THE DIMENSIONAL STABILITY OF TUMBLER DRIED AND SCREEN DRIED COTTON T-SHIRTS

by

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INTRODUCTION

Little research has been done on knit goods, whereas, the use of knit fabrics in ready-to-wear is increasing. The popularity of knitted garments has brought greater demand for better quality. It would be desirable to control the dimensional change which occurs during laundering of knitted fabrics.

Knitting is constructing a fabric on needles, by the interlooping of stitches from one or more yarns in several series of connected loops hanging on to and supporting each other. A complete stitch in knitting is composed of two loops, the needle loop which is formed around the needle, and the sinker loop, which is formed around the dividing wall or edge between two needles. The loops in a knitted fabric form a series of chains lengthwise in the fabric and also form a series of loops across the fabric. Wales are defined as a series of loops forming a chain and running lengthwise of the fabric. The loops forming a line across the fabric at right angles to the wales are called courses. The usual method of indicating the closeness of the texture of knitted fabrics is by the number of wales and courses per inch (Merrill et al.,8).

A staple ready-to-wear garment made of circular flat knit is the cotton T-shirt. It is a type of garment which is repeatedly replaced in kind and is not discarded because of style changes. In view of the general acceptance of the T-shirt, factors contributing to the dimensional stability of this garment are of great importance since such information will enable

families to realize a greater return for the money invested. The price range of T-shirts varies and is not necessarily an indication of quality. It is desirable for the consumer to know which T-shirt will take washings without causing too much shrinkage or too much stretch.

Feuer (3) reported that over 90 per cent of all circular knit underwear is made of cotton, including the T-shirt. The advantages of cotton over synthetics for T-shirts are that cotton is less expensive, it is known for its ready washability, it has a satisfactory wear life, and the ability to maintain colors or to be bleached if it was white originally. Most important is the comfort of cotton which the consumer appreciates, regardless of temperature or humidity conditions. The disadvantages of cotton for T-shirts are that after repeated washing and wearing, it has a strong tendency to lose its resiliency, and it is somewhat slower drying than fabrics composed of spun synthetics. The most important disadvantage in cotton T-shirts is the dimensional change occurring during laundering.

According to Textile Organon (7) the shipments of circular knit T-shirt fabric in 1953 were seven per cent below 1952. However, yarn consumed in the production of knit cloth in 1953 showed cotton to have taken somewhat of an upward trend. The total production of circular knit fabric in 1953 was 116,944,000 pounds; T-shirt fabric accounted for 27,000,000 and of this amount, 26,843,000 pounds were cotton.

Conventionally manufactured tubular knit is reduced in length and increased in width when laundered. The Office of the

Quartermasters General (9) has used a knitting machine attachment for knitting tubular knit fabric for underwear and outerwear. The device changes the shape of the loops and reduces the length of the fabric while on the machine. By means of this attachment the loops are brought to a shape similar to that of the loops of laundered knitted fabric, and the tendency toward shrinkage is offset to a marked degree. This device reduces the length of the fabric during construction so that shrinkage does not take place when laundered. However, because of the high capital investment, it has been considered by only a small group of the larger mills (11).

The purpose of this study was to determine the effects of laundering on the fabrics of nine brands of T-shirts, to determine the dimensional change which occurred in the fabrics after a series of launderings, and to compare the results of tumbler drying and screen drying.

REVIEW OF LITERATURE

In 1951 the first effort was made to develop a standard test method for measuring shrinkage which occurs in the laundering of knit fabrics. The United States Bureau of Standards referred the request of the Underwear Institute (Feuer, 2) to Committee D-13 of the American Society for Testing Material (A. S. T. M.). A committee called the Task Group was formed by A. S. T. M. to develop a test method for measuring shrinkage which occurs in the laundering of knit fabrics. The Task Group was composed of representatives of the Research and Development Branch of the

Office of the Quartermaster General; United States Testing Company, Inc.; Sears, Roebuck and Company; Beaunit Mills; Celanese Corporation; Industrial Rayon Corporation; and the Bureau of Human Nutrition and Home Economics of the United States Department of Agriculture (12). The Task Group (Wyner, 14) decided that due to the increasing use of the automatic washing machine and the frequent use of hot air tumbler dryers, that the test should include the automatic washing machine and both hot air tumbler drying and screen drying methods. The test for cotton knit fabrics that was developed and submitted by the Task Group (Feuer, 2) was adopted June 1952, as a tentative method by A. S. T. M. as Designation: 1231-52 T. In 1954, A. S. T. M. adopted a standard test for cotton knit fabrics known as Designation: D 1231-54(1). The Task Group (11) appointed Dr. Hazel Fletcher of the Bureau of Human Nutrition and Home Economics to prepare reports on the studies that led to the tentative test methods.

Fletcher and Roberts (5) reported on the changes in fabric structure due to laundering. Distortion of knit fabric is inherent in their manufacture. Spiraling effects are common since there can be no widthwise alignment of circular knit goods and since tension is automatically controlled only in the lengthwise direction as new loops are added. Changes may occur in the fabric when it is released from the tension of the machine due to the structure of knitting. In this study, investigation of the rearrangement of the structure of plain, rib, and interlock knit fabrics during laundering was made. The fabrics were made

of cotton, acetate, viscose, and nylon fibers. Since no standard procedure for laundering knit fabrics was set, the standard method for woven cloth was used. The course spacing to wale spacing followed no regular pattern before the cottons were laundered, but after laundering the spacings approximated parabolic curves. These differences indicated distortion in the structure of the unlaundered fabrics. The data on the wale and course spacings of the interlock fabrics were similar to the plain and rib knit. Shrinkage for the tightly knit cloth was significantly more than that for the loosely knit materials. In the case of the rib knit the excessive widthwise stretching resulted in an increase in area of as much as 25 per cent in loosely knit material. The results indicated that changes in dimension of knit goods during laundering are due to a rearrangement of the fabric structure.

The Task Group (Fletcher et al., 4) studied the extent to which knit garments shrink or stretch when washed. Changes in width and length after five launderings were determined on plain knit and plated cotton fabrics, each knit with 32 and 40 courses per inch. The plain and plated cotton fabrics knit with 32 courses per inch stretched progressively in width with repeated laundering. The dimensional change ranged from 14 per cent stretch to 6 per cent shrinkage in width and from 0 to 14 per cent shrinkage in length. Lengthwise shrinkage was considerably more than in certain plain woven fabrics. Results of this study showed that dimensional changes of the knit goods during laundering varied with the type of construction and the number of

courses per inch. The greatest change took place in the first laundering.

Fletcher and Roberts (6) compared the effects of tumbler drying and screen drying on cotton knit fabrics. Tumbler drying tended to consolidate the loop construction of knit goods, and the dimensional change was different from that of screen drying. Shrinkage in length with tumbler drying ranged from 15 to 36 per cent as compared to 11 to 30 per cent with screen drying. In width, dimensional change ranged from 6 per cent to 44 per cent stretch with tumbler drying as compared to 3 per cent shrinkage and 63 per cent stretch with screen drying. Most of the fabrics shrank from 20 to 25 per cent in area with tumbler drying, but only 10 to 15 per cent with screen drying. These results indicated that there was greater dimensional change in area in tumbler drying than in screen drying.

The members of the Task Group (12) concluded from their study on dimensional change of knit fabrics that shrinkage was desirable for some garments; a five to eight per cent shrinkage in width was usually recommended; fabrics with zero width shrinkage were not acceptable for such garments as T-shirts; and substantial shrinkage in the length was not desirable in fabrics used for women's shirts.

The minimum or maximum shrinkage specifications for washing knit goods is still a debatable question according to Smith (10). Most of the present relaxation shrinkage-control processes used in the manufacture of knit fabric are aimed to produce a fabric having three to five per cent shrinkage based on screen drying

methods. Tumbler drying of fabric after washing usually adds approximately five per cent shrinkage over screen drying methods. However, the construction of the fabric must be taken into consideration as an eight per cent shrinkage might be considered poor for one type of knit goods and good for another. It was concluded that perhaps the final answer to minimum shrinkage control on knit goods will be a combination of mechanical shrinkage control in conjunction with a resin treatment in the production of knit fabrics.

A Shrinkage Terminology Committee was appointed by the Underwear Institute (Wyner, 14) which decided that since no process had been developed to eliminate all shrinkage from knit goods, advertising conveying that idea was misleading. The recommendation was made that the phrases "Will Not Shrink," "Shrink Proof," and "Pre-Shrunk," should not be used, as the maximum shrinkage figure for each type of fabric has not been established.

METHOD OF PROCEDURE

All the tests conducted in this study were done according to standards set up by the A. S. T. M. Committee D-13 (1), except for the measurements of the T-shirts which were taken according to Commercial Standards CS146-55 (13).

Selection of T-shirts

Nine brands of white cotton T-shirts for boys were selected and four T-shirts of each brand were purchased locally. The T-shirts and the fabrics of each brand will be designated by a letter and hereafter be referred to as: A, B, C, D, E, F, G, H,

and J. The T-shirts were representative of three price levels: low, medium, and high. The low price level T-shirts were A at 49 cents, B at 45 cents, and C and D at 59 cents. T-shirts E, F, and G were 79 cents each and represented the medium price level. The high price level T-shirts were H and J at one dollar each (Plate I).

The T-shirts were constructed of a flat filling knit. The characteristics of flat filling knit are that the face has a very smooth appearance and the back shows ridges, giving a rough appearance. The neckline of the T-shirts in all brands except B was nylon reinforced. Brand B was labeled "Shrink Controlled" and brand G was labeled "Shrink Resistant."

Laundry Procedure

Two T-shirts of each brand were washed in an automatic type washing machine which had an operating cycle of 40 minutes, including a wash and two rinses. The temperature of the water throughout the cycle was 140° F. Sufficient mild laundry soap, conforming to federal specification PS-566 A, was used to give a good running suds. One T-shirt of each brand was tumbler dried at a temperature of 130° to 160° F. for 45 minutes. The screen dried T-shirts were placed on horizontal screens at room temperature so that air could circulate freely about them until dry. Hereafter, when fabrics are referred to as being tumbler dried and screen dried, it means they have also been laundered. The T-shirts were laundered and dried 40 times.

EXPLANATION OF PLATE I

Fig. 1. Brand A

Fig. 2. Brand B

Fig. 3. Brand C

Fig. 4. Brand D

PLATE I

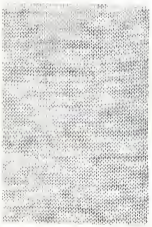


Fig. 1

Fig. 2

Fig. 3

Fig. 4

EXPLANATION OF PLATE I (concl.)

Fig. 5. Brand E

Fig. 6. Brand F

Fig. 7. Brand G

Fig. 8. Brand H

Fig. 9. Brand J

PLATE I (concl.)

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Dimensional Stability

Ten, 10-inch distances were marked on each T-shirt in both the lengthwise and widthwise directions. Two T-shirts of each brand were so marked with fine sewing thread. The lengthwise distances were parallel to the wales; the widthwise distances were perpendicular to the wales. The distances were measured after 1, 3, 5, 10, 20, 30, and 40 tumbler dryings and screen dryings.

Bursting Strength Test

A machine with constant rate-of-traverse equipped with a ball burst attachment was used for the bursting strength tests. The circular specimens were held securely by a ring-clamp mechanism. A polished steel ball was pressed against the center of the specimen until a burst was produced. Plate II indicates the location of specimens cut for testing.

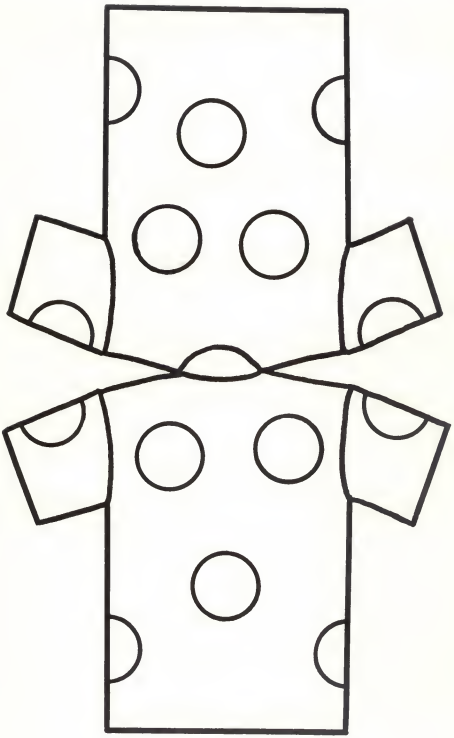
Measurements of T-Shirts

Two measurements of the nine brands of T-shirts were taken as purchased and after 40 tumbler dryings and 40 screen dryings, conforming to Commercial Standard CS146-55 (13). The T-shirts of each brand were measured for length from the shoulder seam next to the neck opening to the bottom of the shirt, giving the measurement where the T-shirt was the longest. The width of the T-shirt was taken below the armseye.

EXPLANATION OF PLATE II

The location of the 10 specimens cut from the T-shirts for the bursting strength tests.

PLATE II



Analyses of T-Shirts and Fabrics

The fabric of each brand of T-shirt was analyzed as purchased for the number of wales and courses per inch, thickness, twist, and bursting strength.

The fabric of the T-shirts after 40 tumbler dryings and 40 screen dryings was analyzed for the number of wales and courses per inch, thickness, and bursting strength. The dimensional change of the tumbler drying and screen drying was compared.

T-shirts as purchased and after 40 tumbler dryings and 40 screen dryings were measured.

FINDINGS AND DISCUSSION

The data collected from the various tests conducted on each brand of T-shirts will be presented.

T-Shirts as Purchased

An analysis was made of each fabric of the nine brands of T-shirts before laundering. No fabric was balanced as to wales and courses for in all cases the number of courses exceeded that of the wales (Table 1). The number of courses varied from 30.1 to 40.6 per inch and the number of wales from 26.7 to 35.5 per inch. The lowest bursting strength was 52.7 pounds and the highest 112.2 pounds (Table 2). The yarn in the fabrics of all the brands was a single ply with "Z" twist. The amount of twist in the yarns varied from 27.5 to 41.9 turns per inch. The thickness of fabrics ranged from .017 to .021 inch (Table 3). The

measurements of the length of the T-shirts ranged from 19.2 to 22.4 inches and the measurement of the width from 24.8 to 28.6 inches (Table 6).

T-Shirt Fabrics After 40 Dryings

Wales and Courses. The number of wales in the fabrics of the T-shirts after 40 tumbler dryings varied from 29.5 to 34.7 loops per inch (Table 1). In fabric E the number of wales per inch did not show any apparent change after 40 tumbler dryings in comparison with the fabric as purchased; fabrics B and D showed only a slight decrease in the number of wales; fabric C showed the greatest change which was from 29.8 to 34.7 wales per inch. Fabrics A, C, G, H, and J showed significant change in the number of wales per inch after 40 tumbler dryings in comparison with the fabrics as purchased.

The number of wales varied from 28.3 to 34.9 per inch after 40 screen dryings (Table 1). Fabrics B, D, E, and F decreased in the number of wales after 40 screen dryings in comparison with the fabrics as purchased. The fabrics that showed significant change after 40 screen dryings in comparison to the fabrics as purchased were A, B, G, and H.

In comparing the results of the two methods of drying, fabrics C, G, and J showed significantly greater change in the number of wales per inch after 40 tumbler dryings than after 40 screen dryings.

The number of courses in the fabric of the T-shirts tumbler dried 40 times varied from 36.7 to 44.8 per inch. The greatest

Table 1. Number of wales and courses per inch in T-shirt fabrics as purchased and after 40 dryings.*

Brands	As purchased	SE	40 tumbler dryings	SE	40 screen dryings	SE
	Wales per inch		Wales per inch		Wales per inch	
A	31.7	.10	33.8	.09	33.2	.51
B	29.8	.09	29.7	.08	28.7	.34
C	29.8	.33	34.7	.06	30.8	.76
D	35.5	.35	35.1	.09	34.8	.09
E	35.2	.08	35.2	.62	34.9	.07
F	28.7	.10	29.0	.08	28.3	.50
G	29.5	.04	32.0	.15	30.7	.58
H	26.7	.54	29.5	.26	28.6	.64
J	28.9	.07	31.4	.10	29.2	.47
	Courses per inch		Courses per inch		Courses per inch	
A	35.4	.08	43.0	.07	42.7	.30
B	31.4	.36	37.8	.20	35.6	.07
C	31.8	.51	41.9	.62	36.8	.22
D	33.1	.09	42.7	.05	41.0	.00
E	40.6	.33	44.8	.09	43.8	.20
F	30.1	.47	37.2	.20	36.5	.20
G	32.0	.60	39.1	.07	36.4	.40
H	30.2	.08	38.2	.13	35.7	.08
J	32.9	.10	36.7	.08	36.3	.07

* SE - Standard Error.

change from 31.8 to 41.9 courses per inch occurred in fabric C compared with the fabric as purchased. Fabric J changed from 32.9 to 36.7 courses per inch, the least change when compared with the fabric as purchased.

The screen dried fabrics at the end of the series of drying showed an increase in courses in all fabrics. The number varied from 35.6 to 43.8 per inch (Table 1). Fabric D showed the greatest increase, from 33.1 to 41 courses per inch compared with the fabric as purchased. The least increase occurred in fabric E, from 40.6 to 43.8 courses per inch. All fabrics showed significant change after 40 screen dryings when compared with the fabrics as purchased. The fabrics, tumbler dried, showed a greater increase in courses per inch than the screen dried fabrics. Fabric A showed the least change which was from 43 to 42.7 courses per inch; fabric C changed the greatest, from 41.9 to 36.8.

In comparing the results of the two methods of drying, fabrics B, C, D, G, and H had a significantly greater number of courses after 40 tumbler dryings than the fabrics screen dried.

Bursting Strength. All the fabrics showed a decrease in bursting strength after 40 dryings in comparison with the fabrics as purchased (Table 2). Fabric H decreased the least in strength, from 73.6 to 71.8 pounds or a loss of 2.5 per cent. The greatest loss of strength was in fabric B which changed from 52.7 to 38.2 pounds or a loss of 25.7 per cent. Fabric F was the strongest fabric with a bursting strength of 112.2 pounds as purchased. Even though it lost 13.7 per cent strength after 40 tumbler

Table 2. Bursting strength of T-shirt fabrics as purchased and after 40 dryings and percentage loss of strength.*

Brands	As purchased		40 tumbler dryings			40 screen dryings		
	in pounds	SE	in pounds	SE	Percentage loss**	in pounds	SE	Percentage loss**
A	64.8	2.08	60.1	1.88	5.7	59.6	1.39	8.1
B	52.7	2.50	38.2	0.45	25.7	44.6	1.95	15.4
C	70.3	2.86	67.5	2.03	4.0	64.2	1.72	10.0
D	79.2	2.30	69.4	1.30	12.4	69.7	0.57	11.9
E	83.3	2.43	71.9	1.62	13.7	77.7	2.71	4.0
F	112.2	3.30	90.9	1.81	19.0	100.2	1.41	11.0
G	74.2	2.38	66.6	1.43	10.3	63.8	0.45	14.1
H	73.6	1.90	71.8	1.00	2.5	71.7	1.40	2.6
J	69.5	1.05	64.2	1.30	7.6	65.7	1.28	5.5

* SE - Standard Error.

** Percentage loss of strength after 40 dryings in comparison to the bursting strength of each fabric as purchased.

dryings, it was still the strongest. All fabrics decreased in bursting strength after 40 screen dryings in comparison with the fabrics as purchased. Fabric H decreased from 73.6 to 71.7 pounds, the least decrease, 2.6 per cent, after 40 screen dryings. Fabric B changed from 52.7 to 44.6 pounds in bursting strength, the greatest change, 15.4 per cent, after 40 screen dryings. Fabric F, the strongest fabric, lost only 4 per cent of its original strength of 112.2 pounds after 40 screen dryings.

In comparing the two methods of drying, fabrics B, E, and F had significantly higher bursting strengths after 40 screen dryings than after 40 tumbler dryings; fabrics C and G had significantly higher bursting strengths after 40 tumbler dryings than after 40 screen dryings; the other fabrics showed no significant differences.

Thickness. The thickness of the fabrics changed during the series of launderings and dryings (Table 3). The greatest change in thickness was in fabric B, from 0.017 to 0.028 inch; the least change in fabric E, from 0.019 to 0.026 inch after 40 tumbler dryings. After 40 screen dryings the greatest change was from 0.017 to 0.026 inch in fabric B; the least change, from 0.019 to 0.024 inch in fabric E. The thickness of the fabrics after 40 tumbler dryings was greater than the thickness of the fabrics after 40 screen dryings.

Dimensional Stability. The fabrics of each brand of T-shirt showed similar characteristics in dimensional change lengthwise. The initial shrinkage was great in all brands and by both methods of drying as compared to the measurement of the fabrics as

Table 3. Amount of twist in yarns and thickness of fabrics.

Brands	Turns per inch as purchased	Thickness in inches		
		as purchased	40 tumbler dryings	40 screen dryings
A	34.9	0.018	0.027	0.025
B	41.1	0.017	0.028	0.026
C	35.9	0.017	0.026	0.025
D	37.1	0.017	0.026	0.025
E	41.9	0.019	0.026	0.024
F	27.5	0.021	0.030	0.028
G	34.2	0.018	0.026	0.024
H	34.1	0.017	0.027	0.025
J	33.4	0.017	0.027	0.025

purchased. The shrinkage during the first laundering ranged from 7 to 14 per cent lengthwise in the tumbler dried fabrics and from 7 to 13 per cent in the screen dried fabrics (Table 4). In general the fabrics continued to shrink during the series of launderings with most of the fabrics tending to stabilize after 20 launderings. The tumbler dried fabrics tended to be more stable than the screen dried fabrics but even so, the shrinkage was excessive. The lengthwise shrinkage after 40 tumbler dryings ranged from 13 to 21 per cent and after 40 screen dryings, from 11 to 19 per cent. After the first laundering, fabrics F and G had the least lengthwise shrinkage, 7 per cent, when tumbler dried and fabric B had the greatest lengthwise shrinkage, 15 per cent, when tumbler dried. After the first laundering, fabric E had the

Table 4. Percentage lengthwise shrinkage of T-shirt fabrics after 1, 3, 5, 10, 20, 30, and 40 dryings.

Brands	1	3	5	10	20	30	40
			Tumbler drying				
A	12	14	15	17	19	19	19
B	15	16	17	20	21	21	21
C	8	11	11	14	15	15	15
D	10	11	12	14	15	15	15
E	8	9	9	12	12	13	13
F	7	8	9	11	12	13	13
G	7	9	10	13	14	14	14
H	12	13	14	15	16	17	18
J	11	14	15	18	20	19	19
			Screen drying				
A	13	15	14	15	15	17	17
B	13	16	16	17	18	18	19
C	8	11	10	11	12	15	13
D	8	11	10	12	13	14	14
E	7	8	8	9	10	11	11
F	8	11	11	11	13	14	14
G	9	11	13	13	14	15	14
H	11	13	12	14	14	15	15
J	12	13	12	13	15	15	16

least lengthwise shrinkage, 7 per cent, when screen dried and fabrics A and B the greatest lengthwise shrinkage, 13 per cent,

when screen dried. After 40 tumbler dryings, fabrics E and F had the least lengthwise shrinkage or 13 per cent. The greatest lengthwise shrinkage occurred in fabric B, 21 per cent. After 40 screen dryings, fabric E had 11 per cent shrinkage, the least shrinkage; after 40 screen dryings, fabric B had the greatest shrinkage, 19 per cent.

The graphic picture of the lengthwise dimensional change of the fabrics shows the effect that the two methods of drying had on the fabrics (Fig. 1). Fabric A reached apparent stability after 20 tumbler dryings. Screen drying seemed to create more irregularity in dimensional change and stability was not reached until after 30 screen dryings. Fabric B reached apparent stability after 20 tumbler dryings but never seemed to reach a point of stability by screen drying. Fabric C reached apparent stability after 20 tumbler dryings; however, when screen dried, the fabric was most unstable dimensionally. Fabric D reached apparent stability after 20 tumbler dryings; however, screen drying seemed to create more irregularity and stability was not reached until after 30 screen dryings. Fabric E showed little variation throughout the series of launderings and dryings. In fabric F the screen dried fabric shrank more than the tumbler dried fabric; only after the tenth laundering was the shrinkage the same by both tumbler drying and screen drying; at all the other periods the screen dried fabric showed greater shrinkage. Fabric G reached apparent stability after 20 tumbler dryings but did not stabilize by screen drying. The shrinkage of fabric H increased after each period of tumbler drying; however, reached apparent

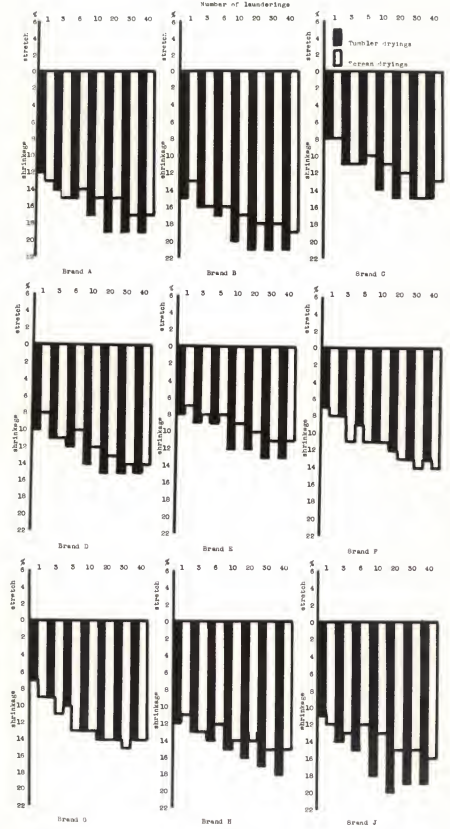


Fig. 1. Percentage lengthwise dimensional change of T-shirt fabrics after 1, 3, 5, 10, 20, 30, and 40 tumbler dryings and screen dryings.

stability after 30 screen dryings. Fabric J seemed to reach stability after 30 tumbler dryings, however, never stabilized by screen drying.

Widthwise shrinkage occurred in the fabrics of all the brands after the first tumbler drying and screen drying. The range of the widthwise shrinkage during initial drying was from 1 to 8 per cent for tumbler dried fabrics and from 1 to 9 per cent for screen dried fabrics (Table 5). Throughout the series of dryings the dimensional change for many of the brands showed less shrinkage after the first drying, indicating stretch in the fabrics after the initial shrinkage. The widthwise dimensional change after 40 dryings ranged from 8 per cent shrinkage to 2 per cent stretch, tumbler dried, and from 7 per cent shrinkage to 9 per cent stretch, screen dried. After the first laundering, the least widthwise shrinkage was in fabric F, 1 per cent when tumbler dried. Fabric H had the greatest widthwise shrinkage, 8 per cent after one tumbler drying. The screen dried fabric B had the least shrinkage of 1 per cent. The greatest shrinkage, 9 per cent, was after one screen drying of fabric H. After 40 tumbler dryings, fabric F had the least stretch of 1 per cent. Fabric H had the greatest shrinkage of 8 per cent after 40 tumbler dryings. Fabrics E and G had the least shrinkage of 1 per cent after 40 screen dryings. Fabric A had the greatest shrinkage of 7 per cent after 40 screen dryings. Some stretch occurred in the widthwise direction of fabrics B, F, and J during 40 launderings and dryings. Stretching occurred in fabrics B and F in both tumbler dried and screen dried fabrics. Fabric F had the least

Table 5. Percentage widthwise shrinkage or stretch of T-shirt fabrics after 1, 3, 5, 10, 20, 30, and 40 dryings.[1]

Brands	1	3	5	10	20	30	40
			Tumbler dryings				
A	5	4	5	5	5	5	5
B	2	1*	1*	0	2*	1*	2*
C	5	4	3	4	3	3	5
D	6	4	5	5	4	5	5
E	3	1	1	2	2	1	1
F	1	0	1*	1*	1*	1*	1*
G	5	5	4	5	4	4	4
H	8	7	7	8	8	8	8
J	7	4	3	5	4	4	4
			Screen dryings				
A	7	7	6	6	5	7	7
B	1	1*	2*	5*	7*	7*	9*
C	7	8	7	7	7	6	5
D	7	6	5	5	4	4	4
E	3	2	2	1	2	2	1
F	2	0	1*	1*	1*	1*	1*
G	6	5	4	4	2	2	1
H	9	9	8	8	8	8	6
J	4	3	3	1	1	1*	3*

[1] Figures indicate percentage shrinkage except when followed by an asterisk (*) which indicates percentage stretch.

stretch, 1 per cent, and fabric B the greatest stretch, 9 per cent, after 40 screen dryings. Fabric J after 40 screen dryings had a 3 per cent widthwise stretch.

The graphs of the widthwise dimensional change of the fabrics are shown in Fig. 2. In general, the fabrics stretched after shrinking in the first laundering in both methods of drying. Fabric A shrank less and was more stable when tumbler dried than when screen dried. Fabric B showed less dimensional change when tumbler dried than when screen dried. Fabric C shrank less and showed more stretch when tumbler dried until the 40th drying when the shrinkage by both methods was the same. At first, fabric D showed less shrinkage and more stretch when tumbler dried; however, after 30 and 40 tumbler dryings, it showed greater shrinkage than when screen dried. The greatest shrinkage of fabric E was after one drying and thereafter the dimensional change was very little by either method of drying. Fabric F shrank during the first laundering by both methods and then the fabric stretched after both series of tumbler dryings and screen dryings. Fabric G showed the greatest shrinkage after one drying; however, after 40 dryings, the fabric showed more stretching than after 40 tumbler dryings. Fabric H showed less irregularity in shrinkage and stretch when tumbler dried than when screen dried. Fabric J when screen dried showed more stability than when tumbler dried.

Measurements of the T-Shirts. In general, the percentage change in the measurements of the T-shirts was greater than the percentage of dimensional change of the areas marked on the fabrics. One reason for the difference may be due to the fact that

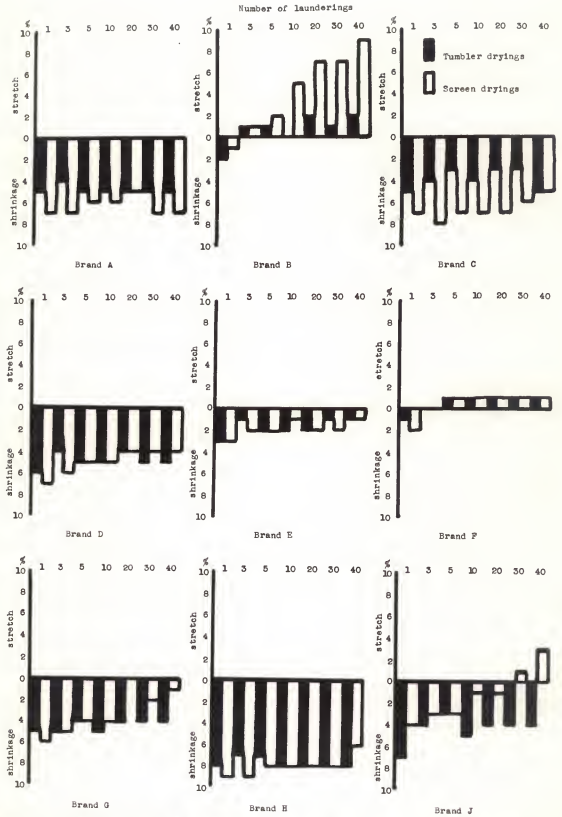


Fig. 2. Percentage widthwise dimensional change of T-shirt fabrics after 1, 3, 5, 10, 20, 30, and 40 tumbler dryings and screen dryings.

the T-shirts were not cut true, making it almost impossible to measure the length and width of the T-shirts following the grain of the wales and courses. The T-shirts that showed the least shrinkage in length after 40 tumbler dryings were E and G; they shrank 16 per cent, a loss of 3.4 and 3.2 inches, respectively. The T-shirts that shrank the most in length were B and J, 27 per cent, a loss of 5.4 and 5.6 inches, respectively. The T-shirt that shrank the least in width after 40 tumbler dryings was F, 1 per cent, a loss of 0.4 inch. The T-shirt that shrank the most in width was H, 11 per cent, a loss of 2.8 inches. The most stretch in width after 40 tumbler dryings was B, 2 per cent, a gain of 0.6 inch (Table 6).

The T-shirt that showed the least shrinkage in length after 40 screen dryings was E, 14 per cent, a loss of 3.7 inches. The greatest shrinkage was in T-shirt H, 27 per cent, a loss of 5.6 inches. The T-shirt that showed no change in width after 40 screen dryings was G. The T-shirt that shrank the most widthwise was H, 9 per cent, a loss of 2.4 inches. The T-shirt that stretched the most in width was B, 6 per cent, a gain of 2.2 inches. T-shirt B, which showed the greatest dimensional change, is pictured in Plate III. T-shirt E, which showed the least dimensional change, is pictured in Plate IV.

Table 6. Measurements of T-shirts as purchased and after 40 dryings with percentage change.[1]

Brands	As purchased in inches		Dryings in inches		Dimensional change in per cent	
	Length	Width	Length	Width	Length	Width
			40 tumbler dryings			
A	21.8	27.0	16.8	25.8	23	4
B	20.0	28.2	14.6	28.8	27	2*
C	20.2	27.2	16.2	25.4	18	6
D	22.3	25.8	17.8	24.0	20	6
E	20.4	27.6	17.0	26.8	16	6
F	22.2	28.8	18.3	28.4	18	1
G	20.4	26.0	17.2	24.6	16	5
H	19.2	24.8	14.8	22.0	23	11
J	20.4	26.0	14.8	24.8	27	5
			40 screen dryings			
A	22.1	27.0	17.4	25.6	22	5
B	20.2	28.4	15.0	30.2	25	6*
C	20.1	25.8	16.3	23.6	19	8
D	22.4	26.0	18.2	24.0	19	8
E	20.5	28.0	17.6	27.4	14	2
F	22.3	28.6	18.6	28.4	17	0
G	21.9	29.2	17.5	27.8	16	4
H	20.7	25.6	15.1	22.2	27	9
J	20.0	26.8	16.0	26.2	20	2

[1] All percentages indicate shrinkage except those marked with an asterisk (*) which indicates stretch.

EXPLANATION OF PLATE III

Fig. 1. Brand B, tumbler dried 40 times.

Fig. 2. Brand B, as purchased.

Fig. 3. Brand B, screen dried 40 times.

PLATE III

Fig. 1 Fig. 2 Fig. 3

EXPLANATION OF PLATE IV

Fig. 1. Brand E, tumbler dried 40 times.

Fig. 2. Brand E, as purchased.

Fig. 3. Brand E, screen dried 40 times.

PLATE IV

Fig. 1 Fig. 2 Fig. 3

SUMMARY AND CONCLUSION

The purpose of this study was to determine the effects of laundering on the fabrics of nine brands of T-shirts; to determine the dimensional change which occurred in the fabrics after a series of launderings; and to compare the results of tumbler drying and screen drying.

The results indicate:

1. After 40 tumbler dryings, the fabrics generally had a greater number of wales per inch than after 40 screen dryings. Fabrics C, G, and J had a significantly greater number of wales per inch after 40 tumbler dryings than after 40 screen dryings. By both methods of drying, fabrics D and E showed the greatest number of wales per inch; the next greatest number of wales per inch were fabrics A, C, and G; fabrics B, F, H, and J had the smallest.

2. In fabrics B, C, D, G, and H the number of courses per inch were significantly greater after 40 tumbler dryings than after 40 screen dryings. By both methods of drying, fabric E showed the greatest number of courses per inch; fabrics A, C, and D showed the next highest number of courses per inch; all other fabrics were about equal.

3. All fabrics lost in bursting strength after 40 dryings. Fabric F had the highest bursting strength; fabrics E and H were about equal and next highest; fabric A was next to the weakest, with fabric B the weakest.

4. All fabrics increased in thickness after 40 dryings.

Fabric F was the thickest and also had the greatest bursting strength. However, the weakest fabrics were not the thinnest fabrics.

5. In general, the fabrics had greater lengthwise shrinkage after 40 tumbler dryings than after 40 screen dryings. However, the fabrics screen dried had less stability than fabrics tumbler dried. Fabric B had the greatest lengthwise shrinkage after 40 dryings; fabrics A, H, and J were about equal and next in amount of shrinkage; fabrics C, D, F, and G were about equal and next in amount of shrinkage; fabric E had the least lengthwise shrinkage.

6. In general, the fabrics had greater widthwise shrinkage and less widthwise stretch after 40 tumbler dryings than after screen dryings. However, the fabrics screen dried had less stability than fabrics tumbler dried. Fabrics A and H had the most widthwise shrinkage; fabrics C and D were about equal and had the next greatest widthwise shrinkage; fabrics E, G, and J were about equal with the least widthwise shrinkage. Fabric F had the least widthwise stretch, fabric B, the greatest.

7. All the tumbler dried fabrics did not show greater shrinkage than the screen dried fabrics after 40 dryings. The tumbler dried fabrics showed more stability during the series of dryings than did the screen dried.

8. The measurements of the T-shirts showed dimensional changes similar but greater than the dimensional changes of the areas marked on the fabrics after 40 tumbler dryings and 40 screen dryings.

9. The fabric and T-shirts of brand B had the greatest

dimensional change and the fabric and T-shirts of brand E had the least change after 40 tumbler dryings and 40 screen dryings.

10. After the series of dryings, the fabric that was weakest and that showed the greatest dimensional change was B, a fabric in the low price level. After the series of dryings, fabric F was the strongest, and fabric E showed the least dimensional change. Both fabrics were in the medium price level.

In conclusion, the effects of laundering and drying on the fabrics of the T-shirts were a decrease in bursting strength; an increase in thickness; an excessive dimensional change due to the instability of the wales and courses.

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THE DIMENSIONAL STABILITY OF TUMBLER DRIED AND SCREEN DRIED COTTON T-SHIRTS

by

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INTRODUCTION

Little research has been done on the factors contributing to the dimensional stability of T-shirts. The cotton T-shirt is constructed of circular flat knit fabric and the closeness of the texture varies by the number of wales and courses per inch. The purpose of this study was to determine the effects of laundering on the fabrics and on the dimensional stability of T-shirts of selected brands, to determine the changes which occurred in the fabrics after a series of launderings, and to compare the results of tumbler drying and screen drying.

METHODS OF PROCEDURE

Nine brands of white cotton T-shirts for boys were selected and purchased locally. The fabrics of the T-shirts were tested according to standard procedures of the American Society for Testing Materials, Committee D-13. The measurements of the T-shirts conformed to the Commercial Standard CS146-55. The fabric of each brand of T-shirt was analyzed, as purchased, for the number of wales and courses per inch, thickness, twist, and bursting strength. Measurements were taken of the T-shirts, as purchased.

Ten, 10-inch distances were marked on each T-shirt in both the lengthwise and widthwise directions. T-shirts of each brand were washed in an automatic type washing machine. One of each brand was dried in a hot air tumbler dryer and one or horizontal screens. The marked areas of the fabrics were measured for percentage dimensional change after 1, 3, 5, 10, 20, 30, and 40

launderings and dryings.

After 40 tumbler dryings and 40 screen dryings, the fabrics of the T-shirts were analyzed for the number of wales and courses, thickness, and bursting strength. The T-shirts were measured after 40 tumbler dryings and 40 screen dryings.

FINDINGS AND SUMMARY

The yarn in the fabric of all the brands was single with a "Z" twist. The fabric of the T-shirts, as purchased, was not balanced as to the wales and courses per inch; in all cases the number of courses per inch exceeded that of the number of wales per inch. After 40 tumbler dryings, the number of wales and courses per inch was generally higher than after 40 screen dryings.

The bursting strength of the fabrics of the T-shirts, as purchased, varied. All fabrics decreased in bursting strength after 40 launderings, tumbler dried or screen dried. The fabrics of some brands showed a greater loss in bursting strength after 40 tumbler dryings; other brands showed a greater loss after 40 screen dryings.

The fabrics of each brand of T-shirts increased in thickness after 40 dryings with the tumbler dried fabrics showing the greatest increase in thickness.

In general, the fabrics had greater lengthwise shrinkage after 40 tumbler dryings than after 40 screen dryings, and had greater widthwise shrinkage and less widthwise stretch after 40 tumbler dryings than after 40 screen dryings. However, the

fabrics screen dried had less stability through the series of launderings and dryings than the tumbler dried fabrics.

The measurements of the T-shirts showed dimensional change similar to, but greater than, the dimensional change of the areas marked on the fabrics.

It may be concluded that: (1) the effect of laundering on the fabrics of the T-shirts was significant, (2) the difference between the fabrics tumbler dried and screen dried was not great enough to recommend one method of drying over the other.