
Untreated All-Cotton								
Type E	86	103	88	79	96	96	86	79

TABLE V, CONTINUED

DRY WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER LINE DRYING

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	149	148	142	136	134	136	134	128
Type B	142	139	144	140	140	138	142	144
Average	146	144	143	138	137	137	138	136
Durable Press All-Cotton								
Type C	129	117	124	114	123	125	112	98
Type D	124	119	128	104	120	108	100	104
Average	126	118	126	109	122	116	106	101
Untreated All-Cotton								
Type E	81	100	89	86	97	100	93	86

TABLE VI

DRY WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER TUMBLE DRYING

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	146	147	148	132	138	138	132	138
Type B	153	140	144	140	141	144	143	147
Average	150	144	146	136	140	141	138	142
Durable Press All-Cotton								
Type C	118	117	114	110	111	126	114	120
Type D	118	118	114	108	112	114	105	110
Average	118	118	114	109	112	120	109	115
Untreated All-Cotton								
Type E	86	100	92	86	83	92	94	88

T A B L E V I , CONTINUED

DRY WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER TUMBLE DRYING

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	149	142	132	134	142	136	130	134
Type B	142	144	146	140	146	143	143	145
Average	146	143	139	137	144	140	136	140
Durable Press All-Cotton								
Type C	129	118	127	117	131	114	124	119
Type D	124	122	124	104	123	118	109	104
Average	126	120	126	110	127	116	116	112
Untreated All-Cotton								
Type E	81	102	98	82	82	102	93	92

TABLE VII

WET WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER LINE DRYING

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	138	126	139	128	131	131	132	126
Type B	130	131	137	132	140	134	137	140
Average	134	128	138	130	136	132	134	133
Durable Press All-Cotton								
Type C	96	92	98	92	91	105	99	104
Type D	100	104	103	98	102	103	102	102
Average	98	98	100	95	96	104	100	103
Untreated All-Cotton								
Type E	71	72	83	74	84	91	92	89

TABLE VII, CONTINUED

WET WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER LINE DRYING

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	142	136	142	136	130	128	132	136
Type B	134	132	142	140	136	137	136	137
Average	138	134	142	138	133	132	134	136
Durable Press All-Cotton								
Type C	113	90	119	101	120	105	97	99
Type D	119	102	123	98	124	102	101	105
Average	116	96	121	100	122	104	99	102
Untreated All-Cotton								
Type E	83	70	85	73	84	94	96	94

TABLE VIII

WET WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER TUMBLE DRYING

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	138	126	136	135	136	127	132	129
Type B	130	130	137	133	137	135	136	138
Average	134	128	136	134	136	131	134	134
Durable Press All-Cotton								
Type C	96	102	98	100	100	97	112	104
Type D	100	108	100	101	103	106	100	98
Average	98	105	99	100	102	102	106	101
Untreated All-Cotton								
Type E	71	74	80	79	84	90	96	93

TABLE VIII, CONTINUED

WET WRINKLE RECOVERY ANGLES OF EXPERIMENTAL SHEETS MEASURED BY THE VERTICAL STRIP METHOD AFTER TUMBLE DRYING

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	142	130	131	130	132	131	131	133
Type B	134	134	140	133	136	139	137	136
Average	138	132	136	132	134	135	134	134
Durable Press All-Cotton								
Type C	113	102	111	100	104	100	108	107
Type D	119	101	116	101	110	100	101	102
Average	116	102	114	100	107	100	104	104
Untreated All-Cotton								
Type E	83	73	89	76	93	90	89	94

TABLE IX

WHITENESS OF LINE DRIED EXPERIMENTAL SHEETS EXCLUSIVE OF FLUORESCENCE

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS								
	0	1	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends									
Type A	74.5	70.4	66.0	63.9	63.1	62.0	59.2	58.2	61.6
Type B	73.4	67.5	61.1	59.2	57.1	56.7	56.2	56.0	51.6
Average	74.0	68.0	63.6	61.6	60.1	59.4	57.7	57.1	56.6
Durable Press All-Cotton									
Type C	82.2	72.7	72.7	66.6	65.2	63.4	61.9	62.7	66.4
Type D	82.0	78.3	73.8	70.8	62.2	63.4	63.2	59.1	64.0
Average	82.1	75.5	73.2	68.7	63.7	63.4	62.6	60.9	65.2
Untreated All-Cotton									
Type E	83.7	75.7	70.3	62.4	61.3	62.2	59.0	59.0	65.3

T A B L E I X , CONTINUED

WHITENESS OF LINE DRIED EXPERIMENTAL SHEETS

EXCLUSIVE OF FLUORESCENCE

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS								
	0	1	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends									
Type A		69.2	70.8	70.0	67.6	64.6	63.7	62.4	62.2
Type B		72.3	66.9	65.5	62.0	62.0	58.5	59.2	56.9
Average		70.8	68.8	67.8	64.8	63.3	61.1	60.8	60.0
Durable Press All-Cotton									
Type C		79.5	75.8	72.0	70.6	70.3	61.6	67.5	71.7
Type D		83.4	77.8	74.3	70.8	68.5	68.6	66.6	66.3
Average		81.4	76.8	73.2	70.7	69.4	65.1	67.0	69.0
Untreated All-Cotton									
Type E		82.0	73.0	68.7	65.8	64.5	62.9	62.4	65.5

TABLE X

WHITENESS OF TUMBLE DRIED EXPERIMENTAL SHEETS EXCLUSIVE OF FLUORESCENCE

PART A. BEFORE LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS								
	0	1	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends									
Type A	73.0	69.9	64.2	60.9	55.2	58.0	56.3	53.8	53.2
Type B	75.0	67.9	62.7	60.0	57.7	56.4	50.9	52.4	51.4
Average	74.0	68.9	63.4	60.4	56.4	57.2	53.6	53.1	52.3
Durable Press All-Cotton									
Type C	84.4	71.3	70.6	64.7	61.6	62.9	59.4	59.8	61.6
Type D	81.2	73.6	71.9	65.9	63.5	61.8	62.2	58.6	60.0
Average	82.8	72.4	71.2	65.3	62.6	62.4	60.8	59.2	60.8
Untreated All-Cotton									
Type E	85.5	77.6	68.2	59.2	60.0	57.3	57.2	53.3	61.7

T A B L E X , CONTINUED

WHITENESS OF TUMBLE DRIED EXPERIMENTAL SHEETS

EXCLUSIVE OF FLUORESCENCE

PART B. AFTER LAUNDERING

TYPE OF SHEET	NUMBER OF LAUNDERINGS								
	0	1	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends									
Type A		65.5	69.0	67.0	65.1	61.1	66.4	57.0	56.0
Type B		72.0	70.2	65.8	66.5	62.1	58.2	56.7	57.0
Average		68.8	69.6	66.4	65.8	61.6	62.3	56.8	57.0
Durable Press All-Cotton									
Type C		78.4	75.8	70.7	68.8	66.1	64.6	65.3	68.4
Type D		79.8	74.3	73.2	70.9	62.2	64.4	64.9	63.2
Average		79.1	75.0	72.0	69.8	64.2	64.5	65.1	65.8
Untreated All-Cotton									
Type E		83.3	73.8	65.3	65.2	60.5	59.9	56.6	59.0

TABLE XI

DRY BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.3	48.2	48.4	51.0	52.9	51.6	50.1	48.0
Type B	43.8	45.8	47.6	46.4	46.0	46.8	46.7	47.6
Average	45.6	47.0	48.0	48.7	49.4	49.2	48.4	47.8
Durable Press All-Cotton								
Type C	43.5	48.4	39.9	43.1	43.3	38.0	41.9	40.7
Type D	45.5	49.2	47.0	48.3	50.2	44.2	44.0	44.2
Average	44.5	48.8	43.4	45.7	46.8	41.1	43.0	42.4
Untreated All-Cotton								
Type E	54.6	49.4	47.4	49.2	47.0	43.5	39.2	41.2

T A B L E X I , CONTINUED

DRY BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.3	46.4	48.4	50.1	48.4	48.0	46.5	42.7
Type B	50.2	53.7	51.6	53.2	54.6	54.6	47.1	54.0
Average	48.8	50.0	50.0	51.6	51.5	51.3	46.8	48.4
Durable Press All-Cotton								
Type C	36.0	42.0	37.8	38.7	43.0	33.6	30.6	34.4
Type D	42.8	46.6	44.6	55.8	44.6	44.4	44.1	41.2
Average	39.4	44.3	41.2	47.2	43.8	39.0	37.4	37.8
Untreated All-Cotton								
Type E	63.2	51.8	57.9	57.6	52.7	52.7	45.9	45.0

TABLE XII

DRY BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.3	46.8	47.8	52.8	50.8	50.3	48.7	48.6
Type B	43.8	46.2	47.6	50.2	47.4	49.3	47.4	44.3
Average	45.6	46.5	47.7	51.5	49.1	49.8	48.0	46.4
Durable Press All-Cotton								
Type C	43.5	42.2	43.0	43.6	43.0	40.2	35.4	32.1
Type D	45.5	44.6	42.8	45.6	42.8	42.4	37.1	37.5
Average	44.5	43.4	42.9	44.6	42.9	41.3	36.2	34.8
Untreated All-Cotton								
Type E	54.6	50.2	45.1	46.4	49.0	38.1	36.9	37.2

TABLE XII, CONTINUED

DRY BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.3	48.5	49.4	48.2	48.4	46.0	45.8	47.0
Type B	50.2	49.7	51.2	53.1	53.2	51.4	50.1	48.0
Average	48.8	49.1	50.3	50.6	50.8	48.7	48.0	47.5
Durable Press All-Cotton								
Type C	36.0	38.8	37.0	38.4	36.6	36.6	36.4	25.4
Type D	42.8	41.0	44.8	42.9	45.5	42.4	38.6	33.6
Average	39.4	39.9	40.9	40.6	41.0	39.5	37.5	29.5
Untreated All-Cotton								
Type E	63.2	57.6	60.0	53.0	56.2	43.8	39.7	46.2

TABLE XIII

WET BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	48.6	49.4	51.6	53.7	58.0	55.3	57.1	53.1
Type B	48.5	48.2	48.8	48.2	47.2	50.0	47.8	48.4
Average	48.6	48.8	50.2	51.0	52.6	52.6	52.4	50.8
Durable Press All-Cotton								
Type C	43.5	55.6	41.2	47.2	45.9	39.9	49.0	50.8
Type D	49.8	54.4	47.6	52.2	53.2	49.3	51.9	46.6
Average	46.6	55.0	44.4	49.7	49.6	44.6	50.4	48.7
Untreated All-Cotton								
Type E	61.5	61.2	55.6	59.0	53.6	55.5	47.6	50.0

TABLE XIII, CONTINUED

WET BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.0	49.3	48.7	51.0	52.8	52.2	48.5	47.0
Type B	53.1	51.6	52.8	53.3	54.6	54.0	53.4	54.3
Average	50.0	50.4	50.8	52.2	53.7	53.1	51.0	50.6
Durable Press All-Cotton								
Type C	36.8	48.6	39.6	43.7	40.4	36.3	44.5	40.3
Type D	47.8	48.4	46.2	47.2	45.1	46.9	51.2	43.4
Average	42.3	48.5	42.9	45.4	42.8	41.6	47.8	41.8
Untreated All-Cotton								
Type E	73.3	62.5	65.0	66.6	60.2	64.3	58.8	54.4

TABLE XIV

WET BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	48.6	50.0	50.2	53.2	55.2	55.3	54.8	55.0
Type B	48.5	48.7	50.3	50.0	49.1	52.7	48.4	44.7
Average	48.6	49.4	50.2	51.6	52.2	54.0	51.6	49.8
Durable Press All-Cotton								
Type C	43.5	45.6	45.8	45.4	47.6	42.2	38.9	40.0
Type D	49.8	49.0	46.4	46.4	45.8	45.8	43.8	39.6
Average	46.6	47.3	46.1	45.9	46.7	44.0	41.4	39.8
Untreated All-Cotton								
Type E	61.5	56.9	58.8	54.6	57.2	46.2	44.3	41.6

TABLE XIV, CONTINUED

WET BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN POUNDS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	47.0	50.9	49.8	49.4	51.9	50.5	49.9	52.6
Type B	53.1	51.6	52.2	53.0	47.2	52.0	51.8	44.2
Average	50.0	51.2	51.0	51.2	49.6	51.2	50.8	48.4
Durable Press All-Cotton								
Type C	36.8	42.6	39.2	41.6	38.2	39.4	36.0	29.0
Type D	47.8	45.2	47.4	44.2	46.6	42.7	44.8	37.2
Average	42.3	43.9	43.3	42.9	42.4	41.0	40.4	33.1
Untreated All-Cotton								
Type E	73.3	63.6	69.6	60.7	67.4	52.7	53.4	55.8

TABLE XV

DRY TEARING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	889	957	960	989	952	911	1011	908
Type B	859	978	997	969	1007	1028	1049	1068
Average	874	968	978	979	980	970	1030	988
Durable Press All-Cotton								
Type C	601	777	610	635	675	653	657	706
Type D	664	647	606	644	661	654	628	670
Average	632	712	608	640	668	654	642	688
Untreated All-Cotton								
Type E	813	785	704	759	752	740	699	897

T A B L E X V , CONTINUED

DRY TEARING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	968	948	1039	1051	976	992	936	958
Type B	1047	1150	1163	1236	1168	1326	1308	1282
Average	1008	1049	1101	1144	1072	1159	1122	1120
Durable Press All-Cotton								
Type C	533	629	515	541	527	506	511	572
Type D	602	622	594	628	582	610	596	565
Average	568	626	554	584	554	558	554	569
Untreated All-Cotton								
Type E	945	734	672	765	706	757	669	825

TABLE XVI

DRY TEARING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	889	924	919	932	965	922	987	1051
Type B	859	863	1007	1022	936	1063	1119	1002
Average	874	894	963	977	950	992	1053	1026
Durable Press All-Cotton								
Type C	601	742	654	657	657	638	615	569
Type D	664	651	606	645	619	646	682	598
Average	632	696	630	651	638	642	648	584
Untreated All-Cotton								
Type E	813	780	861	746	806	649	592	637

T A B L E X V I , CONTINUED

DRY TEARING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	968	1105	979	1000	1052	1025	1093	1064
Type B	1047	1068	1117	1199	1219	1180	1332	1299
Average	1008	1086	1048	1100	1136	1102	1212	1182
Durable Press All-Cotton								
Type C	533	553	520	520	521	525	482	396
Type D	602	577	620	616	587	591	620	494
Average	568	565	570	568	554	558	551	445
Untreated All-Cotton								
Type E	945	809	802	709	759	602	589	597

TABLE XVII

WET TEARING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	1089	1070	1057	1097	1046	927	941	859
Type B	1016	1037	1098	1046	1172	1096	1126	1104
Average	1052	1054	1078	1072	1109	1012	1034	982
Durable Press All-Cotton								
Type C	602	765	525	688	726	602	661	794
Type D	646	560	561	595	643	572	668	853
Average	624	662	543	642	684	587	664	824
Untreated All-Cotton								
Type E	1005	824	776	897	838	779	765	987

TABLE XVII, CONTINUED

WET TEARING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	1107	1048	1056	1058	1033	955	938	857
Type B	1158	1170	1206	1277	1320	1277	1243	1297
Average	1132	1109	1131	1168	1176	1116	1090	1077
Durable Press All-Cotton								
Type C	543	608	438	537	556	526	540	717
Type D	606	510	567	572	574	584	592	834
Average	574	560	502	554	565	555	566	776
Untreated All-Cotton								
Type E	959	760	708	883	824	838	772	926

TABLE XVIII

WET TEARING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	1089	1045	982	997	1045	961	898	946
Type B	1016	1445	1056	1114	1124	1144	1121	1120
Average	1052	1245	1019	1056	1084	1052	1010	1033
Durable Press All-Cotton								
Type C	602	606	582	618	663	610	519	729
Type D	646	570	579	566	565	532	527	691
Average	624	588	580	592	614	571	523	710
Untreated All-Cotton								
Type E	1005	819	924	802	912	706	666	1021

TABLE XVIII, CONTINUED

WET TEARING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS IN GRAMS PER 100 YARNS AT SPECIFIED PERIODS OF EVALUATION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	1107	1155	1026	1044	1097	985	937	963
Type B	1158	1126	1144	1253	1323	1345	1229	1184
Average	1132	1140	1085	1148	1210	1110	1083	1074
Durable Press All-Cotton								
Type C	543	476	467	489	512	569	394	359
Type D	606	518	584	568	567	533	527	672
Average	574	497	526	528	540	551	460	516
Untreated All-Cotton								
Type E	959	868	934	819	883	667	862	1087

TABLE XIX

PER CENT CHANGE IN DRY BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS FOLLOWING FLAT ABRASION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	- 2.3	- 4.1	+ 2.1	- 2.4	- 6.6	- 5.8	- 1.8	- 9.2
Type B	- 7.1	- 7.9	-10.7	- 8.0	-17.2	-17.5	-17.8	-18.7
Average	- 4.7	- 6.0	- 4.3	- 5.2	-11.9	-11.6	- 9.8	-14.0
Durable Press All-Cotton								
Type C	-18.2	- 2.5	-11.3	-16.5	-31.6	-32.1	-31.7	-20.4
Type D	- 9.4	- 4.7	-28.9	-23.0	-33.1	-22.2	-24.1	-32.6
Average	-13.8	- 3.6	-20.1	-19.8	-32.4	-27.2	-27.9	-26.5
Untreated All-Cotton								
Type E	+ 3.3	+11.3	+ 9.3	+ 2.0	-13.2	-14.5	-11.2	-25.2

TABLE XIX, CONTINUED

PER CENT CHANGE IN DRY BREAKING STRENGTH OF LINE DRIED EXPERIMENTAL SHEETS FOLLOWING FLAT ABRASION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	-24.7	-22.0	-16.9	-13.3	-26.4	-19.6	-19.5	-15.7
Type B	-24.3	-20.3	-19.6	-14.8	-28.9	-24.2	-16.8	-23.1
Average	-24.5	-21.2	-18.2	-14.0	-27.6	-21.9	-18.2	-19.4
Durable Press All-Cotton								
Type C	-38.9	-32.4	-30.7	-41.1	-51.6	-50.0	-12.7	-39.5
Type D	-29.0	-45.3	-33.6	-48.1	-46.2	-43.7	-36.8	-43.0
Average	-34.0	-38.8	-32.2	-44.6	-48.9	-46.8	-24.8	-41.2
Untreated All-Cotton								
Type E	- 1.6	+ 2.3	- 7.8	-12.3	-23.7	-29.4	-25.6	-33.3

TABLE XX

PER CENT CHANGE IN DRY BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS FOLLOWING FLAT ABRASION

PART A. WARP DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	- 2.3	+ 2.1	+ 1.9	- 3.4	- 4.7	- 5.8	- 4.7	- 3.9
Type B	- 7.1	- 3.9	- 9.4	- 8.6	-18.1	-17.2	-22.2	-22.8
Average	- 4.7	- 0.9	- 3.8	- 6.0	-11.4	-11.5	-13.4	-13.4
Durable Press All-Cotton								
Type C	-18.2	-18.9	-18.1	-20.9	-21.9	-45.3	-20.3	-17.3
Type D	- 9.4	-11.6	-24.5	-28.9	-32.7	-32.8	-31.5	-32.3
Average	-13.8	-15.2	-21.3	-24.9	-27.3	-39.0	-25.9	-24.8
Untreated All-Cotton								
Type E	+ 3.3	- 2.4	+ 5.3	-11.8	-20.8	- 7.1	-10.0	-29.6

T A B L E X X , CONTINUED

PER CENT CHANGE IN DRY BREAKING STRENGTH OF TUMBLE DRIED EXPERIMENTAL SHEETS FOLLOWING FLAT ABRASION

PART B. FILLING DIRECTION

TYPE OF SHEET	NUMBER OF LAUNDERINGS							
	0	5	10	15	20	25	30	35
Durable Press Cotton-Polyester Blends								
Type A	-24.7	-18.8	-21.4	-17.6	-20.2	-20.4	-16.7	-20.8
Type B	-24.3	-15.5	-18.4	-15.6	-28.4	-26.8	-22.0	-32.9
Average	-24.5	-17.2	-19.9	-16.6	-24.3	-23.6	-19.4	-26.8
Durable Press All-Cotton								
Type C	-38.9	-43.6	-32.2	-44.3	-40.7	-48.6	-29.6	-34.6
Type D	-29.0	-39.5	-39.7	-38.9	-43.5	-48.6	-41.0	-41.1
Average	-34.0	-41.6	-36.0	-41.6	-42.1	-48.6	-35.3	-37.8
Untreated All-Cotton								
Type E	- 1.6	-16.0	-14.8	-23.0	-23.0	-23.3	- 8.0	-29.0