RESEARCH AND DEVELOPMENT REPORT

TEXTILE SERIES - REPORT NO. 76

AN EDUCATIONAL ORDER TRIAL ON 10.5-OUNCE SHRINK RESISTANT WOOL FLANNEL SHIRTING

by

LOUIS I. WEINER

and

FRANK J. RIZZO

DEPARTMENT OF THE ARMY

OFFICE OF THE QUARTERMASTER GENERAL

DOCUMENT DATA WORKSHEET

~~AD~~	--
ATI	STI-ATI 207 486
DATE INITIATED:	22 July 54 ems
SECURITY INFORMATION:	

ORIGINATING AGENCY:
Research and Develonment Div., Office of the Quartermaster General, Wash., D. C.

TITLE:
AN EDUCATIONAL ORDER TRIAL ON 10.5-OUNCE SHRINK RESISTANT WOOL FLANNEL SHIRTING

FOREIGN TITLE:

AUTHOR(S):
Louis I. Weiner and Frank J. Rizzo

TRANSLATOR(S):

TYPE, SERIES, NUMBER AND PERIOD OF REPORT COVERED:
Textile Series

DATE OF REPORT:	NUMBER OF PAGES:	INCL		
Sent 52	23		x	ILLUSTRATIONS
		x	x	TABLES

OA No.:	PA No.:	OTHERS
Rent. no. 76	-------	------

TRANSLATION No. AND FOREIGN SOURCE:

CONTRACT No.:

TRACINGS:

DIVISION(S):

SECTION(S):

DISTRIBUTION NOTE:

TAB:

SPECIAL INSTRUCTIONS:

DSC CONTROL No:	ORIGINAL COPY TO:	LOAN RETURNED TO DSC-SD22 BY (DATE):

DSC FORM 41
REV APR 53

Office of The Quartermaster General
Research and Development Division
Textiles, Clothing, and Footwear Branch

TEXTILE SERIES REPORT NO. 76

AN EDUCATIONAL ORDER TRIAL ON 10.5-OUNCE SHRINK RESISTANT WOOL FLANNEL SHIRTING

by

Louis I. Weiner

and

Frank J. Rizzo

Released for public information
by
The Office of Technical Services
U. S. Department of Commerce
1952

FOREWORD

This report describes an educational order trial for the application of shrink resistant processing to a 10.5-ounce all-wool flannel shirting.

At the time this program was undertaken by the Quartermaster Research and Development Laboratory, textile research had been completed and it was desired to check in a series of plant runs the applicability of the tentative specification requirements.

Accordingly, a program was worked out under which a total of 40,000 yards were procured of the all-wool 10.5-ounce flannel shirting under the proposed specification requirements. The program was so planned that no one contractor would receive more than 2,000 yards for a given type of treatment. Encouragement was extended to all producers of shrink resistant treatments and to all processors to have their methods and treatments represented in the contracts that were placed.

This report summarizes the analysis of the production of the different contractors. Each contractor's product is identified by a code number so that the individual firm name or the treatment will be known only to the firm. As will be noted, this trial was run on both OD 33 and Blue 84 shades.

The importance of this type of approach to research and development problems is borne out by the fact that little or no difficulty was encountered in meeting this specification when large scale procurements were subsequently initiated.

A great deal of credit is due to the many firms that participated in this program. These included both the producers of shrink resistant treatments and the fabric manufacturers and finishers.

The work was performed at the Textile Finishing Research Laboratory in Philadelphia, under the direction of Mr. Louis I. Weiner, assisted by Mr. Frank J. Spagna and Mrs. Gertrude L. Buri Jr; and under the direction of Mr. Frank J. Rizzo, assisted by Miss Helen Buczek and Dr. John H. Fossum. Special acknowledgment should also be made to Mr. Erwin O. Kruegel and Dr. J. Fred Oesterling for their valuable assistance and suggestions.

S. J. KENNEDY
Chief, Textiles, Clothing, and Footwear Branch
Research and Development Division

September 1952

ABSTRACT

A summary is given of the success achieved in the Quartermaster Corps' educational procurement of shrink-resistant shirting. This small-scale run, participated in by many finishers and producers of shrink-resistant compounds, proved the feasibility of treating this particular fabric for shrink resistance and also afforded contractors an advance opportunity to learn by actual experience the production problems involved. The report emphasizes the difficulties encountered, especially as to stiffness, aging, shade, and colorfastness. The results show the quality level met by each contractor (represented by code designation) for each pertinent characteristic.

I INTRODUCTION

Early investigations by the Quartermaster Corps of shrink resistant processes for wool were confined to hosiery and other knitted wool items which presented serious felting problems because of frequent laundering. In 1943 anti-felt treatments were made mandatory in specifications for Socks, Wool Cushion Sole, and Socks, Wool Ski. Later such requirements were established for sweaters and other knit outerwear. Industrial promotion of shrink resistant treatments for wool in this country followed a similar pattern.

Toward the end of World War II, it began to appear that any one of two or three commercially available shrink resistant processes could also be applied to woven fabrics. An intensified research program was then initiated by the Quartermaster Laboratories to adapt these treatments to the processing of wool shirting fabric. At the time this fabric presented the most serious laundering problem of all the woven fabrics used in Army clothing. These early processes used a resin or resin-like material. While they were satisfactory from the standpoint of shrink resistance, the quantities of resin necessary and the nature of the resins tended either to stiffen the fabric markedly or else to predispose it to stiffening after a relatively short period of storage.

During 1946 and 1947 a gradual transition took place in the quality and type of available processes. Improvements were made in resins so that smaller quantities were needed to achieve satisfactory felting resistance. Also techniques were evolved for the utilization of top- and yarn-chlorinated materials in the manufacture of woven fabrics. In addition, piece chlorination treatments were gradually being improved. One chlorination treatment in particular showed satisfactory performance under most conditions of use.

During this period considerable experimentation was conducted by the Quartermaster Laboratories in cooperation with industry to work out proper formulations for the 10.5-ounce shirting, using all the available shrink resistant processes. Extensive field testing was conducted to determine how the treated shirting fabrics would perform under field conditions. In addition, extensive laboratory development work was carried out to evolve effective and reproducible test methods for gaging the performance characteristics of the treated shirting. Finally, this effort culminated in September 1948 in the issuance of a report(1) describing the recommended test methods for evaluating shrink resistant shirting, and in April 1949 Quartermaster Corps Tentative Specification PQD 900, for Cloth, Wool, Flannel, 10.5-ounce Shrink Resistant was issued.

The applicable test methods and the tentative specification were widely circulated to the sponsors of shrink resistant processes, to shrink resistant processors and members of the worsted industry for study and comment.

It became apparent that only a very limited amount of technical "know-how" existed and that manufacturers were reluctant to offer large quantities without first having determined the feasibility of meeting the specification requirements on a production basis.

The Quartermaster Corps, accordingly, initiated an educational order program involving 40,000 yards of the treated shirting in the OD 33 and Blue 84 shades. The quantity awarded to any one bidder was limited to 2000 yards for any one color, or any one process, to obtain as wide a participation in this program as possible.

The worsted industry welcomed this program enthusiastically and made a gratifying response to the invitations. A more representative coverage of the available shrink resistant processes and the various types of plants could not have been obtained if they had been hand picked. The offerings included every shrink resistant process that had attained any degree of commercial acceptance in this country. In addition, a complete cross-section of the industry, including producers who had previously bid and produced on government contracts, was represented. Contracts were awarded on the basis of different processes and stages of application. Further, in order to obtain a wide representation of the various segments of the worsted industry, awards were made to plants that were completely integrated, having shrink resistant equipment; those that were integrated but had no shrink resistant equipment; and finally, non-integrated plants with and without shrink resistant treating equipment.

In this report the complete results of the program are summarized. The test data are plotted and the performance of the cloth submitted by each contractor is compared with that of the others and relative values are given indicating the performance of the various treatments. All treatments and contractors are referred to by code number.

In interpreting the significance of these data, the experimental nature of the study should be considered. Instances of obvious failure to meet performance requirements should be recognized as not necessarily attributable to weaknesses of a specific treatment or mode of application of the treatment, or to the contractor or finisher involved, but more to inherent difficulties normally associated with the introduction of a major change in processing techniques. That many of the contractors were able to meet all of the specification requirements in this small procurement is indeed a tribute to the technical competency of the textile industry.

II SHRINK RESISTANT PROCESSES*

The processes in commercial use in the United States today can be roughly divided into two categories — the wet chlorination type and the resin type. Other types have been developed and used but only to a very limited extent. Such processes as the alcoholic-potash process of Freney-Lipson and the dry chlorination process of the Wool Industries Research Association have been tried out in this country on a limited scale but have not received any degree of commercial acceptance.

A. Wet Chlorination Processes

The wet chlorination processes included in this study were Harriset, Kelpie, Kroy, Sanforlan, and Schollerize. They were applied either to the wool top or to the fabric, and in some instances part of the production on a given award was treated at one stage and part at another, both by the same process.

Harriset: The fabric or top is immersed for a short time (seconds) in a solution containing a wetting agent and available chlorine in the form of hypochlorite. The pH, temperature, and chlorine concentration are regulated by automatic controls and by the use of flowmeters. The wool passes through a pair of squeeze rolls and the action is stopped in a dilute sodium bisulfite solution. After passing through the anti-chlor bath, the wool is squeezed, passed through a series of rinse boxes and then into a conventional drier.

Kelpie: In the Kelpie acid chlorination process, the solution used contains a relatively high quantity of free chlorine and a lesser quantity of hypochlorite and sulfuric acid. The shrink resistant effect is produced by passing the wool through the chlorinating bath continuously and rapidly. The time of immersion is about 30 seconds. The wool then passes through an anti-chlor rinsing bath and softener. The Kelpie process in this series of experiments was applied to the wool in top form.

* Since this work was performed at the end of 1949 and the beginning of 1950 many of the processing techniques described may have been modified. This should be kept in mind in appraising this section of the report

Kroy: Kroy is a rapid wet halogenation process. The effectiveness and uniformity of the process are obtained by control of halogen concentration, time, temperature and pH. Any of these may be varied with respect to the others, thus permitting adjustment to a common level of treatment.

Sanforlan: Sanforlan is an alkaline batch chlorination treatment in which potassium permanganate is used as an adjunct. The process is carried out in a top dyeing machine in the presence of wetting agent and buffer. The action is continued until the wool properly exhausts the chlorine and the permanganate as determined by titration. The fabric is then neutralized, cleared, rinsed, dried, and finished in the conventional manner.

Schollerize: In the Schollerize batch chlorination process, the fabric is first acidified and then brought to the proper pH by means of a buffering agent. A buffered solution of calcium hypochlorite is added to the fabric and the bath is allowed to run for 5 minutes, after which an antichlor is added. The bath is then dropped and the fabric rinsed.

B. Resin Processes

The resin processes include the thermosetting resins, such as the melamine formaldehydes, and the rubber-like resins, which are primarily polybutadienes. The resin treatments used in these orders included Resloom and Lanaset, which are of the melamine formaldehyde type, and Durlana and Koloc, which are rubber-like in nature.

Durlana: The base material in the Durlana process is a soap emulsion of a prepolymerized resin. The resin is applied to the fabric in a standard dye kettle. The fabric is entered into the kettle, thoroughly wet out, brought to a pH of 5 using acetic acid, and treated with sodium chloride and the required amount of resin. Further additions of acid are made until the resin is completely exhausted. The fabric is then rinsed, cooled, extracted, dried, and finished in the usual fashion.

Koloc: The base material used in the Koloc process is a water emulsion of a prepolymerized resin. The fabric is prepared for treatment by fulling, scouring thoroughly, rinsing, and drying. The fabric is padded with a dispersion of the resin and formic acid in water, adjusted to give a 6% concentration of resin solids on the fabric on a dry weight basis. The fabric is folded and allowed to set for approximately one hour, during which time the resin is exhausted much in the manner of dyestuffs. After exhaustion, the fabric is placed in a dye kettle, thoroughly rinsed, extracted open width through squeeze rolls, and dried in an over-feed dryer operating at a temperature of 250 deg.F.

Lanaset: In the Lanaset process, the cloth is scoured, dried, and passed through a padder containing a colloidal solution of the resin. Approximately 5.5% of resin solids are deposited on the fabric, which is then dried at a temperature of 240 deg. F. After drying, the fabric is washed in soda ash, softened, extracted and redried at a temperature of 240 deg. F.

Resloom: In the Resloom process, the resin is applied to the dry cloth after all of the usual wet finishing operations. The fabric is passed through a padder containing resin (melamine formaldehyde monomer), a catalyst (to insure the polymerization of the monomer) and a wetting agent (to insure thorough penetration and wetting out of the fabric). The speed of application is approximately 16 yards per minute. The cloth is dried at a temperature of 210 deg. F. and then cured at a temperature of approximately 300 deg. F. (One of the contractors used a carbonizer which furnished infra-red radiation for the curing). The cloth is then washed in synthetic detergent to remove all the unreacted catalyst, rinsed, dried and finished in the usual way.

III PRODUCTION PROBLEMS

On the basis of preliminary laboratory studies, it was anticipated that where the shrink resistant treatment had been applied at a stage of processing prior to weaving, difficulty might be encountered in finishing, particularly with reference to the surface effect desired.

Accordingly, the results of these findings together with suggested corrective measures were made available to the contractors.

By and large, the problem most frequently encountered in this program was the inability of many of the contractors to meet the established shade tolerances allowed for the fabric. Practically every type of treatment presented its own particular problem. The rapid strike of dyestuffs in the case of the chlorination treatments, although well known and recognized by the dyer, proved to be a difficult problem to cope with. Variations in pH and acid-base balances among the various treatments undoubtedly contributed to the difficulty encountered here.

During the course of production of the samples, the manufacturers, and particularly the finishers, were frequently contacted to determine the causes of any difficulties that were being encountered in meeting the required shade. In addition, the delivered samples were frequently analyzed and compared with norms for untreated production. Study of this problem in all of its aspects led to the conclusion that most of the difficulties that arose were due more to the vagaries of small scale production than to any specific problem posed by either the chlorinated or resin treated wool.

IV TEST METHODS

In addition to the standard physical tests previously used in evaluating the performance of untreated flannel shirting, several special methods were employed to evaluate the characteristics of the fabric that might be specifically affected by the shrink resistant treatment. These tests are for felting shrinkage, stiffness, aging, and alkali solubility.

Shrinkage

Probably one of the most difficult textile test methods to interpret from the standpoint of reproducibility and correlation with end use is the test for shrinkage. The testing of flannel shirting is especially complicated because there are two distinct types of shrinkage (relaxation and felting) which must be taken into consideration. The development from Quartermaster research of reproducible test methods for measuring relaxation and felting shrinkage have advanced the program of shrink resistance and have led to the development of specification requirements that are more realistic than those of the past. The basis for these shrinkage tests has been described elsewhere(1).

Essentially the relaxation test consists of soaking the fabric in water, without agitation, for a period of 2 hours, thoroughly extracting in a centrifugal extractor for 5 minutes and drying in a tumbler drier. The unique features of the felting test are control of pH and elimination of soap or detergent. The felting test is performed in a 24-inch diameter horizontal axis washer. The wool specimens and standard ballast are agitated in 4 inches of water (buffered to a pH of 7) at a temperature of 140 deg. F. for a period of one hour. The specimens are then centrifugally extracted, dried in a tumbler, sprayed, and pressed. This test has now been used continuously for a period of four years and has consistently demonstrated its value in determining the performance of shrink resistant treated materials.

Stiffness

The necessity for a stiffness test was recognized early in the shrink resistance program when it became apparent that in order to meet the shrinkage requirements of the specification, resins might be used in quantities which would adversely affect the handle of the fabric. Establishment of a clear correlation between stiffness and fabric "handle" presents an almost insuperable problem, since "handle" is a composite of stiffness and other factors such as surface friction and compressibility. However, a test was made in which treated and untreated shirting fabrics were first ranked subjectively from the most flexible to the stiffest, disregarding as far as possible sensations due to surface feel and fabric compressibility, and then were evaluated for stiffness on a Tinius Olsen tester.* A good relationship was found between the subjective rankings and the machine values(2).

Aging

Another property of some resin treatments is apparent instability to long-term storage, heat, and ultra-violet radiation. Two aging tests were developed to determine whether the suitability of the treated fabrics had been impaired from this standpoint by the use of unstable materials. Tests showed that fabrics treated with resins sensitive to aging became powdery, changed shade, and stiffened. Increase in stiffness was found to be the simplest method of measuring this response to aging. The aging tests are described in Appendix B.

Alkali solubility

The alkali solubility test has been accepted as a standard method of evaluating damage to wool caused by oxidative treatments. Although a point-for-point correlation has not been established between alkali solubility and wear, it is known that samples with excessive alkali solubility are often harsh to the touch, deteriorate rapidly in laundering and become slimy when wet. Such fabrics have been reported in the literature(3) as abrading more rapidly. The alkali solubility test is described in Specification CCC-T-191b, Method 2800.

Color and Colorfastness

The shade of the samples was evaluated by standard shade board techniques under artificial light having a color temperature of 7500 degrees Kelvin approximating natural North sky light and

* Described in Method 5202, Federal Specification Textile Test Methods CCC-T-191b, 15 May 1951.

also under incandescent lamplight at 2800 degrees Kelvin. Shade swatches representing each roll of cloth produced were evaluated as acceptable or unacceptable, based upon normal tolerances which had been developed for the 10.5-ounce shirting. In addition, photometric measurements were made on samples picked as representative of the outer extremes of the shades delivered. A General Electric Recording Spectrophotomer was used and the curves obtained were integrated, tristimulus values computed, and trichromatic coefficients plotted to furnish an idea of the relative spread of these extreme limit values about the standard.

Fastness to perspiration, wet-dry cleaning and crocking were tested in accordance with standard methods of Federal Specification CCC-T-191b. The fastness to laundering was evaluated by subjecting samples of fabric to multiple cycles of the Army mobile laundering procedure. All samples were laundered together. To achieve uniformity of treatment the bath-to-cloth ratio was cut to 1/2 of the washer capacity. The fastness to light was determined on five replicates for each fabric exposed in a Model FDAR Fadeometer. The OD samples were exposed for 40, 80, and 120 hours and the blues for 40 and 80 hours. Color measurements for both fastness-to-light tests were made on a Hunter Color and Color Difference Meter. The change in color in Judd units was computed using the formula supplied by Mr. Richard Hunter(4) who developed the method:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

where ΔL is the difference in lighness, Δa the difference in amber filter reading, and Δb the difference in blue filter reading.

V RESULTS AND DISCUSSION

The results of the various specification tests made on the treated fabrics are summarized in Table I. The most significant test parameters are presented in graphical form in Figures 1 to 5, inclusive. In each figure the specification requirement is indicated by a broken line drawn perpendicular to the base of the graph. Frequency distribution curves have been drawn which show, for the characteristic measured, the proportion of the pieces tested from all of the contractors falling within the given class interval. The average performance of each contractor is indicated by a code letter at the bottom of the graph. These values represent the average noted for three rolls of the fabric drawn at random from the deliveries of each contractor. A comparison of the areas under the frequency distribution curve on each side of the broken line indicating the specification requirement may be used as an index of the ease with which the contractors as a group met the particular specification requirement.

TABLE I

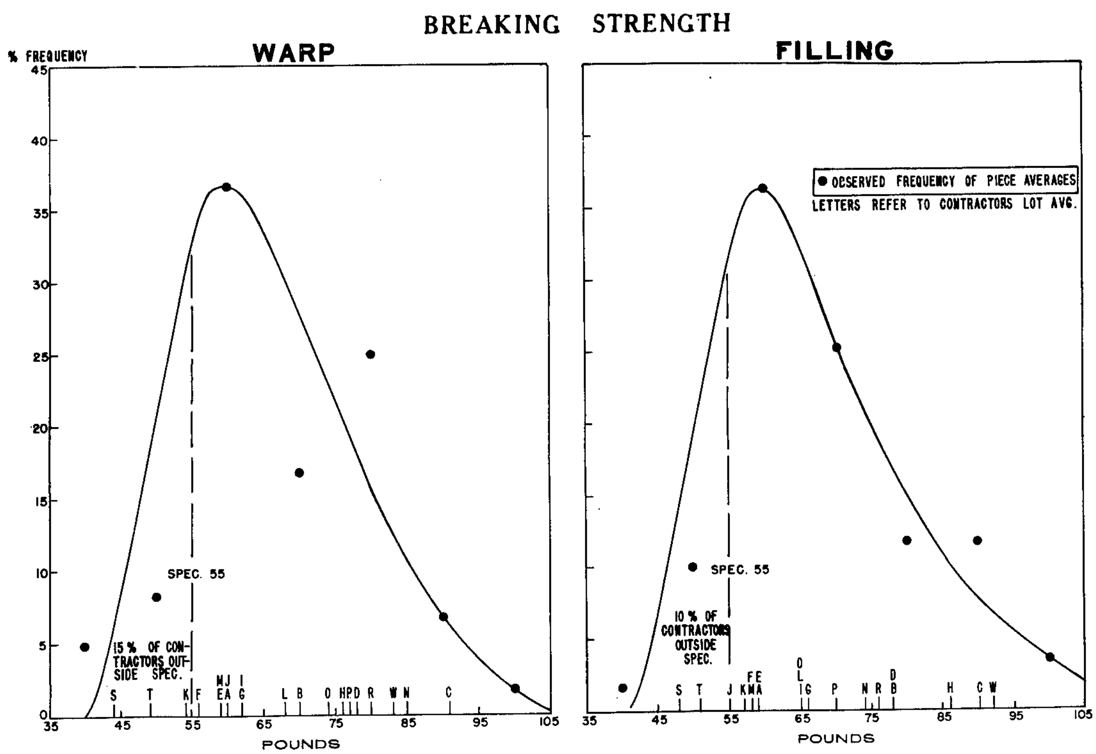
Contractors' Performance in Meeting Specification Requirements

Test	Specification	Overall Avg	Contractors Outside Spec. %	Letters	Lot Value
1. Breaking strength (lb)					
Warp	Min 55	67	15	K	54
				S	44
				T	49
Filling	Min 55	67	10	S	48
				T	51
2. Weight (oz/linear yd)	Min 10.5	10.5	50	E	10.0
				F	10.3
				G	9.9
				H	10.4
				J	10.4
				K	10.1
				M	10.3
				O	10.2
				S	9.6
				T	10.1
	Max 12.6		0		
3. Texture (threads per inch)					
Warp	Min 68	70	0		
Filling	Min 68	69.5	0		
4. Relaxation shrinkage (%)					
Warp	Max 5.0	3.1	10	B	5.4
				O	6.4
Filling	Max 4.0	1.2	10	B	5.1
				G	4.9
5. Felting shrinkage (%)					
Warp	Max 4.0	2.9	10	A	7.5
				F	6.0
Filling	Max 3.0	1.3	5	A	3.5
6. Stiffness (lb)					
Original	Max 0.0030	0.0017	0		
After light aging	Max 0.0040	0.0019	5	K	0.0052
After heat aging	Max 0.0040	0.0027	15	I	0.0058
				J	0.0045
				K	0.0073

Breaking Strength

The warp and filling breaking strengths are plotted in Figure 1. Three out of the 20 contractors failed to meet either the warp or filling strength or both. In all three instances, the low breaking strength is associated with low cloth weight. There is no evidence in the study of these fabrics to indicate that the shrink resistant treatment produced a significant loss in breaking strength of the fabrics. In fact, it has been observed(5) that some of the chlorination treatments have a tendency to increase the strength of fabrics by increasing the fiber-to-fiber friction in the yarns. While some of the pieces of fabric tested ran as high as 90-100 lb in strength the great bulk of them clustered just above the specification requirement of 55 lb. The combined average breaking strength for the warp and filling directions was 67 lb.

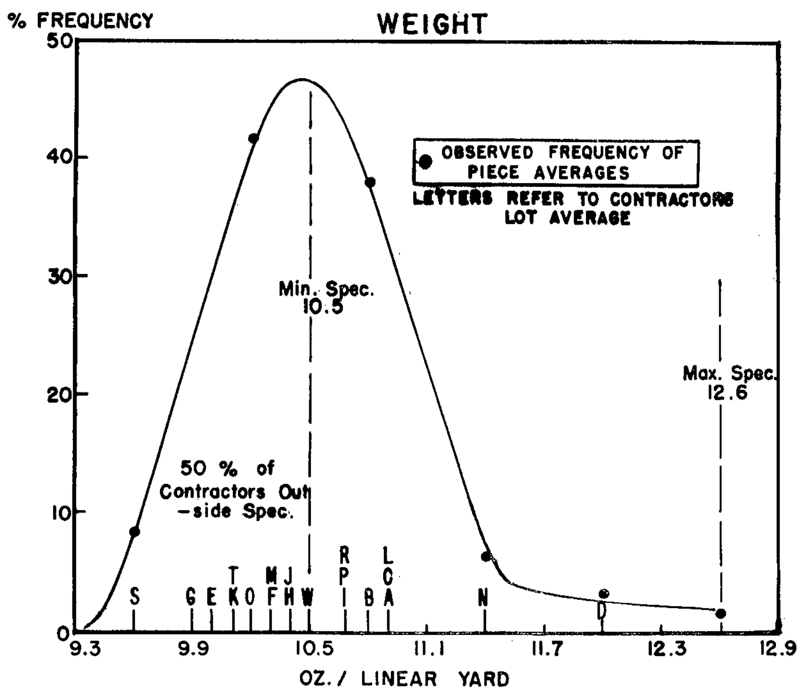
FIG. I
QUALITY LEVEL OF CLOTH, WOOL FLANNEL
(10.5 OZ. SHRINK RESISTANT)



Weight

As shown in Table I and Figure 2, ten of the contractors, or 50%, failed to meet the minimum weight requirement of the specification. For seven of these ten contractors, who used shrink resistant top, this failure was due primarily to the fact that the weight of the fabrics did not increase as expected in scouring and fulling because of the inherent shrink resistance of the treated wool. For the remaining three who employed piece treatments (two resin types and one chlorination) the failure to meet specification weight requirements may be attributed to vagaries in production in such small yardages of fabric. For larger runs it would appear that proper adjustment and allowances could be made early in production to assure delivery within the proper weight range. None of the contractors exceeded the maximum weight requirement of the specification. The two heaviest fabrics were both produced by contractors who used the melamine formaldehyde type of shrink resistant treatment.

FIG. 2
QUALITY LEVEL OF CLOTH, WOOL FLANNEL
(10.5 OZ. SHRINK RESISTANT)



Shrinkage

Plotted in Figures 3 and 4 are frequency distribution curves for relaxation and felting respectively. One contractor failed to meet the requirements for both warp and filling relaxation shrinkage, one failed to meet the requirement for warp only, and one for filling only. Since relaxation shrinkage is evaluated by a rather severe procedure involving tumbler drying, this represents a good level of performance. The very low relaxation shrinkages obtained by some of the contractors (in the vicinity of one and two percent) indicates the possibility of producing wool cloth which would not have to be subjected to the normal sponging operations prior to cutting. The average relaxation shrinkage of 3.1% for the warp and 1.2% for the filling fall well within the specification requirements of 5.0% and 4.0% respectively.

There did not appear to be any association between the amount of relaxation and felting shrinkage. One contractor failed to meet both the warp and filling requirements for felting shrinkage and two contractors failed to meet the warp requirements alone. One of these two contractors exceeded the 4.0% warp felting by such a small amount that his fabric could be considered acceptable. The other, however, along with the contractor whose fabric shrank excessively in both directions, far exceeded the allowable warp felting shrinkage. Both used the same shrink resistant treatment. The averages of 2.9% for the warp and 1.3% for the filling compare favorably with the specification requirement of 4.0% and 3.0% respectively.

Stiffness and Aging

The stiffness of the fabrics originally and after light- and heat-aging is plotted in Figure 5. The specification requirement for an original stiffness of not more than 0.0030 lb was easily met by all of the contractors. With further improvement of the resin processes it is likely that this value can be reduced even further. Results of the aging tests revealed that the heat-aging test is more discriminating than the light-aging test. Three of the fabrics were treated with aging type resins, and all three were identified by the heat-aging test, whereas only one was identified by the light-aging test. The specification level of 0.0040 lb for stiffness after aging appears to be satisfactory, although one piece from one of the contractors who used the aging type resin did meet this requirement after heat aging.

FIG. 3

QUALITY LEVEL OF CLOTH, WOOL FLANNEL

(10.5 OZ. SHRINK RESISTANT)

RELAXATION SHRINKAGE

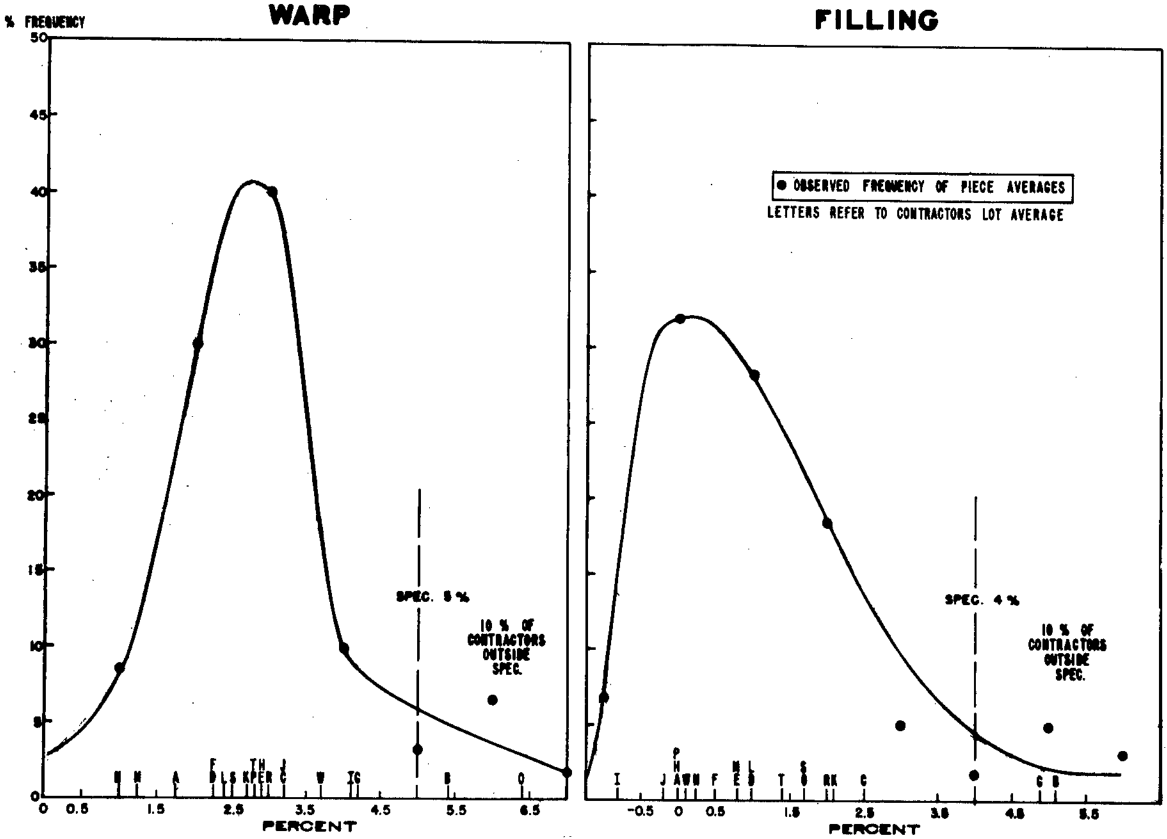


FIG. 4

QUALITY LEVEL OF CLOTH, WOOL FLANNEL

(10.5 OZ. SHRINK RESISTANT)

FELTING SHRINKAGE

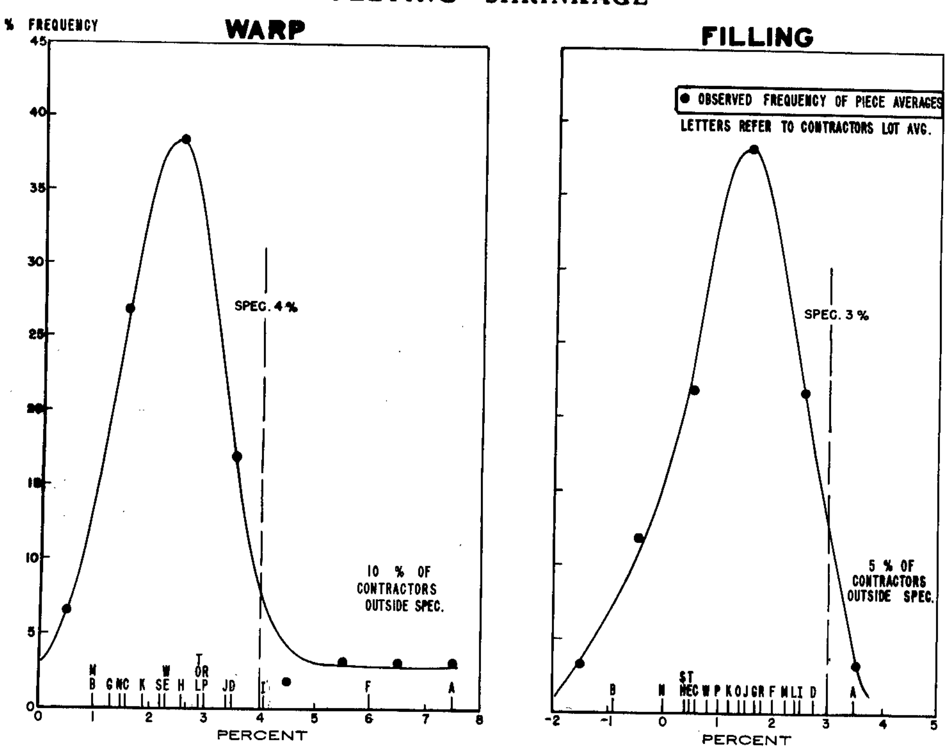


FIG. 5

QUALITY LEVEL OF CLOTH WOOL FLANNEL

(10.5 OZ. SHRINK RESISTANT)

STIFFNESS

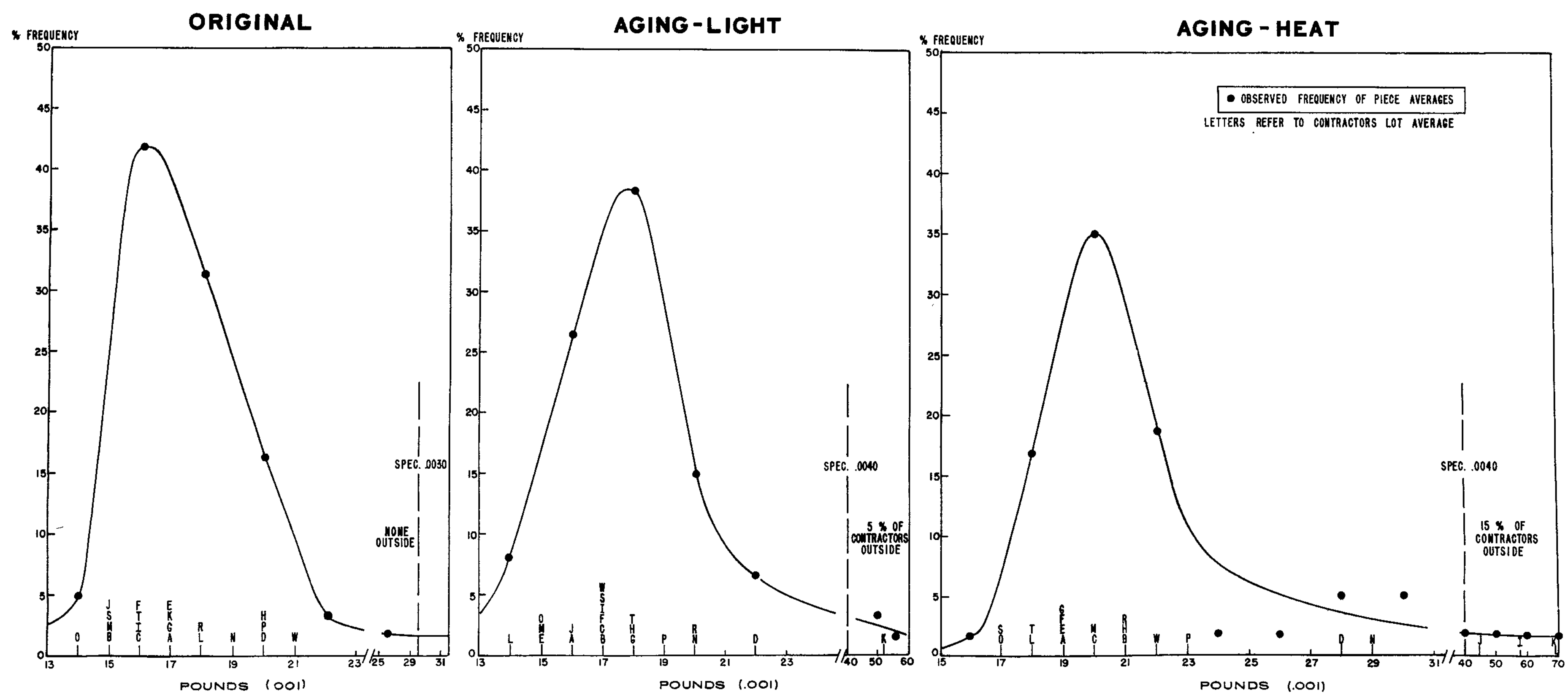


TABLE II

Percentages of Acceptable and Unacceptable Fabric Submitted by Each Contractor on Basis of Liberal Shade Tolerances

O.D. 33

Contractor	% Acceptable	% Unacceptable
C	25	75
D	0	100
F	43	57
G	100	0
I	61	39
K	100	0
L	100	0
M	49	51
P	0	100
R	96	4
S	88	12
W	64	36
Average	60.5	39.5

Blue 84

Contractor	% Acceptable	% Unacceptable
B	0	100
E	57	43
H	100	0
J	59	41
N	65	35
O	100	0
T	0	100
Average	54.4	45.6

TABLE III

Color Characteristics of Individual Sponged Samples Showing Widest Deviations from Standards

Sample No.	$\bar{x}$	$\bar{y}$	Y	Dominant Wave Length	% Excitation Purity	Δ E Judd Units
OD 33						
Standard	0.3577	0.3559	0.545	580.0	23.0	–
1	0.3587	0.3552	0.548			0.84
2	0.3504	0.3525	0.612			1.76
3	0.3517	0.3533	0.591			1.39
4	0.3531	0.3568	0.531			1.01
5	0.3525	0.3560	0.643			2.69
6	0.3548	0.3578	0.537			0.59
7	0.3511	0.3511	0.522			1.39
8	0.3561	0.3543	0.542			0.59
9	0.3544	0.3538	0.535			0.59
10	0.3570	0.3520	0.513			1.26
11	0.3520	0.3514	0.531			0.92
12	0.3551	0.3545	0.544			0.59
13	0.3487	0.3482	0.627			2.44
14	0.3535	0.3506	0.554			0.92
Blue 84						
Standard	0.2601	0.2556	0.419	473.6	25.5	–
1	0.2573	0.2540	0.421			1.26
2	0.2638	0.2610	0.426			0.42
3	0.2581	0.2538	0.440			0.59
4	0.2603	0.2550	0.506			2.44
5	0.2639	0.2569	0.450			0.84
6	0.2577	0.2552	0.458			0.92
7	0.2585	0.2549	0.520			2.56
8	0.2610	0.2574	0.461			1.18
9	0.2552	0.2538	0.440			1.26
10	0.2578	0.2516	0.408			0.71

Color

The variations in shade for both the OD 33 and Blue 84 were quite broad. Inasmuch as the quantities of fabric dyed were relatively small, it was realized that more difficulty would be encountered in the control of shade than in regular full production runs. For this reason, much more liberal tolerances than customary were allowed in the evaluation of the fabrics for shade. The tolerances were placed approximately 1.25 Judd units from the standard. Table II shows the percentages of pieces of cloth from each contractor that would be considered acceptable and unacceptable according to these liberal shade requirements. The variation in shade noted among the deliveries of the various contractors, as well as within a given contract, is indicative of the necessity for careful control of the dyeing and finishing process. It was not possible to relate variations specifically to any one class or type of treatment. For each shade there were instances of 100 per cent acceptable deliveries and 100 per cent unacceptable deliveries, indicating that a resolute effort may have been made in some cases and possibly not in others.

An indication of the spread in shade noted among the fabrics can be obtained from Table III which shows the trichromatic coefficients and color differences calculated by the Nickerson formula(6) for samples representing the extreme limits of shade

FIG. 6

CHANGE IN COLOR OF SHRINK RESISTANT TREATED SHIRTING AFTER 5 MOBILE LAUNDERINGS.

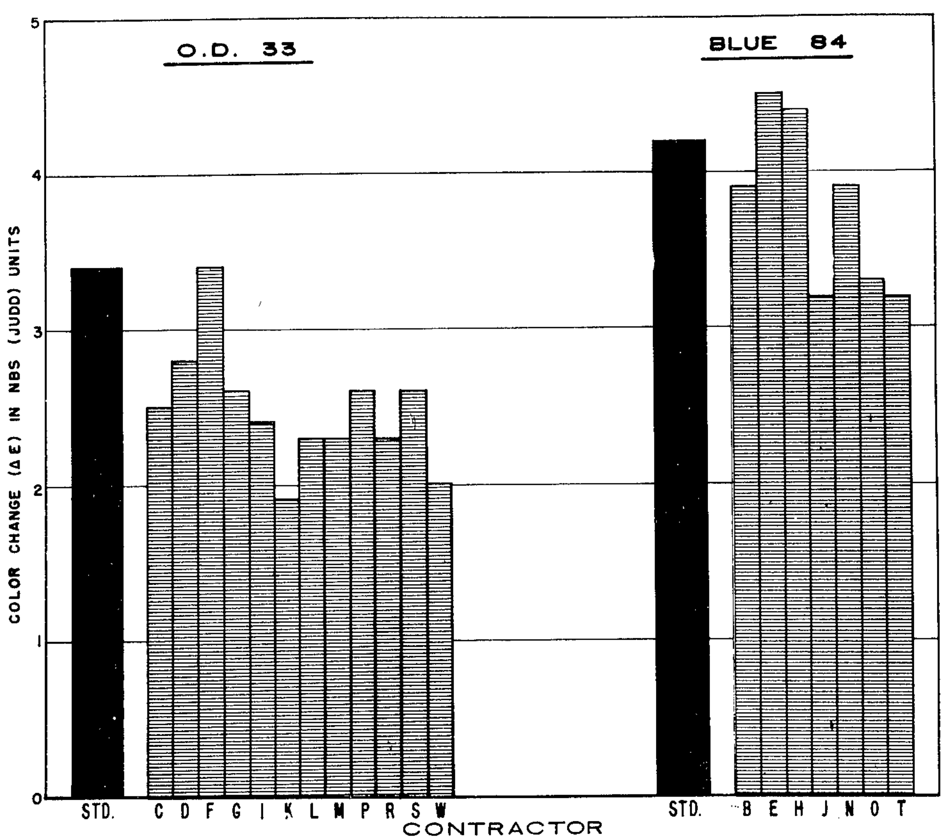
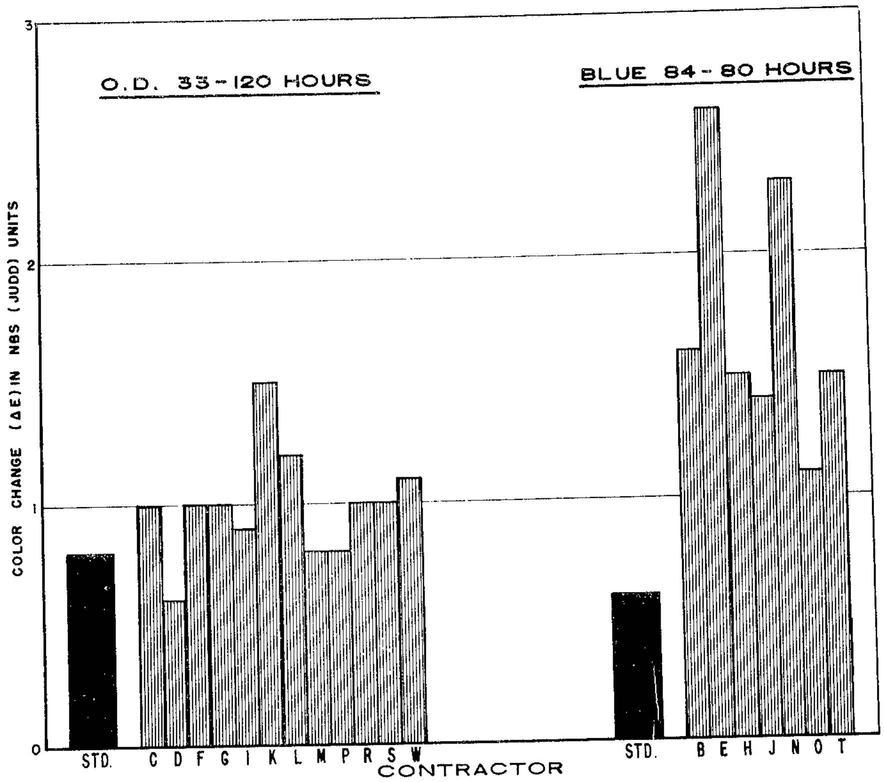


FIG. 7

CHANGE IN COLOR OF SHRINK RESISTANT TREATED SHIRTING AFTER FADEOMETER FADING



delivered. Since the contractors had to use a specified dyestuff formula for the OD 33, it was assumed that these fabrics would fall within a closer visual tolerance than those dyed to the Blue 84 where any dyestuff of the approved class could be employed. This was found to be the case although it is not apparent in the numerical data because of the differences in sensitivity of the human eye in different spectral regions, smaller color differences being observable in the OD range than in the blue. Consideration of the data must also be tempered by the fact that some refinishing is known to have been practiced by individual contractors for one reason or another.

Colorfastness

The color change in Judd (NBS) units noted after five mobile launderings is plotted in Figure 6. Each value shown is an average of five replicates with a mean deviation of ± 0.2 Judd unit. In spite of this wide variance of the values about the mean it can be concluded that the laundering fastness of the shrink resistant treated samples is as good as or better than that of the untreated, with the OD 33 samples showing a more significant difference than the Blue 84 samples.

In Figure 7 is shown the resistance of the samples to Fadeometer fading. The mean deviation of these values is of the same order as that for the data shown in Figure 6. Hence the differences in

TABLE IV

Resistance of Shrink Resistant Fabrics to Wet Cleaning, Perspiration, and Crocking

	Contractor	AATCC Ranking			Munsell Value	
		Resistance to Wet Cleaning	Resistance to Perspiration		Crocking	
			Acid	Alkaline	Wet	Dry
OD 33	Standard	5	4	4	8	9
	C	5	4	4	8	9
	D	4	4	3	8	8
	F	5	2	3	9	9
	G	5	4	4	8	8
	I	3	3	3	8	8
	K	3	4	3	8	9
	L	5	4	4	7	9
	M	5	4	5	8	9
	P	4	3	2	9	9
	R	5	4	4	9	8
	S	4	3	3	9	9
	W	5	3	4	9	9
Blue 84	Standard	5	5	5	9.5	9.5
	B	4	4	1	8	8
	E	5	3	1	9	9
	H	4	4	3	9	9
	J	4	4	4	9	8
	N	4	4	4	9	9
	O	4	4	4	8	9
	T	4	4	4	8	8

fastness to fading between the shrink resistant treated and untreated OD 33 samples cannot be considered significant. Significant variation was obtained with the Blue 84 samples, but this may be due to the use of different dyestuffs, since the dyestuff formulation was not specified here as it was in the case of the OD 33. Inasmuch as the shrink resistant treatments used for the OD 33 and for the Blue 84 were the same, and the Blue 84 samples showed much more variation in light fastness than the OD 33 samples, it is assumed that the dyestuffs rather than the shrink resistant treatments were primarily responsible for the differences noted.

Table IV shows the data obtained for fastness to wet cleaning, perspiration (acid and alkaline), and wet and dry crocking. The relative ranking of the samples for resistance to wet cleaning and perspiration is based on a system propounded by AATCC and used throughout the industry in which 5 denotes a negligible color change or none at all, and 4, 3, 2, and 1 are equivalent to Munsell values of 9, 8, 7, and 6 respectively. To meet vigorous military fastness requirements the relative ranking should be 4 or 5. Crocking values are shown as Munsell numbers in accordance with prevailing practice in military specifications. In general the shrink resistant treated samples appear to be as satisfactory as the untreated standards in their resistance to wet cleaning, perspiration, and crocking. In the few instances where the treated samples were poorer than the untreated, a lack of control and (in the case of the Blue 84) the differences in the dyestuffs used are probably responsible rather than the shrink resistant processes.

VI CONCLUSIONS

1. Approximately 84% of the contractors met the requirements for warp breaking strength and 90% met those for filling breaking strength. Low breaking strength was associated with low cloth weight.

2. Only 50% of the contractors met the weight requirement of the specification, all the rest being below the specification minimum. The most consistent cause for low weight was the failure to recognize that the shrink resistant treated wool would not full and increase in weight during the scouring operation.

3. Ninety per cent of the contractors met the requirements for relaxation shrinkage, both in the warp and filling direction. There appears to be no relationship between relaxation shrinkage and the shrink resistant treatment as such.

4. Ninety per cent of the contractors met the specification requirements for felting shrinkage both in the warp and filling direction. Two of the contractors who failed to meet the felting shrinkage requirements used the same treatment.

5. All the contractors met the specification requirements for original fabric stiffness.

6. Ninety per cent of the contractors met the requirement for stiffness after light aging and 85% met that for stiffness after heat aging. All of the contractors who failed to meet aging requirements used shrink resistant resin treatments which are known to have poor aging characteristics.

7. Approximately 61% of the OD 33 pieces produced by all contractors were considered acceptable from a liberal shade standpoint, while only 54% of the blue samples were considered acceptable. Three contractors who produced OD 33 and two who produced Blue 84 had 100% of their production within these liberal shade tolerances.

8. Both the blue and the OD shrink resistant treated shirting seemed to show slightly better fastness to washing than the respective untreated standards.

9. The OD 33 shrink resistant treated shirtings were not significantly different in resistance to Fadeometer fading from the untreated, but the Blue 84 showed in general somewhat poorer resistance than the untreated standard. These differences in the Blue 84 are probably due to the dyestuff used. Differences in other fastness properties, wet-cleaning, perspiration and crocking could not be significantly related to the shrink resistant treatment.

10. Based on the experiences of this study, the production of shrink resistant shirting appears practical and feasible for military procurements. Production experience subsequent to the completion of these Educational Orders confirms the practicality of shrink resistant treated wool for military use.

APPENDIX A

List of Contractors on Educational Orders

American Woolen Company, 225 Fourth Avenue, New York, New York
Ames Textile Corp., Empire State Building, New York 1, New York
Bachmann Uxbridge Worsted Corp., Uxbridge Worsted Co. Div., Uxbridge, Mass.
Guerin Mills, Inc., 292 East School Street, Woonsocket, Rhode Island
The Livingston Worsted Mills, Inc., Holyoke, Massachusetts
Lorraine Manufacturing Co., Pawtucket, Rhode Island
Merion Worsted Mills, West Conshohocken, Penna.
Metcalf Brothers and Co., 45 East 17th Street, New York 3, New York
Methuen International Mills, Methuen, Massachusetts
Pacific Mills, 261 Fifth Avenue, New York 16, New York
Shamokin Woolen Mills, Inc., 450 Seventh Ave., New York, New York
Shepperd Mills, Inc., Manayunk Station, Phila 27, Penna.
Stillwater Worsted Mills, Inc., Harrisville, Rhode Island
John Walther Fabrics, Inc., Ontario and "D" Streets, Phila 34, Penna.
Windsor Manufacturing Co., Jasper and Butler Streets, Phila 24, Penna.
William Whitman Co., Inc., 261 Fifth Avenue, New York 16, New York
Yorkshire Worsted Mills, Lenni, Penna.

List of Treatments

Lanaset - American Cyanamid Co., Bound Brook, New Jersey
Sanforlan - Cluett Peabody and Co., Inc., 10 E. 40th St., New York, New York
Kroy - Kroy Inc., 80 Market St., Lowell, Mass.
Koloc - Naugatuck Chemical Co., Div. of U.S. Rubber Co., Naugatuck, Conn.
Harriset - Harris Research Laboratories, 1246 Taylor St., Washington, D. C.
Schollerize - Scholler Bros. Inc., Collins and Westmoreland Sts., Phila, Pa.
Resloom - Monsanto Chemical Co., Merrimac Division, Everett Station, Boston, Mass.
Kelpie - S and M Dye Works, Inc., 3419 Richmond St., Phila, Pa.
Durlana - Warwick Chemical Co., West Warwick, Rhode Island

APPENDIX B

AGING TESTS

Light aging

A specimen of the finished cloth approximately 2.5 inches wide and 6.5 inches long shall be exposed in a fading machine for a period of 100 hours with face of the fabric exposed to the source of radiation. At the end ef this time, the specimen shall be removed, conditioned in a standard atmosphere for a period of 4 hours and evaluated for harshness and for stiffness.

Heat aging

Four treated specimens, 3 inches square, shall be used for this test. The apparatus shall consist of a well ventilated oven controlled at 200° ± 5°C. Two glass plates 6 inches square, approximately 3/8 inches thick and each weighing approximately 1.25 pounds shall be used. The four specimens of the treated fabric are placed one on top of the other between the two six-inch square glass plates and placed in theoven at 200°C for a period of one hour. Upon completion of the heating period, the test specimens shall be removed from the oven, conditioned for four hours in a standard atmosphere, and evaluated for harshness and for stiffness.

<u>REFERENCES</u>

1. L. I., Weiner, "Quartermaster Corps Accelerated Test Method for Evaluating Shrink Resistant Wool." Am. Dyestuff Rptr., 38, 289 (1949).

2. L. I., Weiner, et al. "A Method for Measuring the Stiffness of Resin-Treated Wool Shirting." Topical Report No. 30, Textile Finishing Lab., Quartermaster Research and Development Laboratories (Unpublished).

3. M. Harris, and A. L., Smith, "Oxidation of Wool: Alkali-Solubility Test for Determining the Extent of Oxidation." J. Research, Nat. Bur. Standards, 17, 577 (1936).

4. Description and Instructions for the Hunter Color and Color Difference Meter. Bethesda, Md.: Henry A. Gardener Laboratory, Inc., June 1950.

5. H., Phillips, "Modern Methods of Reducing the Normal Felting Properties of Wool and Wool Goods. J. Soc. Dyers and Colourists, 58, 245 (1942).

6. D., Nickerson, "Tables for Use in Comparing Small Color Differences." Am. Dyestuff Rptr., 39, 541 (1950).