# A COMPARATIVE EVALUATION OF DRYING TREATMENTS ON A 65/35 POLYESTER/COTTON BLEND FABRIC WITH PERMANENT PRESS AND SOIL RELEASE FINISHES

by

Constance Annette Hanson

---

A Thesis Submitted to the Faculty of the

SCHOOL OF HOME ECONOMICS

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 6 9

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Constance R. Hanson

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Mary Jean Wylie

Mary Jean Wylie
Assistant Professor of
Home Economics

August 5, 1969

Date

## ACKNOWLEDGMENTS

The author is deeply indebted to Miss Mary Jean Wylie, Assistant Professor of Home Economics, for her helpful suggestions and guidance given so freely throughout the entire project.

Additional acknowledgment is due Mr. Carl N. Hodges, Environmental Research Laboratory, Institute of Atmospheric Physics, Dr. William D. Sellers, Meteorology, Dr. Carl T. Tomizuka, Solid State Physics, and Dr. Robert C. Angus, Agriculture Economics, for all their assistance.

Appreciation is extended to Dr. Robert O. Kuehl and to Dr. Alan B. Humphrey, Agriculture Experiment Station Statisticians, who were instrumental in the presentation of statistical data.

A sincere thank you is given to Mrs. Lettie B. Noe, Mrs. Shirley Fortouw, and Mrs. Sue Stanley, all graduate students in home economics, who assisted in the fabric appearance evaluations.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

LIST OF TABLES

## LIST OF ILLUSTRATIONS

ABSTRACT

Specimens of 65/35 polyester/cotton fabric were washed and/or dried under various conditions. The white broadcloth, with permanent press and soil release finishes, was dried in the dryer, line dried inside, and line dried outside. These fabrics were subsequently tested with regard to appearance, weight, tear strength, and wrinkle recovery.

Fabric appearance ratings, as anticipated, placed the dryer dried samples higher than those line dried. Weight loss was significant in the washed samples when compared with the unwashed samples.

Tear strength and wrinkle recovery indicated the most unexpected results. The fabrics dried for four hours in high radiation conditions were stronger than those dried for shorter periods and/or lower radiation. Also, wrinkle recovery angle was greater in the four hour high radiation treatment than in the other treatments.

# CHAPTER 1

# INTRODUCTION

## Purpose of the Study

The purpose of this study was to determine the effect of various drying treatments on a 65/35 polyester/cotton blend fabric with permanent press and soil release finishes. The fabrics were subsequently tested with regard to appearance, weight, tear strength, and wrinkle recovery.

## Importance of the Study

Permanent press fabrics, initially in one hundred percent cotton garments, brought anticipations that the problems of wash-and-wear were finally overcome (5,9,32). The exaggerated performance claims from manufacturers of wash-and-wear disappointed homemakers (5,32). They hoped that the permanent press garments would be the answer to the drudgery of ironing (9,11,13).

The permanent press fabrics had many good qualities, but they created additional problems for the manufacturer and consumer (31,32). Strength loss of cellulosic fibers was one of the problems encountered from the resin application (12,15,32).

Resin finishes are used to give the wrinkle free quality to permanent press fabrics (5,9,33). This finish

results from the resin application and a curing method. The process significantly reduces cellulosic fabric tear strength (12,15,31). Blending polyester with cotton is one way of reducing the strength loss. This combination is the most widely used (9,14,32).

Polyester fibers are desirable in fabric with a permanent press finish because tear strength is not significantly reduced by resin application (5,12). They are, however, hydrophobic or water repelling as well as oleophilic or oil attracting (13,14,20). The addition of a soil release finish reduces the oil attraction problem of this generic group (22,23).

Soil release finishes were developed as a result of wet soil redeposition on permanent press fabrics, especially those fabrics containing polyester fiber (14,20). Soil release finishes facilitate removal of stains during the laundry process because water and detergent can enter fabric more easily (11,22).

Fabric appearance, as indicated by the amount of wrinkling, is dependent upon the laundering method employed. Full benefit of finishes results from sound laundering procedures (17,20). Manufacturers indicate that no ironing is required if their care instructions are followed. Their directions state that optimum results are obtained by tumble drying (11,17).

The manner of drying items in homes varies greatly because manufacturers instructions are not followed. Homemakers often do not care to launder as suggested, wish to proceed with past habits, or do not have the adequate or proper facilities available to them (19).

## Objective of the Study

Because drying methods vary greatly, was the purpose of this study to determine the effect of various drying treatments on a 65/35 polyester/cotton blend fabric with permanent press and soil release finishes. The effect of various drying treatments on appearance, weight, tear strength, and wrinkle recovery of the fabric was evaluated with special emphasis on outside line drying.

## Limitations of the Study

Special emphasis was placed on outside line drying because of the need for practical consumer-oriented research in Arizona. The majority of Arizona households are without automatic clothes dryers; therefore, this research was aimed toward this group (35).

Twenty-five launderings (washing and/or drying) was chosen as the termination point. Tide XK was chosen by the researcher since it is available to consumers.

## Hypotheses

Fabric appearance, weight, tear strength, and wrinkle recovery are influenced by method of drying, length of outside drying time, and total sun radiation received.

The twenty-five launderings given samples will adversely affect fabric appearance, weight, tear strength, and wrinkle recovery.

Outside line drying will not substantially change fabric appearance, but will reduce tear strength and wrinkle recovery.

Washing will change fabric appearance, reduce weight, reduce tear strength, and reduce wrinkle recovery.

## Definition of Terms

1. Appearance - the amount of wrinkles (creases or ridges) on fabric surface.

2. Buffers - additional fabric pieces (dummies) 36 inches x 36 inches, identical to test fabric, which are added to wash cycle to maintain a 4 pound load.

3. Conditioning - stabilizing fabric at 70' $\pm$ 2' F. and 65 percent relative humidity $\pm$ 2 percent.

4. Control - sample used for comparison purposes which does not undergo washing or drying.

5. Hand anemometer - an instrument for measuring and indicating the velocity of air currents in miles per hour (m.p.h.).

6. High radiation period - solar radiation on the earth's surface from 11:00 a.m. to 3:00 p.m. solar time.

7. Langley - the amount of solar radiation equivalent to one gram-calorie per square centimeter received on a horizontal surface at ground level.

8. Low radiation period - solar radiation on the earth's surface from 6:30 a.m. to 10:30 a.m. solar time.

9. Permanent press finish - a finish which gives fabric the ability to resist wrinkling and to retain its shape-holding property throughout its wear life.

10. Sample - the three replications in each treatment.

11. Sling psychrometer - a hygrometer comprised of two thermometers, one wet and one dry bulb, which indicates air temperature and relative humidity.

12. Soil release finish - a finish which allows absorption of water and stains into fabric and facilitates their removal during laundering.

13. Solar time - actual sun time based on high point of sun radiation as 12 noon; varied between minus 20 and minus 24 minutes from Mountain Standard Time for this study (36).

14. Subjective evaluation - the personal judgment by three graduate home economics students with regard to fabric appearance.

15. Tear strength - the amount of tearing resistance which a fabric is able to withstand.

16. Trained observer - a person (expert) having adequate textile background to be deemed qualified to perform subjective tests on fabric appearance.

17. Treatment - the method of washing and/or drying samples; three samples (replicates) comprised each of the nine treatments.

18. Weight - the number of grams or ounces per linear yard.

19. Wrinkle recovery - the percent of recovery resulting from creasing.

# CHAPTER 2

## REVIEW OF LITERATURE

Today's consumer wants garments that will launder easily and return to their original appearance with minimal effort (31). Homemakers found no-iron claims of wash-and-wear to be misleading; therefore, the advent of the permanent press finish brought much skepticism of its care qualities. Because previous exaggerated promises of wash-and-wear disappointed the homemaker, confusion and doubt prevailed when the fabrics with the permanent press finish were first introduced (15,17).

### Permanent Press Finish

Many definitions and explanations about permanent press finishes are available (8,13,31,33).

Permanent press fabrics, first introduced in 1964, should not be confused with the earlier wash-and-wear fabrics. Permanent press is a finish which gives fabric the ability to resist wrinkling and to retain its shape-holding property throughout its wear life (33).

Specific properties of permanent press fabrics can be achieved in various ways: post-cure, pre-cure, re-cure, and no-cure (8). Success and stability in production of these methods, as well as other newer or experimental

methods, are dependent upon the textile industry. They are responsible for agreement of performance standards. Satisfactory performance begins with industry, but it is also influenced by consumer laundering methods (19,30).

One hundred percent cotton, first used in the manufacture of permanent press garments, was undesirable because of tear strength reduction of thirty-five to fifty percent (15). Polyester fiber tear strength was unaffected by the permanent press finish; therefore, it was blended with cotton. Polyester fibers were added to cellulosic fibers to improve tear strength, wrinkle resistance, and abrasion resistance. This blend met all performance specifications and appeared unlimited in end use possibilities (3,14,22,32).

Consumer satisfaction of polyester/cotton blends of the permanent press finished fabric was very good. Industry experimentation developed a new finish to aid the consumer in care of fabrics.

## Soil Release Finish

The first soil release finish was announced in June, 1966 (22). During the interim, many systems have been developed.

These finishes involve four aspects: (1) soil repellency, (2) soil release, (3) soil redeposition, and (4) anti-static. The soil release systems are of two general types. In one a film is created in which oil or water-borne

stains float away. The other results in a changed surface. This chemical reaction alters the polyester fiber from hydrophobic (water repelling) and oleophilic (oil attracting) to hydrophilic, plus reducing the oil problem. The laundry process is aided since the soil release system allows water and detergent to more easily enter fabric and remove stains (3,22).

Laundry procedures have been aided because of this finish. Previous problems of retaining oil-borne stains have been significantly reduced with the advent of the soil release finish. Because of these finishes, polyester closely resembles the ideal fiber (9,32).

As previously mentioned, satisfactory performance of permanent press is dependent upon the laundering method employed.

## Weathering

Outside drying of fabrics varies with use and laundering methods. Although most textiles are not constantly exposed to sunlight, they are usually exposed sometime during use and wear (10). Because textiles receive radiation at some point, many outdoor exposure tests have been undertaken in the past (16,25,26,28).

Outside drying, or weathering, of cellulosics have been studied in detail (4,19,26,27). Photochemical or fabric degradation of cellulosic fabrics has been studied since

the 1920's. At that time there was questionable evidence about degradation by weathering. Weathering is " . . . the aggregate effect of environmental factors of sunlight, microorganisms, industrial fumes, rain, and wind" (16, p. 75).

Outdoor exposure tests should provide direct correlation with deterioration of textiles in use. Because of uncontrollable variables, a standard weathering pattern does not exist; therefore, results are never precisely predictable or reproducible (16,26). They are valid only for the particular conditions, time and place of exposure. Since climatic conditions vary, published data of weathering varies (26). Present field exposure tests are the most widely accepted method in testing textiles for degradation. They only indicate the relative value (16).

Artificial sunlight, although constant and easily controlled, has substantial disadvantages (10). Laboratory methods do not correlate with outdoor exposure (26). Ideally, effects such as " . . . weather, . . . temperature, moisture, wind, and . . . contaminants" should be correlated. This integrating may be possible someday (4, p. 55).

Measurement of solar radiation was done in the past only by the sun-hour method. Experiments based on time alone are not considered valid, reproducible, or repeatable (27). There is no standard sunlight test (26). The langley,

the only accurate and most widely used measure of total incident radiation, measures the amount and intensity of solar radiation (3,27). "One langley is = 1 gram calorie of radiant energy per square centimeter of exposed area, or 3.69 Btu's per square foot" (4, p. 55).

The Eppley pyroheliometer, which measures solar radiation by langleys, is used by the United States Weather Bureau. It's accuracy, according to the manufacturer, is ± 1½ percent (4).

Light rays in solar radiation are thought the greatest cause of weathering (4). The absorption of light rays may change the molecular structure of textiles. Light may be reflected, transmitted, or absorbed depending upon the textile capacity to absorb the energy of the light rays. Fabric degradation is dependent on the concentration of dye or pigment, yarn, and fabric construction (10,16).

Radiation wave length and associated energy decreases as wave length increases (10). Radiation, or light traveling in the form of waves, is subject to variations in intensity and distribution (10,26). These depend on "season of year, time of day, altitude . . ., amout (sic) of water vapor, dust, and other absorbing materials in the atmosphere . . ." (26, p. 18).

Photochemical reaction is of two types: photolysis (chemical decomposition) and photosensitization. Heat,

which involves light, is not photochemical since light is not absorbed (10,26). "The amount of light converted to thermal energy is absorbed radiation" (26, p. 20). In degradation by heat the maximum temperature occurring during radiation is probably most meaningful (28). Heat, while not photochemical in nature, does not cause light to be absorbed. But, cellulosic degradation occurs because of an increased rate of chemical reaction (10,26).

Photosensitization, with an impurity in the cellulosic fabric which carries the light energy, varies depending on moisture and oxygen present (10,26). Degradation increases with moisture, especially with alternate wetting and drying cycles (13). Damage to cellulosics can be measured by breaking strength loss, cuprammonium fluidity, methylene blue number, tearing strength, etc. Degradation of noncellulosic textiles is presently limited to measuring tensile (tear) strength (26).

# CHAPTER 3

## METHODS AND PROCEDURE

### Introduction

The objective of this study was to determine the effect of various drying treatments on a 65/35 polyester/cotton blend fabric with permanent press and soil release finishes. The effect of these drying treatments on appearance (as indicated by wrinkling), weight, tear strength, and wrinkle recovery was determined.

### Selection and Preparation of Samples

The chosen test fabric was white broadcloth of 65 percent Dacron, polyester and 35 percent cotton with a pre-cured permanent press finish and a soil release finish. The bolt of fabric was purchased at a department store in Tucson, Arizona. Fabric weight had a mean 3.826 ounces per linear yard with an average thread count of 132 in the warp direction and 71 in the filling direction.

Twenty-seven samples, each 29 inches in the warp direction and 23 inches in the filling direction were used in the study. Nine treatments, each with three samples (replications), comprised the fabric for the research. All were from the same bolt of fabric and chosen at random for placement in one of the nine treatments.

All samples were torn on warp and filling threads and zig zagged on the edges to prevent fraying. Two small pockets, plus additional elastic thread, were sewn in the upper right hand area of the samples which were to be hung outside. The pockets were used to hold thermometers and did not interfere with areas reserved for laboratory testing of fabrics (see Figure 1).

Three control samples, to be used for comparison purposes, were withdrawn immediately after cutting.

## Washing Procedure

Six treatments, or eighteen samples, were washed for a total of twenty-five times. The following washing procedure was used for all treatments.

A 1967 Whirlpool top-loading automatic washer (Model LSA 99220) was used. Settings used were: permanent press 6 minute wash; hot water, cold rinse; high agitation; high spin; high water level.

Well water from the University of Arizona water system was used. Temperature was checked with an electronic thermometer and washing began when water was 140' $\pm$ 2' F. Three-quarters cup of Tide XK, nonionic biodegradable detergent, was added to each washer load.

The load consisted of nine samples, each 29 inches x 23 inches, weighing approximately one and one-half pounds. Fifteen buffers (dummies), identical with test fabric, were

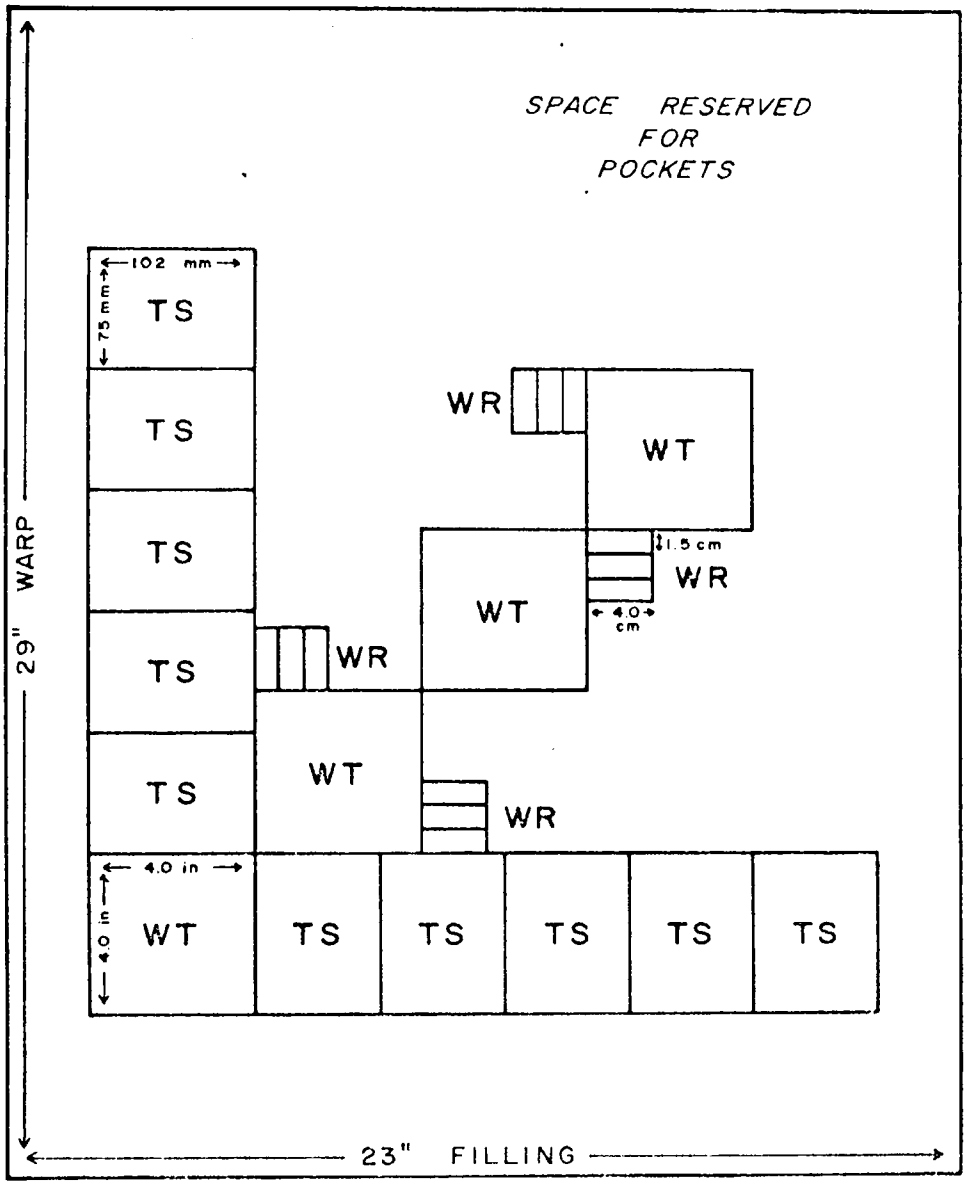


Fig. 1. Cutting Diagram (W = Weight, TS = Tear Strength, and WR = Wrinkle Recovery)

added. These 36 inch x 36 inch buffers weighed approximately two and one-half pounds, bringing the total wash load to approximately four pounds.

In filling the washer the hot setting was alternated with the warm setting until the desired 140° F. was reached. Detergent, added after tub was full, was allowed to agitate until powder appeared dissolved. The samples and buffers were then added to the machine.

A water sample was taken from that entering during the fill cycle of each washer load. It was used to determine hardness in grains per gallon (see Appendix A). Monthly, a water sample was taken from tap entering tub and analyzed for the following: soluble salts, EC x $10^3$, Calcium, Magnesium, Sodium, Chloride, Sulfate, Carbonate, Bicarbonate, Fluoride, Nitrate, Nitrogen, Boron, Copper, Iron, Silicon dioxide, hardness, and pH (see Appendix B).

## Drying Procedure

Samples were given various drying treatments, one of which was tumble drying. This was done in a 1967 Whirlpool dryer (Model LSE 9920). Settings used were: regular permanent press with gentle agitation; 20 minutes with last 10 minutes being a cool-off period. Each dryer load contained 3 samples and 15 buffers.

A second drying treatment was inside line drying. Samples were hung individually from hangers by clothespins.

No attempt was made to record or change conditions of drying room.

Four treatments involved washing and subsequent outside line drying. Each treatment, composed of three samples, was taken to the roof of the home economics building immediately after washer completed cycle.* They were hung in the same order and in the same position on line each time. The four outside drying times for the washed treatments were: (D) 1 hour ± 5 minutes at low radiation; 6:30 a.m. - 7:30 a.m. solar time; (E) 4 hours ± 5 minutes at low radiation; 6:30 a.m. - 10:30 a.m. solar time; (F) 1 hour ± 5 minutes at high radiation; 11:00 a.m. - 12 noon solar time; and, (G) 4 hours ± 5 minutes at high radiation; 11:00 a.m. - 3:00 p.m. solar time (see Appendix F).

Two treatments, involving six samples, underwent outside drying without washing. They were hung at the same time as were the washed samples, with unwashed samples placed on line immediately behind washed samples. Drying times for these were identical with the longer times previously given: (E) 4 hours ± 5 minutes at low radiation;

---

*All outside line drying was done on clothesline facing due South on roof of home economics building at the University of Arizona, Tucson, Arizona D Sec. 7, Twp. 14 S, R 14 E, NE section of SE quadrant. The building was 139' in height, with the clothesline 47 5/8" in height and having 24½" between lines.

6:30 - 10:30 a.m. solar time and (G) 4 hours ± 5 minutes at high radiation, 11:00 a.m. - 3:00 p.m. solar time.

Fabric and environmental factors which were consistently checked at predetermined times were: (1) sample temperature with a thermometer in aforementioned pocket, (2) air temperature with a sling psychrometer, (3) relative humidity with a sling psychrometer, and (4) wind velocity with a hand anemometer (see Appendices C and D). Total incident sun radiation for each drying period was also recorded by an Eppley pyroheliometer at the Environmental Research Laboratory, University of Arizona (see Appendix E).

Data collection began on April 19, 1968 and continued until June 12, 1968. Each treatment received twenty-five washings and/or dryings (excluding control) with a one to five day rest period between each laundering. During the rest period samples were hung from hangers and surrounded with a plastic bag.

Coding of samples is listed in Table I. Replicates of each treatment were listed as $A_1$, $A_2$, $A_3$, and B, etc.

## Laboratory Procedure

All laboratory testing was done under standard atmospheric conditions of 70' ± 2' F. and 65 ± 2 percent relative humidity.

TABLE I

CODING OF FABRIC SAMPLES

| Treatment | Description |
|---|---|
| A | Control |
| B | Washed, dryer dried |
| C | Washed, inside line dried |
| D | Washed, outside dried, 1 hour, low radiation |
| E | Washed, outside dried, 4 hours, low radiation |
| F | Washed, outside dried, 1 hour, high radiation |
| G | Washed, outside dried, 4 hours, high radiation |
| H | Unwashed, outside dried, 4 hours, high radiation |
| I | Unwashed, outside dried, 4 hours, low radiation |

Appearance

The surface appearance of the treatments was evaluated after all launderings were completed. Control samples were evaluated for comparison purposes. AATCC 124-1967 T was used with the following procedures utilized: (1) washing procedure III; machine, 140' F. with variation in rinse temperature (130' - 140' F. instead of suggested 105' F.) ± 5' F., (2) drying procedure A and B (line dry inside and tumble dry), there were no instructions for outside line drying, and (3) evaluation procedure: low-angle using AATCC three-dimensional plastic replicas as standards (see

Table II). The three samples, 29 inches x 23 inches instead of the suggested 15 inches x 15 inches, from each treatment were used in the evaluation of surface smoothness. The trained observers evaluated the specimens by comparing them with closely matched plastic replicas. Results from the three observers were averaged to the nearest tenth of a decimal (see Table III).

TABLE II

FABRIC SMOOTHNESS RATINGS*

| Rating | Description |
|---|---|
| DP-5** | An appearance equivalent to the DP-5 Replica |
| DP-4 | An appearance equivalent to the DP-4 Replica |
| DP-3.5 | An appearance equivalent to the DP-3.5 Replica |
| DP-3 | An appearance equivalent to the DP-3 Replica |
| DP-2 | An appearance equivalent to the DP-2 Replica |
| DP-1*** | An appearance equivalent to or worse than the DP-1 Replica |

* Adapted from Table II, AATCC 124-1967T (1).

** Smoothest appearance and best retention of original appearance.

*** Poorest appearance and poorest retention of original appearance.

TABLE III

MEAN APPEARANCE OF FABRIC TREATMENTS

| Treatment | Mean Rating |
|---|---|
| A | DP-5* |
| B | DP-3.5 |
| C | DP-3 |
| D | DP-2.6 |
| E | DP-3 |
| F | DP-3 |
| G | DP-3 |
| H | DP-5* |
| I | DP-5* |

* Smoothest appearance and best retention of original appearance.

Weight

Determination of fabric weight was done by the method established by the United States Testing Company (37). Four 4-inch squares from each specimen were weighed on a Mettler balance. The ounces per square yard was determined by the formula:

$$\frac{\text{weight in grams of 4 squares}}{64} \times 45.71 = \text{ounces per square yard}$$

This was then converted to ounces per linear yard by:

$$\frac{\text{ounces per square yard} \times \text{width of fabric (45 inches)}}{36} = \text{ounces per linear yard}$$

Weight was determined and reported.

Tear Strength

Tear strength (resistance) was determined by the Elmendorf instrument, a falling pendulum type apparatus, following ASTM 1424-63 specifications. Five warp and five filling specimens, each 75 x 102 millimeters, were cut from each of the fabric samples. Grams per centimeter results were averaged separately for warp and filling. Results indicated the average work performed in tearing the specimen.

Wrinkle Recovery

Wrinkle recovery of fabrics from creasing was determined by the Monsanto Wrinkle Recovery Tester, following AATCC 1295-60 T specifications. Five warp and five filling samples, each 1.5 x 4.0 centimeters, were cut from each of the fabric samples. Long direction represented the direction of the test. The percent of crease recovery was determined by the formula:

$$\frac{\text{crease recovery}}{180} \times 100 = \% \text{ wrinkle recovery}$$

Warp and filling results were averaged separately and

reported to the nearest one percent. These results gave the percent of wrinkle recovery.

## Analysis of Data

A factorial analysis of variance was computed to determine the effect of the various treatments and the interactions of the tests conducted in this study.

Statistical analyses were not used with appearance evaluations because of their subjectivity and since near perfect judge agreement made this unnecessary (see Table III).

Water hardness readings (see Appendix A) were averaged and monthly water analysis results (see Appendix B) recorded. Total incident solar radiation, expressed in langleys, was totaled (see Appendix F). Other recorded outside environmental factors (sample temperature, air temperature, relative humidity, and wind velocity) were given in Appendices C and D. Note that no statistical analyses were done with these figures.

A lsd (least significant difference) value was established where applicable to determine the significance between treatments. In order for two values to be significantly different, their absolute difference must have been greater than the lsd value. In this study, lsd values were established at the .05 level of significance.

Spearman's coefficient of rank correlation was used to find possible correlation between the various treatments.

# CHAPTER 4

# RESULTS

## Appearance

A statistical analysis of the appearance was not necessary since all trained observers (experts) agreed in rating all treatments except in one treatment. Appearance, although evaluated under controlled conditions, was subjective.

The ratings were divided into six categories, as set up by the American Association of Textile Chemists and Colorists (AATCC), with the following smoothness ratings: DP-5, DP-4, DP-3.5, DP-3, DP-2, and DP-1. DP-5 represented the smoothest appearance and DP-1 represented the poorest appearance (see Tables II and III).

Three treatments received means of DP-5. This indicated the smoothest appearance and best retention of original appearance. They included all of the unwashed treatments--control (A), 4 hours at low radiation (I), and 4 hours at high radiation (H).

DP-3.5 mean ratings were given the dryer dried treatment (B) and mean ratings of DP-3 were given four of the washed treatments. Those receiving these were inside line dried (C), outside dried for 4 hours at low radiation

(E), outside dried for 1 hour at high radiation (F), and outside dried for 4 hours at high radiation (G).

Rating differences occurred in the treatment that was washed and outside dried for 1 hour under low radiation conditions (D). Ratings were divided between DP-2 and DP-3 with a mean of 2.6. The above mentioned treatment was the only one receiving a rating in the DP-2 category. This treatment, which caused variance in observer ratings, was the most wrinkled in the study (see Table III). As previously stated, the DP-1 rating represented the poorest appearance and poorest retention of original appearance.

## Weight

The analysis of variance F-test indicated that significant differences existed among the individual weight treatments when averaged across all treatments (see Appendix G). Because F-values were significant, specific treatment comparisons were made using the least significant difference, or lsd. Only those individual treatments that exceeded the lsd at the .05 level will be discussed. Weight lsd (.05) = .095.

A significant increase in weight over the control (A) occurred in the washed and inside line dried treatment (C).

Two treatments showed statistically significant decreases in weight when compared with the control (A).

Both 4-hour line dried treatments that were washed (E and G) had these weight changes. The decrease in weight was somewhat greater in the washed, 4-hour dried high radiation treatment (G) than in the washed, 4-hour dried low radiation treatment (E).

Several other significant differences occurred when comparing individual washed treatments with one another. There was a weight decline in the 4-hour low radiation treatment (E) over the dryer dried treatment (B). A slight weight decrease was noted in the 4-hour high radiation treatment (G) over the dryer dried treatment (B).

All of the following washed and outside dried treatments had weight decreases over the washed and inside dried treatment (C): 4-hour low radiation (E), 1-hour high radiation (F), and 4-hour high radiation (G).

Many weight changes of significant nature were found when comparing the washed and outside line dried treatments with one another. Those compared were listed together with the smaller in weight listed first. These significant weight differences included: washed and 4-hour low radiation treatment (E) weighed less than 1-hour high radiation treatment (F); 4-hour low radiation treatment (E) weighed less than 1-hour low radiation treatment (D); and 4-hour high radiation treatment (G) weighed less than 1-hour high radiation treatment (F).

Two treatments were not washed, but instead given only outside line drying. Significant, comparable differences, existed between the unwashed, 4-hour dried high radiation (H) and the washed and 4-hour dried high radiation treatments (G). The washed treatment had a weight decrease. Also, the washed, 4-hour dried high radiation treatment (E) was lower in weight than the unwashed, 4-hour dried low radiation treatment (I). Table IV shows statistical determination of significance and Appendix G shows the analysis of variance.

TABLE IV*

STATISTICAL DETERMINATION OF SIGNIFICANCE BETWEEN TREATMENTS IN WEIGHT

| Treatment | Mean (Weight in Grams) |
|---|---|
| A | 4.301 |
| B | 4.352 |
| C | 4.437 |
| D | 4.370 |
| E | 4.191 |
| F | 4.295 |
| G | 4.163 |
| H | 4.341 |
| I | 4.304 |
| lsd (.05) = .095 | |

## Tear Strength

### Warp Tear Strength

Significant differences among the various warp tear strength treatments were indicated by the analysis of variance F-test (see Appendix H). The least significant difference, lsd, was used to find specifically which treatments differed from one another. All lsd were made at the .05 level of significance with lsd (.05) = 100.721.

All eight treatments showed significant strength losses when compared with the control. Most strength loss was in the washed, 1-hour dried high radiation treatment (F) followed closely by the washed and 4-hour dried low radiation treatment (E). Two treatments tied for the next strength loss. Both the washed and dryer dried treatment (B) and the washed and 1-hour dried low radiation treatment (D) had the same mean strength loss. Somewhat less strength loss occurred in the washed and inside line dried treatment (C). The least strength loss, of the washed treatments, occurred in the 4-hour dried high radiation treatment (G).

Smaller, yet significant, strength losses occurred in the unwashed treatments when compared with the control (A vs. H and I). The least strength loss was in the unwashed, 4-hour dried low radiation treatment (I).

A comparison of each treatment with each other treatment was undertaken through the use of lsd. No

differences of significance occurred between any of the washed treatments.

Unwashed treatments did differ from their washed counterparts. The unwashed, 4-hour dried low radiation treatment (I) was significantly stronger than the washed, 4-hour dried low radiation treatment (E). Also, the unwashed, 4-hour dried high radiation treatment (H) was stronger than the washed, 4-hour dried high radiation treatment (G). Statistical determination of significance is found in Table V and the analysis of variance is in Appendix H.

Spearman's coefficient of rank correlation indicated a significant correlation between warp and filling tear strength treatments with $r_s = .833$.

Filling Tear Strength

Differences were significant among the filling tear strength treatments. This was indicated by a significant F-value in the analysis of variance (see Appendix I).

An analysis of the individual treatments was undertaken through the use of lsd at the .05 level of significance with lsd (.05) = 98.595.

The control (A) was found to differ significantly from each of the other treatments. Most strength loss occurred in the washed and 4-hour dried low radiation treatment (E). Second in strength loss was in the washed, 1-hour

TABLE V

STATISTICAL DETERMINATION OF SIGNIFICANCE BETWEEN TREATMENTS IN WARP TEAR STRENGTH

| Treatment | Mean (Weight in Grams) |
|---|---|
| A | 1,390.000 |
| B | 840.000 |
| C | 850.000 |
| D | 840.000 |
| E | 826.667 |
| F | 820.000 |
| G | 890.000 |
| H | 1,140.000 |
| I | 1,226.667 |
| lsd (.05) = 100.721 | |

dried high radiation treatment (F). A smaller amount of filling strength loss occurred in the washed and 1-hour dried low radiation treatment (D), followed closely by the washed and dryer dried treatment (B). Lesser differences in strength losses were noted in the washed and inside line dried treatment (C), followed by the washed and outside dried 4-hour high radiation treatment (G). Both unwashed treatments (H and I) were weaker than the control (A), yet stronger than all other treatments. The unwashed, 4-hour

dried low radiation treatment (I) was strongest of the unwashed treatments and stronger than all other treatments (excluding control).

A comparison of each washed treatment with each other washed treatment showed some statistically significant differences. The washed and line dried 4-hour high radiation treatment (G) was stronger than: washed and dryer dried (B), washed and dried for 1 hour at low radiation (D), washed and dried for 4 hours at low radiation (E), and washed and dried for 1 hour at high radiation (F).

The two unwashed treatments (H and I) were significantly different from one another with regard to the filling tear strength differences. The sample exposed to low radiation (H) was stronger than the one exposed to high radiation (I). Also, the unwashed, 4-hour dried low radiation treatment (I) was stronger than the washed and similarly dried treatment (E). No other comparable differences existed between treatments. Table VI shows statistical determination of significance and Appendix I shows the analysis of variance.

A significant correlation was found between filling and warp tear strength treatments when ranked. Spearman's coefficient of rank correlation was used in determining this with $r_s = .833$.

TABLE VI

STATISTICAL DETERMINATION OF SIGNIFICANCE BETWEEN TREATMENTS IN FILLING TEAR STRENGTH

| Treatment | Mean (Weight in Grams) |
|---|---|
| A | 810.000 |
| B | 423.333 |
| C | 446.667 |
| D | 420.000 |
| E | 406.667 |
| F | 416.667 |
| G | 533.333 |
| H | 540.000 |
| I | 663.333 |
| lsd (.05) = 98.595 | |

## Wrinkle Recovery

### Warp Wrinkle Recovery

Significant differences existed among the warp wrinkle recovery treatments according to the F-test in the analysis of variance. Lsd was used to make specific comparisons with lsd (.05) = 2.736.

Treatment differences which were significant were few. The control (A) differed significantly from all other treatments except for the washed and 1-hour dried low

radiation treatment (D). No other differences occurred between any of the other treatments. See Table VII for statistical determination of significance.

Spearman's coefficient of rank correlation was used and showed a significant correlation between warp and filling wrinkle recovery treatments with $r_s = .975$.

TABLE VII

STATISTICAL DETERMINATION OF SIGNIFICANCE BETWEEN TREATMENTS IN WARP WRINKLE RECOVERY

| Treatment | Mean (Recovery Angle in Percent) |
|---|---|
| A | 80.911 |
| B | 83.836 |
| C | 84.111 |
| D | 82.994 |
| E | 84.903 |
| F | 83.853 |
| G | 84.997 |
| H | 85.278 |
| I | 83.700 |
| lsd (.05) = 2.736 | |

Filling Wrinkle Recovery

The F-test in the analysis of variance indicated that the significant differences existed among the filling wrinkle recovery treatments. Specific comparisons were made through use of the least significant difference, or lsd. All lsd were made at the .05 level of significance. The lsd (.05) = 2.896.

Of all possible treatment comparisons, only two treatments showed significant differences. The washed and 4-hour dried high radiation treatment (G) was greater in recovery than the control (A). The other difference occurred between the washed and 1-hour dried low radiation treatment (D) and the washed and 4-hour dried high radiation treatment (G). No other differences occurred between any of the other treatments. The comparison of the averages of the two sides showed no differences. Statistical determination of significance is shown in Table VIII and the analysis of variance appears in Appendix K.

A correlation between rankings of filling and warp wrinkle recovery treatments proved significant. The correlation, determined through use of Spearman's coefficient of rank correlation was $r_s = .975$. No other correlations, excepting warp and filling tear strength, were found between any treatments.

TABLE VIII

STATISTICAL DETERMINATION OF SIGNIFICANCE BETWEEN TREATMENTS IN FILLING WRINKLE RECOVERY

| Treatment | Mean (Recovery Angle in Percent) |
|---|---|
| A | 83.142 |
| B | 84.061 |
| C | 84.039 |
| D | 83.719 |
| E | 85.564 |
| F | 84.811 |
| G | 86.678 |
| H | 85.878 |
| I | 84.675 |
| lsd (.05) = 2.896 | |

## Radiation

The total incident sun radiation received in Tucson during outside drying times was recorded daily (see Appendix E). The readings, expressed in langleys, were recorded by an Eppley pyrheliometer. Totals of the twenty-five days were made (see Table IX).

Treatment G, washed and exposed to high radiation for four hours, as well as the similar unwashed treatment (H), received the greatest number of langleys, 7819.3.

TABLE IX

TOTAL SUN RADIATION (LANGLEYS) EXPOSED TO OUTSIDE DRIED TREATMENTS IN TUCSON, ARIZONA, APRIL 19, 1968 TO JUNE 12, 1968

| Treatment | Total Langleys |
|---|---|
| D, washed, 1 hour, low radiation | 714.0 |
| F, washed, 1 hour, high radiation | 2,065.4 |
| E, washed, 4 hours, low radiation | 5,399.8 |
| G, washed, 4 hours, high radiation | 7,819.3 |
| I, unwashed, 4 hours, low radiation | 5,399.8 |
| H, unwashed, 4 hours, high radiation | 7,819.3 |

Washed and unwashed treatments exposed for 4 hours under low radiation conditions (E and I), had a total 5,399.8 langleys. Treatment F, washed and dried for 1 hour under high radiation conditions, had 2,065.4 total langleys. The washed and 1-hour dried low radiation treatment (D) received the fewest langleys, 714.0.

Statistical determination was not used with these totals as anything other than total langleys received would be misleading. Spearman's coefficient of rank correlation was used, but no correlation of any type existed between radiation and any of the laboratory tests given fabrics.

# CHAPTER 5

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study was conducted to determine the effect of various drying treatments on a 65/35 polyester/cotton blend fabric with permanent press and soil release finishes. The effect of drying treatments on appearance, weight, tear strength, and wrinkle recovery was studied in depth.

### Appearance

Appearance of the various samples within each completed treatment were viewed and judged by a panel of textile experts. Samples were viewed in a predetermined random order. The subjective evaluation ratings were divided into six categories, using AATCC plastic 3-dimensional replicas as standards from which to judge (see Tables II and III).

Rating uniformity was apparent throughout all but one treatment. Subjective evaluation results placed the unwashed treatments (A, H, and I) in the highest appearance category (DP-5), as was expected. All washed treatments, except one, were in the two middle appearance areas (DP-3 and DP-3.5). Thus, washing and subsequent drying created a moderately wrinkled appearance on the treatments.

All textile judges rated the washed and dryer dried treatment (B) slightly better than the other washed and line dried treatments (DP-3.5 and DP-3 respectively). This unanimous finding supported literature regarding optimum drying methods.

The aforementioned evaluation discrepancy occurred in the washed and 1-hour dried low radiation treatment (D). Judges placed choices near the middle and the next lower category (DP-3 and DP-2). The washed and dried 1-hour low radiation treatment (D) was the only one receiving a rating in this low appearance category (DP-2). No explanation was forthcoming with regard to the treatment receiving lowest ratings (see Table II). Because of judging disagreement in this category, evidence is inconclusive. There were many differences expected, which did not occur, probably because plastic replicas and samples were both white in color and similar in texture.

This writer felt that subjective evaluation was exactly that--subjective. It could be used as a basis for comparison as long as other factors were considered. One must realize that, although controlled and standardized factors were used, each judge was an individual and one might be more critical than others. Differences in height of judges could also have been a factor since nearly all

other factors were constant. Also, eyesight and health might have influenced judge evaluations of the fabrics.

## Weight

The washed and inside line dried treatment (C) weighed slightly more than the control (A). This was probably due to the dusty condition of the drying room as no attempt was made to change conditions of this room. Samples were enclosed in plastic only after they appeared dry to the touch.

Decreases in weight, over the control (A), were seen in the two washed and 4-hour dried treatments (E and G). Evidentally the washing and extended radiation period and/or the other uncontrolled factors during these periods caused this weight reduction. The weight decrease was greatest in the 4-hour high radiation treatment (G), possibly indicating that the length and intensity of radiation had a direct influence on weight (see Table IV and Appendix G).

Individual treatment comparisons between washed treatments showed statistically significant weight changes. Both 4-hour washed and dried treatments (E and G), low and high radiation, weighed less than the washed and dryer dried treatment (B). The extended outside drying time and length of radiation probably caused, or was a significant factor, in this weight reduction. Also, many other uncontrolled factors undoubtedly influenced the treatments (sample

temperature, air temperature, relative humidity, and wind velocity, etc.). All listed factors were recorded at predetermined and consistent intervals but were not statistically analyzed (see Appendix C and D).

Three treatments had significant weight reductions over the washed and inside line dried treatment (C). Both 4-hour high radiation treatments (E and G), in addition to the 1-hour high radiation treatment (F), weighed less than the inside line dried treatment (C). Again, a dusty room may have been the partial cause in the weight of the inside line dried treatment. Exposure to solar radiation was probably more significant in this weight reduction than the uncontrolled environmental factors which were present. The other factors were not considered in this analysis since statistical computation was not done.

Time and radiation differences most likely caused weight discrepancies in the following washed treatments: 4-hour high radiation (G) weighed less than the 1-hour high radiation (F); 4-hour low radiation (E) weighed less than the 1-hour low radiation (D); and 4-hour high radiation (G) weighed less than the 1-hour high radiation (F). The first two differences appeared consistent with all other observed weight differences. The 4-hour high radiation treatment (G) weighing more than the 1-hour high radiation treatment (F) appeared inconsistent and unexplanable at this point. A

weight decline was expected due to radiation, but possibly increased outside exposure supplied increased environmental contaminates.

Unwashed treatments, when compared with the washed and identically dried companion treatments, showed significant weight changes. The two unwashed treatments (H and I) were both higher in weight that their washed counterparts (E and G). Washing appeared to have a significant influence, which most likely caused weight reduction, on the samples.

Under existing laboratory conditions it was not possible to ascertain if the weight loss was consistent with both fibers (polyester and cotton) or greater in one. Reference will be made later with regard to the polyester/cotton relationship.

Many factors which could not be controlled or separated may, and undoubtedly did, have an influence on fabric weight. These included water variables (hardness, etc.), sample temperature, air temperature, relative humidity, wind velocity, and various other atmospheric conditions (see Appendix C and D).

Spearman's coefficient of rank correlation did not show correlation between weight and any of the other tests given this fabric.

## Tear Strength

### Warp Tear Strength

Strength losses were apparent in all eight treatments, with most loss (weakest fabric) in the washed, 1-hour dried high radiation treatment (F). The 4-hour low radiation treatment (E) had slightly less strength loss. The high intensity radiation probably affected the former, while an extended exposure period possibly changed the later. These two highly significant strength losses were not anticipated by this researcher.

Two treatments had somewhat less, yet identical strength losses. The washed and dryer dried treatment (B) and the washed and 1-hour dried low radiation treatment (D) had the same mean strength loss. In this case the effect of tumble drying appeared similar to the short time, low radiation conditions the samples received. Their weights were also similar, although no correlation was found to exist between weight and tear strength.

A smaller strength loss was found in the washed and inside line dried treatment (C). This finding was hypothesized by the researcher. Outside environmental influences appeared to be more harmful to fabrics than the inside factors.

The least strength loss, of the washed treatments, occurred in the 4-hour dried high radiation treatment (G).

This finding was unexpected, yet interesting. It was the opinion of this writer that the large amount and high intensity of radiation received (langleys) caused a fabric change. The thermal energy probably degraded a greater portion of the cellulosic fiber than the polyester fiber content; therefore, leaving a greater percentage of polyester in the fabric. Polyester, having greater tear strength than cotton probably caused this unexpected result. Note that tear strength tests appeared to be the only way of measuring noncellulosic fabrics.

Slight, yet significant, strength losses occurred in the unwashed treatments when compared with the control (A). The least strength loss (strongest fabric) was in the 4-hour dried low radiation treatment (I). Evidentally the higher intensity radiation adversely affected the unwashed fabric.

Washed fabrics were significantly weaker than their unwashed counterparts. The washed, 4-hour dried low radiation treatment (E) was weaker than the similar unwashed treatment (I). Also, the washed and 4-hour dried high radiation treatment (G) was weaker than its unwashed counterpart (H). Washing appeared to directly influence the warp tear strength of this fabric. All washed treatments, as the hypotheses stated, were weaker in warp tear strength than the unwashed treatments (see Table V and Appendix H).

It was found that a direct correlation existed between warp and filling tear strength results. Because the fibers were intimately blended in this fabric, this was an expected conclusion.

One cannot generalize concerning outside line drying because of the many uncontrolled environmental factors which existed during outside line drying. The results were in reference only to the particular fabric used and only under the environmental conditions that existed at the time of this experiment.

Filling Tear Strength

In all cases the various treatments differed significantly in filling tear strength from the control (A). Greatest strength loss was found in the 4-hour dried low radiation treatment (E). This was followed closely by the 1-hour dried high radiation treatment (F), the 1-hour dried low radiation treatment (D), and the washed and dryer dried treatment (B). The above findings were similar to the warp tear strength results.

Extended radiation, as well as high intensity radiation, appeared to have a harmful effect on the filling tear strength of this fabric. Again, as in the warp tear strength, the 1-hour dried low radiation treatment (D) was similar to the washed and dryer dried treatment (B). In this instance the outside dried treatment was slightly

weaker. The 20-minute dryer period appeared to have an effect equal to that of the 1-hour low radiation, but only under these particular conditions.

The washed and inside line dried treatment (C) showed, as expected, even lower strength losses. As found with the warp samples, the filling 4-hour dried high radiation treatment (G) had the least strength loss of all washed treatments. As explained in the warp tear strength section, the probable cause was a greater proportion of polyester to cotton due to cotton degradation. We had no existing laboratory equipment to test this.

Unwashed treatments (H and I) were weaker than the control (A) and stronger than all other treatments. As anticipated, the unwashed, 4-hour dried low radiation treatment (I) was stronger than the unwashed, 4-hour dried high radiation treatment (H). Washing appeared to adversely affect all treatments. In the unwashed treatments, the high intensity radiation (greater number of langleys) appeared most harmful to the fabric.

Washed and unwashed treatment comparisons were consistent with the warp tear strength findings. In both instances the unwashed treatment was significantly stronger than its washed companion. Washing was found to be detrimental to fabric in both warp and filling directions (see Table VI and Appendix I).

As previously explained, there existed a substantial correlation between warp and filling tear strength findings.

## Wrinkle Recovery

### Warp Wrinkle Recovery

It was found that there were significant differences among warp wrinkle recovery treatments. Upon further analysis, few treatment differences were found. The control (A) differed slightly from all other treatments, except in the washed and 1-hour dried low radiation treatment (D). No difference was found in that comparison. Seven treatments had significantly greater wrinkle recovery angles than did the control (A). No explanation was forthcoming, other than the possibility of a greater proportion of polyester due to the loss of cotton during the outside line drying.

Since treatments did not differ from one another, except when compared with the control, little was found from this experiment. Both face and back of fabric had been tested separately to determine if side differences existed for this particular fabric. There were no differences; therefore, treatment comparisons were the same regardless of the side tested. Fewer number of samples could have been used in this laboratory procedure with equally accurate findings (see Table VII and Appendix J).

A significant correlation was found to exist between the warp and filling wrinkle recovery results of the various treatments. Again, as with tear strength, this was anticipated.

Filling Wrinkle Recovery

Significant differences in the filling direction were few. The washed and 4-hour dried high radiation treatment (G) was significantly greater in recovery angle than the control (A). This finding was consistent with the warp wrinkle recovery. Also, this same treatment was stronger than all other washed treatments in both warp and filling tear strength tests. This supported the theory that the cotton portion of the fabric decreased with a corresponding greater proportion of polyester fiber present. There appeared a correlation, in this one instance, between tear strength and wrinkle recovery. In both instances the finding was not anticipated.

The only other difference occurred between the washed and 1-hour dried low radiation treatment (D) and the washed and 4-hour dried high radiation treatment (G). The 4-hour high radiation treatment had a significantly greater recovery angle than did the 1-hour low radiation treatment. The opposite finding had been expected, but the supposition that cotton was disintegrated again explained this result.

As with warp samples, both face and back sides of fabric were tested. No differences were found; the sides did not discriminate among treatments (see Table VIII and Appendix K). Because of these findings it was this author's conclusion that testing both sides of this fabric was unnecessary and therefore, a waste of time. The number of samples required in the test should then be cut in half.

As reported, a significant correlation did exist between warp and filling wrinkle recovery. Correlation, also found between warp and filling tear strength, did not exist between any other tests given fabric.

## Radiation

Total incident sun radiation for the twenty-five days are given in Table IX with the daily totals available in Appendix E.

Washed and unwashed treatments (G and H), exposed to high radiation for four hours each day received the highest number of langleys, as anticipated. The two treatments (E and I) exposed for 4 hours at low radiation placed second in number of langleys received. Treatment F, washed and dried for 1 hour under high radiation conditions rated third in number of langleys. This researcher did not know, prior to experiment, which of the two preceeding treatments would receive the most langleys. As expected, the washed and

1-hour dried low radiation treatment (D) received the lowest total amount of sun radiation.

Treatment G, washed and dried high radiation 4 hours, receiving the most total sun radiation supported findings in tear strength and wrinkle recovery areas. Both tests showed this treatment to be superior (stronger or greater recovery angle respectively) to others similarly treated. As stated, the only explanation forthcoming was that cotton decreased in amount present. Polyester, having greater strength than cotton, probably caused the increase in strength and recovery angle.

## Recommendations

A similar study could be undertaken, using electrical restivity or similar tests, to determine the amount of finish present after laundering.

A determination of the amount of cotton, and perhaps polyester, present after similar laundry treatments might be contemplated.

An identical or different study, involving actual wearing of garments would be most helpful to the consumer; one needs soil to effectively evaluate the soil release finish.

A similar project with fabrics mounted horizontally as well as hung vertically during outside line drying would be beneficial.

An evaluation of present tests with regard to creases and wrinkle recovery could be done; perhaps, a better and more meaningful test than that presently used in wrinkle recovery could be developed.

## APPENDIX A

GRAINS PER GALLON HARDNESS OF WATER USED IN WASHED TREATMENTS IN TUCSON, ARIZONA, APRIL 19, 1968 TO JUNE 12, 1968*

| Date | Treatments C, D, and E | Treatments B, F, and G |
|---|---|---|
| 4/19 | 10.324 | 10.324 |
| 4/22 | 7.076 | 9.628 |
| 4/24 | 10.208 | 8.816 |
| 4/26 | 6.496 | 9.512 |
| 4/29 | 8.468 | 8.700 |
| 5/1 | 9.744 | 9.512 |
| 5/3 | 10.208 | 10.208 |
| 5/6 | 8.120 | 8.120 |
| 5/8 | 9.512 | 8.932 |
| 5/10 | 9.860 | 9.860 |
| 5/13 | 5.800 | 8.352 |
| 5/15 | 9.048 | 8.584 |
| 5/17 | 8.816 | 8.816 |
| 5/20 | 8.352 | 8.932 |
| 5/22 | 8.004 | 8.004 |
| 5/23 | 8.352 | 7.424 |
| 5/28 | 9.280 | 7.888 |
| 5/29 | 10.904 | 9.280 |
| 6/3 | 7.076 | 7.308 |
| 6/4 | 8.816 | 6.380 |
| 6/5 | 9.628 | 5.916 |
| 6/6 | 8.816 | 8.700 |
| 6/10 | 7.076 | 6.496 |
| 6/11 | 5.568 | 8.584 |
| 6/12 | 6.380 | 6.380 |
| mean | 8.477 | 8.426 |

*Water taken from The University of Arizona well water system.

APPENDIX B

MONTHLY WATER ANALYSES OF WATER USED IN WASHED TREATMENTS IN TUCSON, ARIZONA, APRIL 19, 1968 TO JUNE 12, 1968*

| Item | March 20-April 19 | April 20-May 19 | May 20-June 19 |
|---|---|---|---|
| Soluble Salts ppm. | 332.00 | 356.00 | 458.00 |
| EC x $10^3$ | .42 | .43 | .50 |
| Calcium ppm. | 41.00 | 48.00 | 64.00 |
| Magnesium ppm. | 4.00 | 7.00 | 8.00 |
| Sodium ppm. | 48.00 | 44.00 | 48.00 |
| Chloride ppm. | 20.00 | 24.00 | 35.00 |
| Sulfate ppm. | 66.00 | 76.00 | 96.00 |
| Carbonate ppm. | 0.00 | 0.00 | 0.00 |
| Bicarbonate ppm. | 147.00 | 146.00 | 189.00 |
| Fluoride ppm. | .20 | .50 | .50 |
| Nitrate ppm. | 6.00 | 11.00 | 18.00 |
| Nitrogen (N) #/A.ft. | 3.69 | 6.76 | 11.10 |
| Boron ppm. | .22 | .18 | .26 |
| Silicon dioxide ppm. | 32.00 | 32.00 | 32.00 |
| Copper ppm. | .11 | .11 | .10 |
| Iron ppm. | .09 | .44 | .12 |
| Hardness gr./gal. | 6.83 | 8.70 | 11.40 |
| pH | 7.78 | 7.77 | 7.64 |

*Samples taken the 20th of each month from The University of Arizona well water system.

APPENDIX C

LOW RADIATION SAMPLE TEMPERATURE, AIR TEMPERATURE, RELATIVE HUMIDITY, AND WIND VELOCITY READINGS IN TUCSON, ARIZONA, APRIL 19, 1968 TO JUNE 12, 1968

| Date | Solar Time | Sample Temperature (°F.) Treatment $D_1$ | $D_2$ | $D_3$ | $E_1$ | $E_2$ | $E_3$ | Air Temperature (°F.) | Relative Humidity (%) | Wind Velocity (m.p.h.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/19 | 7:10 | 41.0 | 41.0 | 41.0 | 41.0 | 39.2 | 39.2 | 45 | 57 | * |
| | 8:00 | | | | 51.8 | 51.8 | 51.8 | 51 | 39 | * |
| | 9:00 | | | | 59.0 | 59.0 | 60.8 | 57 | 31 | * |
| | 10:00 | | | | 66.2 | 71.6 | 66.2 | 60 | 30 | * |
| 4/22 | 7:10 | 55.4 | 55.4 | 55.4 | 53.6 | 53.6 | 53.6 | 54 | 59 | 6 |
| | 8:00 | | | | 60.8 | 59.0 | 59.0 | 59 | 42 | 5 |
| | 9:00 | | | | 62.6 | 62.6 | 62.6 | 59 | 38 | 10 |
| | 10:00 | | | | 64.4 | 64.4 | 64.4 | 60 | 34 | 9 |
| 4/24 | 7:10 | 57.2 | 57.2 | 57.2 | 57.2 | 57.2 | 57.2 | 61 | 44 | 1 |
| | 8:00 | | | | 64.4 | 62.6 | 66.2 | 64 | 34 | 3 |
| | 9:00 | | | | 71.6 | 71.6 | 73.4 | 71 | 33 | 1 |
| | 10:00 | | | | 78.8 | 78.8 | 78.8 | 73 | 25 | 1 |
| 4/26 | 7:10 | 55.4 | 55.4 | 53.6 | 55.4 | 55.4 | 55.4 | 60 | 43 | 0 |
| | 8:00 | | | | 68.0 | 68.0 | 68.0 | 69 | 35 | 1 |
| | 9:00 | | | | 71.6 | 73.4 | 73.4 | 74 | 26 | 1 |
| | 10:00 | | | | 80.6 | 82.4 | 82.4 | 78 | 24 | 1 |

APPENDIX C--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/29 | 7:10 | 69.8 | 69.8 | 71.6 | 69.8 | 71.6 | 69.8 | 72 | 49 | 9 |
| | 8:00 | | | | 75.2 | 75.2 | 75.2 | 74 | 36 | 8 |
| | 9:00 | | | | 80.6 | 80.6 | 78.8 | 79 | 34 | 9 |
| | 10:00 | | | | 84.2 | 84.2 | 84.2 | 81 | 32.5 | 8 |
| 5/1 | 7:10 | 64.4 | 62.6 | 64.4 | 62.6 | 64.4 | 60.8 | 70 | 40 | 0 |
| | 8:00 | | | | 73.4 | 73.4 | 75.2 | 75 | 34 | 0 |
| | 9:00 | | | | 80.6 | 80.6 | 80.6 | 78 | 33 | 1 |
| | 10:00 | | | | 89.6 | 91.4 | 91.4 | 85 | 25 | 4 |
| 5/3 | 7:10 | 60.8 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 66 | 95 | 0 |
| | 8:00 | | | | 71.6 | 71.6 | 71.6 | 69 | 55 | 0 |
| | 9:00 | | | | 78.8 | 78.8 | 77.0 | 73 | 46 | 1 |
| | 10:00 | | | | 84.2 | 84.2 | 84.2 | 79 | 46 | 2 |
| 5/6 | 7:10 | 64.4 | 64.4 | 64.4 | 64.4 | 64.4 | 64.4 | 67 | 41 | 3 |
| | 8:00 | | | | 68.0 | 69.8 | 69.8 | 70 | 36 | 1 |
| | 9:00 | | | | 77.0 | 77.0 | 77.0 | 37.5 | 34 | 0 |
| | 10:00 | | | | 80.6 | 82.4 | 82.4 | 76 | 31 | 0 |
| 5/8 | 7:10 | 66.2 | 64.4 | 64.4 | 64.4 | 64.4 | 64.4 | 68 | 34 | 1 |
| | 8:00 | | | | 73.4 | 73.4 | 75.2 | 73 | 32 | 0 |
| | 9:00 | | | | 80.6 | 80.6 | 80.6 | 78 | 30 | 0 |
| | 10:00 | | | | 87.8 | 87.8 | 87.8 | 84 | 26 | 1 |
| 5/10 | 7:10 | 64.4 | 64.4 | 64.4 | 64.4 | 64.4 | 62.6 | 65 | 52 | 0 |
| | 8:00 | | | | 71.6 | 71.6 | 71.6 | 70 | 44 | 5 |
| | 9:00 | | | | 75.2 | 77.0 | 75.2 | 78 | 30 | 5 |
| | 10:00 | | | | 82.4 | 82.4 | 82.4 | 78 | 30 | 2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/13 | 7:10 | 59.0 | 57.2 | 57.2 | 55.4 | 55.4 | 55.4 | 60 | 37 | 1 |
| | 8:00 | | | | 64.4 | 64.4 | 64.4 | 64 | 27 | 1 |
| | 9:00 | | | | 69.8 | 69.8 | 69.8 | 66 | 28 | 0 |
| | 10:00 | | | | 78.8 | 78.8 | 78.8 | 71 | 21 | 2 |
| 5/15 | 7:10 | 60.8 | 60.8 | 60.8 | 59.0 | 60.8 | 60.8 | 61 | 31 | 0 |
| | 8:00 | | | | 66.2 | 66.2 | 66.2 | 66 | 29 | 0 |
| | 9:00 | | | | 75.2 | 75.2 | 75.2 | 72 | 21 | 0 |
| | 10:00 | | | | 80.6 | 82.4 | 80.6 | 76 | 21 | 0 |
| 5/17 | 7:10 | 62.6 | 62.6 | 62.6 | 60.8 | 60.8 | 62.6 | 64 | 26 | 1 |
| | 8:00 | | | | 69.8 | 69.8 | 69.8 | 70 | 22 | 2 |
| | 9:00 | | | | 77.0 | 78.8 | 78.8 | 75 | 14 | 0 |
| | 10:00 | | | | 86.0 | 86.0 | 86.0 | 79 | 13 | 0 |
| 5/20 | 7:10 | 71.6 | 71.6 | 68.0 | 66.2 | 66.2 | 66.2 | 72 | 24 | 0 |
| | 8:00 | | | | 77.0 | 77.0 | 77.0 | 76 | 25 | 0 |
| | 9:00 | | | | 86.0 | 86.0 | 86.0 | 85 | 15 | 1 |
| | 10:00 | | | | 95.0 | 95.0 | 95.0 | 90 | 11 | 2 |
| 5/22 | 7:10 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 74 | 36 | 4 |
| | 8:00 | | | | 80.6 | 80.6 | 80.6 | 78 | 27 | 3 |
| | 9:00 | | | | 86.0 | 86.0 | 86.0 | 82 | 25 | 15 |
| | 10:00 | | | | 89.6 | 89.6 | 89.6 | 84 | 24 | 12 |
| 5/23 | 7:10 | 64.4 | 66.2 | 62.6 | 64.4 | 64.4 | 64.4 | 68 | 31 | 0 |
| | 8:00 | | | | 71.6 | 71.6 | 73.4 | 72 | 28 | 0 |
| | 9:00 | | | | 80.6 | 80.6 | 80.6 | 76 | 28 | 1 |
| | 10:00 | | | | 87.6 | 87.6 | 87.6 | 81 | 21 | 1 |

APPENDIX C--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/28 | 7:10 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 77 | 26 | 0 |
| | 8:00 | | | | 89.6 | 89.6 | 89.6 | 87 | 19 | 0 |
| | 9:00 | | | | 95.0 | 95.0 | 95.0 | 90 | 19 | 0 |
| | 10:00 | | | | 100.4 | 100.4 | 100.4 | 93 | 18 | 0 |
| 5/29 | 7:10 | 69.8 | 68.0 | 68.0 | 68.0 | 68.0 | 68.0 | 72 | 31 | 0 |
| | 8:00 | | | | 78.8 | 78.8 | 78.8 | 79 | 28 | 0 |
| | 9:00 | | | | 86.0 | 86.0 | 87.8 | 86 | 23 | 0 |
| | 10:00 | | | | 100.4 | 100.4 | 100.4 | 93 | 16 | 0 |
| 6/3 | 7:10 | 77.0 | 77.0 | 78.8 | 77.0 | 78.8 | 77.0 | 78 | 27 | 0 |
| | 8:00 | | | | 87.8 | 87.8 | 87.8 | 85 | 25 | 1 |
| | 9:00 | | | | 95.0 | 95.0 | 95.0 | 90 | 19 | 1 |
| | 10:00 | | | | 98.6 | 100.4 | 100.4 | 93 | 16 | 0 |
| 6/4 | 7:10 | 78.8 | 78.8 | 80.6 | 80.6 | 80.6 | 80.6 | 81 | 30 | 0 |
| | 8:00 | | | | 89.6 | 89.6 | 89.6 | 86 | 23 | 4 |
| | 9:00 | | | | 93.2 | 93.2 | 93.2 | 89 | 21 | 1 |
| | 10:00 | | | | 98.6 | 98.6 | 98.6 | 91 | 23 | 4 |
| 6/5 | 7:10 | 75.2 | 77.0 | 77.0 | 77.0 | 75.2 | 77.0 | 77 | 39 | 1 |
| | 8:00 | | | | 80.6 | 80.6 | 80.6 | 80 | 35 | 9 |
| | 9:00 | | | | 87.8 | 86.0 | 87.8 | 83 | 34 | 8 |
| | 10:00 | | | | 91.4 | 89.6 | 89.6 | 87 | 24 | 14 |
| 6/6 | 7:10 | 78.8 | 77.0 | 77.0 | 75.2 | 77.0 | 75.2 | 75 | 40 | 1 |
| | 8:00 | | | | 80.6 | 80.6 | 78.8 | 77 | 34 | 4 |
| | 9:00 | | | | 82.4 | 84.2 | 82.4 | 80 | 35 | 17 |
| | 10:00 | | | | 84.2 | 86.0 | 84.2 | 81 | 36 | 11 |

APPENDIX C--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/10 | 7:10 | 64.4 | 64.4 | 62.6 | 62.6 | 62.6 | 62.6 | 65 | 44 | 0 |
| | 8:00 | | | | 69.8 | 69.8 | 71.6 | 69 | 39 | 0 |
| | 9:00 | | | | 77.0 | 77.0 | 77.0 | 74 | 29 | 4 |
| | 10:00 | | | | 84.2 | 84.2 | 84.2 | 79 | 28 | 1 |
| 6/11 | 7:10 | 71.6 | 66.2 | 68.0 | 68.0 | 68.0 | 64.4 | 70 | 36 | 0 |
| | 8:00 | | | | 78.8 | 78.8 | 78.8 | 77 | 32 | 0 |
| | 9:00 | | | | 84.2 | 84.2 | 84.2 | 81 | 27 | 0 |
| | 10:00 | | | | 93.2 | 93.2 | 93.2 | 85 | 22 | 0 |
| 6/12 | 7:10 | 73.4 | 73.4 | 73.4 | 73.4 | 73.4 | 71.6 | 73 | 29 | 0 |
| | 8:00 | | | | 84.2 | 82.4 | 84.2 | 80 | 29 | 1 |
| | 9:00 | | | | 87.8 | 87.8 | 87.8 | 85 | 22 | 0 |
| | 10:00 | | | | 93.2 | 93.2 | 93.2 | 88 | 20 | 1 |

*Data not available.

APPENDIX D

HIGH RADIATION SAMPLE TEMPERATURE, AIR TEMPERATURE, RELATIVE HUMIDITY, AND WIND VELOCITY READINGS IN TUCSON, ARIZONA, APRIL 19, 1969 TO JUNE 12, 1968

| Date | Solar Time | Sample Temperature ('F.) Treatment $F_1$ | $F_2$ | $F_3$ | $G_1$ | $G_2$ | $G_3$ | Air Temperature ('F.) | Relative Humidity (%) | Wind Velocity (m.p.h.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/19 | 11:20 | 66.2 | 69.8 | 66.2 | 66.2 | 64.4 | 68.0 | 64 | 26 | * |
| | 12:30 | | | | 75.2 | 73.4 | 75.2 | 65 | 24 | * |
| | 1:30 | | | | 75.2 | 75.2 | 75.2 | 66 | 25 | * |
| | 2:30 | | | | 77.0 | 73.4 | 75.2 | 70 | 25 | * |
| 4/22 | 11:20 | 66.2 | 66.2 | 66.2 | 66.2 | 66.2 | 66.2 | 62 | 36 | 11 |
| | 12:30 | | | | 66.2 | 66.2 | 68.0 | 63 | 25 | 11 |
| | 1:30 | | | | 66.2 | 68.0 | 68.0 | 63 | 29 | 8 |
| | 2:30 | | | | 68.0 | 68.0 | 66.2 | 65 | 24 | 6 |
| 4/24 | 11:20 | 78.8 | 78.8 | 80.6 | 78.8 | 77.0 | 78.8 | 74 | 23 | 9 |
| | 12:30 | | | | 84.2 | 84.2 | 84.2 | 79 | 18 | 0 |
| | 1:30 | | | | 84.2 | 84.2 | 84.2 | 80 | 20 | 2 |
| | 2:30 | | | | 86.0 | 87.8 | 86.0 | 82 | 21 | 0 |

APPENDIX D--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4/26 | 11:20 | 84.2 | 86.0 | 87.8 | 87.8 | 87.8 | 87.8 | 83 | 23 | 1 |
| | 12:30 | | | | 91.4 | 91.4 | 91.4 | 83 | 21 | 3 |
| | 1:30 | | | | 87.8 | 87.8 | 89.6 | 84 | 19 | 8 |
| | 2:30 | | | | 87.8 | 87.8 | 89.6 | 84 | 21 | 4 |
| 4/29 | 11:20 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 91.4 | 84 | 32 | 5 |
| | 12:30 | | | | 93.2 | 93.2 | 91.4 | 86 | 36 | 7 |
| | 1:30 | | | | 93.2 | 93.2 | 91.4 | 87 | 29 | 3 |
| | 2:30 | | | | 93.2 | 95.0 | 93.2 | 89 | 26 | 3 |
| 5/1 | 11:20 | 93.2 | 93.2 | 93.2 | 93.2 | 91.4 | 91.4 | 89 | 21 | 0 |
| | 12:30 | | | | 96.8 | 96.8 | 96.8 | 87 | 24 | 2 |
| | 1:30 | | | | 91.4 | 91.4 | 91.4 | 87 | 29 | 1 |
| | 2:30 | | | | 91.4 | 91.4 | 91.4 | 88 | 20 | 0 |
| 5/3 | 11:20 | 86.0 | 84.2 | 82.4 | 84.2 | 82.4 | 82.4 | 82 | 24 | 1 |
| | 12:30 | | | | 91.4 | 91.4 | 91.4 | 84 | 35 | 3 |
| | 1:30 | | | | 91.4 | 91.4 | 91.4 | 86 | 31 | 3 |
| | 2:30 | | | | 91.4 | 91.4 | 91.4 | 85 | 30 | 3 |
| 5/6 | 11:20 | 86.0 | 86.0 | 84.2 | 84.2 | 84.2 | 82.4 | 80 | 26 | 3 |
| | 12:30 | | | | 86.0 | 86.0 | 86.0 | 82 | 22 | 10 |
| | 1:30 | | | | 89.6 | 89.6 | 89.6 | 84 | 21 | 8 |
| | 2:30 | | | | 84.2 | 86.0 | 86.0 | 82 | 22 | 8 |
| 5/8 | 11:20 | 91.4 | 91.4 | 91.4 | 93.2 | 91.4 | 91.4 | 86 | 21 | 5 |
| | 12:30 | | | | 93.2 | 93.2 | 93.2 | 86 | 21 | 2 |
| | 1:30 | | | | 95.0 | 95.0 | 95.0 | 89 | 19 | 2 |
| | 2:30 | | | | 91.4 | 91.4 | 91.4 | 88 | 15 | 7 |

APPENDIX D--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/10 | 11:20 | 84.2 | 82.4 | 84.2 | 84.2 | 84.2 | 82.4 | 78 | 30 | 1 |
| | 12:30 | | | | 89.6 | 89.6 | 89.6 | 83 | 27 | 0 |
| | 1:30 | | | | 80.6 | 80.6 | 78.8 | 79 | 24 | 1 |
| | 2:30 | | | | 91.4 | 91.4 | 91.4 | 85 | 23 | 0 |
| 5/13 | 11:20 | 80.6 | 80.6 | 80.6 | 80.6 | 80.6 | 80.6 | 73 | 18 | 1 |
| | 12:30 | | | | 84.2 | 82.4 | 84.2 | 77 | 16 | 1 |
| | 1:30 | | | | 84.2 | 84.2 | 84.2 | 79 | 18 | 4 |
| | 2:30 | | | | 89.6 | 89.6 | 89.6 | 81 | 14 | 2 |
| 5/15 | 11:20 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 80 | 18 | 0 |
| | 12:30 | | | | 89.6 | 89.6 | 89.6 | 82 | 12 | 3 |
| | 1:30 | | | | 91.4 | 91.4 | 91.4 | 84 | 14 | 0 |
| | 2:30 | | | | 89.6 | 91.4 | 91.4 | 84 | 14 | 1 |
| 5/17 | 11:20 | 91.4 | 89.6 | 89.6 | 89.6 | 89.6 | 89.6 | 83 | 13 | 1 |
| | 12:30 | | | | 89.6 | 89.6 | 89.6 | 83 | 11 | 5 |
| | 1:30 | | | | 93.2 | 93.2 | 93.2 | 85 | 10 | 2 |
| | 2:30 | | | | 89.6 | 89.6 | 89.6 | 85 | 13 | 1 |
| 5/20 | 11:20 | 98.6 | 98.6 | 100.4 | 98.6 | 100.4 | 100.4 | 92 | 11 | 2 |
| | 12:30 | | | | 102.2 | 102.2 | 102.2 | 95 | 13 | 4 |
| | 1:30 | | | | 104.0 | 105.8 | 104.0 | 95 | 13 | 3 |
| | 2:30 | | | | 100.4 | 100.4 | 100.4 | 97 | 9 | 7 |
| 5/22 | 11:20 | 93.2 | 93.2 | 93.2 | 93.2 | 91.4 | 91.4 | 88 | 18 | 13 |
| | 12:30 | | | | 95.0 | 93.2 | 93.2 | 89 | 14 | 10 |
| | 1:30 | | | | 95.0 | 95.0 | 93.2 | 91 | 14 | 18 |
| | 2:30 | | | | 93.2 | 93.2 | 93.2 | 90 | 13 | 9 |

APPENDIX D--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5/23 | 11:20 | 89.6 | 89.6 | 89.6 | 89.6 | 89.6 | 89.6 | 85 | 17 | 9 |
| | 12:30 | | | | 89.6 | 89.6 | 89.6 | 86 | 16 | 8 |
| | 1:30 | | | | 89.6 | 89.6 | 91.4 | 85 | 17 | 12 |
| | 2:30 | | | | 89.6 | 89.6 | 91.4 | 85 | 15 | 8 |
| 5/28 | 11:20 | 104.0 | 104.0 | 104.0 | 105.8 | 105.8 | 104.0 | 99 | 13 | 0 |
| | 12:30 | | | | 107.6 | 105.8 | 105.8 | 100 | 10 | 0 |
| | 1:30 | | | | 105.8 | 105.8 | 105.8 | 100 | 12 | 0 |
| | 2:30 | | | | 107.6 | 107.6 | 107.6 | 102 | 8 | 2 |
| 5/29 | 11:20 | 98.6 | 98.6 | 98.6 | 98.6 | 98.6 | 100.4 | 93 | 14 | 0 |
| | 12:30 | | | | 105.8 | 104.0 | 105.8 | 97 | 11 | 0 |
| | 1:30 | | | | 105.8 | 105.8 | 105.8 | 100 | 10 | 0 |
| | 2:30 | | | | 105.8 | 105.8 | 107.6 | 100 | 12 | 5 |
| 6/3 | 11:20 | 102.2 | 102.2 | 104.0 | 104.0 | 102.2 | 102.2 | 96 | 14 | 1 |
| | 12:30 | | | | 107.6 | 107.6 | 107.6 | 100 | 12 | 5 |
| | 1:30 | | | | 107.6 | 107.6 | 107.6 | 102 | 11 | 2 |
| | 2:30 | | | | 107.6 | 107.6 | 105.8 | 101 | 11 | 4 |
| 6/4 | 11:20 | 95.0 | 96.8 | 96.8 | 96.8 | 95.0 | 96.8 | 92 | 19 | 8 |
| | 12:30 | | | | 105.8 | 105.8 | 105.8 | 98 | 17 | 0 |
| | 1:30 | | | | 102.2 | 102.2 | 102.2 | 98 | 14 | 0 |
| | 2:30 | | | | 100.4 | 98.6 | 100.4 | 97 | 17 | 3 |
| 6/5 | 11:20 | 95.0 | 96.8 | 96.8 | 95.0 | 96.8 | 96.8 | 91 | 20 | 11 |
| | 12:30 | | | | 95.0 | 95.0 | 95.0 | 90 | 22 | 12 |
| | 1:30 | | | | 96.8 | 96.8 | 96.8 | 92 | 17 | 10 |
| | 2:30 | | | | 95.0 | 95.0 | 95.0 | 92 | 17 | 11 |

APPENDIX D--Continued

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/6 | 11:20 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 86.0 | 82 | 33 | 13 |
| | 12:30 | | | | 84.2 | 84.2 | 84.2 | 82 | 36 | 8 |
| | 1:30 | | | | 86.0 | 86.0 | 86.0 | 83 | 34 | 11 |
| | 2:30 | | | | 89.6 | 89.6 | 89.6 | 85 | 30 | 12 |
| 6/10 | 11:20 | 87.8 | 87.8 | 89.6 | 89.6 | 89.6 | 89.6 | 81 | 24 | 1 |
| | 12:30 | | | | 93.2 | 95.0 | 95.0 | 84 | 19 | 1 |
| | 1:30 | | | | 91.4 | 93.2 | 91.4 | 85 | 17 | 1 |
| | 2:30 | | | | 93.2 | 93.2 | 93.2 | 86 | 18 | 2 |
| 6/11 | 11:20 | 96.8 | 96.8 | 96.8 | 98.6 | 96.8 | 98.6 | 91 | 16 | 0 |
| | 12:30 | | | | 102.2 | 100.4 | 100.4 | 93 | 16 | 0 |
| | 1:30 | | | | 102.2 | 102.2 | 102.2 | 94 | 14 | 2 |
| | 2:30 | | | | 100.4 | 100.4 | 102.2 | 94 | 13 | 0 |
| 6/12 | 11:20 | 100.4 | 100.4 | 102.2 | 104.0 | 104.0 | 102.2 | 94 | 16 | 1 |
| | 12:30 | | | | 104.0 | 104.0 | 104.0 | 95 | 13 | 0 |
| | 1:30 | | | | 104.0 | 105.8 | 104.0 | 98 | 14 | 1 |
| | 2:30 | | | | 104.0 | 104.0 | 102.2 | 98 | 12 | 7 |

*Data not available.

## APPENDIX E

SUN RADIATION (LANGLEYS) EXPOSED TO OUTSIDE LINE DRIED TREATMENTS IN TUCSON, ARIZONA, APRIL 19, 1968 TO JUNE 12, 1968

| Date | Low Radiation Treatment D* | Low Radiation Treatments E & I** | High Radiation Treatment F* | High Radiation Treatments G & H** |
|---|---|---|---|---|
| 4/19 | 23.3 | 200.1 | 85.9 | 318.5 |
| 4/22 | 22.8 | 206.0 | 87.6 | 324.8 |
| 4/24 | 30.4 | 217.9 | 74.0 | 287.8 |
| 4/26 | 24.6 | 204.0 | 83.7 | 312.1 |
| 4/29 | 24.6 | 248.1 | 85.2 | 315.0 |
| 5/1 | 24.5 | 207.2 | 85.0 | 247.8 |
| 5/3 | 26.4 | 208.3 | 82.0 | 312.6 |
| 5/6 | 27.1 | 217.4 | 87.6 | 334.7 |
| 5/8 | 27.5 | 211.4 | 82.9 | 300.3 |
| 5/10 | 27.9 | 215.6 | 85.9 | 327.0 |
| 5/13 | 29.4 | 223.7 | 86.3 | 330.4 |
| 5/15 | 30.0 | 221.8 | 87.1 | 334.3 |
| 5/17 | 31.2 | 225.0 | 87.0 | 334.3 |
| 5/20 | 31.5 | 221.7 | 83.7 | 324.9 |
| 5/22 | 31.2 | 223.8 | 87.1 | 333.3 |
| 5/23 | 31.2 | 228.3 | 89.4 | 341.4 |
| 5/28 | 31.2 | 223.7 | 85.0 | 325.7 |
| 5/29 | 21.9 | 189.0 | 69.8 | 280.4 |
| 6/3 | 30.0 | 216.3 | 83.4 | 322.8 |
| 6/4 | 30.0 | 209.0 | 64.3 | 267.3 |
| 6/5 | 23.4 | 179.1 | 83.7 | 322.2 |
| 6/6 | 31.2 | 215.7 | 66.0 | 261.0 |
| 6/10 | 34.2 | 232.3 | 80.4 | 320.3 |

APPENDIX E--Continued

| | | | | |
|---|---|---|---|---|
| 6/11 | 34.2 | 227.3 | 84.6 | 320.4 |
| 6/12 | 34.3 | 227.1 | 84.2 | 320.0 |
| Total | 714.0 | 5,399.8 | 2,065.4 | 7,819.3 |

* 1 hour
** 4 hours

## APPENDIX F

## CONVERSION OF MOUNTAIN STANDARD TIME TO TRUE SOLAR TIME IN TUCSON, ARIZONA, FOR APRIL, MAY AND JUNE 1968

| Month | Dates | Algebraical Subtraction (in minutes) |
|---|---|---|
| April | 18-22 | -23 |
| | 23-27 | -22 |
| | 28-30 | -21 |
| May | 1-6 | -21 |
| | 7-21 | -20 |
| | 22-31 | -21 |
| June | 1-6 | -22 |
| | 7-11 | -23 |
| | 12-16 | -24 |

*Adapted from the American Ephemeris and Nautical Almanac (36).

## APPENDIX G

### ANALYSIS OF VARIANCE INDICATING SIGNIFICANT VALUES FOR THE WEIGHT OF THE POLYESTER/COTTON FABRIC

| Source | DF | Mean Square | F-Value |
|---|---|---|---|
| T | 8 | .022 | 7.19* |
| R x T | 16 | .003 | |

T = Treatment

R = Replication

*.05 level of significance

## APPENDIX H

### ANALYSIS OF VARIANCE INDICATING SIGNIFICANT VALUES FOR THE WARP TEAR STRENGTH OF THE POLYESTER/COTTON FABRIC

| Source | DF | Mean Square | F-Value |
|---|---|---|---|
| S | 4 | 8,222.222 | |
| T | 8 | 689,726.852 | 40.74* |
| S x T | 32 | 2,961.805 | |
| Error a | 16 | 16,928.241 | 4.86* |
| Error b | 108 | 3,481.481 | |

S = Sample

T = Treatment

*.05 level of significance

## APPENDIX I

### ANALYSIS OF VARIANCE INDICATING SIGNIFICANT VALUES FOR THE FILLING TEAR STRENGTH OF THE POLYESTER/COTTON FABRIC

| Source | DF | Mean Square | F-Value |
|---|---|---|---|
| S | 4 | 1,185.185 | |
| T | 8 | 287,666.666 | 17.73* |
| S x T | 32 | 1,237.268 | |
| Error a | 16 | 16,222.222 | 12.70* |
| Error b | 108 | 1,277.777 | |

S = Sample

T = Treatment

*.05 level of significance

APPENDIX J

ANALYSIS OF VARIANCE INDICATING SIGNIFICANT VALUES FOR THE WARP WRINKLE RECOVERY OF THE POLYESTER/COTTON FABRIC

| Source | DF | Mean Square | F-Value |
|---|---|---|---|
| S | 1 | 548.080 | 169.71* |
| T | 8 | 62.651 | 1.94 |
| S x T | 8 | 20.520 | .06 |
| Error a | 34 | 32.295 | 7.67* |
| H | 1 | 1,756.541 | 417.23* |
| H x S | 1 | 4.646 | 1.10 |
| H x T | 8 | 6.974 | 1.66 |
| H x S x T | 8 | 1.053 | .03 |
| Error b | 36 | 4.210 | |

S = Side

T = Treatment

H = Time

*.05 level of significance

## APPENDIX K

### ANALYSIS OF VARIANCE INDICATING SIGNIFICANT VALUES FOR THE FILLING WRINKLE RECOVERY OF THE POLYESTER/COTTON FABRIC

| Source | DF | Mean Square | F-Value |
|---|---|---|---|
| S | 1 | 310.934 | 8.60* |
| T | 8 | 46.284 | 1.28 |
| S x T | 8 | 11.070 | .31 |
| Error a | 34 | 36.168 | 12.14* |
| H | 1 | 1,624.986 | 545.30* |
| H x S | 1 | .296 | .10 |
| H x T | 8 | 5.000 | 1.68 |
| H x S x T | 8 | 1.032 | .35 |
| Error b | 36 | 2.980 | |

S = Side

T = Treatment

H = Time

*.05 level of significance

LIST OF REFERENCES


1. American Association for Textile Chemists and Colorists. Technical Manual. 43. New York: Howes Publishing Company, 1967.

2. American Society for Testing and Materials. 1967 Book of ASTM Standards, Pt. 24. Philadelphia: American Society for Testing and Materials, 1967.

3. "As You Like It," American Fabrics, no. 81 (Winter, 1968), 91-8.

4. Caryl, Coleman R. "The Langley as a Unit for Timing Outdoor Exposures," ASTM Bulletin, no. 243 (Jan., 1960), 55-9.

5. Coughlin, W. E. "Permanent Press--a Short Sales Training Course," Department Store Journal (May, 1967). 3 pp.

6. Daniels, Farrington. Direct Use of the Sun's Energy. New Haven: Yale University Press, 1964. 374 pp.

7. Daniels, Farrington, and John A. Duffie, eds. Solar Energy Research. Madison: University of Wisconsin Press, 1955. 290 pp.

8. A Definitive Guide to Permanent Press: Technology, Processes, End-Uses. New York: Celanese Fibers Marketing Company, 1965. 19 pp.

9. Denyes, Wells. "Durable Press--the Role of Polyesters," Modern Textiles Magazine, 47 (Sept., 1966), 79-84.

10. Egerton, G. S. "The Properties of Textile Materials, part V: The Action of Light on Textile Materials," Journal of the Textile Institute, 47 (July, 1956), 476-480.

11. "Fiber and Fabric Facts from Beaunit--Soil Release," no. 5. New York: Beaunit Corp. 8 pp.

12. Fortess, Fred. "Durable Press Garments--a Challenge to Industry," Modern Textiles Magazine, 47 (Jan., 1966), 34-41.

13. Fynn, P. J. "A Critical Look at Permanent Press," Modern Textiles Magazine, 47 (Jan., 1966), 63-7.

14. Ghionis, C. A., and C. L. Browne. "Some Aspects and Trends of Finishing Polyester/Cotton Blend Fabrics," American Dyestuff Reporter, 57 (April 8, 1968), 28-34.

15. Goldstein, Herman B., and J. Michael May. "Permanent Press: Finishing and Performance Evaluation," American Dyestuff Reporter, 54 (Sept. 13, 1965), 78-83.

16. Howard, John W., and Frank A. McCord. "Cotton Quality Study IV: Resistance to Weathering," Textile Research Journal, 30 (Feb., 1960), 75-117.

17. "Industry Standards for Durable Press?," Modern Textiles Magazine, 47 (Nov., 1966), 47-54.

18. Latour, Celine Giering. "The Effect of Selected Laundry Methods on the Appearance and Physical Properties of Three Brands of Durable Press Men's White Shirts." Unpublished M. S. thesis. Purdue University, June, 1966. 78 numb. leaves.

19. "Laundering Procedures in the Commercial Laundry and in the Home," American Dyestuff Reporter, 47 (Mar. 24, 1958), 187-190.

20. Mills, Nancy. "Soil Release Finishes: a Boon to Laundering Permanent Press," Forecast for Home Economics, 13 (Mar., 1968), F-60.

21. "New Finish for Polyesters: Improves Antistatic and Antisoiling Properties," Modern Textiles Magazine, 47 (Nov., 1966), 29.

22. "Out Damned Spot," American Fabrics, no. 76 (Summer, 1967), 51-58.

23. Peters, R. H. Textile Chemistry. New York: Elsevier Publishing Company, 1967. 374 pp.

24. Petersen, A. T. "Soil Release Headed for 'Required' Status," Women's Wear Daily (Jan. 15, 1968), 28.

25. Pomroy, Estella Roberts. "A Comparison of the Effects of Various Storage Conditions on Fluidity and Breaking Strength of Weathered Cotton." Unpublished Ph.D. dissertation. Florida State University, August, 1966. 76 numb. leaves.

26. Robinson, Helen M., and Wilson A. Reeves. "A Survey of the Effect of Light on Cotton and Other Cellulosic Fabrics," American Dyestuff Reporter, 50 (Jan. 9, 1961), 17-30.

27. Schmitt, C. H. A. "Daylight Fastness Testing by the Langley System," American Dyestuff Reporter, 51 (Sept. 3, 1962), 31-42.

28. Singleton, R. W., and others. "Factors Influencing the Evaluation of Actinic Degradation," Textile Research Journal, 35 (Mar., 1965), 228-236.

29. Steel, Robert G. D., and James H. Torrie. Principles and Procedures of Statistics. New York: McGraw-Hill Book Company, 1960. 480 pp.

30. Stavrakas, E. James. "Appearance of Durable Press Fabrics After Repeated Home Launderings," American Dyestuff Reporter, 56 (Sept. 11, 1967), 41-3.

31. Stultz, Robert L. "The Contribution of the Polyester Fiber," Modern Textiles Magazine, 45 (Dec., 1964), 55-7.

32. Stultz, Robert L. "Permanent Press: Major Accomplishments and Current Problems," American Dyestuff Reporter, 55 (Mar. 14, 1966), 48-50.

33. Technical Advisory Committee of the American Apparel Manufacturers Association. Crease Retention Wrinkle Free Process Handbook. Washington: American Apparel Manufacturers Association, 1966. 65 pp.

34. University of California. Effect of Weathering on Cotton Fabrics, by Mary Ann Morris. Bulletin no. 823. June, 1966. 29 pp.

35. United States Department of Commerce. Bureau of the Census. "Arizona Table 6," 1960 Census of Housing, States and Small Areas. 1, Pt. 2. Washington: 1960, 4-9.

36. United States Naval Observatory. Astronomical Council. The American Epheremis and Nautical Almanac for the Year 1967. Washington: U.S. Government Printing Office, 1965.

37. United States Testing. Textiles and Testing, Course of Study. Hoboken, New Jersey: United States Testing Company, 1953.